**Final Report**

# INVESTIGATION OF NITROGEN OXIDES EMISSIONS FROM A MAJOR ROADWAY

**by**

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**Hampton University**
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**INVESTIGATION OF NITROGEN OXIDES EMISSIONS FROM A MAJOR ROADWAY**


## Executive Summary

Despite recent advances in the automobile industry in reducing emissions from individual vehicles, air pollution in some localities still persist at problematic levels because of the regional increases in the traffic volumes. Vehicular emissions are the major contributors to atmospheric $NO_x$, constituting about half of all anthropogenic emissions. The secondary species formed in the atmosphere as the result of the reactions of $NO_x$ with other species, are known to cause a wide variety of health and environmental problems.

Measurements done at the air pollution monitoring stations provide regional data with some temporal resolution but their numbers are too few to provide a detailed spatial resolution. Air pollutant concentrations can be significantly higher close to major roadways. This makes the local pollutant concentration measurements and finding ways to predict concentrations with a much higher spatial resolution essential in making decisions about locating buildings that will house sensitive populations, such as hospitals, day care centers, elementary schools, retirement homes and assisted living facilities. Therefore, there is a need for more data on $NO_x$ concentrations especially near major roadways, and for models, which can predict $NO_x$ concentrations with more accuracy and more spatial resolution.

Two recent developments highlighted the importance of our work. The first one is the proposed revisions to the National Ambient Air Quality Standards (NAAQS) for nitrogen dioxide announced on June 26, 2009. EPA is proposing a new 1-hour standard at a level between 80 and 100 ppb while retaining the current average $NO_2$ standard of 53 ppb. This proposal increases the importance of measuring the peak concentrations over shorter time periods especially near major roads in urban areas. The second development is the January 7, 2010 announcement by EPA proposing to change the standard for ground level ozone to no more than 0.06 to 0.07 ppm from the current value of 0.075 ppm. Since ground level ozone is formed by the reaction of nitrogen oxides with volatile organic compounds, the proposed change emphasizes the importance of the investigation of nitrogen oxide concentrations around major roadways.

In this research project, we

1. built a mobile NO and $NO_2$ measurement unit with the associated weather monitoring instrumentation.
2. obtained coordinated measurements of NO and $NO_2$ concentrations and meteorological conditions at varying distances from the roadway, together with the traffic volume data.
3. used CALINE4 to estimate the $NO_2$ concentrations at receptors located at the measurement points.
4. analyzed the data obtained to elucidate the adequacy of CALINE4 in predicting the local $NO_2$ concentrations near roadways.

Measurements showed that $NO_x$ concentration decreases rapidly with the distance from the roadway and drops from 25.4 ppb to a value around 8.3 ppb, which remains fairly constant for distances greater than about 150 m from the I-64 median. The reason for this decrease is

atmospheric dispersion and conversion of $NO_x$ to other nitrogen containing compounds. Close to the roadway (less than about 100 m from the I-64 median), the majority of $NO_x$ is NO, which converts to $NO_2$ and other nitrogen compounds and falls from17.3 to a value about 3.4 ppb at distances greater than 150 m from the median. The decrease in nitrogen dioxide concentration is not as much and falls from about 12 ppb at 74 m to about 5.5 ppb beyond 150 m. This may be due to the conversion of some NO to $NO_2$ possibly through its reaction with ozone. Close to the roadway, there was significant variation in the measured NO and $NO_x$ concentrations due to the effects of emissions coming from individual vehicles passing close to the analyzer intake. This effect became less significant at larger distances from the roadway.

The $NO_2$ concentrations at the receptor locations were predicted using CALINE4, which can provide estimates with a sensitivity of ± 5 ppb. Since the measured $NO_2$ concentrations were between 5 and 15 ppb, CALINE4 was expected to predict 0.010 ppm $NO_2$ at each receptor location. As expected, the predicted $NO_2$ concentrations at receptors beyond 100 m of the I-64 median were 0.01 ppm. CALINE4 also correctly predicted 0.01 ppm $NO_2$ at the first receptor location, which had a measured value of 0.012 ppm. These observations indicate that the current data cannot provide an adequate evaluation of the CALINE4 program. To obtain a reasonable evaluation, data are needed during the rush hour traffic and closer to the roadway, which are expected to give higher $NO_2$ concentrations.

Since the measured $NO_x$ levels are lower than the 24-hr EEGL value of 0.04 ppm for $NO_2$, they do not by themselves represent a significant health risk. But since the main health effects of nitrogen oxides are through their role in the formation of ground level ozone (smog) and nitrogen containing particulates, **it is imperative that ozone and particulates are also measured.**

**FINAL REPORT ON THE**
**INVESTIGATION OF NITROGEN OXIDES EMISSIONS FROM A MAJOR ROADWAY**

## I. Introduction

Despite recent advances in the automobile industry in reducing emissions from individual vehicles, because of the regional increases in the traffic volumes, air pollution in those localities still persist at problematic levels. Of the six air pollutants covered by the Clean Air Act of 1970, a reduction could not be achieved only in nitrogen oxides ($NO_x$) emissions. Vehicular emissions are the major contributors to atmospheric $NO_x$, constituting about half of all anthropogenic emissions. Most of the $NO_x$ coming off the vehicle exhausts is NO and for that reason, it is called a primary pollutant. Most of $NO_2$ and all other nitrogen species are formed in air as a result of the chemical reactions of NO with other pollutants. Therefore, nitrogen oxides play a major role in the atmospheric photochemistry, controlling ozone formation and generation of the hydroxyl (OH) and other reactive radicals. Nitrogen oxides are removed from the atmosphere through conversion into nitric acid ($HNO_3$), which, in turn, is removed by rainout or wet deposition onto the surfaces of particulates. Reactions of $NO_x$ in the atmosphere are summarized below (radical formation and reaction steps are not included)[1]:

- Nitrogen dioxide formation: $NO + O_3 \rightarrow NO_2 + O_2$
- Daytime nitric acid formation: $NO_2 + OH + M \rightarrow HNO_3 + M$
- Nitrate radical formation: $NO_2 + O_3 \rightarrow NO_3 + O_2$
- Dinitrogen pentoxide formation $NO_3 + NO_2 + M \leftrightarrow N_2O_5 + M$
- Nitric acid formation via surface reaction: $N_2O_5 + H_2O \text{ (surface)} \rightarrow 2HNO_3$
- Nitrate removal: $NO_3 + NO \rightarrow 2NO_2$
- Renoxification by surface nitric acid: $NO + HNO_3 \text{ (surface)} \rightarrow NO_2 + HONO$

These reactions produce a complex mixture of chemicals, which can further transform into secondary aerosols that increase the particulate matter (PM) content of the ambient air. Although ammonia ($NH_3$) is not formed in atmosphere, some ammonia is produced in the catalytic converters of gasoline-fueled vehicles during the lean part of their engine's operating cycle. Ammonia selectivity was found to be highest at catalyst temperatures between the light-off temperature and 300 ºC[2]. In the atmosphere, ammonia can produce salts such as ammonium nitrate ($NH_4NO_3$) and ammonium sulfate ($(NH_4)_2SO_4$) that can deposit on the ground and lead to acidification of soils and surface waters.

The secondary species formed in the atmosphere are known to cause a wide variety of health and environmental problems. Tropospheric ozone, $NO_2$, nitrate particles, and acid aerosols can trigger chronic respiratory and cardiopulmonary ailments[3,4]. Children were found to be more susceptible to $NO_x$ exposures that lead to asthma. Positive associations between $O_3$ and $NO_2$ levels and human mortality were reported[5,6]. In addition to these health effects, air pollutants may also have psychological effects such as annoyance or minor disorders, which are important for human well-being[7].

Environmental effects of $NO_x$ include the formation of acid rain that can lead to nutrient overload and deterioration of water quality and aquatic life. They are also greenhouse gases and contribute to global warming. Ozone and $NO_2$ are potent oxidizers and cause oxidative stress on biological organisms. High levels of $NO_2$ harm vegetation by disturbing the nitrogen balance and ozone is known to have phytotoxic effects[8].

Measurements done at the air pollution monitoring stations provide regional data with some temporal resolution. These stations are generally located sufficiently away from heavily traveled roadways so that they provide background data and the numbers are too few to provide a detailed spatial resolution. Air pollutant concentrations can be significantly higher close to major roadways. This makes the local pollutant concentration measurements and finding ways to predict concentrations with a much higher spatial resolution essential in making decisions about locating buildings that will house sensitive populations, such as hospitals, day care centers, elementary schools, retirement homes and assisted living facilities.

Two recent developments highlighted the importance of our work. The first one is the proposed revisions to the National Ambient Air Quality Standards (NAAQS) for nitrogen dioxide announced on June 26, 2009. EPA is proposing a new 1-hour standard at a level between 80 and 100 ppb while retaining the current average $NO_2$ standard of 53 ppb. This proposal increases the importance of measuring the peak concentrations over shorter time periods especially near major roads in urban areas. The second development is the January 8, 2010 announcement by EPA proposing to change the standard for ground level ozone to no more than 0.06 to 0.07 ppm from the current value of 0.075 ppm. Since ground level ozone is formed by the reaction of nitrogen oxides with volatile organic compounds, the proposed change emphasizes the importance of the investigation of nitrogen oxide concentrations around major roadways.

## II. Recent related work

There have been several recent studies that reported measurements of the variation of pollutant concentrations with distance from major roadways, and development of models that can predict the pollutant concentrations near roadways. Models that simulate the dispersion of non-reactive species were reviewed by Sharma and Khare[9].

Several models such as CALINE4[10] and CAR-FMI[11] include the ozone and nitrogen dioxide formation reactions

$NO_2 + h\upsilon \rightarrow NO + O$

$O + O_2 + M \rightarrow O_3 + M$

$NO + O_3 \rightarrow NO_2 + O_2$

Kukkonen, et al.[12] used the CAR-FMI model to predict the NO, $NO_2$, and $O_3$ concentrations near a major rural 2-lane roadway in Finland and compared the results to the measured daytime values. The measurements were taken at 34-m on western side of the road and at 17-m and 57-m (background) on the eastern side. Measurement heights varied between 3.5 m and 10 m. Nitrogen oxides were measured using chemiluminiscence monitors (Thermo Environment 42S). The agreement between the measured and predicted data was good with some over-prediction of $O_3$ and $NO_x$ concentrations and a slight under-prediction of $NO_2$.

Kenty, et al.[13] applied CALINE4 to predict $NO_2$ concentrations near a 4-lane divided highway in Florida located on a small peninsula on Tampa Bay, with the objective of evaluating the adequacy of the reaction scheme used in the model. Nitrogen oxides were measured using a differential optical absorption spectrometer located 47 m from the median. Background measurements were obtained from a monitoring station 148 m from the road. Meteorological measurements were obtained at the receiver end of the spectrometer. Data sets were formed by taking the hourly averages of the measurements. Comparison of the predicted and measured $NO_2$ concentrations indicated that for ambient $O_3$ concentrations less than 40 ppb, the model under-predicted the chemical transformation of NO. This was tentatively attributed to reactions of NO with oxidants such as peroxy radicals.

Lin and Lin[14] used a geographical information system, which integrated a vehicle emission model, pollutant dispersion model (CALINE4), backward trajectory model, and related data bases to estimate the emissions and spatial distribution of traffic pollutants in an urban setting in Taiwan. The resulting model could analyze the existing air pollution in the city and predict the consequences of changing traffic patterns or management policies. When compared to the values measured by the monitoring stations, the model was found to under-estimate the $NO_x$ values by about 20-50 %.

Marshall, et al.[15] compared three approaches for estimating the spatiotemporal variation of pollutant concentrations for Vancouver, Canada. These methods were the spatial interpolation of monitoring data; land-use regression (LUR), an empirical statistical model; and the community multiscale air quality model (CMAQ), an Eulerian grid model. They concluded that LUR and CMAQ predicted the concentrations at the monitoring sites with an average absolute bias less than 50 % for NO and less than 20 % for $NO_2$. LUR provided the greatest spatial resolution. Ainslie, et al.[16] developed a source area model to predict pollutant concentrations with high spatial and temporal resolution. The model is intermediate in complexity between the three dimensional Eulerian air quality models and the simple LUR approach.

Pandey, et al.[17] reported the results of their analysis of NOx data obtained from two monitoring stations over an 11-year period in Seoul, Korea. One monitoring station, located 1 m from an 8-lane roadway, represented the urban roadside conditions; while the other located 904 m from the roadway represented the urban background pollution. Nitrogen oxide concentrations were measured by chemiluminescence instruments at 3.8 m (from the ground) at the roadside monitor and at 27.8 m (from the ground) at the background monitor. Over the 11 years, the roadside $NO_x$ emissions decreased roughly threefold, while the background emissions stayed fairly constant. The mean NO and $NO_2$ levels at the background station were about equal but at the roadside station, mean value of NO was more than twice that of $NO_2$.

Roorda-Knape, et al.[18] measured traffic-related air pollutants in six city districts near motorways in Netherlands and reported rapid declines in $NO_2$ concentrations with distance from the roadway. $NO_2$ was measured using diffusion tubes at 50, 100, and 150 m from the roadway. Background emissions were obtained at 300 m from the roadside.

Schnitzhofer at al.[19] conducted air pollutant measurements over a one-year period near a motorway in a valley in Austria. The measuring station was located less than 3 m from the roadside and sampling was done 3 m above the ground level. NO and $NO_2$ were measured by chemiluminescence. Daily and seasonal cycles in pollutant concentrations were reported with maximum concentrations observed during winter. This observation was attributed to shorter daylight hours and prolonged periods of high traffic and bad meteorological conditions for atmospheric mixing. The measured $NO_x$ concentrations correlated with heavy duty vehicle traffic and especially $NO_2$ was predominantly emitted by the heavy duty vehicles.

Beckerman, et al.[20] monitored air pollutants at various locations perpendicular to an expressway in Canada, at varying distances from the roadway with the objective of finding a correlation between $NO_2$ concentrations and other pollutant concentrations. They deployed passive samplers for one week in August at 14 locations and used active samplers at each passive measurement point on multiple days during peak traffic periods. They also performed detailed measurements at selected upwind and downwind passive measurement points using a mobile lab. Meteorological measurements were taken at a fixed station. For $NO_2$ and NO measurements Thermo-Electron TECO 42C chemiluminescence gas analyzers were used. They observed that both $NO_2$ and NO concentrations decreased with distance from the expressway, with NO concentrations decreasing more rapidly. $NO_2$ was found to have a strong association with NO and $O_3$. VOC levels did not correlate highly with $NO_2$ but they displayed consistent and significant associations. Other air toxics showed significant correlation with $NO_2$.

## III. Work Done

In this research project, we proposed

1. To build a mobile NO and $NO_2$ measurement unit with the associated weather monitoring instrumentation.
2. To obtain coordinated measurements of NO and $NO_2$ concentrations and meteorological conditions at varying distances from the roadway, together with the traffic volume and vehicle type data.
3. To use CALINE4 to estimate the $NO_2$ concentrations at receptors located at the measurement points.
4. To analyze the data obtained to elucidate the adequacy of CALINE4 in predicting the local $NO_2$ concentrations near roadways and perform a sensitivity analysis on the input variables, which are not directly measured, to suggest possible improvements.

Some of these proposed tasks had to be modified due to the data acquisition problems with the traffic camera at interchange 267 as explained below in the section on the estimation of traffic volume. Also, CALINE4 can predict $NO_2$ concentrations down to 10 ppb. Only the measurement at point 1, the closest location to I-64 that could be reached by a hand pushed cart, had $NO_2$ concentration slightly above 10 ppb. Therefore, to accomplish proposed task 4, more measurements are needed closer to I-64 and during high traffic volumes, which requires the installation of the experimental setup on a vehicle and the ability to obtain traffic data during high volumes; this will be done in the future.

**Site selected for the investigation:** The site selected for the proposed monitoring and modeling work is a section of I-64 containing the Hampton University interchange (interchange 267). The reasons for this selection are the proximity to Hampton University and the existence of a traffic camera at the Hampton University I-64 interchange 267, so that real time traffic data can be obtained for the road section of interest. Additionally, the Marshall Avenue in Hampton University property lies roughly perpendicular to I-64, making it logistically easy to locate the mobile monitoring setup on this road at various distances from I-64. The effects of the traffic on I-64, ramps, and Settlers Landing Road are expected to be confined to within less than 300 m of the roadway. The background measurements can be obtained at a location sufficiently away from the effect of vehicular traffic. The main contributors to the background $NO_x$ emissions are expected to be the naval traffic over the Hampton Roads Bridge Tunnel and the Hampton University steam plant. We plan to investigate the effects of the steam plant and the naval traffic at a later stage.

**Estimation of traffic volume**: Originally it was planned to obtain the traffic count on I-64 by obtaining screen images at regular time intervals, so that by following the vehicles in successive images, average speed and vehicle count would be obtained. However, a continuous streaming of traffic data could not be obtained due to the limited transmission rate, which stopped the traffic image at random intervals that varied between a few seconds to about a minute. Therefore, we decided to use the following procedure to obtain the vehicle count on I-64: Two roadside lampposts were selected and the distance between them were measured from Google satellite images as 287.5 ft. The average vehicle speed between 10 am and 12:00 pm was taken to be 65 mph (95 ft/s). Therefore, all vehicles that pass the first lamppost would be between the two lampposts within 3 seconds and the number of cars travelling per second is the number of cars between the two lampposts divided by 3 seconds. Since the traffic count time was very short, the vehicle type distributions could not be determined; and $NO_x$ measurements were limited to non-rush hour times when the average vehicle speed was at the limit.

The vehicle speeds on the east off ramp and west on ramp were sufficiently low to allow vehicle counts during the time the streaming video data were available. The traffic volumes on the Settlers Landing Road, the Emancipation Drive, the east on ramp and the east off ramp (as a check for the value obtained from the traffic camera) were manually counted. The west off ramp was considered to be sufficiently away from the measurement points to make its effect to be negligible and the traffic volume was taken to be the same as on the east off ramp.

Traffic data were taken before and after the $NO_x$ measurements and their averages were used for model predictions.

**Experimental Measurements:** The following procedure was used to obtain data:

1. Take equipment to location. Place generator exhaust as far away as possible.
2. Start the generator and turn on all equipment.
3. Take traffic data.
4. Collect weather data every minute for half an hour.
5. Collect $NO_x$ data every minute for half an hour simultaneously with the weather data (30 readings).
6. Turn off equipment.
7. Take traffic data.

**The Model for the Estimation of $NO_2$ Concentrations:** CALINE4 is a line source Gaussian plume dispersion model that was mainly developed by the California Department of Transportation-University of California at Davis Air Quality Project to predict carbon monoxide, particulate matter, and nitrogen dioxide concentrations near roadways. It is available with the graphical windows-based user interface, CL4, only for carbon monoxide analysis. Use of CALINE4 to predict nitrogen dioxide and particulate matter is possible in the MS-DOS mode. As inputs, the model requires source strength, meteorology and site geometry and can predict pollutant concentrations within 500 meters of the roadway. CALINE4 uses vertical and horizontal dispersion curves modified for the effects of surface roughness, averaging time and vehicle-induced turbulence. It uses line source formulation and a mixing zone concept, and has multilink capabilities. It has special modeling options for intersections, street canyons and parking facilities.

<u>The Geometry of the Roadways and Traffic Data Used</u>: To establish the geometry of the selected interchange, maps from Google Maps were used. The receptors were placed in a parking lot and along Marshall Avenue, so that samples could be taken easily using the instruments placed on a cart and the generator placed on a dolly.  The receptors were placed within 200 m of the roadway (Figure 1).

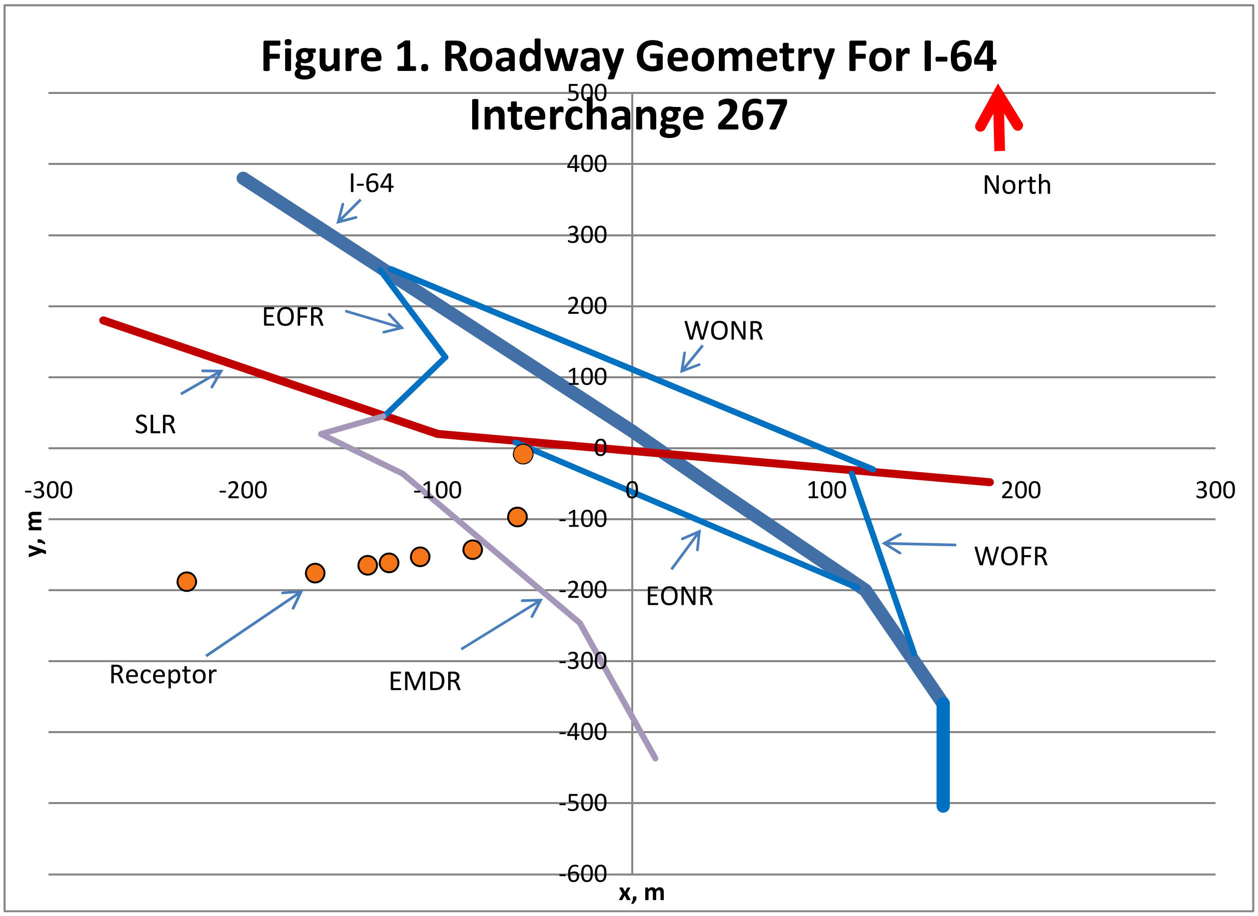



**Figure 1. Roadway Geometry For I-64 Interchange 267**

The traffic volume data were obtained as described above. The $NO_x$ composite emission factor at each receptor was computed using MOBILE62, which is the EPA emissions factor model for estimating pollution from on-road motor vehicles in states outside California. For this purpose the measured hourly temperatures, cloud cover, relative humidity, barometric pressure, and average speed were used. To obtain the average speed, fraction of the total traffic volume that were on the freeway, arterial road, local roads, and ramps were found from the measured traffic volumes (VMT distribution), and the average velocities on the freeway, arterial road, local road, and ramps were taken as 65 mph, 45 mph, 25 mph, and 34.6 mph, respectively. Areawide scenario and oxygenated fuels were specified. The measured meteorological data were used along with default variables.

Other Inputs for CALINE4: *Aerodynamic roughness coefficient* was taken as 100 cm, which was the recommended value for a suburban landscape. Initially the *settling velocity* and the *deposition velocity* were taken as 0.0 cm/s. When measurements closer to the roadway and/or at higher traffic volumes become available, these variables will be subjects for sensitivity analyses. The *altitude* of the roadway was taken to be 6 m above the sea level. Except Link B, which is a bridge, all links were considered *at-grade*. In all computations, measured average wind directions were used and the *atmospheric stability* was determined from the measured mean solar radiation intensity and wind velocities. Since the values used for worst case mixing heights do not have a significant impact on model results, the *mixing height* was kept constant at 100.0 m for all computations. The *ambient concentrations of* $NO_2$ *and NO* were obtained from measurements obtained sufficiently far away from the roadway. Since the $O_3$ background concentration could not be measured, the value reported by the Hampton Virginia School station 179-C was used and the calculations will be repeated when ozone measurements at the receptor sites become available. Initially, 0.004 $s^{-1}$ was used as the $NO_2$ *photolysis rate constant*; this variable will also be a subject for sensitivity analysis in the future. The *wind speeds, wind direction standard deviation* and the *ambient temperature* were obtained from measurements.

**Measurement of $NO_x$ levels and meteorological variables:** For nitrogen oxide measurements a Thermo Fisher Scientific Inc. (Franklin, MA) 42i chemiluminescence NO-$NO_2$-$NO_x$ analyzer was purchased and mounted on a Little Giant 3-shelf cart with writing tray so that the analyzer intake was at a level about 1.5 m above the ground. Ozone could not be measured because the funds in the equipment category in the budget were not sufficient to purchase an ozone analyzer. For the same reason, a multi-point-calibration equipment could not be purchased and a two-point-calibration was performed on the 42i rather than the preferred 5-point calibration. A zero grade air and a primary standard certified span gas mixture containing 1.004 ppm NO with 12 ppb $NO_2$ were purchased from Airgas Specialty Gases (Riverton, NJ) and used for the calibration of the NO-$NO_2$-$NO_x$ analyzer. The $NO_x$ measurement range of the analyzer is 0 – 200 ppb.

A Climatronics Corp. (Bohemia, NY) AIO compact weather station with capabilities to measure temperature, relative humidity, wind speed, wind direction, and barometric pressure; and a LI-COR Inc. (Lincoln, Nebraska) pyranometer (LI 200SA) with a mounting and leveling fixture and a light meter (LI 250A) were purchased and installed on the cart to form a mobile monitoring system. Instrument software was loaded on an existing Dell Inspiron 8100 laptop computer.

As described above, the instruments were mounted on a hand pushed cart and the generator was placed on a dolly. This limited our mobility and access to various parts of the roadway system under investigation. As a result, the closest receptor position was immediately adjacent to the east on ramp and 74 meters from I-64 median.

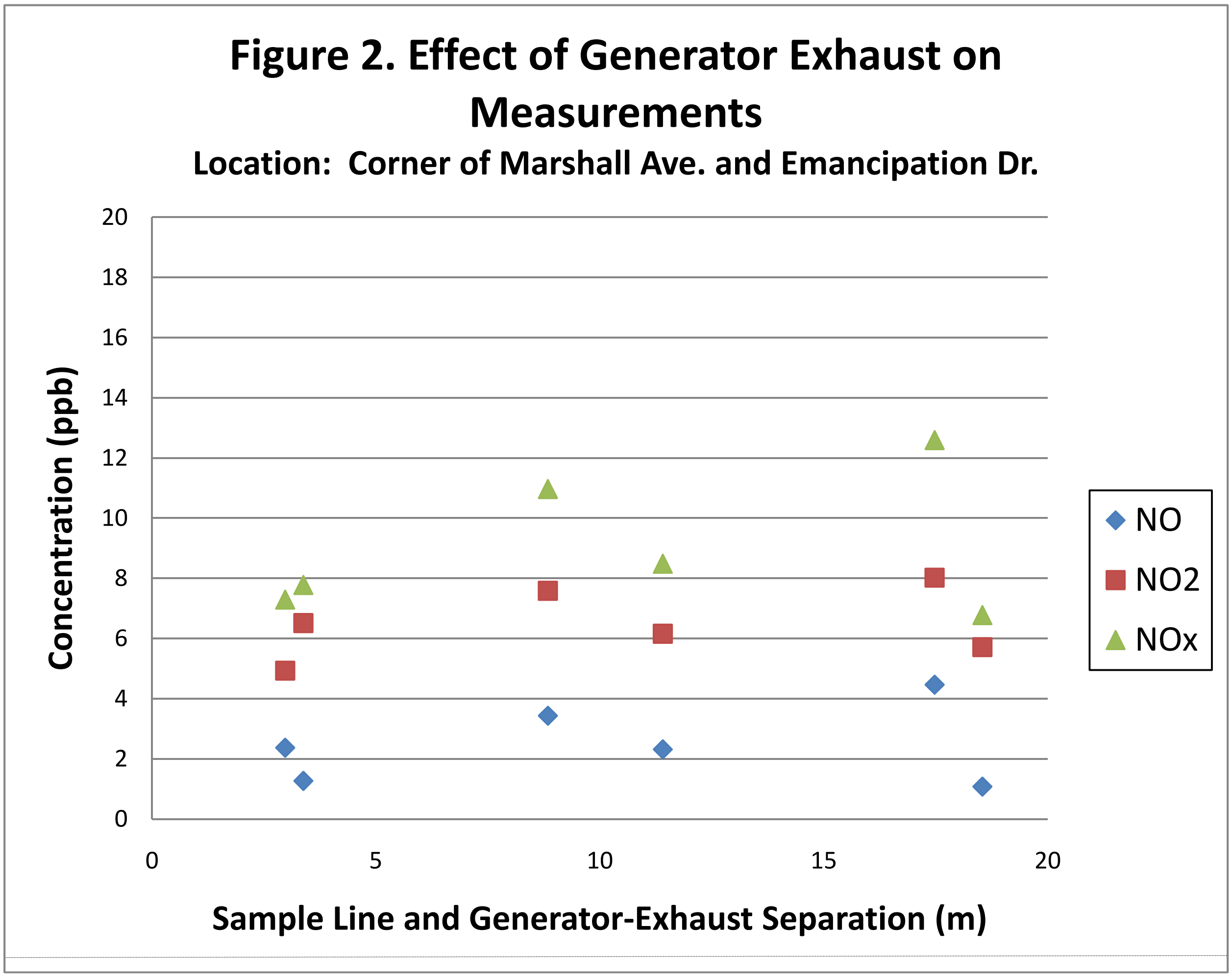
The mobile monitoring system is powered by a 2-kW Honda generator EU2000i connected to the cart by a 50-ft extension cord.

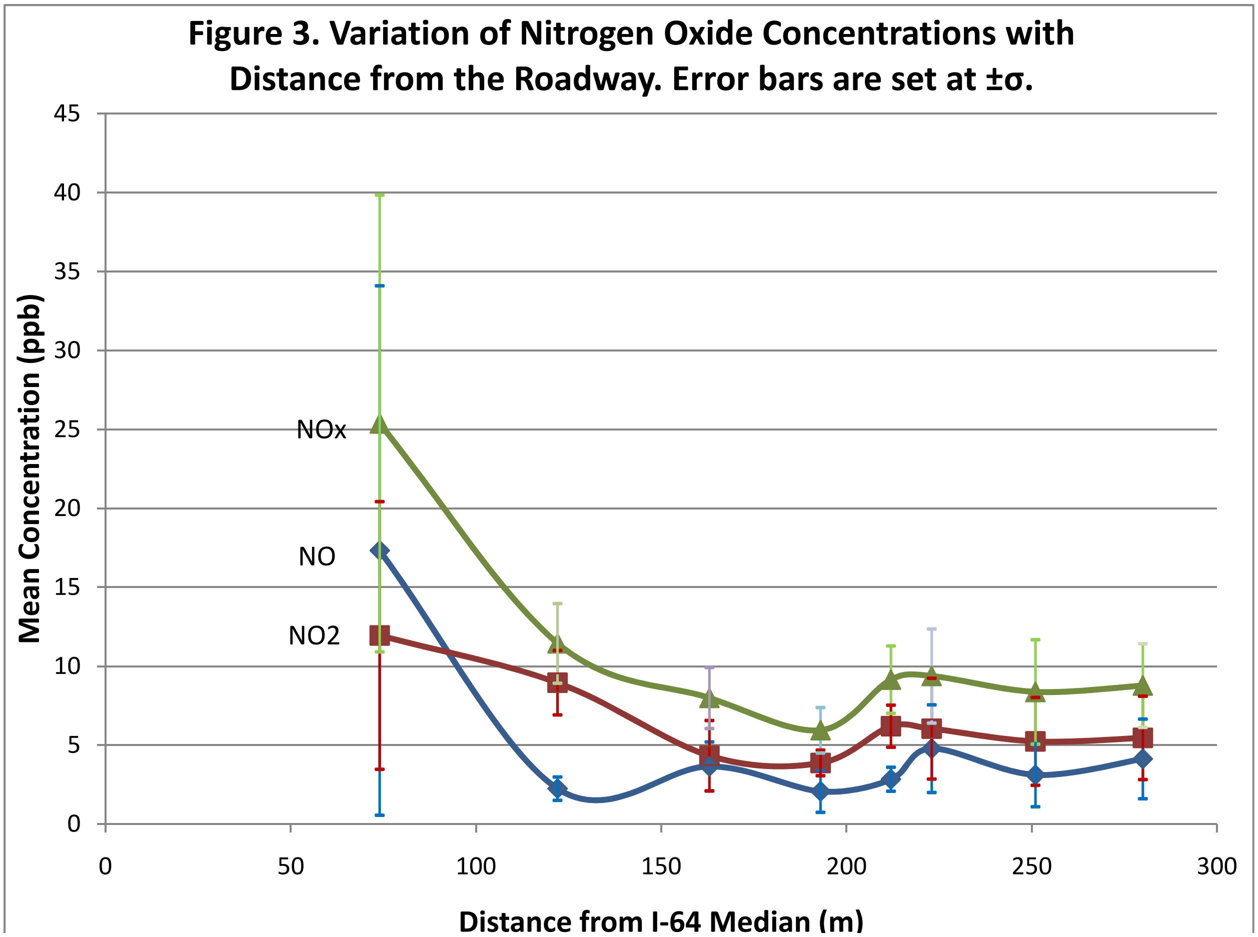
Collaboration was established with the Monitoring Group at the Virginia Department of Environmental Quality (VDEQ) and they were consulted on the type of equipment to be purchased and the measurement protocols to be used.

## IV. Results

**Effect of generator exhaust on $NO_x$ measurements:** Since it is expected that the generator exhaust will contain some $NO_x$, the effect of the distance between the $NO_x$ analyzer intake and generator exhaust was first investigated. Figure 2 shows that the presence of the generator exhaust does not have a significant effect on $NO_x$ measurements if placed at least 3 meters from the intake.

**Variation of $NO_x$ Concentrations with distance from the roadway median:** The changes in NO, $NO_2$, and $NO_x$ concentrations with distance from the roadway (I-64) median is shown in Figure 3 and Table 1. Error bars in Figure 3 designate ±σ ranges.






$NO_x$ concentration decreases rapidly with the distance from the roadway and drops from 25.4 ppb to a value around 8.3 ppb, which remains fairly constant for distances greater than about 150 m from the I-64 median. The reason for this decrease is atmospheric dispersion and conversion of $NO_x$ to other nitrogen containing compounds. Close to the roadway (less than about 100 m from the I-64 median), the majority of $NO_x$ is NO, which converts to $NO_2$ and other nitrogen compounds and falls from17.3 to a value about 3.4 ppb at distances greater than 150 m from the median. The decrease in nitrogen dioxide concentration is not as much and falls from about 12 ppb at 74 m to about 5.5 ppb beyond 150 m. This may be due to the conversion of some NO to $NO_2$ possibly through its reaction with ozone.

If we look at the standard deviations given in Table 1, we see that close to the roadway, there is significant variation in the measured NO and $NO_x$ concentrations due to the effects of emissions coming from individual vehicles passing close to the analyzer intake. This effect becomes less significant at larger distances from the roadway. Reported mean $NO_2$ concentrations for the first receptor (74 m away from the I-64 median) do not contain the 6 negative $NO_2$ readings (out of a total of 30) obtained due to a shortcoming of the $NO_x$ analyzer that was used. Because of the budget constrains, the purchased analyzer did not contain the “Lag Volume” option. Therefore, the measured NO and $NO_x$ concentrations were from samples taken 5 seconds apart. When the effect of individual exhausts are significant, and since $NO_2$ concentrations are obtained as the difference of $NO_x$ and NO, this sometimes can result in negative $NO_2$ readings. Other factors that increase the standard deviations are the rapid changes in the wind speed and direction.

| **Table 1. Variation of Nitrogen Oxide Concentrations and standard deviations with Distance from I-64 median** | | | | | | | |
|---|---|---|---|---|---|---|---|
| Distance, m | Mean Concentration, ppb | | | | Standard Deviations | | |
| | **NO** | **$NO_2$** | **$NO_x$** | | **sd NO** | **sd NO2** | **sd NOx** |
| 74 | 17.3313 | 11.95 | 25.375 | | 16.77 | 11.95 | 14.47 |
| 122 | 2.24545 | 8.954545 | 11.44688 | | 0.74 | 8.95 | 2.52 |
| 163 | 3.65152 | 4.333333 | 7.987879 | | 1.55 | 2.23 | 1.93 |
| 193 | 2.07273 | 3.872727 | 5.945455 | | 1.33 | 0.81 | 1.44 |
| 212 | 2.84 | 6.2 | 9.15 | | 0.76 | 1.33 | 2.13 |
| 223 | 4.77714 | 6.044828 | 9.377143 | | 2.78 | 3.19 | 2.98 |
| 251 | 3.116 | 5.236 | 8.372 | | 2.02 | 2.78 | 3.31 |
| 280 | 4.12917 | 5.463636 | 8.775 | | 2.52 | 2.64 | 2.65 |
| | | | | | | | |
| Average beyond 150 m | 3.43109 | 5.191754 | 8.267913 | | 1.826667 | 2.163333 | 2.406667 |

**Prediction of $NO_2$ concentrations by CALINE4:** The $NO_2$ concentrations at the receptor locations were predicted using CALINE4, which can provide estimates with a sensitivity of ± 5 ppb; a value of 6 ppb was specified as the background $NO_2$ concentration; this was the measured value beyond 150 m. Since the measured $NO_2$ concentrations were between 5 and 15 ppb, CALINE4 was expected to predict 0.010 ppm $NO_2$ at each receptor location.

The results of MOBILE62 emission factor calculations and CALINE4 predictions are given in Appendices 1 and 2. As expected, the predicted $NO_2$ concentrations at receptors beyond 100 m of the I-64 median were 0.01 ppm. CALINE4 also correctly predicted 0.01 ppm $NO_2$ at the first receptor location (at 74 m from the I-64 median), which had a measured value of 0.012 ppm.

**Contribution to Education:** Two students, Ms. Courtney Mitchell, a chemical engineering undergraduate, and Mr. Bryan Brown, an electrical engineering undergraduate, worked on the project. They learnt to use the equipment to make measurements. Ms. Mitchell was also trained to use CALINE4. Ms. Mitchell was selected as the 'Outstanding Student of the Year' for ESITAC and she represented Hampton University at the 2009 Council of University Transportation Centers awards banquet in Washington, DC.

**Papers submitted for presentation:**

- Akyurtlu, A., Mitchell, C. and Akyurtlu, J., "Investigation of Nitrogen Oxides Emissions from Roadways", submitted to 12$^{th}$ National Conference on Transportation Planning for Small and Medium Sized Communities-"Tools of the Trade", September 22-24, 2010, Williamsburg, VA.

- Akyurtlu, A., Mitchell, C. and Akyurtlu, J., "Investigation of Nitrogen Oxides Emissions from I-64", accepted for presentation at the 51st Annual Transportation Research Forum, March 11-13, 2010, Washington, D.C.

## V. Discussion, Conclusions and Recommendations

The measured $NO_x$ concentrations are less than 0.03 ppm. The one-hour emergency exposure guidance level (EEGL) from the National Research Council (NRC) for $NO_2$ is 1 ppm and the 24-hour EEGL is 0.04. The time weighted average threshold limit value (TLV-TWA) from the American Conference of Governmental Industrial Hygienists is 3 ppm and the permissible exposure level (PEL) from the National Institute for Occupational Safety and Health (NIOSH) is 5 ppm. Since the measured $NO_x$ levels are lower than the 24-hr EEGL value for $NO_2$, they do not by themselves represent a significant health risk. But since the main health effects of nitrogen oxides are through their role in the formation of ground level ozone (smog) and nitrogen containing particulates, **it is imperative that ozone and particulates are also measured.**

The predictions obtained using CALINE4 indicate that current data cannot provide an adequate evaluation of the program. To obtain a reasonable evaluation, data are needed during the rush hour traffic and closer to the roadway under the conditions that will give higher $NO_2$ concentrations. Since the ground level ozone is formed by the reactions of nitrogen oxides, simultaneous measurement of ozone is also needed.

The data reported in this study were taken during summer time when the temperatures are high. The effect of ambient temperature is expected to be mainly through the changes in gas physical properties and through its effect on the vehicle-generated thermal turbulence, which, together with the vehicle-generated mechanical turbulence will be the dominant dispersive mechanism. As a consequence, the highest $NO_2$ concentrations are expected to be found at high temperatures. The effect of temperature on gas density will be linear while the vehicle-induced thermal turbulence will be larger at lower ambient temperatures due to larger difference between the ambient temperature and the temperature of the vehicle exhaust. To investigate these effects, it is recommended that data also be obtained at lower temperatures.

The presented data were obtained at relatively low wind speeds. It is expected that the lower the wind speed, the higher the $NO_2$ concentrations will be at the receptors, due to the decreased atmospheric stability at higher wind speeds. The prevailing wind direction was SSW and it varied between SSE and SSW. This puts the receptors mainly in the downwind position. The variation in wind direction ranged from small (standard deviation about 20 degrees) to significant (standard deviation about 130 degrees). The wind direction standard deviation affects the results through its effects on the horizontal dispersion. The smaller the wind direction variability, the smaller the horizontal dispersion and therefore, larger amounts of $NO_x$ can be transported to the receptors farther away from the roadways before dilution occurs due to dispersion.

Data at the two receptors closest to the roadway were obtained on a day with low cloud cover and high insolation. The rest of the data were obtained on a day with medium cloud cover and insolation. Therefore, it can be concluded that the data at receptors more than 150 away from the I-64 median were obtained under conditions that will result in higher $NO_x$ concentrations at the receptors.

As the result of these considerations, the following recommendations are made for future work:

1. Obtain data during high traffic volumes and closer to the roadway to have higher measured $NO_2$ concentrations so that the results can be used to evaluate CALINE4 predictions. The band width for Hampton University internet access was recently expanded and it is expected that this will help get better traffic data using the traffic camera at the interchange. We plan to apply for a supplemental funding from the Virginia Transportation Research Center (VTRC) to purchase a cargo van to increase the mobility of our measurement setup.
2. Obtain data at lower temperatures to provide information on the effects of temperature.
3. Make simultaneous ozone and particulates measurements to have information on the interrelationships among nitrogen oxides, ozone, and particulate matter generated by nitrogen oxides such as nitrate particles and acid aerosols. Thanks to funds provided by the Norfolk Southern Corporation, an ozone analyzer has just been acquired and we plan to make it operational in the very near future. We plan to submit a proposal to VTRC to supplement the equipment funds in the ESITAC budget to purchase a particulates analyzer.
4. MOVES software will be used to replace MOBILE62.

## VI. Acknowledgements


1. Mr. Jim Ponticello of VDOT and Mr. Thomas Ballou of VDEQ are acknowledged for several meetings to determine the direction of the project and for being an advocate for the project.
2. Mr. Thomas Jennings and Mr. Anton Sorkin of VDEQ were consulted on the type of equipment to be purchased and the measurement protocols to be used.

## VII. References

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## Appendix I

## MOBILE6 EMISSION FACTORS

```
***************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT1.IN (file 1, run 1).
*
***************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 07-08-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.30.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  74.0 (F)
              Maximum Temperature:  85.0 (F)
                Minimum Rel. Hum.:  48.0 (%)
                Maximum Rel. Hum.:  60.0 (%)
              Barometric Pressure: 29.88 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.8 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No
```

```
              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010       Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027     Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
              GVWR:                <6000     >6000     (All)
                        ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  ------------------------------------------------------------------------
----------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.690     0.710     1.174     0.829     0.763
0.198     0.413     0.328      2.34     0.741
     Composite CO  :      9.50     10.57     14.21     11.50      8.94
0.930     0.768     1.798     16.40     9.859
     Composite NOX :      0.622     0.790     1.163     0.885     2.876
0.707     1.096    10.488      1.45     1.691
  ------------------------------------------------------------------------
----------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.300     0.218
0.084     0.167               0.383
      VOC   Running:     0.154     0.183     0.288     0.210
0.114     0.246               1.288
  VOC Total Exhaust:     0.305     0.373     0.588     0.428     0.204
0.198     0.413     0.328      1.67     0.374

           CO Start:      1.71      2.90      4.41      3.29
0.402     0.338               2.752
         CO Running:      7.79      7.67      9.80      8.22
0.527     0.430              13.652
   CO Total Exhaust:      9.50     10.57     14.21     11.50      8.94
0.930     0.768     1.798     16.40     9.859

          NOx Start:     0.101     0.139     0.207     0.156
0.022     0.032               0.372
        NOx Running:     0.521     0.651     0.955     0.729
0.685     1.064               1.079
  NOx Total Exhaust:     0.622     0.790     1.163     0.885     2.876
0.707     1.096    10.488      1.45     1.691
  ------------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.171     0.146     0.251     0.173     0.235
0.000     0.000     0.000     0.329     0.160
       Diurnal Loss:     0.012     0.012     0.022     0.015     0.025
0.000     0.000     0.000     0.001     0.013
```

```
       Resting Loss:     0.083     0.084     0.157     0.103     0.153
0.000     0.000     0.000     0.339     0.090
       Running Loss:     0.109     0.086     0.146     0.101     0.135
0.000     0.000     0.000     0.000     0.096
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.384     0.338     0.586     0.402     0.558
0.000     0.000     0.000     0.669     0.367
  ---------------------------------------------------------------------------
----------------------------------------------
***************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT2.IN (file 1, run 1).
*
***************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 07-15-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.15.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  77.0 (F)
              Maximum Temperature:  88.0 (F)
                Minimum Rel. Hum.:  33.0 (%)
                Maximum Rel. Hum.:  40.0 (%)
              Barometric Pressure: 30.16 (inches Hg)
                  Nominal Fuel RVP:   9.0 psi
```

```
                    Weathered RVP:   8.7 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010       Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027     Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:              <6000     >6000     (All)
                        ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  ------------------------------------------------------------------------
---------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.709     0.725     1.200     0.847     0.793
0.198     0.413     0.328      2.43     0.758
     Composite CO  :      9.82     10.81     14.50     11.75      9.16
0.930     0.768     1.798     17.57    10.118
     Composite NOX :      0.675     0.853     1.255     0.956     2.884
0.707     1.096    10.488      1.53     1.747
  ------------------------------------------------------------------------
---------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.300     0.218
0.084     0.167               0.385
      VOC   Running:     0.156     0.185     0.290     0.212
0.114     0.246               1.302
  VOC Total Exhaust:     0.308     0.375     0.591     0.430     0.205
0.198     0.413     0.328      1.69     0.376

           CO Start:      1.72      2.93      4.46      3.32
0.402     0.338               2.840
         CO Running:      8.10      7.88     10.04      8.43
0.527     0.430              14.729
   CO Total Exhaust:      9.82     10.81     14.50     11.75      9.16
0.930     0.768     1.798     17.57    10.118

          NOx Start:     0.109     0.150     0.224     0.169
0.022     0.032               0.393
        NOx Running:     0.566     0.703     1.032     0.787
0.685     1.064               1.133
```

```
  NOx Total Exhaust:     0.675     0.853     1.255     0.956     2.884
0.707     1.096    10.488      1.53     1.747
  -------------------------------------------------------------------------
---------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.177     0.152     0.262     0.180     0.248
0.000     0.000     0.000     0.394     0.167
       Diurnal Loss:     0.013     0.013     0.023     0.016     0.027
0.000     0.000     0.000     0.001     0.013
       Resting Loss:     0.085     0.085     0.160     0.104     0.156
0.000     0.000     0.000     0.345     0.092
       Running Loss:     0.117     0.090     0.155     0.106     0.145
0.000     0.000     0.000     0.000     0.102
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.401     0.350     0.610     0.418     0.587
0.000     0.000     0.000     0.740     0.382
  -------------------------------------------------------------------------
---------------------------------------------
**************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT3.IN (file 1, run 1).
*
**************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 1-07-16-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.35.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b
```

```
                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  79.0 (F)
              Maximum Temperature:  86.0 (F)
                Minimum Rel. Hum.:  58.0 (%)
                Maximum Rel. Hum.:  67.0 (%)
              Barometric Pressure: 30.16 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.8 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010       Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027     Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:               <6000     >6000     (All)
                                ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  ------------------------------------------------------------------------
----------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.703     0.721     1.192     0.841     0.780
0.198     0.413     0.328      2.42     0.753
     Composite CO  :     10.01     10.92     14.62     11.87      9.17
0.930     0.768     1.798     17.42    10.240
     Composite NOX :      0.589     0.740     1.089     0.829     2.882
0.707     1.096    10.488      1.29     1.650
  ------------------------------------------------------------------------
----------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.300     0.218
0.084     0.167               0.383
      VOC   Running:     0.158     0.186     0.292     0.213
0.114     0.246               1.301
  VOC Total Exhaust:     0.309     0.376     0.592     0.431     0.206
0.198     0.413     0.328      1.68     0.377

           CO Start:      1.73      2.93      4.46      3.32
0.402     0.338               2.800
```

```
         CO Running:      8.28      7.98     10.16      8.54
0.527     0.430              14.617
   CO Total Exhaust:     10.01     10.92     14.62     11.87      9.17
0.930     0.768     1.798     17.42    10.240

          NOx Start:     0.092     0.127     0.189     0.143
0.022     0.032               0.333
        NOx Running:     0.497     0.613     0.900     0.687
0.685     1.064               0.959
  NOx Total Exhaust:     0.589     0.740     1.089     0.829     2.882
0.707     1.096    10.488      1.29     1.650
  ---------------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.177     0.152     0.262     0.180     0.248
0.000     0.000     0.000     0.392     0.167
       Diurnal Loss:     0.008     0.008     0.014     0.010     0.017
0.000     0.000     0.000     0.001     0.008
       Resting Loss:     0.085     0.085     0.160     0.105     0.156
0.000     0.000     0.000     0.345     0.092
       Running Loss:     0.116     0.089     0.153     0.106     0.143
0.000     0.000     0.000     0.000     0.101
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.394     0.345     0.599     0.411     0.575
0.000     0.000     0.000     0.738     0.376
  ---------------------------------------------------------------------------
----------------------------------------------
***************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT4.IN (file 1, run 1).
*
***************************************************************************
*
  M603 Comment:
             User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 2-07-16-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
             User supplied alternate AC input: Cloud Cover Fraction set
to 0.58.
  M 15 Warning:
           The combined area wide average speed entered cannot be
           greater than 43.3 miles per hour.
           The average speed will be reset to this value.
```

```
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  77.0 (F)
              Maximum Temperature:  88.0 (F)
                Minimum Rel. Hum.:  59.0 (%)
                Maximum Rel. Hum.:  68.0 (%)
              Barometric Pressure: 29.89 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.7 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010       Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027     Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:              <6000     >6000     (All)
                        ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  -------------------------------------------------------------------------
----------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.709     0.726     1.201     0.847     0.793
0.198     0.413     0.328      2.43     0.759
     Composite CO  :      9.92     10.86     14.56     11.81      9.16
0.930     0.768     1.798     17.57    10.180
     Composite NOX :      0.578     0.727     1.070     0.815     2.884
0.707     1.096    10.488      1.27     1.639
  -------------------------------------------------------------------------
----------------------------------------------
Exhaust emissions (g/mi):
```

```
        VOC   Start:     0.151     0.190     0.300     0.218
0.084     0.167               0.385
      VOC   Running:     0.157     0.185     0.291     0.212
0.114     0.246               1.302
  VOC Total Exhaust:     0.308     0.375     0.591     0.430     0.205
0.198     0.413     0.328      1.69     0.376

           CO Start:      1.72      2.93      4.46      3.32
0.402     0.338               2.840
         CO Running:      8.20      7.93     10.10      8.49
0.527     0.430              14.729
   CO Total Exhaust:      9.92     10.86     14.56     11.81      9.16
0.930     0.768     1.798     17.57    10.180

          NOx Start:     0.090     0.125     0.186     0.140
0.022     0.032               0.326
        NOx Running:     0.488     0.603     0.885     0.675
0.685     1.064               0.943
  NOx Total Exhaust:     0.578     0.727     1.070     0.815     2.884
0.707     1.096    10.488      1.27     1.639
  ------------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.177     0.152     0.262     0.180     0.248
0.000     0.000     0.000     0.394     0.167
       Diurnal Loss:     0.013     0.013     0.023     0.016     0.027
0.000     0.000     0.000     0.001     0.013
       Resting Loss:     0.085     0.085     0.160     0.104     0.156
0.000     0.000     0.000     0.345     0.092
       Running Loss:     0.117     0.090     0.155     0.106     0.145
0.000     0.000     0.000     0.000     0.102
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.401     0.350     0.610     0.418     0.587
0.000     0.000     0.000     0.740     0.382
  ------------------------------------------------------------------------
----------------------------------------------
**************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT5.IN (file 1, run 1).
*
**************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 3-07-16-09
```

```
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.67.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  79.0 (F)
              Maximum Temperature:  86.0 (F)
                Minimum Rel. Hum.:  58.0 (%)
                Maximum Rel. Hum.:  66.0 (%)
              Barometric Pressure: 29.89 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.8 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010      Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027    Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:               <6000     >6000     (All)
                         ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  -----------------------------------------------------------------------
----------------------------------------------
 Composite Emission Factors (g/mi):
```

```
     Composite VOC :      0.705     0.722     1.195     0.843     0.785
0.198     0.413     0.328     2.43     0.755
     Composite CO  :      9.89     10.88     14.60     11.83      9.21
0.930     0.768     1.798    17.54    10.184
     Composite NOX :      0.583     0.735     1.081     0.823     2.882
0.707     1.096    10.488     1.28     1.645
  -------------------------------------------------------------------------
----------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.301     0.219
0.084     0.167               0.383
      VOC   Running:     0.157     0.185     0.291     0.212
0.114     0.246               1.302
  VOC Total Exhaust:     0.308     0.376     0.592     0.431     0.206
0.198     0.413     0.328     1.69     0.377

           CO Start:      1.73      2.94      4.48      3.34
0.402     0.338               2.811
         CO Running:      8.16      7.94     10.12      8.50
0.527     0.430              14.732
   CO Total Exhaust:      9.89     10.88     14.60     11.83      9.21
0.930     0.768     1.798    17.54    10.184

          NOx Start:     0.092     0.126     0.188     0.142
0.022     0.032               0.331
        NOx Running:     0.491     0.608     0.893     0.681
0.685     1.064               0.953
  NOx Total Exhaust:     0.583     0.735     1.081     0.823     2.882
0.707     1.096    10.488     1.28     1.645
  -------------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.178     0.153     0.263     0.181     0.250
0.000     0.000     0.000     0.399     0.168
       Diurnal Loss:     0.008     0.008     0.014     0.010     0.017
0.000     0.000     0.000     0.001     0.008
       Resting Loss:     0.086     0.086     0.160     0.105     0.157
0.000     0.000     0.000     0.346     0.092
       Running Loss:     0.117     0.090     0.155     0.106     0.145
0.000     0.000     0.000     0.000     0.102
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.397     0.347     0.603     0.413     0.579
0.000     0.000     0.000     0.746     0.378
  -------------------------------------------------------------------------
----------------------------------------------
***************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
```

```
* Input file: SUM09\POINT6.IN (file 1, run 1).
*
*************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 4-07-16-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.70.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  79.0 (F)
              Maximum Temperature:  86.0 (F)
                Minimum Rel. Hum.:  57.0 (%)
                Maximum Rel. Hum.:  65.0 (%)
              Barometric Pressure: 29.89 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.8 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010      Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027    Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No
```

| Vehicle Type: | LDGV | LDGT12 | LDGT34 | LDGT | HDGV | LDDV | LDDT | HDDV | MC | All Veh |
|---|---|---|---|---|---|---|---|---|---|---|
| GVWR: | | <6000 | >6000 | (All) | | | | | | |
| VMT Distribution: | 0.3597 | 0.3800 | 0.1306 | | 0.0360 | 0.0003 | 0.0019 | 0.0860 | 0.0055 | 1.0000 |
| **Composite Emission Factors (g/mi):** | | | | | | | | | | |
| Composite VOC : | 0.705 | 0.722 | 1.195 | 0.843 | 0.785 | 0.198 | 0.413 | 0.328 | 2.43 | 0.755 |
| Composite CO : | 9.85 | 10.86 | 14.57 | 11.81 | 9.21 | 0.930 | 0.768 | 1.798 | 17.54 | 10.158 |
| Composite NOX : | 0.585 | 0.738 | 1.087 | 0.828 | 2.882 | 0.707 | 1.096 | 10.488 | 1.29 | 1.648 |
| **Exhaust emissions (g/mi):** | | | | | | | | | | |
| VOC Start: | 0.151 | 0.190 | 0.301 | 0.219 | | 0.084 | 0.167 | | 0.383 | |
| VOC Running: | 0.157 | 0.185 | 0.291 | 0.212 | | 0.114 | 0.246 | | 1.302 | |
| VOC Total Exhaust: | 0.308 | 0.375 | 0.592 | 0.431 | 0.206 | 0.198 | 0.413 | 0.328 | 1.69 | 0.376 |
| CO Start: | 1.73 | 2.94 | 4.48 | 3.34 | | 0.402 | 0.338 | | 2.811 | |
| CO Running: | 8.12 | 7.92 | 10.09 | 8.47 | | 0.527 | 0.430 | | 14.732 | |
| CO Total Exhaust: | 9.85 | 10.86 | 14.57 | 11.81 | 9.21 | 0.930 | 0.768 | 1.798 | 17.54 | 10.158 |
| NOx Start: | 0.092 | 0.127 | 0.190 | 0.143 | | 0.022 | 0.032 | | 0.334 | |
| NOx Running: | 0.493 | 0.611 | 0.897 | 0.684 | | 0.685 | 1.064 | | 0.960 | |
| NOx Total Exhaust: | 0.585 | 0.738 | 1.087 | 0.828 | 2.882 | 0.707 | 1.096 | 10.488 | 1.29 | 1.648 |
| **Non-Exhaust Emissions (g/mi):** | | | | | | | | | | |
| Hot Soak Loss: | 0.178 | 0.153 | 0.263 | 0.181 | 0.250 | 0.000 | 0.000 | 0.000 | 0.399 | 0.168 |
| Diurnal Loss: | 0.008 | 0.008 | 0.014 | 0.010 | 0.017 | 0.000 | 0.000 | 0.000 | 0.001 | 0.008 |
| Resting Loss: | 0.086 | 0.086 | 0.160 | 0.105 | 0.157 | 0.000 | 0.000 | 0.000 | 0.346 | 0.092 |
| Running Loss: | 0.117 | 0.090 | 0.155 | 0.106 | 0.145 | 0.000 | 0.000 | 0.000 | 0.000 | 0.102 |
| Crankcase Loss: | 0.008 | 0.010 | 0.010 | 0.010 | 0.010 | 0.000 | 0.000 | 0.000 | 0.000 | 0.009 |

```
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.397     0.347     0.603     0.413     0.579
0.000     0.000     0.000     0.746     0.378
  --------------------------------------------------------------------------
----------------------------------------------
***************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT7.IN (file 1, run 1).
*
***************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 5-07-16-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.70.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  79.0 (F)
              Maximum Temperature:  86.0 (F)
                Minimum Rel. Hum.:  57.0 (%)
                Maximum Rel. Hum.:  65.0 (%)
              Barometric Pressure: 29.89 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.8 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
```

```
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010       Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027     Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:              <6000     >6000     (All)
                         ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  -----------------------------------------------------------------------
----------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.705     0.722     1.195     0.843     0.785
0.198     0.413     0.328      2.43     0.755
     Composite CO  :      9.85     10.86     14.57     11.81      9.21
0.930     0.768     1.798     17.54    10.158
     Composite NOX :      0.585     0.738     1.087     0.828     2.882
0.707     1.096    10.488      1.29     1.648
  -----------------------------------------------------------------------
----------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.301     0.219
0.084     0.167               0.383
      VOC   Running:     0.157     0.185     0.291     0.212
0.114     0.246               1.302
  VOC Total Exhaust:     0.308     0.375     0.592     0.431     0.206
0.198     0.413     0.328      1.69     0.376

           CO Start:      1.73      2.94      4.48      3.34
0.402     0.338               2.811
         CO Running:      8.12      7.92     10.09      8.47
0.527     0.430              14.732
   CO Total Exhaust:      9.85     10.86     14.57     11.81      9.21
0.930     0.768     1.798     17.54    10.158

          NOx Start:     0.092     0.127     0.190     0.143
0.022     0.032               0.334
        NOx Running:     0.493     0.611     0.897     0.684
0.685     1.064               0.960
  NOx Total Exhaust:     0.585     0.738     1.087     0.828     2.882
0.707     1.096    10.488      1.29     1.648
  -----------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.178     0.153     0.263     0.181     0.250
0.000     0.000     0.000     0.399     0.168
```

```
      Diurnal Loss:     0.008     0.008     0.014     0.010     0.017
0.000     0.000     0.000     0.001     0.008
      Resting Loss:     0.086     0.086     0.160     0.105     0.157
0.000     0.000     0.000     0.346     0.092
      Running Loss:     0.117     0.090     0.155     0.106     0.145
0.000     0.000     0.000     0.000     0.102
    Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
    Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:    0.397     0.347     0.603     0.413     0.579
0.000     0.000     0.000     0.746     0.378
  -----------------------------------------------------------------------
----------------------------------------------
**************************************************************************
*
* MOBILE6.2.03 (24-Sep-2003)
*
* Input file: SUM09\POINT8.IN (file 1, run 1).
*
**************************************************************************
*
  M603 Comment:
               User has disabled the calculation of REFUELING emissions.


* # # # # # # # # # # # # # # # # # # # # # # # # #
* 07-09-09
* File 1, Run 1, Scenario 1.
* # # # # # # # # # # # # # # # # # # # # # # # # #
  M617 Comment:
               User supplied alternate AC input: Cloud Cover Fraction set
to 0.69.
  M 15 Warning:
             The combined area wide average speed entered cannot be
             greater than 43.3 miles per hour.
             The average speed will be reset to this value.
  M584 Warning:
            The user supplied area wide average speed of 43.3
            will be used for all hours of the day.  100% of VMT
            has been assigned to a fixed combination of freeways,
            freeway ramps, arterial/collector and local roadways
            for all hours of the day and all vehicle types.
  M 48 Warning:
              there are no sales for vehicle class HDGV8b

                    Calendar Year:  2009
                            Month:  July
                         Altitude:  Low
              Minimum Temperature:  74.0 (F)
              Maximum Temperature:  81.0 (F)
                Minimum Rel. Hum.:  48.0 (%)
                Maximum Rel. Hum.:  60.0 (%)
```

```
              Barometric Pressure: 30.09 (inches Hg)
                 Nominal Fuel RVP:   9.0 psi
                    Weathered RVP:   8.9 psi
              Fuel Sulfur Content:   30. ppm

              Exhaust I/M Program:  No
                 Evap I/M Program:  No
                      ATP Program:  No
                 Reformulated Gas:  No

              User supplied hourly temperatures.

   Ether Blend Market Share: 0.010      Alcohol Blend Market Share: 0.500
   Ether Blend Oxygen Content: 0.027    Alcohol Blend Oxygen Content:
0.035
                                          Alcohol Blend RVP Waiver: No

       Vehicle Type:      LDGV    LDGT12    LDGT34      LDGT      HDGV
LDDV      LDDT      HDDV        MC   All Veh
               GVWR:               <6000     >6000     (All)
                         ------    ------    ------    ------    ------
------    ------    ------    ------    ------
   VMT Distribution:    0.3597    0.3800    0.1306              0.0360
0.0003    0.0019    0.0860    0.0055    1.0000
  -----------------------------------------------------------------------
---------------------------------------------
 Composite Emission Factors (g/mi):
     Composite VOC :      0.669     0.693     1.144     0.808     0.731
0.198     0.413     0.328      2.27     0.721
     Composite CO  :      8.91      10.19     13.75     11.10      8.76
0.930     0.768     1.798     15.48     9.431
     Composite NOX :      0.617     0.792     1.167     0.888     2.870
0.707     1.096    10.488      1.52     1.691
  -----------------------------------------------------------------------
---------------------------------------------
Exhaust emissions (g/mi):
        VOC   Start:     0.151     0.190     0.300     0.218
0.084     0.167                0.381
      VOC   Running:     0.150     0.179     0.283     0.206
0.114     0.246                1.278
  VOC Total Exhaust:     0.301     0.369     0.583     0.424     0.203
0.198     0.413     0.328      1.66     0.370

           CO Start:      1.70      2.87      4.36      3.25
0.402     0.338                2.664
         CO Running:      7.21      7.32      9.39      7.85
0.527     0.430               12.819
   CO Total Exhaust:      8.91     10.19     13.75     11.10      8.76
0.930     0.768     1.798     15.48     9.431

          NOx Start:     0.104     0.143     0.213     0.160
0.022     0.032                0.390
```

```
        NOx Running:     0.514     0.650     0.954     0.728
0.685     1.064               1.130
  NOx Total Exhaust:     0.617     0.792     1.167     0.888     2.870
0.707     1.096    10.488      1.52     1.691
  ------------------------------------------------------------------------
----------------------------------------------
Non-Exhaust Emissions (g/mi):
      Hot Soak Loss:     0.167     0.141     0.242     0.167     0.225
0.000     0.000     0.000     0.275     0.155
       Diurnal Loss:     0.007     0.008     0.014     0.009     0.016
0.000     0.000     0.000     0.001     0.008
       Resting Loss:     0.082     0.083     0.156     0.101     0.150
0.000     0.000     0.000     0.335     0.088
       Running Loss:     0.104     0.083     0.139     0.097     0.127
0.000     0.000     0.000     0.000     0.091
     Crankcase Loss:     0.008     0.010     0.010     0.010     0.010
0.000     0.000     0.000     0.000     0.009
     Refueling Loss:     0.000     0.000     0.000     0.000     0.000
0.000     0.000     0.000     0.000     0.000
  Total Non-Exhaust:     0.368     0.324     0.561     0.386     0.528
0.000     0.000     0.000     0.610     0.351
  ------------------------------------------------------------------------
----------------------------------------------
```

**APPENDIX II**

**CALINE4 FILES**

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: 1POINT1 EXP-07-08-09
RUN: POINT1
POLLUTANT: Nitrogen Dioxide

I. SITE VARIABLES

```
        U=   2.1 M/S              Z0= 100. CM              ALT=     6. (M)
      BRG= 191.0 DEGREES          VD=  0.0 CM/S
     CLAS=     1 (A)              VS=  0.0 CM/S
     MIXH= 1000. M              TEMP= 26.4 DEGREE (C)
    SIGTH=  133. DEGREES
```

NOX VARIABLES

```
      NO2= 0.01 PPM      NO= 0.01 PPM     O3= 0.08 PPM        KR= 0.004
1/SEC
```

II. LINK VARIABLES

| LINK DESCRIPTION | * | LINK COORDINATES (M) X1 | Y1 | X2 | Y2 | * | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | * | -200 | 380 | 0 | 24 | * | AG | 4114 | 1.69 | 4.4 | 34.0 |
| B. L2I642 | * | 0 | 24 | 40 | -52 | * | BG | 4114 | 1.69 | 8.0 | 34.0 |
| C. L3I643 | * | 40 | -52 | 120 | -200 | * | AG | 4114 | 1.69 | 8.0 | 34.0 |
| D. L4I644 | * | 120 | -200 | 160 | -360 | * | AG | 4114 | 1.69 | 8.0 | 34.0 |
| E. L5I645 | * | 160 | -360 | 160 | -504 | * | AG | 4114 | 1.69 | 8.0 | 34.0 |
| F. L6SLR1 | * | -272 | 180 | -100 | 20 | * | AG | 1140 | 1.69 | 0.0 | 24.0 |
| G. L7SLR2 | * | -100 | 20 | 184 | -48 | * | AG | 1140 | 1.69 | 0.0 | 24.0 |

```
  H. L8EOFR1       *  -140   248   -96   128 *  AG    432  1.69    4.0
10.0
  I. L9EOFR2       *   -96   128  -120    52 *  AG    432  1.69    4.0
10.0
  J. L10WONR       *  -124   256   108   -16 *  AG    264  1.69    4.0
10.0
  K. L11EONR       *   -60     8   108  -200 *  AG    264  1.69    4.0
10.0
  L. L12WOFR       *   112   -44   148  -280 *  AG    432  1.69    4.0
10.0
  M. L13EMDR1      *  -120    52  -160    20 *  AG    300  1.69    0.0
24.0
  N. L14EMDR2      *  -160    20  -118   -36 *  AG    300  1.69    0.0
24.0
  O. L15EMDR3      *  -118   -36   -27  -246 *  AG    300  1.69    0.0
24.0
  P. L16EMDR4      *   -27  -246    12  -437 *  AG    300  1.69    0.0
24.0


  III.  RECEPTOR LOCATIONS

              *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*---------------------
  1. R1EOR    *    -56     -9   1.5


1





          CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                   JUNE 1989 VERSION
                   PAGE   2

              JOB: 1POINT1 EXP-07-08-09
              RUN: POINT1
        POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

              * PRED  *                     CONC/LINK
              * CONC  *                       (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
 -------------*-------*-------------------------------------------------
  1. R1EOR    *   0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
```

| RECEPTOR | CONC/LINK (PPM) K | L | M | N | O | P |
|---|---|---|---|---|---|---|
| 1. R1EOR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

1

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: 1POINT2 EXP-07-15-09
RUN: POINT2
POLLUTANT: Nitrogen Dioxide

I. SITE VARIABLES

U= 1.5 M/S    Z0= 100. CM    ALT= 6. (M)
BRG= 169.9 DEGREES    VD= 0.0 CM/S
CLAS= 1 (A)    VS= 0.0 CM/S
MIXH= 1000. M    TEMP= 28.5 DEGREE (C)
SIGTH= 27. DEGREES

NOX VARIABLES

NO2= 0.01 PPM    NO= 0.01 PPM    O3= 0.08 PPM    KR= 0.004 1/SEC

II. LINK VARIABLES

| LINK DESCRIPTION | LINK COORDINATES (M) X1 | Y1 | X2 | Y2 | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | -200 | 380 | 0 | 24 | AG | 5158 | 1.75 | 4.4 | 34.0 |
| B. L2I642 | 0 | 24 | 40 | -52 | BG | 5158 | 1.75 | 8.0 | 34.0 |
| C. L3I643 | 40 | -52 | 120 | -200 | AG | 5158 | 1.75 | 8.0 | 34.0 |

```
  D. L4I644       *   120  -200   160  -360 *  AG   5158  1.75    8.0
34.0
  E. L5I645       *   160  -360   160  -504 *  AG   5158  1.75    8.0
34.0
  F. L6SLR1       *  -272   180  -100    20 *  AG    984  1.75    0.0
24.0
  G. L7SLR2       *  -100    20   184   -48 *  AG    984  1.75    0.0
24.0
  H. L8EOFR1      *  -140   248   -96   128 *  AG    492  1.75    4.0
10.0
  I. L9EOFR2      *   -96   128  -120    52 *  AG    492  1.75    4.0
10.0
  J. L10WONR      *  -124   256   108   -16 *  AG    276  1.75    4.0
10.0
  K. L11EONR      *   -60     8   108  -200 *  AG    276  1.75    4.0
10.0
  L. L12WOFR      *   112   -44   148  -280 *  AG    336  1.75    4.0
10.0
  M. L13EMDR1     *  -120    52  -160    20 *  AG    396  1.75    0.0
24.0
  N. L14EMDR2     *  -160    20  -118   -36 *  AG    396  1.75    0.0
24.0
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    396  1.75    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    396  1.75    0.0
24.0


  III.  RECEPTOR LOCATIONS

              *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*---------------------
  1. R2PL     *    -59    -97   1.5


1


            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   2

                JOB: 1POINT2 EXP-07-15-09
                RUN: POINT2
          POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

              * PRED  *                     CONC/LINK
              * CONC  *                       (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
```

```
 -------------*-------*--------------------------------------------------------
  1. R2PL      *  0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00



               *           CONC/LINK
               *             (PPM)
   RECEPTOR    *   K    L    M    N    O    P
  -------------*------------------------------
  1. R2PL      * 0.00 0.00 0.00 0.00 0.00 0.00


1


            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   1

                JOB: 1POINT3 EXP1-07-16-09
                RUN: POINT3
          POLLUTANT: Nitrogen Dioxide


    I.  SITE VARIABLES

          U=   2.3 M/S             Z0= 100. CM            ALT=     6. (M)
        BRG= 252.8 DEGREES         VD=  0.0 CM/S
       CLAS=     1 (A)             VS=  0.0 CM/S
       MIXH= 1000. M             TEMP= 28.5 DEGREE (C)
      SIGTH=   21. DEGREES

      NOX VARIABLES

        NO2= 0.01 PPM      NO= 0.01 PPM     O3= 0.08 PPM        KR= 0.004
1/SEC


   II.  LINK VARIABLES

        LINK      *  LINK COORDINATES (M)   *               EF     H     W
     DESCRIPTION  *   X1    Y1    X2    Y2  * TYPE  VPH  (G/MI)  (M)   (M)
  ----------------*-------------------------*-----------------------------
-
  A. L1I641       *  -200   380     0    24 *  AG   4583  1.65    4.4
34.0
  B. L2I642       *     0    24    40   -52 *  BG   4583  1.65    8.0
34.0
  C. L3I643       *    40   -52   120  -200 *  AG   4583  1.65    8.0
34.0
  D. L4I644       *   120  -200   160  -360 *  AG   4583  1.65    8.0
34.0
```

```
  E. L5I645       *   160  -360   160  -504 *  AG   4583  1.65    8.0
34.0
  F. L6SLR1       *  -272   180  -100    20 *  AG   1404  1.65    0.0
24.0
  G. L7SLR2       *  -100    20   184   -48 *  AG   1404  1.65    0.0
24.0
  H. L8EOFR1      *  -140   248   -96   128 *  AG    636  1.65    4.0
10.0
  I. L9EOFR2      *   -96   128  -120    52 *  AG    636  1.65    4.0
10.0
  J. L10WONR      *  -124   256   108   -16 *  AG    306  1.65    4.0
10.0
  K. L11EONR      *   -60     8   108  -200 *  AG    360  1.65    4.0
10.0
  L. L12WOFR      *   112   -44   148  -280 *  AG    276  1.65    4.0
10.0
  M. L13EMDR1     *  -120    52  -160    20 *  AG    618  1.65    0.0
24.0
  N. L14EMDR2     *  -160    20  -118   -36 *  AG    618  1.65    0.0
24.0
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    618  1.65    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    618  1.65    0.0
24.0


  III.  RECEPTOR LOCATIONS

              *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*---------------------
  1. R3MAED   *    -82   -143   1.5


1


            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   2

                JOB: 1POINT3 EXP1-07-16-09
                RUN: POINT3
          POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

              * PRED  *                    CONC/LINK
              * CONC  *                      (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
 -------------*-------*-------------------------------------------------
  1. R3MAED   *  0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
```

```
             *           CONC/LINK
             *             (PPM)
   RECEPTOR  *   K    L    M    N    O    P
  -----------*------------------------------
  1. R3MAED  * 0.00 0.00 0.00 0.00 0.00 0.00
```

1

```
            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   1

                JOB: 1POINT4 EXP2-07-16-09
                RUN: POINT4
          POLLUTANT: Nitrogen Dioxide
```

I.  SITE VARIABLES

```
           U=   2.9 M/S              Z0= 100. CM            ALT=     6. (M)
         BRG= 200.5 DEGREES          VD=   0.0 CM/S
        CLAS=     1 (A)              VS=   0.0 CM/S
        MIXH= 1000. M              TEMP= 28.4 DEGREE (C)
       SIGTH=   36. DEGREES
```

NOX VARIABLES

```
         NO2= 0.01 PPM      NO= 0.01 PPM     O3= 0.08 PPM        KR= 0.004
1/SEC
```

II.  LINK VARIABLES

| LINK DESCRIPTION | * | X1 | Y1 | X2 | Y2 | * | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | * | -200 | 380 | 0 | 24 | * | AG | 4583 | 1.64 | 4.4 | 34.0 |
| B. L2I642 | * | 0 | 24 | 40 | -52 | * | BG | 4583 | 1.64 | 8.0 | 34.0 |
| C. L3I643 | * | 40 | -52 | 120 | -200 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| D. L4I644 | * | 120 | -200 | 160 | -360 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| E. L5I645 | * | 160 | -360 | 160 | -504 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| F. L6SLR1 | * | -272 | 180 | -100 | 20 | * | AG | 1404 | 1.64 | 0.0 | 24.0 |

(X1, Y1, X2, Y2 = LINK COORDINATES (M))

```
  G. L7SLR2       *  -100    20   184   -48 *  AG   1404  1.64    0.0
24.0
  H. L8EOFR1      *  -140   248   -96   128 *  AG    636  1.64    4.0
10.0
  I. L9EOFR2      *   -96   128  -120    52 *  AG    636  1.64    4.0
10.0
  J. L10WONR      *  -124   256   108   -16 *  AG    306  1.64    4.0
10.0
  K. L11EONR      *   -60     8   108  -200 *  AG    360  1.64    4.0
10.0
  L. L12WOFR      *   112   -44   148  -280 *  AG    276  1.64    4.0
10.0
  M. L13EMDR1     *  -120    52  -160    20 *  AG    618  1.64    0.0
24.0
  N. L14EMDR2     *  -160    20  -118   -36 *  AG    618  1.64    0.0
24.0
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    618  1.64    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    618  1.64    0.0
24.0


  III.  RECEPTOR LOCATIONS

             *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*---------------------
  1. R4MAED+3 *   -109   -153   1.5


1

            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   2

                JOB: 1POINT4 EXP2-07-16-09
                RUN: POINT4
          POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

             * PRED  *                     CONC/LINK
             * CONC  *                       (PPM)
   RECEPTOR  * (PPM) *   A    B    C    D    E    F    G    H    I    J
 ------------*-------*-----------------------------------------------------
  1. R4MAED+3 *  0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00



             *           CONC/LINK
             *             (PPM)
```

| RECEPTOR | * | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|
| 1. R4MAED+3 | * | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

1

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: 1POINT5 EXP3-07-16-09
RUN: POINT5
POLLUTANT: Nitrogen Dioxide

I. SITE VARIABLES

```
     U=   1.6 M/S             Z0= 100. CM            ALT=     6. (M)
   BRG= 246.0 DEGREES         VD=  0.0 CM/S
  CLAS=     1 (A)             VS=  0.0 CM/S
  MIXH= 1000. M             TEMP= 28.8 DEGREE (C)
 SIGTH=    1. DEGREES
```

NOX VARIABLES

```
   NO2= 0.01 PPM      NO= 0.01 PPM     O3= 0.08 PPM        KR= 0.004
1/SEC
```

II. LINK VARIABLES

| LINK DESCRIPTION | * | X1 | Y1 | X2 | Y2 | * | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | * | -200 | 380 | 0 | 24 | * | AG | 4583 | 1.64 | 4.4 | 34.0 |
| B. L2I642 | * | 0 | 24 | 40 | -52 | * | BG | 4583 | 1.64 | 8.0 | 34.0 |
| C. L3I643 | * | 40 | -52 | 120 | -200 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| D. L4I644 | * | 120 | -200 | 160 | -360 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| E. L5I645 | * | 160 | -360 | 160 | -504 | * | AG | 4583 | 1.64 | 8.0 | 34.0 |
| F. L6SLR1 | * | -272 | 180 | -100 | 20 | * | AG | 1404 | 1.64 | 0.0 | 24.0 |
| G. L7SLR2 | * | -100 | 20 | 184 | -48 | * | AG | 1404 | 1.64 | 0.0 | 24.0 |
| H. L8EOFR1 | * | -140 | 248 | -96 | 128 | * | AG | 636 | 1.64 | 4.0 | 10.0 |
| I. L9EOFR2 | * | -96 | 128 | -120 | 52 | * | AG | 636 | 1.64 | 4.0 | 10.0 |

```
  J. L10WONR      *  -124   256   108   -16 *  AG    306  1.64    4.0
10.0
  K. L11EONR      *   -60     8   108  -200 *  AG    360  1.64    4.0
10.0
  L. L12WOFR      *   112   -44   148  -280 *  AG    276  1.64    4.0
10.0
  M. L13EMDR1     *  -120    52  -160    20 *  AG    618  1.64    0.0
24.0
  N. L14EMDR2     *  -160    20  -118   -36 *  AG    618  1.64    0.0
24.0
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    618  1.64    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    618  1.64    0.0
24.0


  III.  RECEPTOR LOCATIONS

            *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*---------------------
  1. R5MAED+6 *   -136   -165   1.5


1

            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   2

                JOB: 1POINT5 EXP3-07-16-09
                RUN: POINT5
          POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

            * PRED  *                    CONC/LINK
            * CONC  *                      (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
 -------------*-------*--------------------------------------------------
  1. R5MAED+6 *  0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00



            *          CONC/LINK
            *            (PPM)
   RECEPTOR   *   K    L    M    N    O    P
  ------------*------------------------------
  1. R5MAED+6 * 0.00 0.00 0.00 0.00 0.00 0.00


1
```

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: 1POINT6 EXP4-07-16-09
RUN: POINT6
POLLUTANT: Nitrogen Dioxide

## I. SITE VARIABLES

```
    U=   1.1 M/S            Z0= 100. CM           ALT=     6. (M)
  BRG= 212.0 DEGREES        VD=  0.0 CM/S
 CLAS=     1 (A)            VS=  0.0 CM/S
 MIXH= 1000. M            TEMP= 29.0 DEGREE (C)
SIGTH=   20. DEGREES
```

NOX VARIABLES

```
  NO2= 0.01 PPM      NO= 0.01 PPM     O3= 0.08 PPM        KR= 0.004
1/SEC
```

## II. LINK VARIABLES

| LINK DESCRIPTION | * | X1 | Y1 | X2 | Y2 | * | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LINK COORDINATES (M) | | | | | | | | | |
| A. L1I641 | * | -200 | 380 | 0 | 24 | * | AG | 4583 | 1.65 | 4.4 | 34.0 |
| B. L2I642 | * | 0 | 24 | 40 | -52 | * | BG | 4583 | 1.65 | 8.0 | 34.0 |
| C. L3I643 | * | 40 | -52 | 120 | -200 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| D. L4I644 | * | 120 | -200 | 160 | -360 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| E. L5I645 | * | 160 | -360 | 160 | -504 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| F. L6SLR1 | * | -272 | 180 | -100 | 20 | * | AG | 1404 | 1.65 | 0.0 | 24.0 |
| G. L7SLR2 | * | -100 | 20 | 184 | -48 | * | AG | 1404 | 1.65 | 0.0 | 24.0 |
| H. L8EOFR1 | * | -140 | 248 | -96 | 128 | * | AG | 636 | 1.65 | 4.0 | 10.0 |
| I. L9EOFR2 | * | -96 | 128 | -120 | 52 | * | AG | 636 | 1.65 | 4.0 | 10.0 |
| J. L10WONR | * | -124 | 256 | 108 | -16 | * | AG | 306 | 1.65 | 4.0 | 10.0 |
| K. L11EONR | * | -60 | 8 | 108 | -200 | * | AG | 360 | 1.65 | 4.0 | 10.0 |
| L. L12WOFR | * | 112 | -44 | 148 | -280 | * | AG | 276 | 1.65 | 4.0 | 10.0 |

```
  M. L13EMDR1     *  -120    52  -160    20 *  AG    618  1.65    0.0
24.0
  N. L14EMDR2     *  -160    20  -118   -36 *  AG    618  1.65    0.0
24.0
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    618  1.65    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    618  1.65    0.0
24.0


  III.  RECEPTOR LOCATIONS

               *    COORDINATES (M)
    RECEPTOR   *    X      Y      Z
  ------------*---------------------
  1. R6MAED+9 *   -163   -176   1.5


1

            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   2

                JOB: 1POINT6 EXP4-07-16-09
                RUN: POINT6
          POLLUTANT: Nitrogen Dioxide


   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

              * PRED  *                     CONC/LINK
              * CONC  *                       (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
 -------------*-------*------------------------------------------------
  1. R6MAED+9 *   0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00



              *           CONC/LINK
              *             (PPM)
   RECEPTOR   *   K    L    M    N    O    P
  ------------*------------------------------
  1. R6MAED+9 * 0.00 0.00 0.00 0.00 0.00 0.00


1


            CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                     JUNE 1989 VERSION
                     PAGE   1
```

JOB: 1POINT6 EXP4-07-16-09
RUN: POINT6
POLLUTANT: Nitrogen Dioxide

I. SITE VARIABLES

U= 1.1 M/S                Z0= 100. CM          ALT= 6. (M)
BRG= 212.0 DEGREES        VD= 0.0 CM/S
CLAS= 1 (A)               VS= 0.0 CM/S
MIXH= 1000. M             TEMP= 29.0 DEGREE (C)
SIGTH= 20. DEGREES

NOX VARIABLES

NO2= 0.01 PPM    NO= 0.01 PPM    O3= 0.08 PPM    KR= 0.004 1/SEC

II. LINK VARIABLES

| LINK DESCRIPTION | X1 | Y1 | X2 | Y2 | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | -200 | 380 | 0 | 24 | AG | 4583 | 1.65 | 4.4 | 34.0 |
| B. L2I642 | 0 | 24 | 40 | -52 | BG | 4583 | 1.65 | 8.0 | 34.0 |
| C. L3I643 | 40 | -52 | 120 | -200 | AG | 4583 | 1.65 | 8.0 | 34.0 |
| D. L4I644 | 120 | -200 | 160 | -360 | AG | 4583 | 1.65 | 8.0 | 34.0 |
| E. L5I645 | 160 | -360 | 160 | -504 | AG | 4583 | 1.65 | 8.0 | 34.0 |
| F. L6SLR1 | -272 | 180 | -100 | 20 | AG | 1404 | 1.65 | 0.0 | 24.0 |
| G. L7SLR2 | -100 | 20 | 184 | -48 | AG | 1404 | 1.65 | 0.0 | 24.0 |
| H. L8EOFR1 | -140 | 248 | -96 | 128 | AG | 636 | 1.65 | 4.0 | 10.0 |
| I. L9EOFR2 | -96 | 128 | -120 | 52 | AG | 636 | 1.65 | 4.0 | 10.0 |
| J. L10WONR | -124 | 256 | 108 | -16 | AG | 306 | 1.65 | 4.0 | 10.0 |
| K. L11EONR | -60 | 8 | 108 | -200 | AG | 360 | 1.65 | 4.0 | 10.0 |
| L. L12WOFR | 112 | -44 | 148 | -280 | AG | 276 | 1.65 | 4.0 | 10.0 |
| M. L13EMDR1 | -120 | 52 | -160 | 20 | AG | 618 | 1.65 | 0.0 | 24.0 |
| N. L14EMDR2 | -160 | 20 | -118 | -36 | AG | 618 | 1.65 | 0.0 | 24.0 |

```
  O. L15EMDR3     *  -118   -36   -27  -246 *  AG    618  1.65    0.0
24.0
  P. L16EMDR4     *   -27  -246    12  -437 *  AG    618  1.65    0.0
24.0
```

```
  III.  RECEPTOR LOCATIONS

              *    COORDINATES (M)
    RECEPTOR  *    X      Y      Z
  ------------*--------------------
  1. R6MAED+9 *   -163   -176   1.5
```

1

```
           CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                    JUNE 1989 VERSION
                    PAGE   2

               JOB: 1POINT6 EXP4-07-16-09
               RUN: POINT6
         POLLUTANT: Nitrogen Dioxide
```

```
   IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

              * PRED  *                     CONC/LINK
              * CONC  *                       (PPM)
   RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
 -------------*-------*-------------------------------------------------
  1. R6MAED+9 *  0.01 * 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
```

```
              *          CONC/LINK
              *            (PPM)
   RECEPTOR   *   K    L    M    N    O    P
  ------------*-----------------------------
  1. R6MAED+9 * 0.00 0.00 0.00 0.00 0.00 0.00
```

1

```
           CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                    JUNE 1989 VERSION
                    PAGE   1

               JOB: 1POINT7 EXP5-07-16-09
               RUN: POINT7
         POLLUTANT: Nitrogen Dioxide
```

I. SITE VARIABLES

U= 1.2 M/S Z0= 100. CM ALT= 6. (M)
BRG= 234.4 DEGREES VD= 0.0 CM/S
CLAS= 1 (A) VS= 0.0 CM/S
MIXH= 1000. M TEMP= 29.0 DEGREE (C)
SIGTH= 31. DEGREES

NOX VARIABLES

NO2= 0.01 PPM NO= 0.01 PPM O3= 0.08 PPM KR= 0.004 1/SEC

II. LINK VARIABLES

| LINK DESCRIPTION | * | X1 | Y1 | X2 | Y2 | * | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LINK COORDINATES (M) | | | | | | | | | |
| A. L1I641 | * | -200 | 380 | 0 | 24 | * | AG | 4583 | 1.65 | 4.4 | 34.0 |
| B. L2I642 | * | 0 | 24 | 40 | -52 | * | BG | 4583 | 1.65 | 8.0 | 34.0 |
| C. L3I643 | * | 40 | -52 | 120 | -200 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| D. L4I644 | * | 120 | -200 | 160 | -360 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| E. L5I645 | * | 160 | -360 | 160 | -504 | * | AG | 4583 | 1.65 | 8.0 | 34.0 |
| F. L6SLR1 | * | -272 | 180 | -100 | 20 | * | AG | 1404 | 1.65 | 0.0 | 24.0 |
| G. L7SLR2 | * | -100 | 20 | 184 | -48 | * | AG | 1404 | 1.65 | 0.0 | 24.0 |
| H. L8EOFR1 | * | -140 | 248 | -96 | 128 | * | AG | 636 | 1.65 | 4.0 | 10.0 |
| I. L9EOFR2 | * | -96 | 128 | -120 | 52 | * | AG | 636 | 1.65 | 4.0 | 10.0 |
| J. L10WONR | * | -124 | 256 | 108 | -16 | * | AG | 306 | 1.65 | 4.0 | 10.0 |
| K. L11EONR | * | -60 | 8 | 108 | -200 | * | AG | 360 | 1.65 | 4.0 | 10.0 |
| L. L12WOFR | * | 112 | -44 | 148 | -280 | * | AG | 276 | 1.65 | 4.0 | 10.0 |
| M. L13EMDR1 | * | -120 | 52 | -160 | 20 | * | AG | 618 | 1.65 | 0.0 | 24.0 |
| N. L14EMDR2 | * | -160 | 20 | -118 | -36 | * | AG | 618 | 1.65 | 0.0 | 24.0 |
| O. L15EMDR3 | * | -118 | -36 | -27 | -246 | * | AG | 618 | 1.65 | 0.0 | 24.0 |
| P. L16EMDR4 | * | -27 | -246 | 12 | -437 | * | AG | 618 | 1.65 | 0.0 | 24.0 |

III. RECEPTOR LOCATIONS

| RECEPTOR | COORDINATES (M) X | Y | Z |
|---|---|---|---|
| 1. R7MAED+1 | -229 | -188 | 1.5 |

1

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 2

JOB: 1POINT7 EXP5-07-16-09
RUN: POINT7
POLLUTANT: Nitrogen Dioxide

IV. MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

| RECEPTOR | PRED CONC (PPM) | CONC/LINK (PPM) A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. R7MAED+1 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| RECEPTOR | CONC/LINK (PPM) K | L | M | N | O | P |
|---|---|---|---|---|---|---|
| 1. R7MAED+1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

1

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: 1POINT8 EXP5-07-16-09
RUN: POINT8
POLLUTANT: Nitrogen Dioxide

I. SITE VARIABLES

U= 2.0 M/S  Z0= 100. CM  ALT= 6. (M)
BRG= 116.8 DEGREES  VD= 0.0 CM/S
CLAS= 1 (A)  VS= 0.0 CM/S

MIXH= 1000. M TEMP= 25.6 DEGREE (C)
SIGTH= 45. DEGREES

NOX VARIABLES

NO2= 0.01 PPM NO= 0.01 PPM O3= 0.08 PPM KR= 0.004 1/SEC

II. LINK VARIABLES

| LINK DESCRIPTION | LINK COORDINATES (M) X1 | Y1 | X2 | Y2 | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|
| A. L1I641 | -200 | 380 | 0 | 24 | AG | 10684 | 1.69 | 4.4 | 34.0 |
| B. L2I642 | 0 | 24 | 40 | -52 | BG | 10684 | 1.69 | 8.0 | 34.0 |
| C. L3I643 | 40 | -52 | 120 | -200 | AG | 10684 | 1.69 | 8.0 | 34.0 |
| D. L4I644 | 120 | -200 | 160 | -360 | AG | 10684 | 1.69 | 8.0 | 34.0 |
| E. L5I645 | 160 | -360 | 160 | -504 | AG | 10684 | 1.69 | 8.0 | 34.0 |
| F. L6SLR1 | -272 | 180 | -100 | 20 | AG | 1128 | 1.69 | 0.0 | 24.0 |
| G. L7SLR2 | -100 | 20 | 184 | -48 | AG | 1128 | 1.69 | 0.0 | 24.0 |
| H. L8EOFR1 | -140 | 248 | -96 | 128 | AG | 492 | 1.69 | 4.0 | 10.0 |
| I. L9EOFR2 | -96 | 128 | -120 | 52 | AG | 492 | 1.69 | 4.0 | 10.0 |
| J. L10WONR | -124 | 256 | 108 | -16 | AG | 264 | 1.69 | 4.0 | 10.0 |
| K. L11EONR | -60 | 8 | 108 | -200 | AG | 264 | 1.69 | 4.0 | 10.0 |
| L. L12WOFR | 112 | -44 | 148 | -280 | AG | 492 | 1.69 | 4.0 | 10.0 |
| M. L13EMDR1 | -120 | 52 | -160 | 20 | AG | 324 | 1.69 | 0.0 | 24.0 |
| N. L14EMDR2 | -160 | 20 | -118 | -36 | AG | 324 | 1.69 | 0.0 | 24.0 |
| O. L15EMDR3 | -118 | -36 | -27 | -246 | AG | 324 | 1.69 | 0.0 | 24.0 |
| P. L16EMDR4 | -27 | -246 | 12 | -437 | AG | 324 | 1.69 | 0.0 | 24.0 |

III. RECEPTOR LOCATIONS

| RECEPTOR | COORDINATES (M) X | Y | Z |
|---|---|---|---|

```
   ------------*--------------------
   1. R8MAED+5 *   -125   -162   1.5


1
             CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
                      JUNE 1989 VERSION
                      PAGE   2

                 JOB: 1POINT8 EXP5-07-16-09
                 RUN: POINT8
          POLLUTANT: Nitrogen Dioxide


    IV.  MODEL RESULTS (PRED. CONC. INCLUDES AMB.)

               * PRED  *                     CONC/LINK
               * CONC  *                       (PPM)
    RECEPTOR   * (PPM) *   A    B    C    D    E    F    G    H    I    J
  -------------*-------*------------------------------------------------------
   1. R8MAED+5 *  0.03 * 0.00 0.00 0.01 0.01 0.00 0.00 0.00 0.00 0.00 0.00


               *          CONC/LINK
               *            (PPM)
    RECEPTOR   *   K    L    M    N    O    P
   ------------*------------------------------
   1. R8MAED+5 * 0.00 0.00 0.00 0.00 0.00 0.00

1
```