Diesel Truck Idling Emissions

Measurements at $PM_{2.5}$ Hot Spot

Terry L. Miller, Joshua S. Fu, Boris Hromis, John M. Storey, and James E. Parks

The University of Tennessee and Oak Ridge National Laboratory conducted a 5-month-long air monitoring study at the Watt Road interchange on I-40 in Knoxville, Tennessee, where 20,000 heavy-duty trucks travel the Interstate each day. In addition, three large truck stops are situated at this interchange, where as many as 400 trucks idle engines at night. As a result, high levels of $PM_{2.5}$ have been measured near the interchange, often exceeding National Ambient Air Quality Standards. This paper presents the results of the air monitoring study, illustrating average hourly patterns of $PM_{2.5}$ resulting from diesel truck emissions on the Interstate and at the truck stops. Most of the $PM_{2.5}$ concentrations detected occurred during the night, when the largest contribution of emissions was from idling trucks rather than trucks on the Interstate. A nearby background air monitoring site was used to identify the contribution of regional $PM_{2.5}$ emissions, which were also a significant factor in the concentrations measured at the site. The relative contributions of regional background, local truck idling, and trucks on the Interstate to local $PM_{2.5}$ concentrations are presented and discussed in the paper. The results indicate the potential significance of diesel truck idling emissions to the occurrence of hot spots of high $PM_{2.5}$ concentrations near large truck stops, ports, or border crossings. The significance of truck idling emissions is similar to the findings of other studies.

Ambient monitors were installed at two locations to continuously measure ambient concentrations of particulate matter $PM_{1.0}$, $PM_{2.5}$, and PM_{10}. These locations were named the ramp site and the ridgetop site. Both sites were located at the interchange of I-40 and Watt Road in Knoxville, Tennessee. The ramp site was located 100 ft south of the eastbound Interstate shoulder and 100 ft north of the eastbound off-ramp within the highway right-of-way. The ridgetop site was located southeast of the interchange on top of Black Oak Ridge, 300 ft higher than the ramp site elevation. The intended purpose of the site locations was that the ramp site would measure the highest concentrations due to vehicle emissions on the Interstate and nearby travel centers, while the ridgetop site would measure background concentrations in the general area. Monitoring was conducted continuously from January through June of 2005 at both sites. Figure 1 shows the locations of both sites on an aerial photograph of the area. The two sites are 3,300 ft apart.

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INSTRUMENTATION

Continuous monitoring instruments were installed in portable trailers at each site and connected to standard electrical power. Each trailer was equipped with air heaters and air conditioners to maintain a constant 72°F temperature for stable operation of the instrumentation. Air samples were drawn from sampling probes on the trailer roofs at a height of 4 m above the ground. PM samplers utilized particle size separation impactors to control the size of particles being sampled. $PM_{2.5}$ and $PM_{1.0}$ were measured using tapered element oscillating microbalances (TEOMs) at the ramp site. PM_{10} and $PM_{2.5}$ also were measured with E-BAM beta gauge instruments at the ramp site. PM_{10} was measured using an E-BAM beta gauge instrument at the ridgetop site, while $PM_{2.5}$ was measured with a TEOM. Each site also was equipped with continuously monitoring meteorological packages measuring hourly average wind speed, wind direction, standard deviation of wind direction, solar intensity, temperature, humidity, and rainfall. The wind sensors were located at the top of 10-m-high towers at each site. All data were recorded on digital data loggers and downloaded to PCs in a standard spreadsheet format.

TRAFFIC DATA COLLECTION METHODS

Traffic data were collected using a combination of manual observation counts, pneumatic road tube traffic counters, and side-fired radar traffic counters. Road tube counters were used to obtain hourly vehicle counts on the eastbound and westbound off-ramps of the Interstate at Watt Road. Manual counts were used to estimate the percentage of tractor-trailer trucks exiting the Interstate at the road tube locations, to estimate vehicle traffic and truck volumes on the Watt Road overpass, to count idling trucks at the travel centers, and to check the accuracy of the Remote Traffic Microwave Sensor (RTMS) automatic traffic counters. RTMS vehicle detection sensors from Electronic Integrated Systems, Inc. (EIS) of Toronto, Canada, were utilized to measure hourly vehicle counts, long truck counts, and vehicle average speeds on the I-40. The RTMS provides 5-min counts of total vehicles, average vehicle speeds, and long truck counts 24 h per day for each of six traffic lanes (three eastbound and three westbound). Long trucks are defined as those more than 2.5 times longer than the average vehicle. This primarily provides a count of tractor-trailer rigs, but not single-unit trucks or cabs without trailers.

AVERAGE DAILY TRAFFIC RESULTS

Data were collected with the RTMS units covering the period from February 7 to June 30, 2005. Traffic volume, truck volume, and vehicle speeds were monitored every hour for the 20-week period.

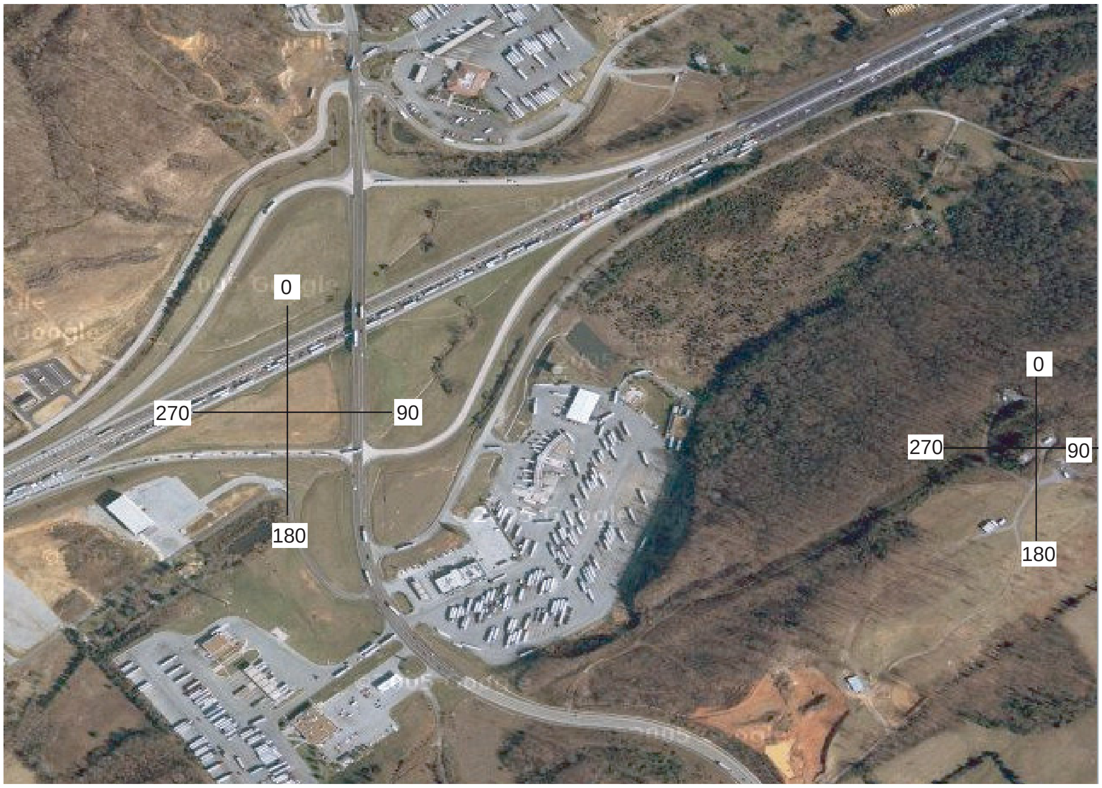

FIGURE 1 Site map at I-40 and Watt Road showing locations of monitoring sites, Interstate, and nearby truck travel centers (scale: monitoring sites are 3,300 ft apart).

The average vehicle count was 90,498 vehicles per day on I-40 just east of Watt Road. The average daily long truck count was 17,361 trucks per day. The average percentage of trucks was 19.2%. Although there were reproducible patterns of traffic variation by day of week and by hour of day, there was no appreciable seasonal change in traffic volumes over the 20-week period (i.e., February through June 2005).

The RTMS units also measure average vehicle speeds. Daily average vehicle speed measured over the 20-week period was 63 mph. Most hourly average speeds ranged from 60 to 70 mph with dips to 50 mph during peak-hour traffic conditions. During the highest congestion conditions, speeds sometimes dropped to 10 to 20 mph for short periods. This section of the Interstate has six lanes of traffic, which is more than enough to accommodate the traffic volumes using the facility most of the time. As a result, vehicle speeds stayed in the 60 to 70 mph range most of the time except during traffic incidents.

DAILY TRENDS IN VEHICLE TRAFFIC

Figure 2 shows the variation of daily traffic volume by day of the week. As shown in the figure, Fridays have the highest total vehicle traffic volume with more than 100,000 vehicles per day. Wednes-

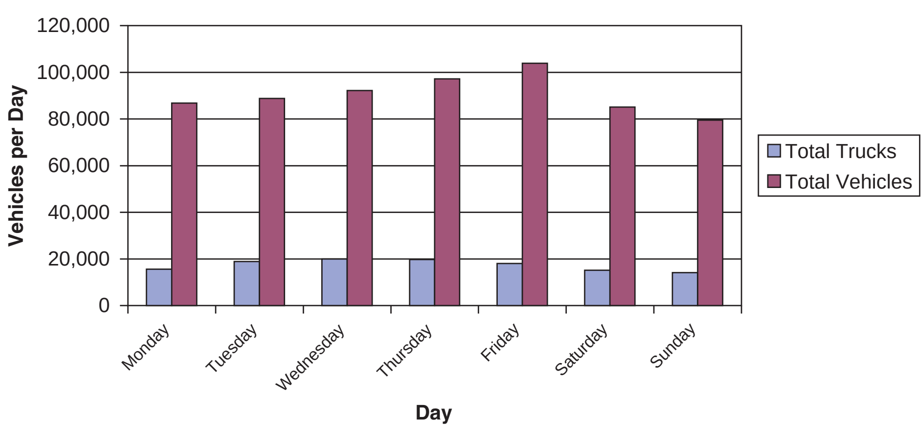

FIGURE 2 Daily traffic volume by day of week.

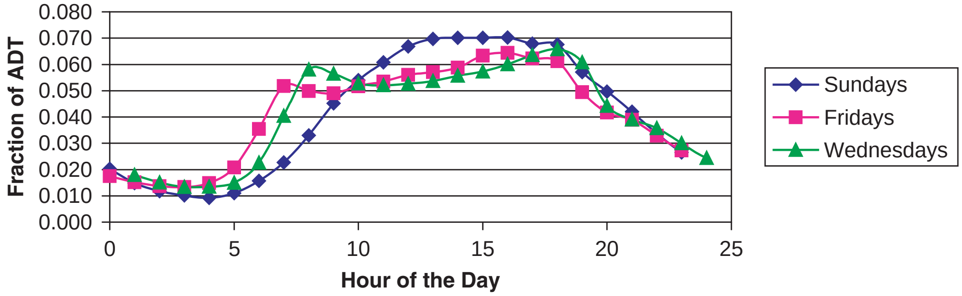

FIGURE 3 Hourly vehicle traffic as fraction of daily vehicle ADT on I-40 at Watt Road, Sundays, Wednesdays, and Fridays (20-week average).

days and Thursdays generally were the highest truck traffic days, averaging almost 20,000 long trucks per day. Saturdays and Sundays showed the lowest traffic volumes of any day of the week, averaging 82,275 vehicles per day and 14,627 trucks per day. Total daily traffic volume was fairly well balanced equally between eastbound and westbound vehicles.

HOURLY TRENDS IN VEHICLE TRAFFIC

Hourly trends in traffic were clearly different on weekdays versus weekends. Figure 3 shows the hourly variation of traffic on I-40 at Watt Road measured on Sundays, Wednesdays, and Fridays during the 20-week period. On weekdays, total vehicle traffic shows the typical morning and afternoon peak-hour increases. The city of Knoxville is to the east, so this traffic reflects the morning and afternoon peaks due to the commute from home to work and back. On weekends, the traffic volume slowly rises during the early morning, peaking during the early afternoon. Figure 3 shows total vehicle traffic as the fraction of the average daily traffic (ADT) that occurs each hour. Peak-hour traffic volumes usually reach 6% to 7% of the ADT, peaking in the late afternoon. Minimum traffic volumes occur in the early morning hours around 5 a.m. with hourly traffic only 1% to 2% of the ADT.

Hourly variations in truck traffic follow a different pattern as illustrated in Figure 4. There is no morning peak during weekdays or weekends. The truck traffic slowly increases from a low at 5 a.m. and does not peak until 6 or 7 p.m. The hourly peak rate is 5.5% to 6% of the daily truck volume. At night, the truck volume drops off to 2% or less of daily truck volume per hour between 2 a.m. and 6 a.m.

IDLING TRUCKS AT TRAVEL CENTERS

Trucks idle at the travel centers while waiting to refuel, while truck drivers eat meals, and during hoteling when drivers sleep or rest. There are a total of approximately 700 truck parking spaces at the three travel centers and along the Interstate ramps where trucks sometimes park. The largest travel center is the Petro facility on the southeast side of the interchange. This facility has 270 truck parking spaces. During previous studies (*1*), the number of idling trucks was counted at the Petro facility at various times of the day. The highest number of idling trucks was 150 to 200 observed during the late night hours from 10 p.m. to 7 a.m. During the day, most truck drivers leave the site; this reduces the number of idling vehicles to fewer than 50 during midday. The number of idling trucks measured during a previous 8-month study showed a similar pattern (*1*). Trucks also idle at the Travel America and Flying J travel centers. On a typical night, often more than a total of 400 trucks idle at the three travel centers. This value will decrease to 100 or less during midday.

PARTICULATE MATTER AIR MONITORING RESULTS

A large amount of variability was observed in the hourly average concentrations of PM_{10}, ranging from near zero to more than 150 μg/m^3. Although some of the highest concentrations were measured during winter and summer months, there was no clearly identifiable seasonal trend in $PM_{2.5}$ or PM_{10} concentrations.

Figure 5 shows the daily trend of hourly $PM_{2.5}$ concentrations measured for the entire 20-week period. The highest concentrations were measured at night, whereas the lowest concentrations were measured

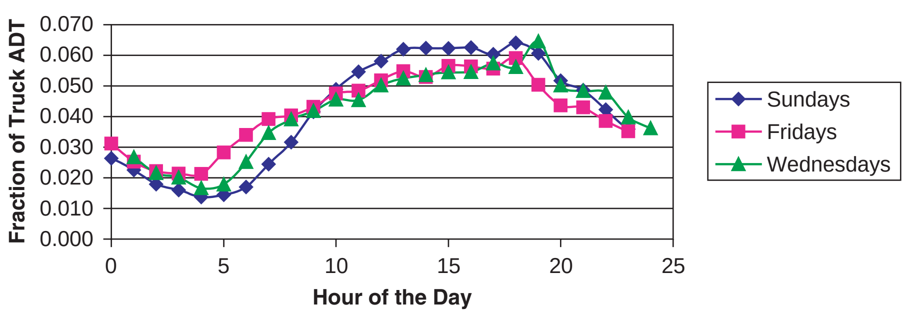

FIGURE 4 Hourly truck traffic as fraction of daily truck ADT on I-40 at Watt Road, Sundays, Wednesdays, and Fridays (20-week average).

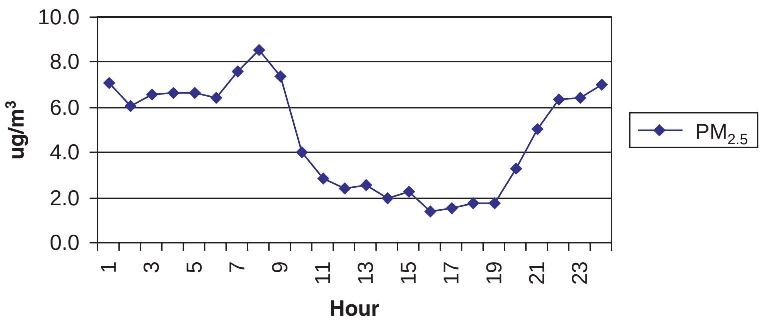

FIGURE 5 Daily profile of 1-h delta $PM_{2.5}$ concentrations (without background) at ramp site.

in the afternoon. A significant portion of the $PM_{2.5}$ concentrations shown in Figure 5 is due to background concentrations and not due to nearby emissions from trucks. The average measured concentrations at the ridgetop site were used to estimate background levels. These concentrations were subtracted from the concentrations measured at the ramp site to yield "delta $PM_{2.5}$ concentrations" as an estimate of the $PM_{2.5}$ concentrations attributable to nearby emissions from trucks on the Interstate and idling at the travel centers. The average hourly delta $PM_{2.5}$ concentrations measured at the ramp site are shown in Figure 5. Figure 5 shows peak hourly concentrations near 8 $\mu g/m^3$ from 7 to 9 a.m. when many trucks exit the travel centers. Average hourly concentrations fell to less than 2 $\mu g/m^3$ during late afternoon (4 to 7 p.m.) when truck occupancy at the travel centers was low, but truck traffic on the Interstate was high. Delta $PM_{2.5}$ concentrations show higher hourly variation than total $PM_{2.5}$ concentrations that include background.

METEOROLOGY

Wind direction patterns were complex at the study site, with different patterns observed at the two measurement sites. The ridgetop site showed winds from all directions except the southeast. The prevailing wind direction measured at the ridgetop site was from the northwest. Wind directions measured at the ramp site on the valley floor showed the wind to be channeled in a predominantly northeast/southwest alignment like the valley floor. The prevailing direction during the night was out of the northeast (more than 25% of the time). The prevailing direction during the day was out of the southwest to west. Very few winds blew from out of the southeast or the northwest (night or day) as measured at the ramp site. Wind speeds during the day tended to be higher than at night, as illustrated in the graph in Figure 6 showing average hourly wind speeds for 20 weeks during the study. In Figure 6, hourly wind speeds were multiplied by 5 so they could be plotted on the same graph showing hourly average $PM_{2.5}$ concentrations in $\mu g/m^3$. Higher wind speeds during the day provide more air to dilute air pollutants, generally causing lower concentrations during the day and higher concentrations at night. This inverse relationship between wind speed and air pollution concentration is illustrated in Figure 6, which shows the hourly average $PM_{2.5}$ concentrations and the average wind speeds observed over the 20-week study. Clearly the highest $PM_{2.5}$ concentrations occur when wind speeds are low and the lowest $PM_{2.5}$ concentrations occur when wind speeds are higher.

Also shown in Figure 6 is a curve of estimated $PM_{2.5}$ emissions in the area. $PM_{2.5}$ emissions have been multiplied by 5 so the results can be plotted using the same *y*-axis scale as used for $PM_{2.5}$ concentrations in $\mu g/m^3$. Idling trucks emit more $PM_{2.5}$ than trucks on the Interstate, especially during the night. As a result, the emission profile shows higher $PM_{2.5}$ emissions during the night than during the day, with the highest value at 6 a.m. and the lowest at 4 p.m.

To illustrate the combined effect of $PM_{2.5}$ emissions and wind speeds, the $PM_{2.5}$ emission rates were divided by the wind speed and plotted on the same graph as the average hourly $PM_{2.5}$ concentration. The results are shown in Figure 6. The graph of $PM_{2.5}$ emissions adjusted for wind speed follows a similar pattern as the observed $PM_{2.5}$ concentrations for this 20-week period. This indicates that $PM_{2.5}$ concentrations measured at the ramp site are strongly influenced by $PM_{2.5}$ emissions from diesel trucks and wind speeds. Other factors may also be significant, such as atmospheric stability and wind direction, but over a 20-week period emissions and wind speeds appear to be dominant factors influencing $PM_{2.5}$ concentrations.

EMISSION FACTORS

Hourly estimates of emissions as shown in Figure 6 were calculated using the U.S. Environmental Protection Agency (USEPA) MOBILE emission factor model. Emission estimates were developed for moving vehicles on the Interstate and idling trucks in the travel centers. USEPA has developed the MOBILE emissions model (*2*) for the purpose of estimating air pollution emission factors for cars and trucks operating on highways and streets. The model accounts for emissions as a function of vehicle type and calendar year. PM emission factors do not vary by speed in MOBILE6.2. The emission factors were calculated for the national average vehicle type and age mix for calendar year 2005. Emission factors were calculated for heavy-duty diesel trucks class HDDV8b, which is the heaviest diesel vehicle class (>60,000 lb gross vehicle weight rating) in the MOBILE model and typical of the 18-wheeler tractor-trailer trucks that were counted as "long vehicles" by the traffic counters used for this study. The $PM_{2.5}$ emission factor for HDDV8b trucks traveling on the Interstate was 0.38 g/mi. The composite $PM_{2.5}$ emission factor for all other vehicles traveling on the Interstate was 0.027 g/mi. Even though HDDV8b vehicles averaged only 22% of the vehicles on the Interstate, the $PM_{2.5}$ emissions were 80% attributable to HDDV8b trucks and 20% attributable to all other vehicles on the Interstate.

The MOBILE model does not predict idling truck emissions. USEPA has, however, published recommended emission factors for idling diesel trucks for use in developing state emission inventories

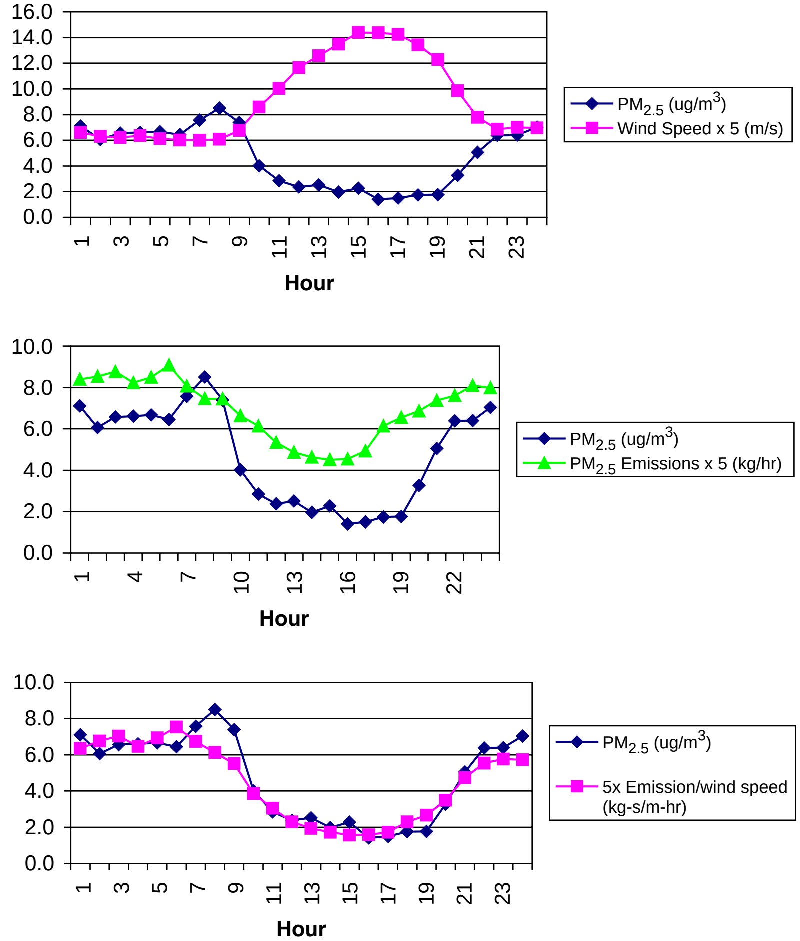

FIGURE 6 Three graphs showing delta $PM_{2.5}$ concentrations, wind speeds, emissions, and emissions divided by wind speed.

and implementation plans (*3*). The emission factor used in this study for idling trucks at the travel centers was 3.68 g/h of $PM_{2.5}$.

Interstate Emissions

Hourly traffic counts on I-40 of all vehicles and trucks (long vehicles) were used to estimate hourly emissions of $PM_{2.5}$ from the Interstate. The hourly truck count was multiplied by 0.38 g/mi to yield an hourly emission rate in grams per hour. This emission estimate applied to traffic operating over a 1.0-mi segment of I-40 (i.e., within ± 0.5 mi of the ramp site). The emissions of these pollutants were then estimated for every hour of the study when traffic data were available.

Idling Truck Emissions

Estimates of emissions from idling trucks were based on the idling truck emission factor (3.68 g/h) and counts of idling trucks by hour of the day at the Petro Travel Center. The Petro Travel Center was the largest of the three travel centers at Watt Road where diesel trucks were parked while drivers rested. The Petro Travel Center had 268 truck parking spaces, and the other two travel centers had approximately 432 truck parking spaces, for a total of 700 spaces at all three travel centers combined. Manual counts of the number of trucks parked and trucks idling at the Petro Travel Center during a previous study (*1, 4*) were used to estimate the number of idling trucks each hour of the day at all travel centers combined. The number of idling trucks at all three travel centers was estimated by multiplying the ratio of the number of parking spaces at all three travel centers (700) by the number of parking spaces at the Petro Center.

Truck parking and idling at the travel centers usually occur less on weekends than on weekdays, but detailed counts of the number of parked and idling trucks were not available during the entire study period. Truck traffic counts on I-40 also showed that truck volumes were lower on weekends than during the week. A model was developed so that hourly estimates of the number of trucks idling at the travel centers could be estimated for every hour of the study based on the Interstate truck counts that were available for the entire study. It was found that the number of idling trucks at the three travel centers could be reasonably estimated based on 40% of the truck hourly count on I-40 for the same day but with an 11-h lag time.

Using the model, the highest number of idling trucks was predicted to occur during the late nighttime period between midnight and 6 a.m., and the lowest number of idling trucks was predicted to occur between noon and 5 p.m. This prediction is consistent with observations.

Emissions of idling trucks for each hour of the study were estimated based on the number of idling trucks present during each hour times the idling emission factor.

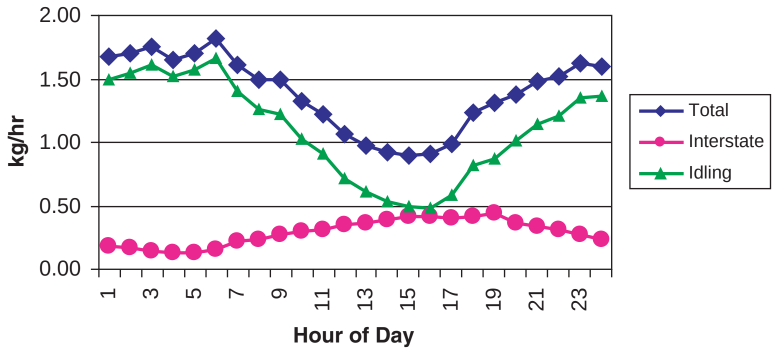

FIGURE 7 Average hourly emissions of $PM_{2.5}$ from trucks.

Emissions from Interstate Traffic Versus Idling Trucks

Emission estimates from trucks on the Interstate and idling trucks were combined to determine the trend of emissions for all sources in the study area (i.e., within 0.5 mi of the ramp site). Emissions of $PM_{2.5}$ from light-duty vehicles were not considered because their emission factors are more than 100 times lower than for heavy diesel trucks. Figure 7 illustrates the relative contribution of idling diesel trucks versus all trucks on the Interstate. The graph shows the emissions attributable to idling trucks, trucks on the Interstate, and the total emissions by hour of the day for the entire 20-week period of the study. As illustrated in Figure 7, the relative contribution of emissions from trucks on the Interstate is highest during the afternoon when these vehicles contribute nearly 50% of the $PM_{2.5}$. In contrast, idling trucks account for a large percentage of emissions at night, contributing up to 90% of $PM_{2.5}$ emissions. The average contribution over a 24-h day is 80% due to idling and 20% due to trucks on the Interstate.

SUMMARY OF AIR MONITORING RESULTS

Table 1 presents a summary of the results of 5 months of continuous air monitoring near a six-lane Interstate with approximately 100,000 vehicles per day, including 20,000 heavy-duty diesel trucks, and near three truck travel centers with 700 parking spaces, where up to 400 diesel trucks idle engines at night. The table shows the average concentrations of PM measured at the ramp and ridgetop sites for the duration of the study (typically 5 months) and for selected averaging times. Only $PM_{2.5}$ concentrations showed the potential for exceeding National Ambient Air Quality Standards (NAAQS) and then only at the ramp site located in the Interstate interchange within the highway right-of-way.

The ramp site monitoring location should represent a worst case scenario for air quality impacts for emissions from the Interstate because measurements were made within the highway right-of-way and concentrations outside the highway right-of-way should be lower due to atmospheric dispersion as distance from the road increases.

The column labeled “delta conc” in Table 1 is the difference between the concentrations measured at the ramp site and the background ridgetop site. PM concentrations measured at the background site were consistent with PM measured at other area monitoring stations where PM is attributable largely to regional sources of all types. The delta conc represents an estimate of the concentrations attributable to vehicle emissions in the near vicinity of the ramp site. This estimate is probably lower than the actual value, because the background site was not perfect and sometimes was affected by local emissions. As a result, the background concentration may be overestimated and the delta conc underestimated.

USEPA’S ANNUAL AND 24-h AVERAGE $PM_{2.5}$ NAAQS

USEPA has adopted NAAQS for $PM_{2.5}$ of 35 μg/m³ for the 24-h average and 15 μg/m³ for the annual average. The air monitoring performed during this study showed potential exceedances of both

TABLE 1 Summary of Continuous Air Monitoring Results

Pollutant	Avg Time	Ramp Site (μg/m³)	Ridgetop Site (μg/m³)	Delta Conc (μg/m³)	NAAQS (μg/m³)
$PM_{1.0}$	5 month	14.6	NA	NA	NA
$PM_{2.5}$ TEOM	5 month	17.6	12.8	4.8	15 1-yr avg
$PM_{2.5}$ TEOM	24-h max	47.6	35.3	13.0	35
$PM_{2.5}$ EBAM	5 month	16.2	NA	NA	15 1-yr avg
$PM_{2.5}$ EBAM	24-h max	49.0	NA	NA	35
PM_{10}	5 month	29.7	22.9	6.8	50 1-yr avg
PM_{10}	24-h max	99	75	24	150

TABLE 2 Highest Measured 24-h Average PM Concentrations

	Ramp $PM_{2.5}$ TEOM ($\mu g/m^3$)	Ramp $PM_{2.5}$ EBAM ($\mu g/m^3$)	Ramp $PM_{2.5}$ Average ($\mu g/m^3$)	Ridgetop $PM_{2.5}$ ($\mu g/m^3$)	Delta $PM_{2.5}$ ($\mu g/m^3$)	Ridgetop PM_{10} ($\mu g/m^3$)
Day						
April 19	36.9		36.9	30.5	6.4	39.5
May 13		35.2	35.2	28.2	7.0	40.2
May 19	36	36.9	36.5	31.9	4.6	45.4
June 22		41	41.0	34.5	6.5	49.1
June 23	47.6	48.9	48.3	35.3	13.0	50.3
June 24	41.6	39.3	40.5	29.4	11.1	41.9
June 25	43.8	43.1	43.5	32.4	11.1	46.2
June 26	38.3	41	39.7	31.2	8.5	44.4
Average			40.2	31.7	8.5	44.6

NAAQS for $PM_{2.5}$ at the ramp site. Table 2 shows the measured concentrations of $PM_{2.5}$ on 8 days during the study when $PM_{2.5}$ levels exceeded 35 $\mu g/m^3$.

Concentrations at the ramp site exceeded 35 $\mu g/m^3$ eight times over a 5-month period. This is equivalent to exceeding the proposed NAAQS 5% of the time. The NAAQS allows 24-h concentrations to be exceeded no more than 2% of the time. $PM_{2.5}$ levels measured at this site are likely to exceed both the annual and the 24-h average NAAQS. This indicates that idling truck facilities like the ones near the ramp site are potential hot spots with respect to both the annual and the 24-h average NAAQS for $PM_{2.5}$.

CONCLUSIONS

Most of the $PM_{2.5}$ concentrations measured during this study were attributable to idling emissions from diesel trucks in the travel centers. Based on estimates of vehicle emissions within ±0.5 mi of the monitoring site, 80% of the $PM_{2.5}$ concentrations measured were attributable to idling trucks, while 20% of the $PM_{2.5}$ concentrations were attributable to vehicle emissions on the Interstate.

With respect to $PM_{2.5}$ air quality hot spots, planners should be more concerned about the impact of large travel centers with hundreds of idling diesel trucks, rather than emissions of diesel trucks traveling free-flowing Interstates. In this study, the average $PM_{2.5}$ concentration at the ramp site attributable to idling trucks was 3.8 $\mu g/m^3$, whereas the concentration attributable to exhaust emissions from vehicles on the Interstate was only 1.0 $\mu g/m^3$. This result is based on a delta $PM_{2.5}$ of 4.8 $\mu g/m^3$ with 80% of emissions from idling trucks and 20% from vehicles on the Interstate, as illustrated in Figure 7. These estimates are based on 5 months of data but should reasonably approximate an annual mean for comparison with the NAAQS. (Traffic incidents or congestion due to construction might cause a short-term PM problem.)

Other interesting results are shown in Table 1. $PM_{1.0}$ concentrations at the ramp site averaged 14.6 $\mu g/m^3$, whereas $PM_{2.5}$ averaged 17.6 $\mu g/m^3$. This indicates that particles less than 1.0-µm diameter make up 83% of the measured $PM_{2.5}$. This is consistent with the knowledge that diesel exhaust emissions are very small particles and much, if not all, of the $PM_{2.5}$ measured at the ramp site was the result of diesel exhaust emissions. PM_{10} concentrations measured at the ramp site averaged 29.7 $\mu g/m^3$, which was 6.8 $\mu g/m^3$ higher than measured at the ridgetop site. This indicates that vehicle emissions contributed at least 6.8 $\mu g/m^3$ to average PM_{10} levels at the ramp site. Five-month average PM_{10} concentrations were 70% and 80% higher than $PM_{2.5}$ concentrations measured at the ramp and ridgetop sites, respectively. In both cases, the PM_{10} concentrations were well below NAAQS and should not be a significant hot spot problem.

The results of this study are consistent with other studies (*4–8*) and support the theory that diesel truck idling at travel centers represents a potential hot spot for $PM_{2.5}$ air pollution concentrations. Hot spots are not well defined, but generally are thought to be localized areas in which air pollution levels are significantly elevated above background concentrations. The California Air Resources Board (CARB) has identified truck idling as a cause of hot spots, stating "Idling emissions are particularly significant at idling 'hotspots' such as truck stops, travel centers, and rest areas where truck drivers stop to rest for long hours" (*5*).

The lateral extent of these hot spots depends on the magnitude of the emissions occurring within a small area and meteorological conditions. Large numbers of idling diesel trucks, parked closely together at a travel center, can create an emission source capable of significantly elevating ambient $PM_{2.5}$ concentrations above background over a distance of at least 2,000 ft. In this study, the ramp site monitoring station was located between 1,000 and 2,000 ft of 400 or more idling trucks at three travel centers. The $PM_{2.5}$ concentrations measured were significantly above background concentrations by an average of 4.8 $\mu g/m^3$ (5-month average), and up to 13.0 $\mu g/m^3$ for a 24-h average period.

In a previous study (*1*), dispersion modeling of idling truck emissions was performed at the same site. Figure 8 shows the results of dispersion modeling of annual average $PM_{2.5}$ concentrations resulting from emissions of idling trucks at the travel centers and emissions from moving trucks on I-40. Concentration isopleths shown in the figure do not include background concentrations. Maximum concentrations greater than 12 $\mu g/m^3$ were predicted to occur near the two travel centers south of the Interstate. Predicted concentrations decreased with distance from the travel centers, dropping to 1.0 $\mu g/m^3$ at 2,000 ft west of the two travel centers. The annual concentration predicted at the location of the ramp site (shown as a dot) was 3.2 $\mu g/m^3$, compared with a 5-month average measured concentration of 4.8 $\mu g/m^3$ (excluding background). The predicted concentrations were about 65% of measured concentrations without background.

The monitoring results and the modeling results both support a conclusion that diesel truck idling emissions may cause elevated ambient concentrations of $PM_{2.5}$ to distances of approximately

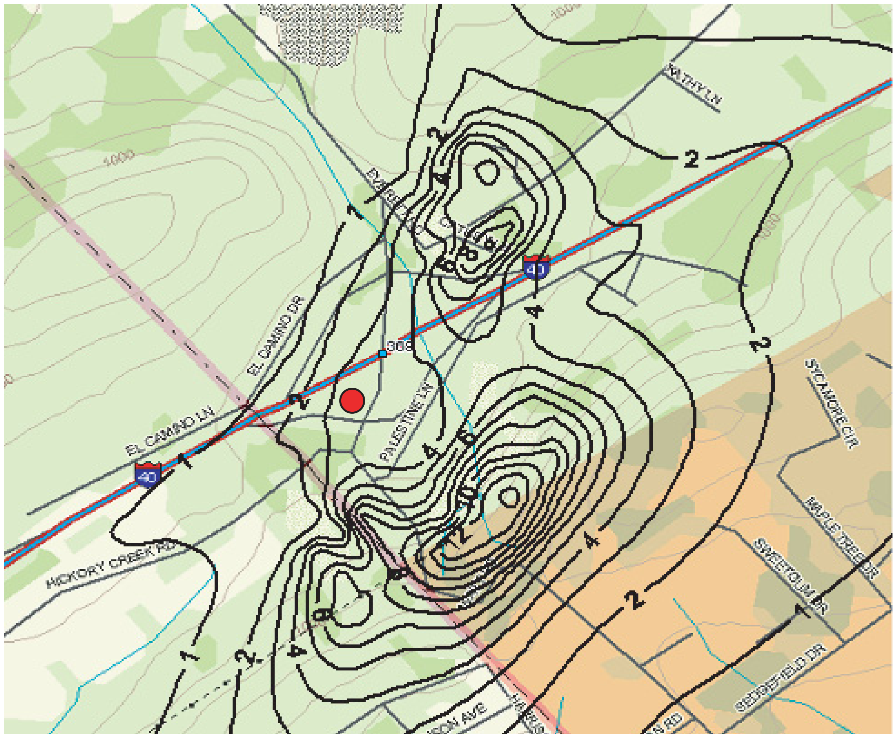

FIGURE 8 Isopleths of predicted $PM_{2.5}$ annual concentrations ($\mu g/m^3$).

2,000 ft from the travel centers. This may be used as a first-order approximation of the lateral extent of the potential hot spot. The significance of hot spots at other locations will depend on the number of idling trucks, the size and shape of the parking area, meteorological conditions, and the level of background concentrations occurring at the site. In areas where background concentrations are high compared with the NAAQS, even small increases in ambient concentrations from idling trucks may be significant.

RESEARCH NEEDS

Research is needed to better define the attributes of projects with sufficient emissions to create potential hot spots needing project-level air quality analyses identifying the pollutants to consider, the distance near the project to be analyzed, and the meteorological conditions and averaging times that are important. Other factors that may be important include the extent of buffer zones separating travel centers from highways and neighboring receptors, the influence of noise barriers and trees in diluting and mixing air pollutants, and how different sizes and configurations of travel centers, truck stops, port areas, border crossing, and weigh stations influence the magnitude and extent of potential air quality hot spots near transportation facilities.

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