# SECTION 4

## *Air Quality Analysis*

TMS Consultants • Lonco Inc.
Hook Engineering • Dr. George Hearn

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# Task 4 - Air Quality Analysis

## Introduction

This chapter presents the impacts that the nondivisible load has on air quality. Intuitively, it would seem that fewer trucks on the roadway would correspond to a reduction in air emissions. The main pollutants tracked by the Environmental Protection Agency (EPA) are VOx, CO, NOx and PM10.

The trucks reviewed in this study are mostly powered by diesel fuels. Diesel fuels are comprised of hydrocarbons, compounds which contain hydrogen and carbon. During the combustion process, oxygen is combined with the hydrocarbons to produce energy. The byproduct of this process is unburned hydrocarbons, nitrogen oxides, carbon monoxide, and water. Sulfur is also present in fuel which causes the creation of hydrated sulfuric acid.

*Hydrocarbons*

Hydrocarbons are the major component of fuel. Not all of the fuel molecules in the engine will burn completely. Unburned and partially burned hydrocarbons will be emitted during the combustion process. Hydrocarbons will also be lost through evaporation such as:

- Diurnal evaporation occurs when the temperature rises during the day increasing the pressure in the fuel tank where gasoline vapor will be emitted.
- Running losses occur as the hot engine and exhaust system vaporize gasoline as the truck is running.
- Hot soak losses happen immediately after truck is turned off and unburned fuel continues to evaporate as the car returns to outside air temperature.
- Refueling losses will also occur as fuel vapor is forced out of the tank to make room for the diesel fuel.

Hydrocarbons will combine with nitrogen oxides and sunlight to form ground-level ozone. This ozone is a major component of smog and has other effects such as lung and eye irritation. Ozone also aggravates the respiratory system. Unburned hydrocarbons can also be toxic and are believed to be carcinogenic.

*Nitrogen Oxides*

During the combustion process, the nitrogen and oxygen found in air are reacted together due to the high temperature and pressure. Various oxides of nitrogen (commonly referred to as NOx) are created. These are also responsible for the creation of ozone. Nitrogen oxides are also contributors to the formation of acid rain.

*Carbon Monoxide*

Carbon Monoxide would not be created if all of the hydrocarbons in the fuel oxidized completely to carbon dioxide. However, carbon in the fuel is partially oxidized forming carbon monoxide. Carbon monoxide forms a tight bond with the hemoglobin in the bloodstream and takes up space that would normally be used by oxygen. Carbon monoxide is particularly dangerous to people with heart conditions.

*PM-10*

Small particles of matter will be emitted from the movement of the vehicle and from the diesel exhaust. If these particles are less than 10 microns, they can have an impact on the respiratory system. Diesel particulate matter (DPM) is the most problematic emission. DPM is comprised of elemental carbon and heavy hydrocarbons derived from the fuel and lubricating oil.

*Carbon Dioxide*

Carbon dioxide does not impact human health and is a prevalent component of air.

However, the EPA has recently started to view this byproduct of combustion with concern as it could trap heat into the earth's atmosphere.

*Sulfuric Acid*

Heavy duty vehicles are powered by diesel fuel which have a high sulfur content. Diesel fuel burns similar to gasoline, but have slightly different emissions. Hydrated sulfuric acid is derived from the sulfur in the fuel. Sulfuric acid is a component of acid rain.

## EPA Regulation of Heavy Vehicles

Until recently, heavy duty vehicles (including SUVs) have not been as regulated as the gasoline powered light duty vehicles. This will change with the Advance Notice of Proposed Rulemaking (ANPRM) which was released in May, 1999 and February, 2000. Under this rule, heavy truck manufacturers will be required to meet the following standards:

- PM emissions will be limited to .01 grams per brake horsepower-hour to take full effect in the 2007 heavy-duty engine model year. The corresponding vehicle will be limited to .02 grams per mile PM emissions.
- NOx will be limited to .20 grams per brake horsepower hour. These would be phased in between 2007 and 2010. The vehicle will be limited to .4 grams per mile.
- The sulfur content of diesel fuel will be limited to no greater than 15 parts per million beginning June 1, 2006.

With these new standards, it is estimated that the emissions from heavy duty vehicles will be cut in half. NOx, a key ingredient of ozone, will be reduced by 2.8 million tons per year in 2030. Particulate emissions will be reduced by 110,000 tons per year in 2030.

## MOBILE 5

To calculate emissions, the MOBILE 5 model developed by The Environmental Protection Agency (EPA) was used. The EPA has performed extensive research on the emissions of mobile sources. These have been performed at simulated altitudes, temperatures, and various fuel mixtures. The results from this research are extensive and are used by every major city to predict mobile source emissions.

To facilitate the calculation of emissions, the EPA has developed the Mobile model. The model was first developed as MOBILE1 in the late 1970s, and has been periodically updated to reflect the collection and analysis of additional emission factor testing results over the years, as well as changes in vehicle, engine, and emission control system technologies, changes in applicable regulations and emission standards and test procedures, and improved understanding of in-use emission levels and the factors that influence them.

The output from the model is in the form of emission factors expressed as grams of pollutant per vehicle mile traveled (g/mi). Thus, emission factors from MOBILE can be combined with estimates of total vehicle miles traveled (VMT) to develop highway vehicle emission inventories (in terms of tons per day, per month, per season, per year). The change in emission factors for a given vehicle category over time are a reflection of the impacts of fleet turnover (over time, older vehicles built to less stringent emission standards are retired through collisions and other scrappage activities, and replaced in the fleet by newer vehicles built in compliance with more stringent standards).

The model also provides a number of estimates of non-exhaust (non-tailpipe) VOC emission sources from gasoline-powered vehicles. These include: diurnal emissions (evaporated gasoline emissions generated by the rise in temperature over the course of a day when the vehicle is not being driven), hot soak emissions (evaporated gasoline emissions occurring after the end of a vehicle trip, due to the heating of the fuel, fuel lines, fuel vapors), running loss emissions (evaporated gasoline emissions occurring while a vehicle is driven, due to the heating of the fuel and fuel lines), resting loss emissions (small but continuous seepage and minor leakage of gasoline vapor through faulty connections, permeable hoses and other materials in the fuel system), and refueling emissions (gasoline vapor emissions generated by the refueling of vehicles, where in the absence of controls the vapor in the vehicle fuel tank is displaced by the incoming liquid fuel and released to the atmosphere).

MOBILE provides these non-exhaust VOC emission factors in either g/mi units (facilitating development of overall inventory estimates) or other units as appropriate for more detailed and specific modeling requirements. Each generation of the MOBILE model has become more sophisticated in its approach to modeling average in-use emissions and has provided the model user with additional options for tailoring emission factor estimates to specific times and geographic locations.

### EPA MODEL "PART5"

PART5 is another model developed by the EPA to calculate PM10 emissions from various sources. PART5 was added to the mobile emissions suite of modeling when particulates became a concern in the early 80s.

### Nondivisible Emissions Calculations

For the purposes of this analysis, it was agreed that the overall benefit of the nondivisible load would come from the simple fact that fewer trucks would be on the road. It was agreed that the reduction in emissions could be calculated by determining the number of nondivisible trips that were taken and calculating the emissions. If the trips were divisible, then this level of emissions would have been added.

This isn't quite true for two reasons. First, the heavy duty trucks would be pulling larger loads and therefore, the emissions from one nondivisible load isn't half of two divisible loads. Secondly, the trucking industry informed us that if the loads weren't divisible, then an older fleet would need to be mobilized which corresponds to older engine technology. These two factors are minimal in their impact and also tend to cancel each other out and were therefore ignored for this study.

### Development of Average Trip Length and Number of Trips

The first step in developing the savings in emissions was to determine the number of trips annually that were nondivisible loads and to determine the average trip length. The study team researched the available manufacturers of precast panels and found that the only manufacturer that would admit to the nondivisible load was Rocky Mountain Prestress. They provided comprehensive data as to the total number of loads by month, and a detailed description of each load for the months of February and June. This information is contained in Appendix A-1.

Using the data provided by Rocky Mountain Prestress, it was determined that nondivisible loads were used for 42 of the 2516 total loads. This calculates to 1.67 percent of the total loads. This percentage was then applied to the total number of loads per month to develop an estimate of the total load by month that were nondivisible. This is presented in Table 1.

Table 1. Nondivisible Loads Per Month

| **Month** | **Total Loads** | **Nondivisible Loads** |
|---|---|---|
| January | 1021 | 17 |
| February | 1223 | 20 |
| March | 1018 | 17 |
| April | 943 | 16 |
| May | 1068 | 18 |
| June | 1293 | 22 |
| July | 983 | 13 |
| August | 967 | 16 |
| September | 952 | 16 |
| October | 1561 | 26 |
| November | 1369 | 23 |
| December | 1215 | 20 |
| **Total** | **13,413** | **224** |

Trip data were also provided by Rocky Mountain Prestress to develop average trip length by interstate and off-interstate types. By reviewing the trip data, it was determined that the average trip consisted of 16.7 miles with 15.6 miles on the interstate and 1.1 miles off-interstate.

The mobile emissions model was then utilized to determine the average emissions by vehicle speed. The model was run using various speeds from 10 to 60 miles per hour. Emissions were calculated for VOC, CO, and NOx. Table 2 shows the resulting emissions by speed.

Table 2. Emissions by Speed for VOC, CO and NOx.

| Speed (MPH) | VOC (g/mile) | CO (g/mile) | NOX (g/mile) | PM10 (g/mile) |
|---|---|---|---|---|
| 10 | 7.61 | 34.27 | 15.00 | 1.583 |
| 20 | 5.01 | 18.67 | 11.49 | 1.583 |
| 30 | 3.60 | 12.21 | 10.14 | 1.583 |
| 40 | 2.83 | 9.58 | 10.31 | 1.583 |
| 50 | 2.42 | 9.01 | 12.09 | 1.583 |
| 60 | 2.27 | 10.17 | 16.33 | 1.583 |

These data are also presented in Figure 1.

Using an average off-interstate speed of 20 MPH and an average interstate speed of 50 MPH, average emissions per month of VOC, CO and NOX were created. These are provided in Table 3.

Table 3. Emissions by Month

| Month | VOC (g) | CO (g) | NOX (g) | PM10 (g) |
|---|---|---|---|---|
| January | 737 | 2745 | 3431 | 451 |
| Februrary | 883 | 3288 | 4109 | 540 |
| March | 735 | 2737 | 3420 | 449 |
| April | 681 | 2535 | 3168 | 416 |
| May | 771 | 2871 | 3588 | 471 |
| June | 934 | 3476 | 4344 | 571 |
| July | 565 | 2106 | 2631 | 346 |
| August | 698 | 2600 | 3249 | 427 |
| September | 687 | 2560 | 3199 | 420 |
| October | 1127 | 4197 | 5245 | 689 |
| November | 989 | 3681 | 4600 | 604 |
| December | 877 | 3267 | 4082 | 536 |
| TOTAL | 9,685 | 36,062 | 45,067 | 5,920 |

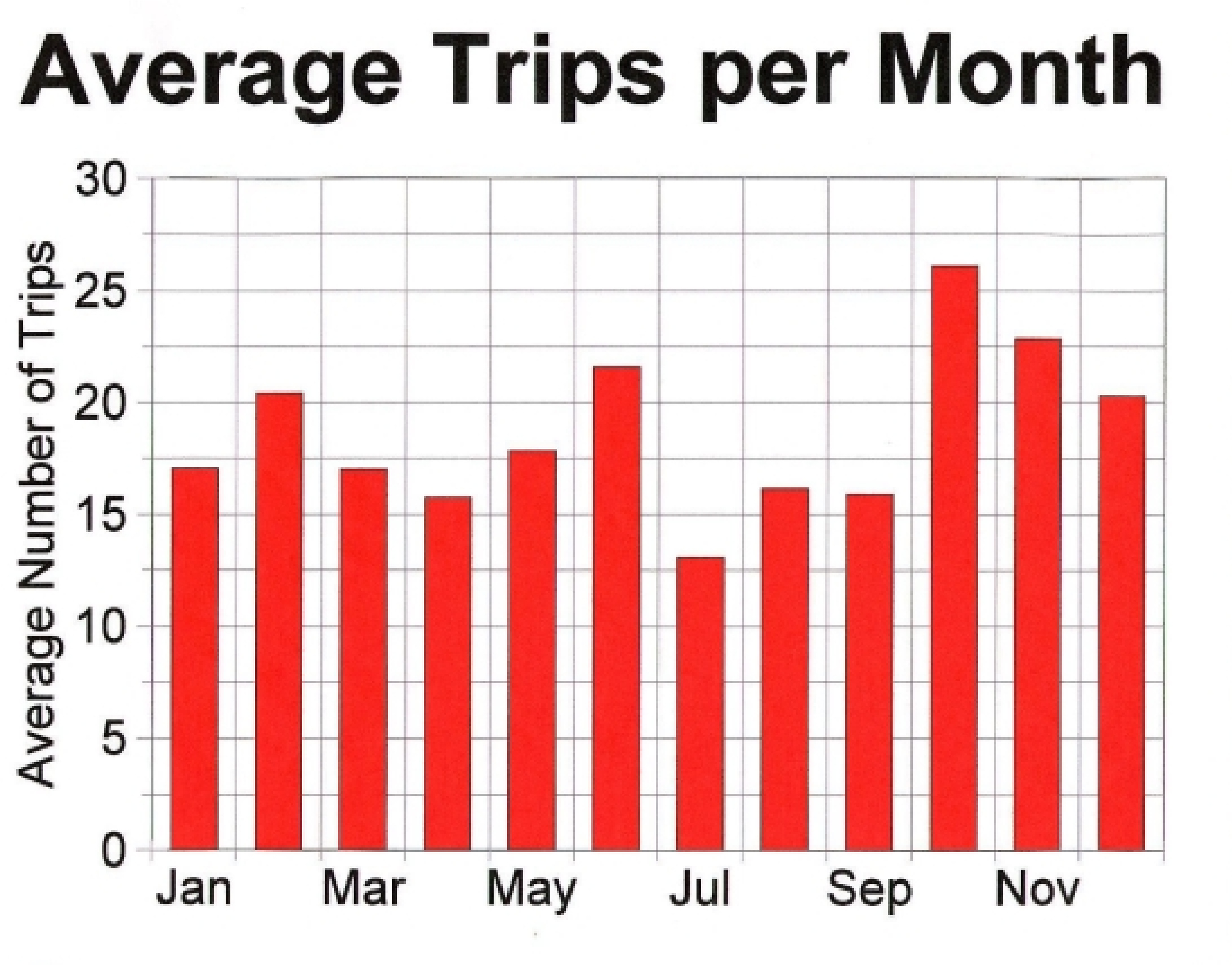
These are also provided in Figure 2.

## Summary

Based upon the emissions as calculated by MOBILE and PART5, at its current level, the nondivisible load is reducing air emissions by the following:

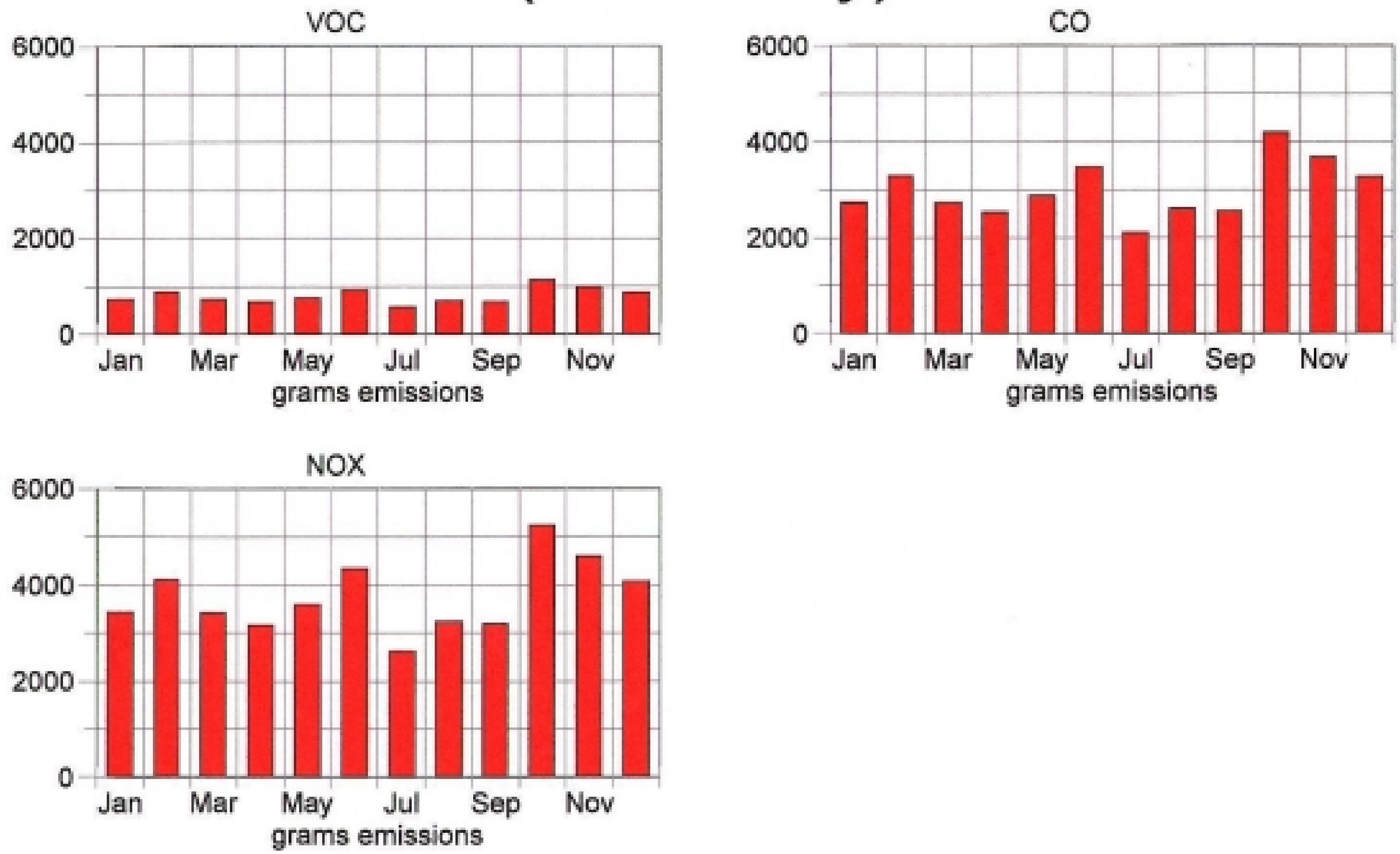
- VOC are being reduced by 9.7 Kg annually
- CO is being reduced by 36 Kg annually
- NOX are being reduced by 45 Kg annually
- Particulates are being reduced by 5.9 Kg annually

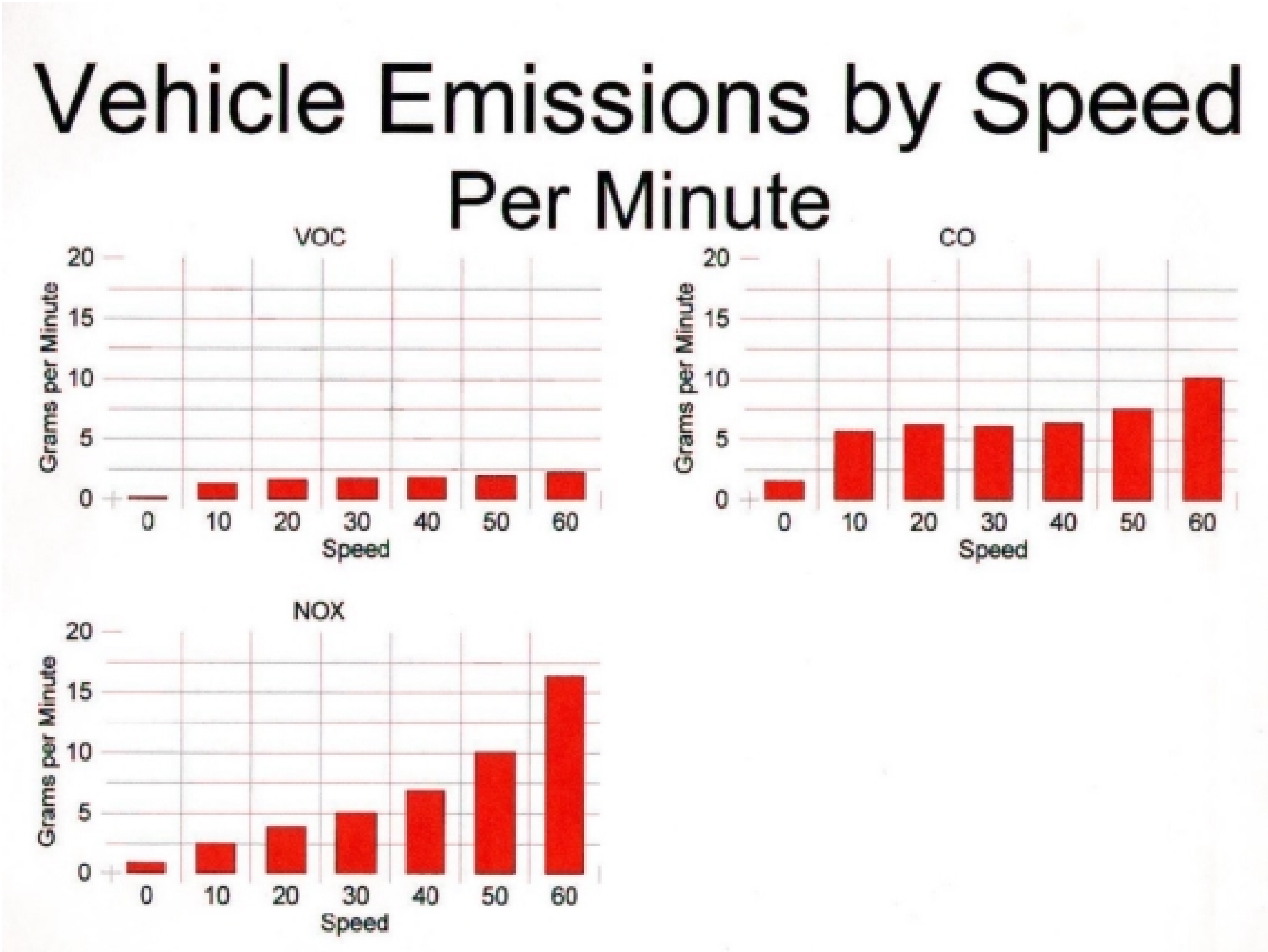
These estimates are based upon the assumption that the savings for nondivisible loads is equal to the emissions for the loads that would have happened if the loads were nondivisible.


Average Trips per Month
Average Number of Trips
30
25
20
15
10
5
0
Jan
Mar
May
Jul
Sep
Nov

# Emissions By Month

## (RMP Only)




Vehicle Emissions by Speed
Per Minute
VOC
CO
NOX
Grams per Minute
Speed
0
5
10
15
20
0
10
20
30
40
50
60