Projet d'amélioration du réseau routier à Vaudreuil-Dorion
Suite du mémoire
John Burcombe

ANNEXE F

Qualité de l'air, relais routier Flying J

En commençant par la demande d'audience, j'ai critiqué l'analyse du consultant[1] ainsi: « *... je questionne la méthodologie du consultant, qui ne semble pas prendre en compte le grand nombre de camions lourds qui y sont stationnés chaque nuit avec leurs moteurs en marche au ralenti pendant que les conducteurs dorment dans leurs cabines. De plus, entre autres, le consultant doit justifier ses hypothèses de taux d'émission de polluants.* » (CR-3, pdf p. 4)

Lors de la première partie des audiences (30 mai 2997) j'ai interpellé M. Hammouche d'Enviromet Internationale, le consultant spécialisé dans la qualité de l'air (DT-1, pdf p. 121 et+).

Question:

> **M. JOHN BURCOMBE :**
> ... Est-ce que le modèle prend en compte le fait qu'il y a des véhicules avec leur moteur en marche au ralenti? (ligne 5090)

Réponse:

> **M. RABAH HAMMOUCHE :** Non. Moi, je n'ai pas considéré les véhicules qui tournent pendant toute la nuit. Parce que techniquement, dans le modèle, il n'est pas possible de le faire. (ligne 5155)

et plus loin:

> ... C'est sûr que la méthodologie n'est pas exactement l'idéal qu'on aurait pu avoir, mais il n'y a pas de modèle qui permet de modéliser de façon très objective et de façon réaliste la problématique du Flying J. (ligne 5225)

Le consultant concluait ainsi:

> **M. RABAH HAMMOUCHE :**
> ... <u>C'est sûr et certain qu'il n'y a aucun modèle qui permet de reproduire la réalité. La seule chose qu'il y a, la véritable réalité, c'est la mesure.</u>
>
> Je veux juste rappeler, si je peux me permettre, la Ville de Vaudreuil-Dorion, bien avant le mandat, nous a demandé de voir les possibilités d'implanter une station d'échantillonnage non loin du Flying J et puis le projet n'a pas abouti pour une raison que j'ignore. (ligne 5320)
> (mon soulignement)

Par la suite, la Commission questionne ainsi le MDDEP: « *Selon vous, est-ce que les résultats de cette étude* [sur la qualité de l'air]*, et compte tenu des hypothèses avancées au regard du site Flying J (véhicules stationnaires dont le moteur tourne pendant plusieurs heures, longueur des bretelles d'accès de A-540), pourraient affecter la validité du modèle ou des résultats ?* »

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[1] *Addenda à l'étude sectoriel sur la qualité de l'air*, PR-5.1, Annexe 6.

En réponse, le MDDEP déclare que:
« [le modèle] *CALINE4 a fait l'objet, au fil des années, de plusieurs vérifications ou comparaisons avec des données réelles de terrain.* » (DQ-2.1, pdf p. 2)

Commentaire:
Le ministère ne donne pas d'exemples en référence pour l'utilisation particulière visant un relais routier.

Le MDDEP admet que:
« *Les émissions provenant de la marche au ralenti des véhicules lourds stationnés pendant une longue période de temps n'ont pas été spécifiquement calculées.* »
et prétend que:
« *... selon l'analyse effectuée par les spécialistes du MDDEP, il n'est pas possible, avec les données fournies par l'initiateur et les informations disponibles dans la littérature, de quantifier les émissions qui pourraient s'ajouter avec la contribution des véhicules dont le moteur tourne au ralenti.* »

Commentaire:
On verra plus loin qu'il existe des données sur les taux d'émission pour la marche au ralenti et des exemples du calcul de l'effet des relais routiers sur la qualité de l'air environnante.

La Commission demande de plus:
« *Est-ce que l'implantation d'une station de mesure de la qualité de l'air à Vaudreuil-Dorion serait une valeur ajoutée au réseau de stations existant ?* »

En réponse, le MDDEP indique que:
« *Les stations déjà en place permettent de brosser un portrait régional relativement fiable de la qualité de l'air. L'implantation d'une station additionnelle à Vaudreuil-Dorion apporterait sans doute une information supplémentaire au niveau local sans toutefois modifier nos connaissances du portrait régional de la qualité de l'air* » (pdf pp. 3 et 4)

Commentaire:
Le but premier d'un station de mesure à Vaudreuil-Dorion serait de caractérisé un éventuel « point chaud » ("hot spot") pour les particules fins nuisibles à la santé. Subsidiairement, il y aurait des données supplémentaires pour le réseau de stations existantes. Le cas du Flying J donne l'opportunité de quantifié les effets d'une concentration de moteurs diesel en marche au ralenti sur la qualité de l'air locale, en particulier à une école primaire à une demi kilomètre de la source des émanations. Tel que prononcé par le consultant (plus haut) et étayé plus tard dans ces commentaires, la mesure sur place prime sur toute modélisation.

Connaissant que la marche au ralenti est une préoccupation aux États-Unis, la recherche sur Internet trouvait une étude très pertinente: *Diesel Truck Idling Emissions – Measurements at a PM2.5 Hot Spot* (voir Référence 1 extraits, ci-joints).

La zone d'étude (Réf 1, photo aérienne) est à l'intersection d'une autoroute de trois voies dans chaque direction (I-40) et une route local qui abrite trois relais routiers ("truck stops") près de

Knoxville dans l'État de Tennessee. Deux stations de mesure étaient installés, le "*Ramp Site*" dans les bretelles de l'autoroute et la "*Ridgetop Site*", pour mesurer les niveaux de fond, sur une colline de 100m situé à 1,1 km du *Ramp Site.* La mesure en continue de matière particulaire, notamment PM2,5, et les conditions météorologiques, était réalisée sur 20 semaines de janvier à juin 2005.

Le débit journalier moyen (DJM) (Average Daily Traffic, ADT) mesuré sur l'autoroute était de 95 000 véhicules par jour, dont 17 360 (19,2%) de camions lourds (tracteur-remorque). Au total il avait environ 700 places de stationnement disponibles pour camions et au maximum il y avait 400 camions avec leurs moteurs en marche au ralenti la nuit.

Les chiffres comparables pour l'intersection de l'autoroute A-540 et le boulevard Cité-des-Jeunes à Vaudreuil-Dorion sont de 40 000 véhicules par jour (en 2004) dont 19% (7 600) de camions (PR-3.1, ch2, Tab6, pdf p. 17), 140 places de stationnement (au Flying J), un maximum de 80 moteurs en marche au ralenti et un DJM de camions du Flying J d'environ 2 200 camions par jour (PR-5.1, Ann6, Ann1, pdf pp. 2, 3 et 5).

En sus des mesures, les émissions de PM2,5 contribuées par la circulation sur 1,6 km de l'autoroute I-40 et par la marche au ralenti aux relais routiers étaient calculées.

Ce qui ressorte des résultats est l'effet prédominant des émissions de PM2,5 provenant de la marche au ralenti par rapport aux émissions provenant de l'autoroute (Réf 1, Figure 13) et leur effet mesurable sur la concentration de ces particules dans l'air du voisinage.

Il y avait des bonnes corrélations entre la concentration dans l'air (microgrammes par mètre cube, µg/m³) et le nombre de moteurs en marche au ralenti et la vitesse du vent (Réf 1, Figure 11).

La conclusion de l'étude était que le niveau moyen de PM2,5 était en hausse de 4,8 µg/m³ dans les environs de l'intersection et que 80% de cette augmentation était imputable à la marche au ralenti. Sur une période de 24 heures l'augmentation maximale de PM2,5 était de 13 µg/m³.

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Préalable à cette programme de mesure, il y avait une étude dans le cadre d'une thèse de doctorat, pour le même site, axée sur la modélisation de la dispersion d'émissions intitulé *Effects of Heavy-Duty Diesel Vehicle Idling Emissions on Ambient Air Quality at a Truck Travel Center and Air Quality Benefits Associated with Advanced Truck Stop Electrification Technology*[2] (voir Référence 2, extraits ci-joints).

Dans ce cas il y avait deux stations de mesure de NOx et PM2,5 à l'intérieur du plus grand relais routier (Réf 2, photo aérienne) opérées de décembre 2003 à août 2004.

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[2] Une version abrégée sous le titre *Effects of Heavy-Duty Diesel Vehicle Idling Emissions on Ambient Air Quality at a Truck Stop – Measurements and Modeling of NOx and PM2.5 Concentrations,* était présenté à la conférence annuelle 2005 de l'Air & Waste Management Association (AWMA).
Auteurs, Guenet T. Indale, Terry L. Miller and Wayne T. Davis; University of Tennessee, Knoxville.
Référence: http://secure.awma.org/OnlineLibrary/ProductDetails.aspx?productID=7378

Bien que le modèle CALINE est mentionné c'est plutôt le modèle ISCST3 (Industrial Source Complex Short Term (model)) qui était choisi pour prédire la dispersion des polluants dans l'aire d'étude (Réf. 2, Fig 3.9 et Fig 3.10). Le model était adapté afin de représenter les sources linéaires comme des sources volumétriques. Le model semble être assez compliqué et exigeant en termes d'intrants, y inclus des données météorologiques.

La performance du modèle par rapport aux mesures était plutôt médiocre, tel que montré dans les figures 4.39 et 4.40 de Référence 2 où un rapport idéal de 1 à 1 est représenté par la ligne mauve.

À noter que les deux références contient un chiffre pour les émissions de camions lourds en marche au ralenti de PM2,5 (= 3,68 g/heure), une lacune citée par le MDDEP.

À la lumière de Référence 2 et en apprenant plus sur le modèle CALINE4 (voir *Certains éléments de CALINE4* en annexe), je crois que la modélisation de ce dernier pour les aires de stationnement pourrait être adaptée facilement afin de prendre en compte la marche au ralenti.

En effet, cette adaptation devrait être plus facile que celle pour les démarrages puisque les émissions de la marche au ralenti ne varient pas dans le temps. En utilisant les 10 maillons ("links") à l'ouest du stationnement du Flying J dans la Figure 4.3 de PR-5.1, Annexe 6, soit l'aire réservée pour les camions lourds, on devrait être en mesure d'assigner à ces maillons un nombre de véhicules par heure, une vitesse virtuelle et un facteur d'émission équivalent afin de représenter les émissions de la marche au ralenti d'un certain nombre de camions lourds. C'est le défi que je lance aux experts de la qualité de l'air.

Cependant, même si on peut ainsi améliorer la modélisation, il faut toujours talonner les résultats par une année de mesures prises au stationnement même, ou à côté. En sus, notamment, des PM2,5, la station de mesure doit enregistrer les conditions météorologiques afférentes. Cette station s'ajouterait à celle déjà recommandée pour l'école Vision, qui pourrait être moins sophistiqué peut-être.

Le but de la modélisation et les mesures sont de quantifier un problème qui est bien évident: la marche au ralenti est nuisible[3] et représente une gaspillage de carburant.

Pour le cas particulier d'un aire de repos pour camionneurs, il existe des solutions de rechange tel que discutés dans le document DC-20, *A Municipal Official's Guide to Diesel Idling Reduction*. Déjà la marche au ralenti est interdite à l'État voisine de New-York, donc pourquoi pas au Québec aussi?

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[3] Voir *L'impact des contaminants provenant du transport* dans: ***Le transport urbaine, une question de santé***, Rapport annuel 2006 sur la santé de la population montréalaise (pdf p. 25) http://www.santepub-mtl.qc.ca/Publication/rapportannuel/2006/rapportannuel2006.pdf

Le DC-20 contient en annexe (pf p. 27) un règlement type sur les conditions à imposer sur les stationnements de camions lourds (Model Local Diesel Idle Reduction Ordinance).

Étant donné la concentration de compagnies impliquées dans le transport lourd sur le territoire de Vaudreuil-Dorion, la Ville devrait adopter un règlement limitant la marche au ralenti en attendant d'action au sein des paliers supérieurs du gouvernement.

Quant à l'action par le MDDEP, il se félicite sur l'implantation du *Programme d'inspection et d'entretien* [aléatoire] *des véhicules automobiles lourds,* qui vise à réduire la fumée noir provenant des moteurs à diesel mal entretenus et indique qu'il a l'intention de:

- *Poursuivre la réflexion sur l'implantation d'un programme d'inspection et d'entretien des véhicules légers.*
- *Poursuivre l'implantation d'autres mesures dans les secteurs du transport, de l'énergie et des changements climatiques.*[4]

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[4] *Les standards pancanadiens relatifs aux particules et à l'ozone* : Rapport quinquennal (2001-2005) du Québec http://www.mddep.gouv.qc.ca/air/particules_ozone/rapport_quin.pdf

Référence 1 (extraits en annexe p. 7)
Diesel Truck Idling Emissions – Measurements at a PM2.5 Hot Spot
Terry Miller, Josh Fu and Boris Hromis, University of Tennessee;
John Storey and James Parks, Oak Ridge National Laboratory.
in TRB (Transportation Research Board) 2007 Annual Meeting CD-ROM

Référence 2 (extraits en annexe p. 18)
Effects of Heavy-Duty Diesel Vehicle Idling Emissions on Ambient Air Quality at a Truck Travel Center and Air Quality Benefits Associated with Advanced Truck Stop Electrification Technology
Guenet T. Indale
PhD Dissertation, University of Tennessee, Knoxville
http://idserver.utk.edu/?id=200500000000939

Certains éléments de CALINE4 (p.28)

Référence 1

DIESEL TRUCK IDLING EMISSIONS - MEASUREMENTS AT A $PM_{2.5}$ HOT SPOT

(pdf p. 3)

Authors: Terry Miller, Josh Fu and Boris Hromis, University of Tennessee;
John Storey and James Parks, Oak Ridge National Laboratory.

(published in TRB (Transportation Research Board) 2007 Annual Meeting CD-ROM)

ABSTRACT

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 there are 20,000 heavy-duty trucks per day traveling the interstate. In addition, there are 3 large truck stops at this interchange where as many as 400 trucks idle engines at night. As a result, high levels of $PM_{2.5}$ were measured near the interchange often exceeding National Ambient Air Quality Standards [NAAQS]. This paper presents the results of the air monitoring study illustrating the hourly, day-of-week, and seasonal patterns of $PM_{2.5}$ resulting from diesel truck emissions on the interstate and at the truck stops. Surprisingly, most of the $PM_{2.5}$ concentrations 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 also contribute significantly to 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 are similar to the findings of other studies (1-8).

INTRODUCTION

Ambient monitors were installed at two locations to continuously measure ambient concentrations 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 feet south of the eastbound interstate shoulder and 100 feet 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 feet 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 3300 feet apart.

(pdf p. 4)

Figure 1. Site map at I-40 and Watt Road showing locations of monitoring sites, the interstate and nearby truck travel centers. Scale: Monitoring sites are 3300 ft apart.

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-degree temperature for stable operation of the instrumentation. Air samples were drawn from sampling probes on the trailer roofs at a height of 4 meters 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 TEOMs (Tapered Element Oscillating Microbalance) at the Ramp Site. PM_{10} and $PM_{2.5}$ were also measured using E-BAM beta gage instruments at the Ramp Site. PM_{10} was measured using an E-BAM beta gage instruments at the Ridgetop Site, while $PM_{2.5}$ was measured using a TEOM. Each site was also equipped with continuously monitoring meteorological packages measuring one-hour 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-meter high towers at each site. All data were recorded on digital data loggers and downloaded to PCs in a standard spreadsheet format.

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pdf p. 5

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 percent of tractortrailer 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 RTMS [Remote Traffic Microwave Sensor] automatic traffic counters. EIS (ElectronicIntegrated Systems, Inc of Toronto Canada) RTMSTM vehicle detection sensors were utilized to measure hourly vehicle counts, long truck counts, and vehicle average speeds on the I-40. The RTMS provides 5-minute counts of total vehicles, average vehicle speeds and long truck counts 24 hours per day for each of 6 traffic lanes (3 eastbound and 3 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 using the RTMS units covering the period from 2/7/05 to 6/30/05. Traffic volume, truck volume and vehicle speeds were monitored every hour for the 20-week period.

The average vehicle count was 90,498 vehicles per day on I-40 just east of Watt Rd. The average daily long truck count was 17,361 trucks/day. The average percentage of trucks of all vehicles was 19.2%. While 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. January 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 very short periods. This section of interstate has 6 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.

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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 3 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. Figure 6 shows the results of 8-days of idling truck counts performed during December 2004. As shown in Figure 6, the highest number of idling trucks was 150 to 200 observed during the late night hours from 10 pm to 7 am. During the day, most truck drivers leave the site reducing the number of idling vehicles to less 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, there are often more than 400 trucks idling at the three travel centers. This value will drop to 100 or less during midday.

PARTICULATE MATTER AIR MONITORING RESULTS

The results of PM monitoring are illustrated in the four graphs shown in Figures 7 - 10. Figure 7 shows the seasonal variability of results over the 20-week study. The most complete data set for the 20-weeks was the PM_{10} results. Shown in Figure 7 are the hourly and 24-hour average PM_{10} concentrations measured at the RAMP Site. Lots of variability was observed in the 1-hour average concentrations ranging from near zero to more than 150 ug/m3 (micrograms per cubic meter). While some of the highest concentrations were measured during winter (February) and summer (June) months, there was no clearly identifiable seasonal trend in PM_{10} concentrations.

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Figure 9 shows the daily trend of hourly $PM_{2.5}$ concentrations measured for the entire 20-week period. The highest concentrations were measured at night, while the lowest concentrations were measured in the afternoon. This is consistent with the higher PM emissions from idling trucks at night compared to the lower idling truck emissions during the afternoon. A significant portion of the $PM_{2.5}$ concentrations shown in Figure 9 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 10. Figure 10 shows peak hourly concentrations near 8 ug/m3 from 7-9 am when many trucks exit the travel centers. Average hourly concentrations fell to less than 2 ug/m3 during late afternoon (4 – 7 pm) 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.

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Wind speeds during the day tended to be higher than at
night as illustrated in the graph in Figure 11 showing average hourly wind speeds for 20 weeks during the study. In Figure 11 hourly wind speeds have been multiplied times 5 so it could be plotted on the same graph showing hourly average $PM_{2.5}$ concentrations in ug/m3. 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 11 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.

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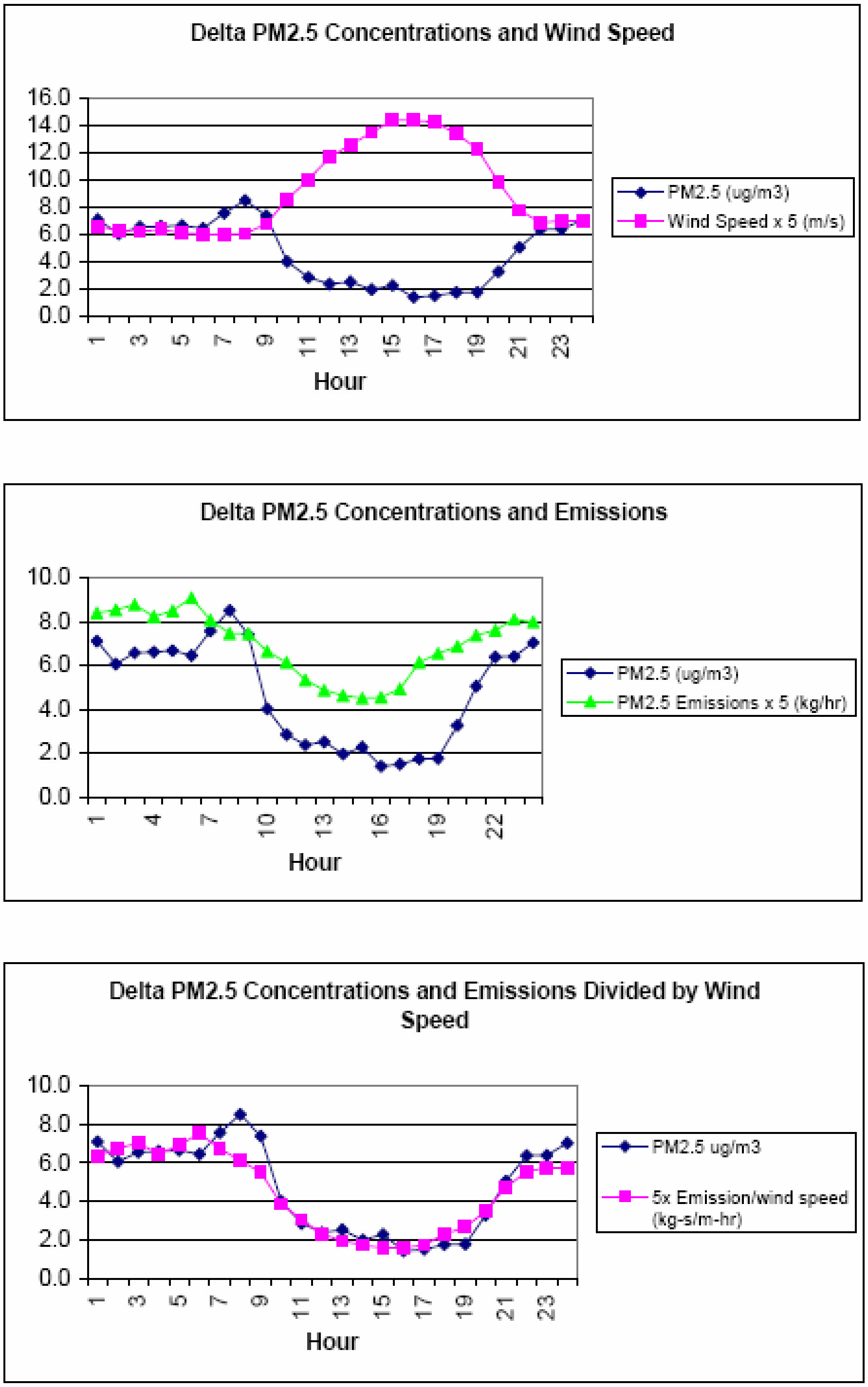

Figure 11. Three graphs showing Delta PM$_{2.5}$ Concentrations, Wind Speeds, Emissions and Emissions Divided by Wind Speed.

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Also shown in Figure 11 is a curve of estimated $PM_{2.5}$ emissions in the area. $PM_{2.5}$ emissions have been multiplied times 5 so the results can be plotted using the same y-axis scale as used for $PM_{2.5}$ concentrations in ug/m3. 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 am and the lowest at 4 pm.

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 11. The graph of $PM_{2.5}$ emissions adjusted for wind speed follows a very 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 11 were calculated using the 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 lbs 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 HHDV8b trucks traveling on the interstate was 0.38 g/mile. The composite $PM_{2.5}$ emission factor for all other vehicles traveling on the interstate was 0.027 g/mile. 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 and Implementation Plans (3). The emission factor used in this study for idling trucks at the travel centers was 3.68 grams/hour 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 times 0.38 g/mile to yield an hourly emission rate in grams/hour. This emission estimate applied to traffic operating over a 1.0-mile segment of I-40 (i.e. within

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± 0.5 miles 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/hour) 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 Rd 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) were used to estimate the number of idling trucks each hour of the day at all travel centers combined. On weekdays, truck use at the Petro Travel Center was the highest. All available spaces were usually in use by midnight each night and continued to be used until 6 am when trucks began to leave. The number of idling trucks at night was often 2/3 of the total with up to 180 idling trucks per night (See Figure 6). Trucks continued to leave the travel center during the morning up until about noon when the number of idling trucks was typically 50 or less. By late afternoon the number of trucks parked at the Petro Travel Center would usually begin to increase for the rest of the day and early evening until the site was full of trucks again at midnight. 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) to the number of parking spaces at the Petro Center. On Wednesday nights, following the highest truck travel day, the total number of idling trucks at all three travel centers was estimated at 468.

Truck parking and idling at the travel centers are usually 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 less 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-hour lag time. Figure 12 shows the results of this model compared to the estimated number of idling trucks based on manual counts at the Petro Travel Center adjusted for the additional parking spaces at the two other travel centers. The 11-hour lag time was selected by “trial and error” after trying other lag times. The 11-hour lag time fit the observed truck counts fairly closely as can be seen in the Figure 12.

Using the model, the highest number of idling trucks was predicted to occur during the late night-time period between midnight and 6 am, and the lowest number of idling trucks were predicted to occur between noon and 5 pm. This is consistent with observations.

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Emissions of idling trucks for each hour of the study was estimated based on the number of idling trucks occurring each hour times the idling emission factor.

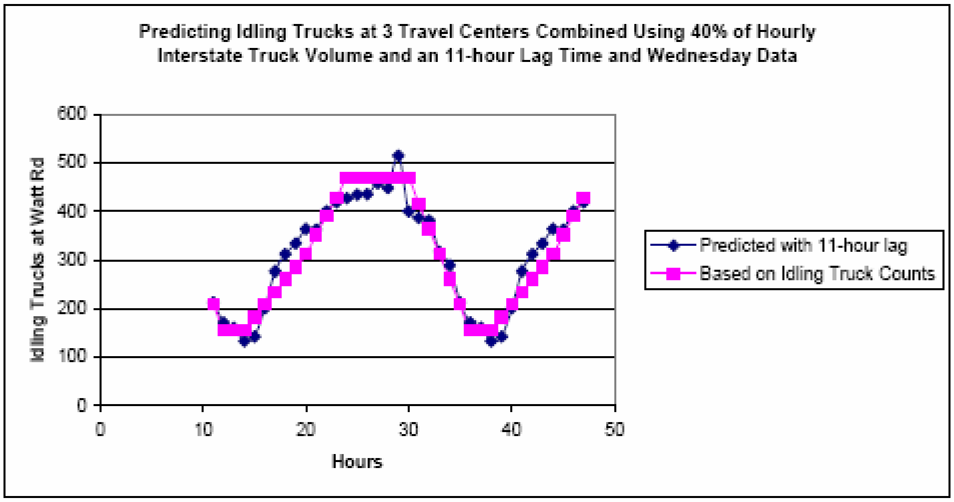

Figure 12. Predicted Hourly Idling Trucks Compared to Counted Values.

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 miles of the Ramp Monitoring 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 13 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 13, the relative contribution of emissions from trucks on the interstate are 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-hour day is 80% due to idling and 20% due to trucks on the interstate.

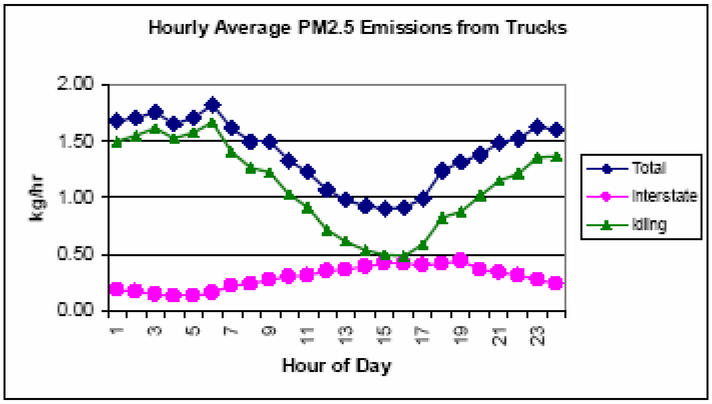

Figure 13. Average Hourly Emissions of $PM_{2.5}$ from Trucks

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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 Ridge-top 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 NAAQS (National Ambient Air Quality Standards) and then only at the Ramp Site located in the interstate interchange within the highway right-of-way.

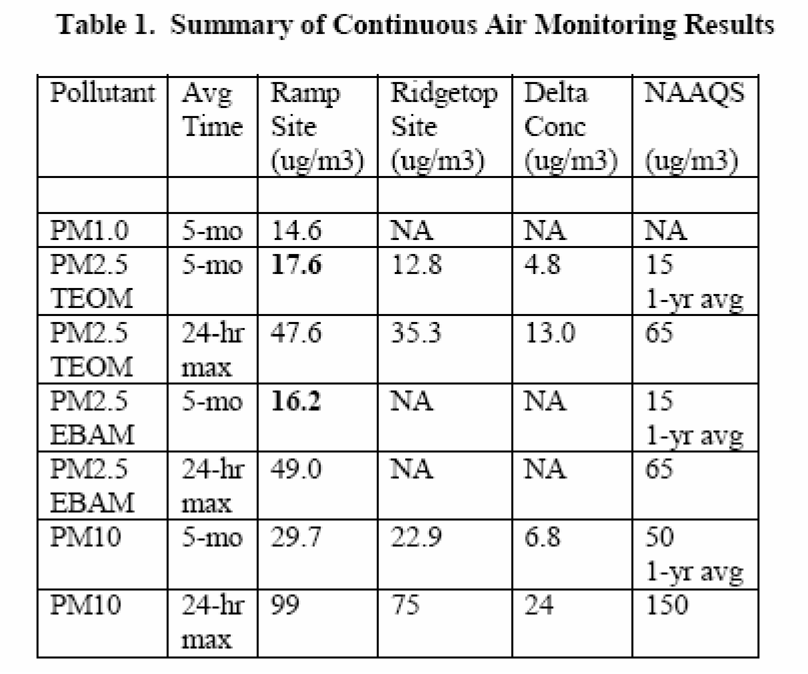

Table 1. Summary of Continuous Air Monitoring Results

Pollutant	Avg Time	Ramp Site (ug/m3)	Ridgetop Site (ug/m3)	Delta Conc (ug/m3)	NAAQS (ug/m3)
PM1.0	5-mo	14.6	NA	NA	NA
PM2.5 TEOM	5-mo	**17.6**	12.8	4.8	15 1-yr avg
PM2.5 TEOM	24-hr max	47.6	35.3	13.0	65
PM2.5 EBAM	5-mo	**16.2**	NA	NA	15 1-yr avg
PM2.5 EBAM	24-hr max	49.0	NA	NA	65
PM10	5-mo	29.7	22.9	6.8	50 1-yr avg
PM10	24-hr max	99	75	24	150

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, in that the background site was not perfect and sometimes was impacted by local emissions. As a result the background concentration may be overestimated and the “Delta Conc” underestimated. The “Delta Conc” values are all below the NAAQS.

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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 miles of the monitoring site, 80% of the $PM_{2.5}$ concentrations

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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" the greater concern should be 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 ug/m3, while the concentration attributable to exhaust emissions from vehicles on the interstate was only 1.0 ug/m3. This is based on a Delta $PM_{2.5}$ of 4.8 with 80% of emissions from idling trucks and 20% from vehicles on the interstate as illustrated in Figure 13. These estimates are based on 5 months of data, but should reasonably approximate an annual mean for comparison to the NAAQS. (Note: Traffic incidents and/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 ug/m3, while $PM_{2.5}$ averaged 17.6 ug/m3. This indicates that particles less than 1.0-micrometer 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 due to diesel exhaust emissions. PM_{10} concentrations measured at the Ramp Site averaged 29.7 ug/m3 which was 6.8 ug/m3 higher than measured at the Ridgetop Site. This indicates that vehicle emissions contributed at least 6.8 ug/m3 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 Ridge-top 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 support the theory that diesel truck idling at travel centers represents a potential "hotspot" for $PM_{2.5}$ air pollution concentrations. Hotspots are not well defined, but are generally thought to be localized areas where air pollution levels are significantly elevated above background concentrations. The California Air Resources Board (CARB) has identified truck idling as a cause of "hotspots" 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 "hotspots" 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 2000 feet. In this study, the Ramp monitoring station was located between 1000 to 2000 feet 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 ug/m3 (5-month average), and up to 13.0 ug/m3 for a 24-hour average period.

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In a previous study (1), dispersion modeling of idling truck emissions was performed at the same site. Figure 14 shows the results 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. Concentrations isopleths shown in the figure do not include background concentrations. Maximum concentrations greater than 12 ug/m3 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 ug/m3, 2000 ft west of the two travel centers. The annual concentration predicted at the location of the Ramp monitoring site (shown as a red dot) was 3.2 ug/m3, compared to a 5-month average measured concentration of 4.8 ug/m3 (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 2000 ft [600m] from the travel centers. This may be used as a first order approximation of the lateral extent of the potential "hotspot". The significance of "hotspots" 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 to the NAAQS, even small increases in ambient concentrations from idling trucks may be significant.

Référence 2

Effects of Heavy-Duty Diesel Vehicle Idling Emissions on Ambient Air Quality at a Truck Travel Center and Air Quality Benefits Associated with Advanced Truck Stop Electrification Technology
Guenet T. Indale
PhD Dissertation, University of Tennessee, Knoxville
http://idserver.utk.edu/?id=200500000000939

Extraits

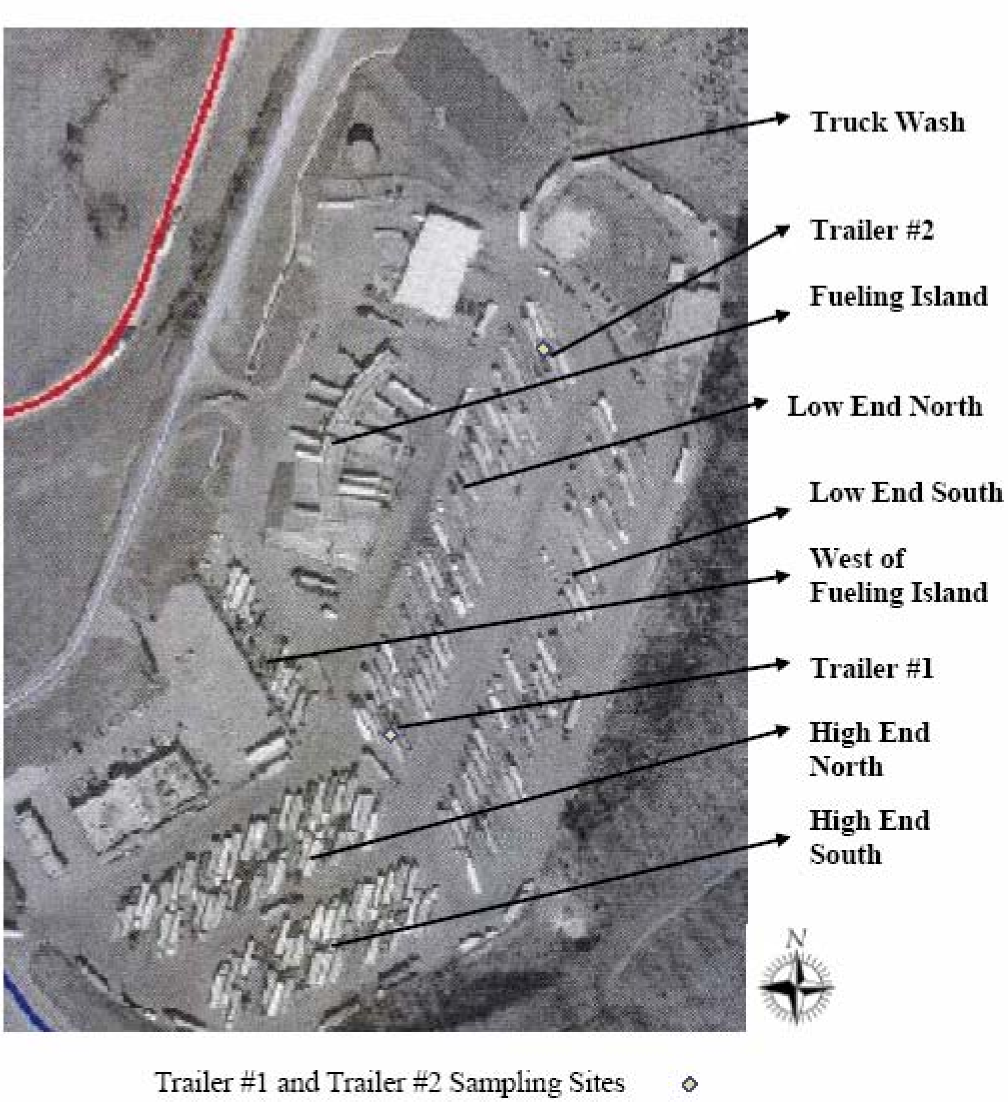

Figure 3.1 Aerial Photo of Petro Truck Stop with the Assigned Names of Different Sections of The Truck Stop and Locations of Sampling Trailers.

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3.4 Modeling

Line source models such as CALINE are air dispersion models for predicting air quality impacts of pollutants near roadways at the micro-scale. Such models estimate total air pollutant concentrations based on the Gaussian diffusion equation and employ a mixing zone concept to characterize pollutant dispersion over the roadway. On the other hand, the ISCST3 model uses dispersion coefficients in the horizontal and vertical directions and predicts concentrations around point, area, volume or open pit sources using emission rates and meteorological conditions as model input. The ISCST3 EPA approved model was used to predict ambient $PM_{2.5}$ and NOx concentrations at the sampling sites. The predicted values were then compared to actual measured concentrations. The volume source option was used to simulate emission from idling trucks and other highway sources. The source information includes source location and source emission rate while temperature, wind speed, wind direction, mixing heights and stability classes are included in meteorological information. The ISC Short Term model accepts hourly meteorological data records to define the conditions for plume rise, transport, diffusion, and deposition. The model estimates the concentration for each source and receptor combination for each hour of input meteorology, and calculates user-selected short-term averages.

The meteorological file developed from the met data collected at Watt Road Station was used to run the model. The meteorological station measures wind speed, wind direction, ambient temperature, rainfall, barometric pressure, standard deviation of wind direction and solar radiation. Wind speed, wind direction ambient temperature and standard deviation of wind direction were used for developing a meteorological file needed for running the dispersion computer model. Standard deviation of wind direction and wind speed from the met station were used to estimate atmospheric stability class as needed by a dispersion model using a Sigma Theta (σ_A) method following EPA's " Meteorological Monitoring Guidance for Regulatory Modeling Applications". This method is a turbulence-based method which uses the standard deviation of wind direction in combination with the scalar mean wind speed and time of the day (day or night) to

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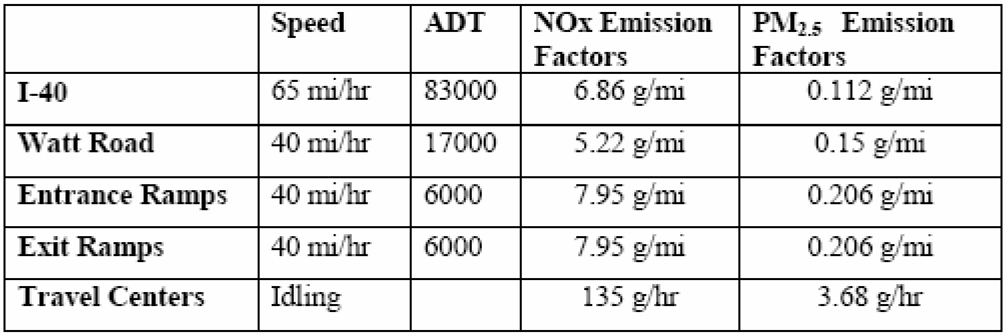
determine stability classes.(EPA, 2000). Appendix A-4 and A-5 show tables used for the prediction of stability classes using the Sigma Theta (σ_A) method.

Computer modeling was performed using EPA's ISCST3 model to determine annual average NOx and $PM_{2.5}$ concentrations around the Watt Road area. Figure 3.9 shows the location of sources and the modeling domain. As is shown on the figure the modeled area includes the Flying J, Travel America and Petro truck stops, part of I-40/I-75 interstate, part of Watt Road and the entrance and exit ramps of the interstate at Watt Road. All emission sources were modeled as volume sources. MOBILE6.2 emission factors were used for traffic on the interstate, ramps and Watt road. These emission factors from MOBILE6.2 have units of gm/vehicle mile. Since those line sources were modeled as volume sources in ISCST3 the emission factor units were converted to g/hr by multiplying MOBILE6.2 emission factors by the traffic volume in vehicles/hour, and the length of each volume source in miles. For idling trucks inside the truck stop areas emission factors of 135g/hr of NOx and 3.68g/hr of $PM_{2.5}$ from EPA "Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity" released in January 2004 were used (EPA, 2004). Table 3.1 shows the emission factors and ADT values used to calculate emission rates from sources considered in the model at different sections of the Watt Road area. An example ISCST3 input file for the prediction of ambient NOx concentration is shown in Appendix A-6.

Table 3.1 Speed, Emission Factor and ADT Values Used for Modeling Watt Road Area



	Speed	ADT	NOx Emission Factors	$PM_{2.5}$ Emission Factors
I-40	65 mi/hr	83000	6.86 g/mi	0.112 g/mi
Watt Road	40 mi/hr	17000	5.22 g/mi	0.15 g/mi
Entrance Ramps	40 mi/hr	6000	7.95 g/mi	0.206 g/mi
Exit Ramps	40 mi/hr	6000	7.95 g/mi	0.206 g/mi
Travel Centers	Idling		135 g/hr	3.68 g/hr

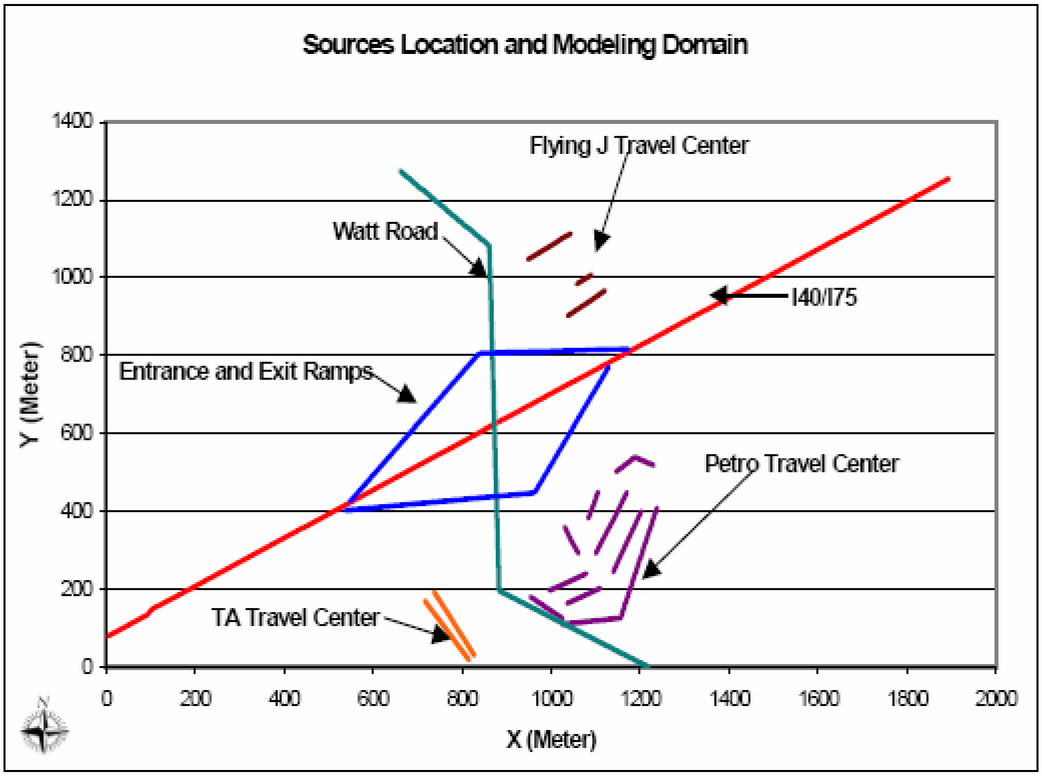


Figure 3.9 Location of Emission sources and Modeling Domain

Estimation of initial lateral (σ_{YO}) and vertical (σ_{ZO}) dimensions was also done using the ISCST3 user's guide. Initial lateral and vertical dimensions were set to be equal to W/2.15 and h_e / 2.15 respectively where W is the length of the side of the volume source and h_e is the effective emission height (EPA 1995). Emission sources on I40/I75 interstate, Watt Road and entrance and exit ramps were modeled as 29 meters X 29 meters, 11 meters X 11 meters, and 6 meters X 6 meters volume sources, respectively.

Three different dimensions of volume sources were used for different sections of the Petro travel center: Volume sources are arranged along the center line of the line sources. 47 meters X 47 meters was used for the High End North, High End South, Low End North and Low End South parking areas based on the distance of two trucks parked facing each other plus the space between them; the Fueling Island and West of Fueling Island sections were modeled as 20 meters X 20 meters volume sources (representing the length of a single truck). Volume sources at the Truck Wash and at the Perimeter were modeled as 4 meters X 4 meters volume sources (the width of a single truck). Figure 3.10 shows the detailed location of volume sources considered in the model at Petro truck travel center. Volume source heights of 4 meters were assigned for all volume sources based on the height of the exhaust stack of most trucks. Emission sources at the Low End South, Low End North sections, Fueling Island and West of Fueling Island were each represented by five volume sources and emission sources at the High End North and High End South sections were each represented by three volume sources. Sources at the Truck Wash were modeled as 27 volume sources and those at the Perimeter were modeled as 133 volume sources.

Prediction of achievable reductions in ambient concentrations of NOx and $PM_{2.5}$ were made by running the model for a "no-long term idling" case. This case represents a condition where enough IdleAire electrifications units are available to accommodate all idling trucks inside the truck stop.

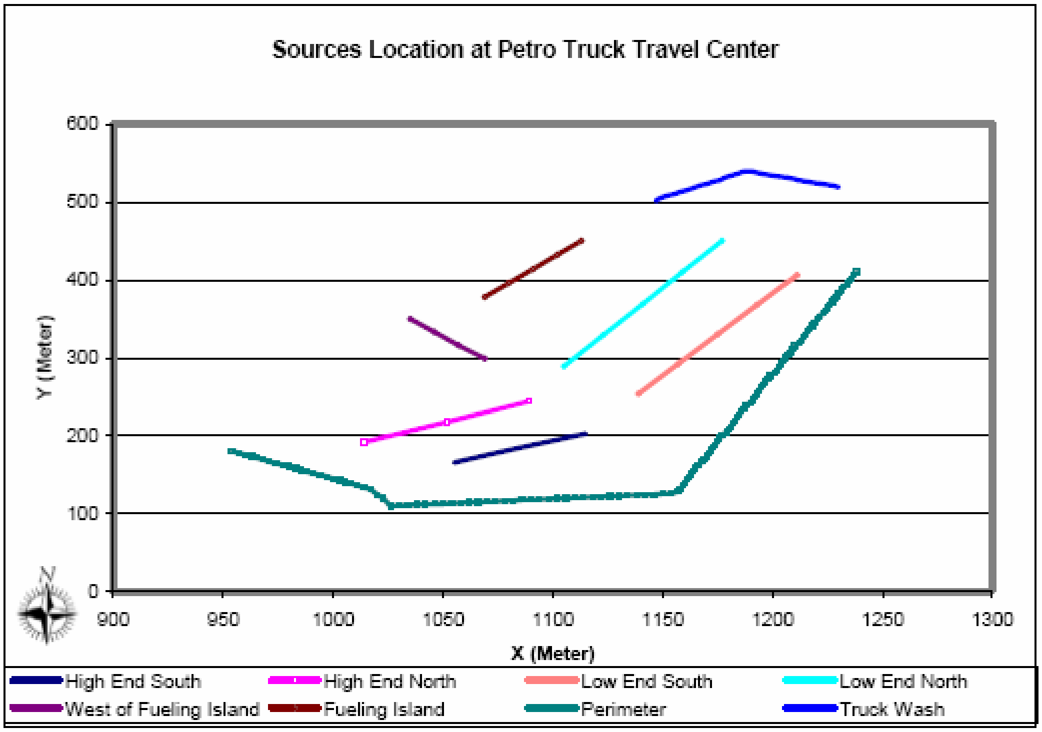


Figure 3.10 Location of Emission Sources at Petro Truck Travel Center

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All emission sources considered in the computer modeling are line sources and were treated as volume sources as suggested by ISC user's guide.

The following computer runs were performed.

☐ Detailed runs of Petro truck travel center to determine 1-hour and 24-hours average concentrations of NOx and $PM_{2.5}$ inside the travel center at the two monitoring stations for the duration of this study. This was done to determine the accuracy of the model by comparing monitored and predicted values. Comparison was done using a scatter plot diagram and statistical performance tests. Monitored and modeled 24-hour average NOx concentrations at the two monitoring sites were directly compared while monitored $PM_{2.5}$ concentrations were adjusted for background $PM_{2.5}$ concentration.

☐ Runs to determine annual average and maximum 24-hour average concentrations of NOx, and $PM_{2.5}$ around the Watt Road.

☐ A single run to determine the achievable emission reduction from IdleAire electrification technology.

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Figure 4.3 shows the number of idling trucks at the Petro travel center versus time of the day. The number of idling trucks starts to increase in the afternoon, reaches a peak near midnight and remains to be high until early morning. The figure also shows a visually fit curve showing an average trend line of the number of idling trucks at the Petro travel center in a day. The number of idling trucks shows a similar trend to that of the total number of trucks parked (i.e. higher at night and early morning compared to day-time). This trend varies little by day of the week.

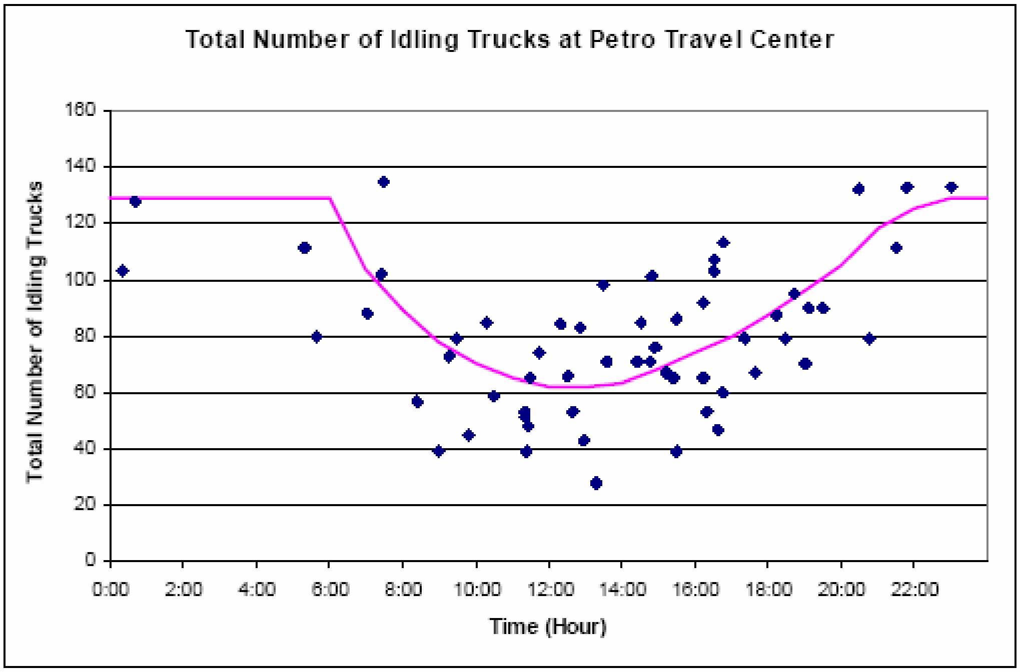

Figure 4.3 Total Number of Idling Trucks at Petro Travel Center at Different Hours of The Day

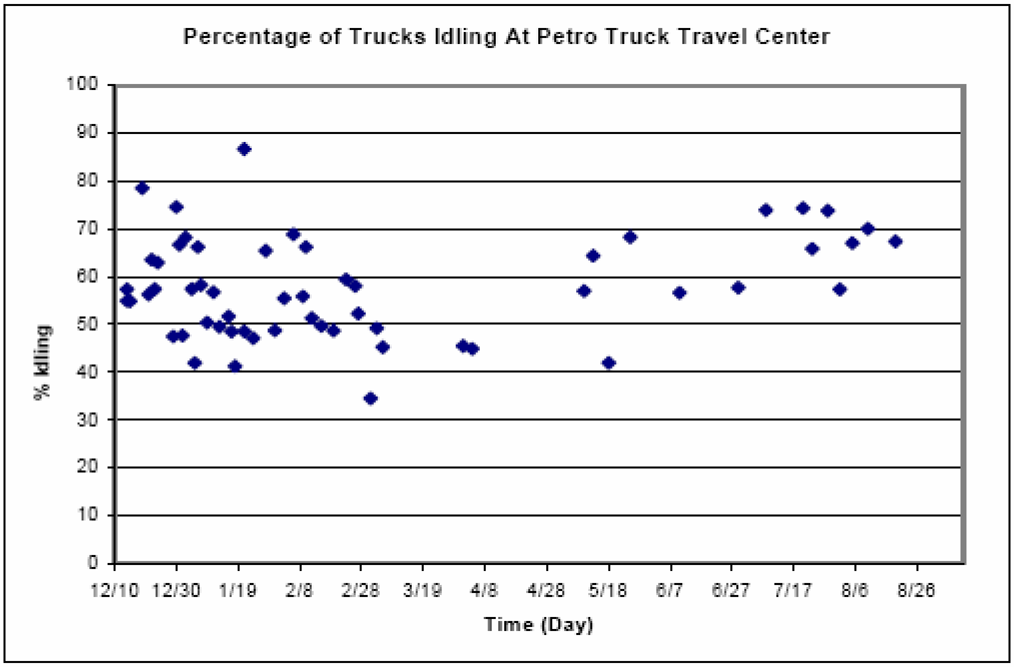

Figure 4.4 Percentage of Idling Trucks at Petro Truck Travel Center

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4.2 Analysis of Monitored Ambient Concentrations

4.2.1 24-Hour Average Values

$PM_{2.5}$

Scatter plots of 24- hour average measured 1-hour average $PM_{2.5}$ concentrations at trailer #1 and trailer #2 are shown in Figure 4.6 and Figure 4.7. The 24-hour average values were calculated for days that have 18 hours or more of hourly average $PM_{2.5}$ concentration records. Between March 27 and April 27 the E-BAM $PM_{2.5}$ analyzer at trailer #1 was not functioning due to a problem with its barometric pressure sensor and no data was collected during that period at trailer #1 until the instrument was repaired.

As can be seen in the figures the 24-hour average $PM_{2.5}$ concentration values were greater than the annual average NAAQS of 15 $\mu g/m^3$ at trailer #1 throughout the entire study period while at trailer #2 the 24-hour average values were greater than the standard on 95 % of the monitored days. On the other hand there are only a few days that exceeded the 24-hour average NAAQS of 65 $\mu g/m^3$ at both monitoring trailers. The highest 24 hour average value at trailer #1 was 116 $\mu g/m^3$ followed by 86 $\mu g/m^3$ and 82 $\mu g/m^3$. At trailer #2 the 24-hour average NAAQS was exceeded 6 times, the highest concentrations being 116 $\mu g/m^3$, 114 $\mu g/m^3$ and 94 $\mu g/m^3$. The lowest 24-hour average $PM_{2.5}$ concentrations observed were 15 $\mu g/m^3$ at trailer #1 and 9 $\mu g/m^3$at trailer #2. The 24-hour average NAAQS was exceeded only 3.7% of the time at trailer #1 and 2.3 % of the time at trailer #2. The figures also show that most of the 24-hour average readings are between 20 and 40 $\mu g/m^3$ at both trailers, which is half to two-thirds of the 24-hour average NAAQS.

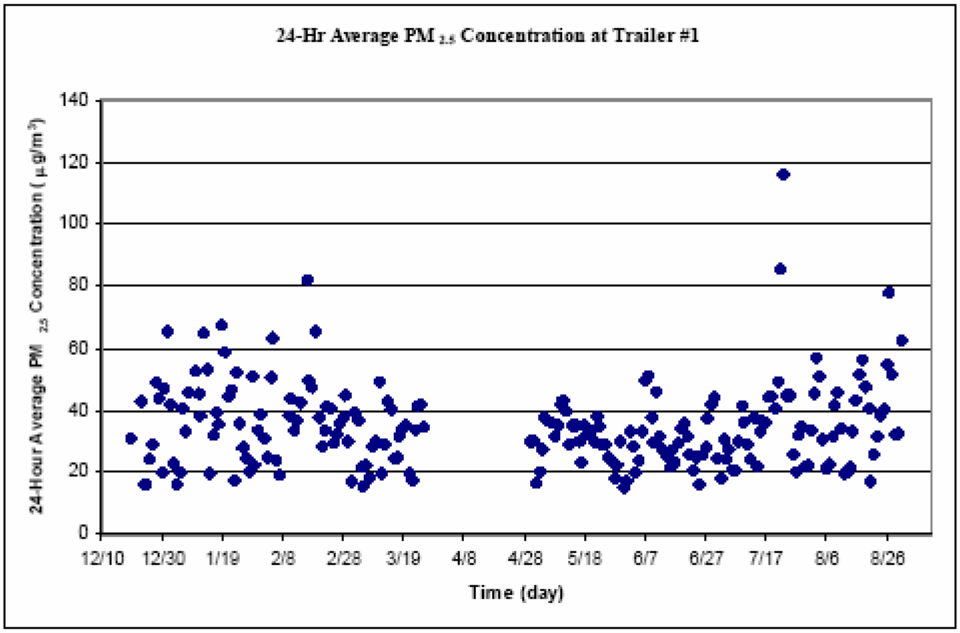

Figure 4.6 24-Hour Average of Monitored PM $_{2.5}$ Concentration at Trailer #1

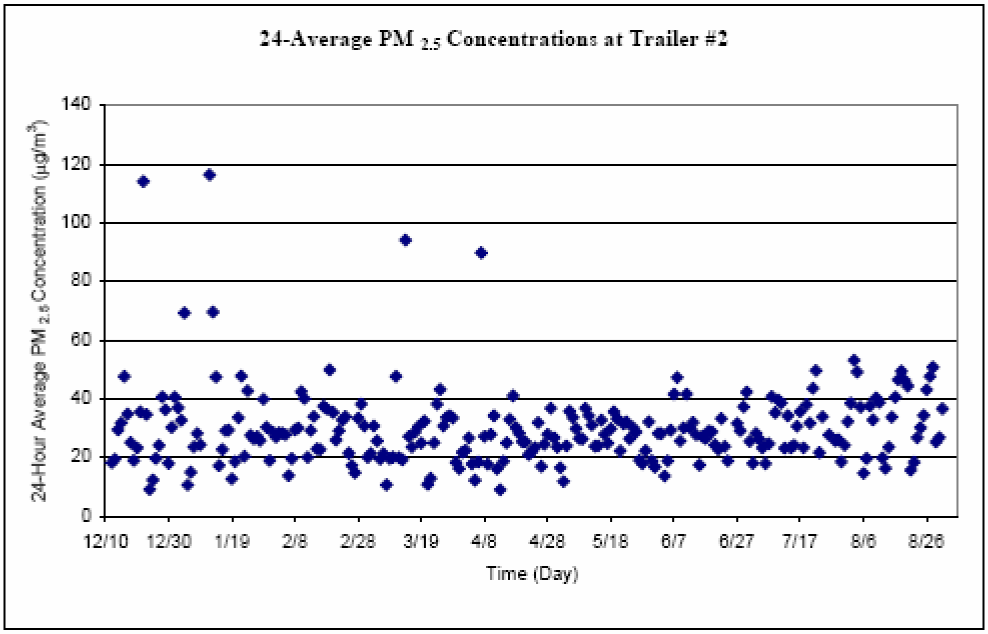

Figure 4.7 24-Hour Average of Monitored PM $_{2.5}$ Concentration at Trailer #2

4.4 Modeling Results

4.4.1 Evaluation of Model Performance

Dispersion of pollution is a process by which pollutants are mixed or diluted and transported in the atmosphere. Model performance was done using direct comparison of model prediction with observations. Uncertainties in observation and model prediction arise from different sources. Uncertainty in observation could be due to random turbulence in the atmosphere and instrument errors, while uncertainties in model prediction could be due uncertainties in input data and model physical performance.

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The performance of the ISCST3 model was evaluated by using a direct comparison of observed and predicted 24-hour average NOx concentrations. Scatter plot diagrams of measured and predicted 24-hour average NOx concentrations at trailer #1 and trailer #2 are shown in Figure 4.33 and Figure 4.34. Visual inspection of the scatter plots reveals that the model over-predicts most of the 24-hour NOx concentrations at both trailers. The pink line on the scatter plot diagrams is a 45-degree line. This line represents an ideal match of modeled and measured values. As can be seen on the figures most of the points lie above the 45 degree line showing that the model over-predicted the 24-hour average NOx concentrations at the two monitoring trailers.

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The 24-hour average and monthly average $PM_{2.5}$ concentrations were also predicted at the two trailers and compared to measured values to evaluate performance of the model. Measured $PM_{2.5}$ concentrations were adjusted to take into account the background portion of $PM_{2.5}$ before comparison was made with the predicted value. $PM_{2.5}$ concentrations measured at Look Rock were used as an adjustment to measured values. Figure 4.39 and Figure 4.40 show scatter plot diagrams of 24-hour average $PM_{2.5}$ concentrations at trailer#1 and trailer #2, respectively. Scatter plots of monthly average measured and predicted $PM_{2.5}$ concentrations are shown in Figure 4.41 and Figure 4.42. As shown in the scatter plot diagrams the model under-predicted 24-hour concentration on a number of days at the two trailers. The under-prediction is more obvious at trailer #2 compared to trailer #1. Since a significant amount of measured $PM_{2.5}$ concentration accounts for background concentration it cannot be concluded that the under prediction of the model is necessarily due to the performance of the model. There could be some other sources of $PM_{2.5}$ that were not considered in the model or the $PM_{2.5}$ concentration measured at Look Rock could be less than the actual background concentration at the study area. There could also be trucks that have high emission rate of $PM_{2.5}$ idling next to the monitoring trailers resulting in high concentrations measured at the trailers. In the case of monthly average $PM_{2.5}$ concentration predictions, the model again performs better as the averaging time increases. All predictions at trailer #1 were within a factor of two of observed concentrations (after adjusting measured concentration for background concentrations), whereas at trailer #2, 70% of the predicted concentrations were within a factor of two of corrected observed concentration.

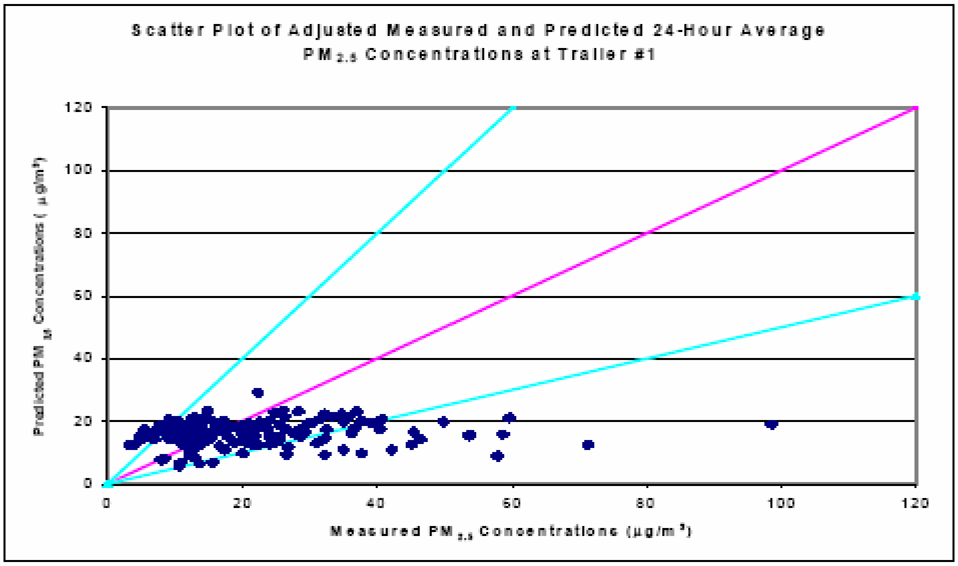

Figure 4.39 Scatter Plot of Measured and Predicted 24-Hour Average $PM_{2.5}$ Concentrations at Trailer #1

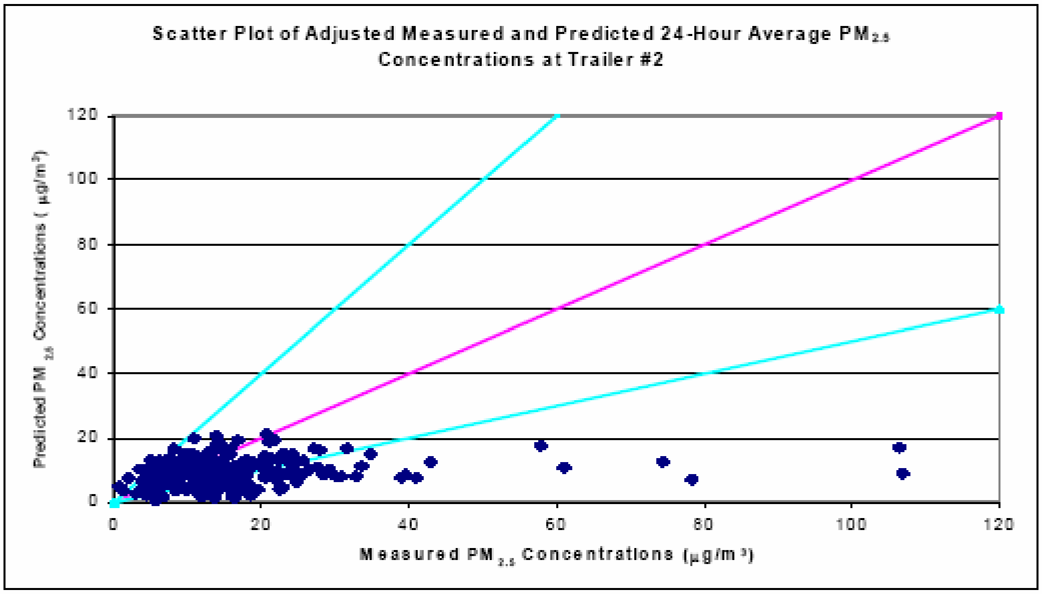

Figure 4.40 Scatter Plot of Measured and Predicted 24-Hour Average $PM_{2.5}$ Concentrations at Trailer #2

fin

Certains éléments de CALINE4

[N'ayant pas eu de réponses aux questions (DC-21) sur l'étude des émissions du Flying J (PR-5.1, Annexe 6 et DA-2), j'ai m'informé sur certains aspects du modèle de dispersion CALINE4]

6.3 Transient Emissions

[on parle ici notamment des véhicules légers à essence]

Before an engine reaches hot-stabilized running temperature, it operates less efficiently because fuel is not readily vaporized in a cold engine. This results in excess CO and hydrocarbon emissions during the engine start-up phase. The problem is compounded for catalyst-equipped vehicles by the need for the catalyst to reach operating temperature before it can perform efficiently. Both these effects are temporary in nature, and therefore the resulting excess emissions are termed transient emissions. They are usually treated as trip-end contributions for mesoscale emission inventories, or as weighted components in a composited emission factor for microscale applications.

Two variables that have a direct effect on transient emissions are ambient temperature and soak time. The ambient temperature determines the initial temperature of the engine block and catalyst at start-up. The soak time is the elapsed time between engine operations. It controls the extent to which the system has been able to reach ambient temperature. Depending on the length of the soak and the type of vehicle (catalyst or non-catalyst), a start is categorized as either cold or hot. Both are transient states and result in excess emissions. Excess cold-start emissions are significantly greater than hot-start emissions.

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Excess transient emissions are often a significant component of a composite emission factor. The conventional method of modeling transient emissions for microscale applications is to assume a fixed percentage of vehicles traveling in a transient operating mode, and to assign an average excess transient emission rate, etr to these vehicles. The value of etr is defined as

$$\bar{e}_{tr} = E_{tr}/R, \qquad (6\text{-}5)$$

where Etr equals the mass of excess transient emissions per vehicle-trip (aggregated over vehicle types) and R equals the total distance traveled during the transient cycle. For cold and hot-starts, R is defined by FTP-75 as 3.59 miles.

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A more realistic model of excess emissions during a transient cycle can easily be arrived at by establishing a set of boundary conditions consistent with the physics of the transient process. By definition, excess transient emissions will dissipate to zero by the end of the transient cycle so that,

$$e(r)\Big|^{R} = 0, \qquad (6\text{-}10)$$

where e(r) represents the distance rate of excess emissions as a function of distance traveled, r. Futhermore, it is reasonable to assume that the rate of change of excess emissions with distance will be decreasing over the transient cycle, and will approach zero as a smooth function at the end of the cycle. Thus,

$$\frac{\partial e(r)}{\partial r}\Big|^{R} = 0. \qquad (6\text{-}11)$$

A quadratic function,

$$e(r) = a + br + cr^2, \qquad (6\text{-}12)$$

is chosen as the simplest functional form to describe e(r) that will satisfy the boundary conditions given in Equations 6-10 and 6-11 (Figure 19).

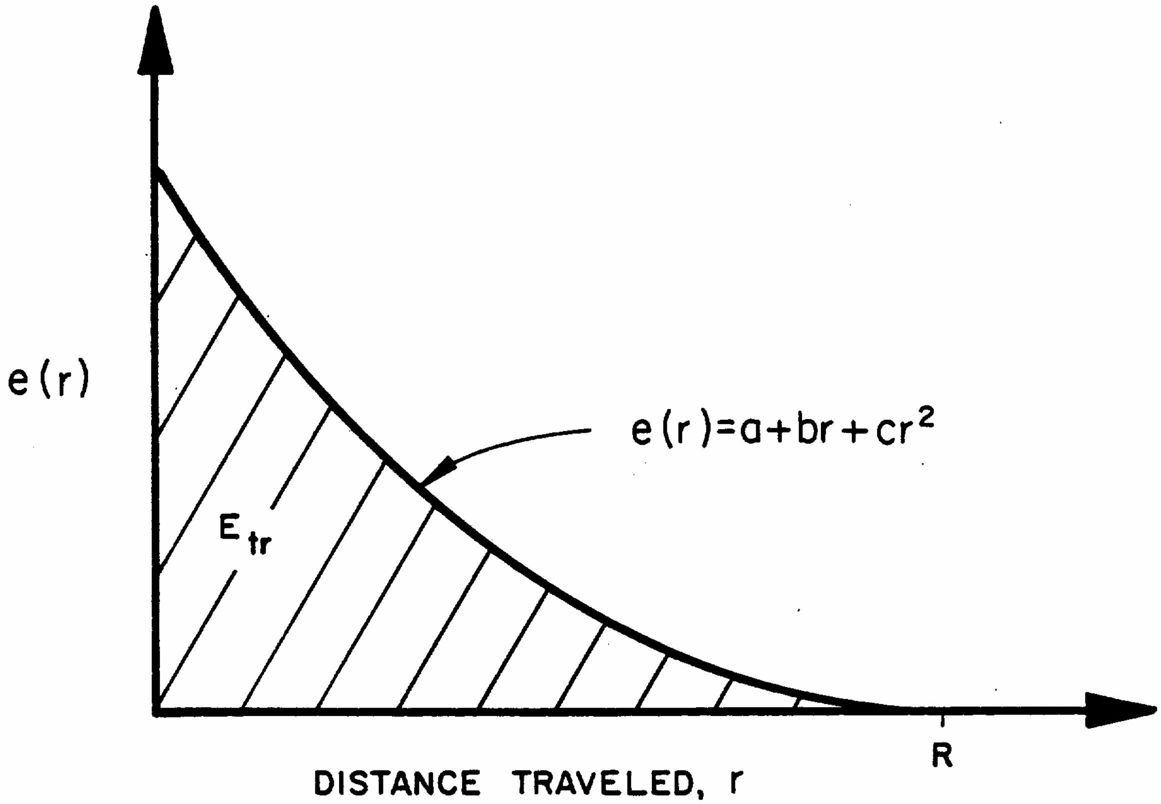
A final boundary condition is needed to evaluate the coefficients in Equation 6-12. This is supplied by the definition of Etr:

$$E_{tr} = \int_{0}^{R} e(r)\,dr \quad . \qquad (6\text{-}13)$$

Simultaneous solution of Equations 6-10, 6-11 and 6-13 yields the following relationship for the excess transient emission rate:

$$e(r) = \frac{3E_{tr}}{R}\left(1 - \frac{2}{R}r + \frac{1}{R^2}r^2\right) . \qquad (6\text{-}14)$$

Equation 6-14 may also be cast as a function of fraction of transient cycle completed, fr=r/R. This form of the equation leads to a generalized relation between the fraction excess transient emissions, fe and fr through the equation,



EMISSION RATE FUNCTION FOR EXCESS TRANSIENT EMISSIONS.

FIGURE 19

$$f_e = \frac{\int_0^{f_r} e(f_r)\, df_r}{E_{tr}} \quad . \tag{6-15}$$

Performing the indicated integration and simplifying gives

$$f_e = f_r^3 - 3f_r^2 + 3f_r . \tag{6-16}$$

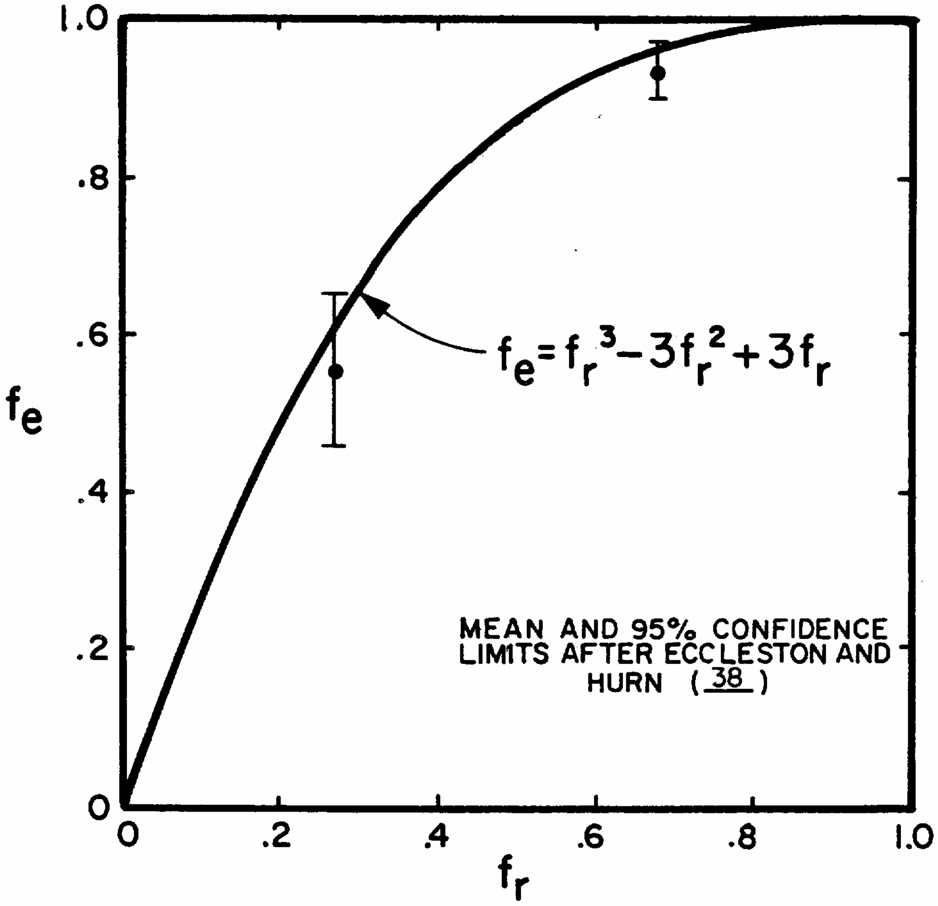
A plot of Equation 6-16 is shown in Figure 20. Superimposed on this plot are the results from an FTP-75 cold- start study conducted by Eccleston and Hurn(38). The mean and 95% confidence limits are shown for interim cold-start CO emissions from the 9 gasoline-powered vehicles studied. Equation 6-16 yields slightly higher fractions on average because of the boundary condition described in Equation 6-10. The measured results include both excess and running emissions so that e(r) will equal a value greater than zero at the end of the cycle. However, the running (or hot-stabilized) emission rate is typically much less than the excess cold-start emission rate, so that the difference is minor. The measured results, though few in number, give some degree of verification to Equation 6-14.

To find a properly weighted excess transient emission rate for urban freeways, one must multiply e(r) by the elemental weighting factor contained in Equation 6-9 and integrate over the complete transient cycle. Using y to represent the correction factor for etr, this can be stated as yetr

$$\gamma \bar{e}_{tr} = \frac{2}{R^2} \int_0^R e(r) \cdot r \; dr \quad . \tag{6-17}$$

Substituting Equation 6-14 yields

$$\gamma \bar{e}_{tr} = \frac{6E_{tr}}{R^3} \int_0^R \left(r - \frac{2}{R} r^2 + \frac{1}{R^2} r^3 \right) dr \quad . \tag{6-18}$$



FRACTION EXCESS TRANSIENT EMISSIONS, fe . VERSUS
FRACTION OF TRANSIENT CYCLE COMPLETED, fr

FIGURE20

Integrating Equation 6-18 and simplifying gives

$$\gamma \bar{e}_{tr} = \frac{E_{tr}}{2R} \quad . \qquad (6\text{-}19)$$

By definition, etr = Etr/R. Therefore, y = 1/2 for conditions consistent with the assumptions of the foregoing derivation. This means that cold and hot-start excess emission rates should be reduced by 50% for microscale analyses in cases where trip generation and the probability of attracting trips is uniformly distributed over a distance R from the microscale location. In urban freeway locations removed from "point" source trip generators such as stadiums or convention centers, the 50% reduction is appropriate. Even if trips are generated out of isolated sectors radiating away from the microscale location, Equation 6-9 is still valid because of symmetry.

For composite emission computations, the 50% reduction can easily be accomplished by using cold and hot-start vehicle fractions of half the amount they are assumed to be.

A useful by-product of Equation 6-16 is its application to transient emissions from parking lots. A significant portion of air quality impacts from these types of facilities is attributable of excess cold-start emissions. By determining an average egress time for vehicles leaving a parking lot, the fraction of the transient cycle assignable to the lot can be computed (FTP-75 cold and hot-start cycles are 505 seconds long). Equation 6-16 can then be used to determine the fraction of excess transient emissions assignable to the lot. The resultant quantity is distributed uniformly over the parking lot links. The distance rate emission factor needed by CALINE4 can be computed as follows,

$$EFL = \frac{1}{LL_T} * \left[(E_{tr} * f_e) + (EF_{hot} * SPD * t_e) \right] \; , \qquad (6\text{-}20)$$

where LL_T = Average distance traveled within the parking lot,

SPD = Average speed in the lot (say 5 mph),

EF_{hot} = Hot-stabilized emission rate at SPD,

t_e = Average egress time.

Care should be taken to use consistent units in Equation 6-20. For use in CALINE4, EFL must be in units of grams per vehicle mile (gm/veh-mi).

[Celle-ci est l'équation cité a PR-5.1, Annexe 6, pdf p. 13]

From CALINE4 Ch 9

9.3.4 Example 4: Parking Lot

An example of a parking lot modeled as a series of short CALINE4 links is given in Figure 61. The link widths do not include the usual six meter augmentation because the vehicle wakes are not well developed in the parking lot. The emission factor is unusually high because of the large component of transient emissions (cold and hot-starts) released in the lot. For this example, the egress time was estimated at 120 seconds. This means that approximately 56%; of the transient emissions will occur in the lot (Equation 6-16, fr = 120/505 seconds).

[$fr = 0.2376$, $fr^2 = 0.056$, $fr^3 = 0.0134$ so $fe = fr^3 + 3fr - 3fr^2 = 0.56 = 56\%$]

The lot contains 350 parking stalls and is assumed to be filled to capacity at the start of the one-hour time period being considered. The lot is expected to empty completely during the hour, with 40%øS of the starts assumed to be cold and 60% hot. Given excess transient emissions of 150 gms/veh-start (cold) and 15 gms/veh-start (hot), a composite excess transient emission factor is computed as follows:
p. 183
Etr = (150 gms/veh)(0.4)+(15 gms/veh)(0.6)
= 69 gms/veh-start.

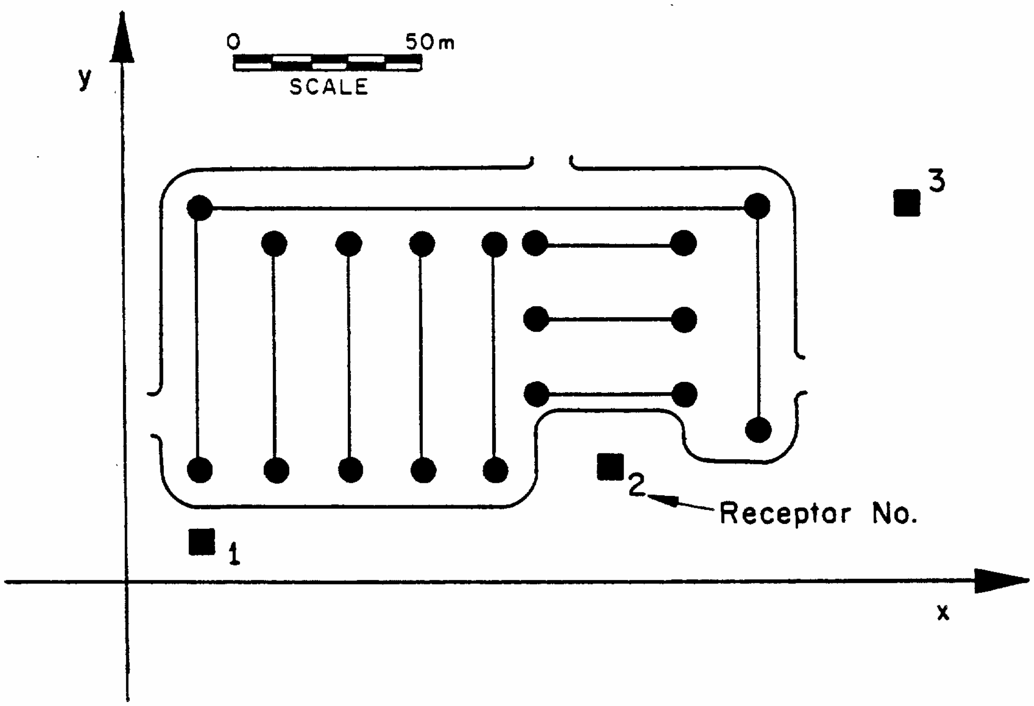
Equation 6-20 is then used to compute the link emission factor. Running emissions at 5 mph of 35 gms/veh-mi are assumed. The average distance traveled at 5 mph over 120 seconds (minus 60 seconds for warm-up, back-up and exit queue) [= 60 seconds] is 134 meters (0.083 mile [= LLT]). The resulting emission factor is approximately 530 gms/veh-mi. Transient emissions account for 87% of this figure!

[EFL = 1 ÷ 0,083 (69 x 0.56 + 35 x 5 x 120 ÷ 3600) = 465 + 35 x 2 = 535]

The input file (Exhibit 12) is set-up for RTYP=3 (worst-case wind angle search). Note that the parking lot link type is specified (TYP=5). The continuation code is used for several of the contiguous links. Also, 100 meters is assigned for the mixing height. This will automatically engage the mixing height algorithm.

The output (Exhibit 13) is similar to previous worst-case wind angle runs. Note that the traffic volume and emission factor are identical for all links. This is attributable to the method used to compute the emission factor. The emission factor represents the lump sum emissions per vehicle distributed over the average distance traveled by vehicles leaving the parking lot. The traffic volume per link is determined by multiplying the ratio of the average distance traveled to the total link length (134m/640m in this example) by the total number of vehicles leaving the parking lot per hour (350 in this example). The resulting volume of 73 vph is used on each of the links. When multiplied in the model by 530 gms/veh-mi, this traffic volume will yield a uniform distribution of the emissions over all the links.

EXAMPLE 4: PARKING LOT



LINK VARIABLES
(ALL LINKS)

TYP = 5 (PK)
VPHL = 73
EFL = 530 (g/mi)
HL = 0 m
WL = 4 m

(See Output for
Link Coordinates)

SITE VARIABLES

U = 0.5 m/s
BRG = WORST
CLAS = 5 (E)
Z0 = 50 cm
SIGTH = 35°
VS,VD = 0 cm/s
AMB = 3.0 ppm
MIXH = 100 m
TEMP = 7.5° C

RECEPTOR COORDINATES

	X	Y	Z
1.	20	10	1.5
2.	130	30	1.5
3.	210	100	1.5

FIGURE 61

EXHIBIT 13

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

              JOB: EXAMPLE FOUR: PARKING LOT
              RUN: WORST BRG        (WORST CASE ANGLE)
        POLLUTANT: CO

  I.  SITE VARIABLES

       U=   0.5 M/S            Z0=  50. CM            ALT=      0. (M)
     BRG= WORST CASE           VD=  0.0 CM/S
    CLAS=     5 (E)            VS=  0.0 CM/S
    MIXH=  100. M             AMB=  3.0 PPM
   SIGTH=   35. DEGREES      TEMP=  7.5 DEGREE (C)

 II.  LINK VARIABLES

       LINK      *  LINK COORDINATES (M)  *              EF      H     W
    DESCRIPTION  *  X1     Y1     X2    Y2  * TYPE  VPH  (G/MI)  (M)   (M)
-----------------*------------------------*------------------------------
A.  LINK A      *  20     30     20    100 *  PK      73 530.0    0.0   4.0
B.  LINK B      *  20    100    170    100 *  PK      73 530.0    0.0   4.0
C.  LINK C      * 170    100    170     40 *  PK      73 530.0    0.0   4.0
D.  LINK D      *  40     30     40     90 *  PK      73 530.0    0.0   4.0
E.  LINK E      *  60     30     60     90 *  PK      73 530.0    0.0   4.0
F.  LINK F      *  80     30     80     90 *  PK      73 530.0    0.0   4.0
G.  LINK G      * 100     30    100     90 *  PK      73 530.0    0.0   4.0
H.  LINK H      * 110     90    150     90 *  PK      73 530.0    0.0   4.0
I.  LINK I      * 110     70    150     70 *  PK      73 530.0    0.0   4.0
J.  LINK J      * 110     50    150     50 *  PK      73 530.0    0.0   4.0

III.  RECEPTOR LOCATIONS

            *   COORDINATES (M)
  RECEPTOR  *   X       Y      Z
------------*---------------------
1. RECPT  1 *   20      10    1.5
2. RECPT  2 *  130      30    1.5
3. RECPT  3 *  210     100    1.5
```

EXHIBIT 13 (CONT.)

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

            JOB: EXAMPLE FOUR: PARKING LOT
            RUN: WORST BRG        (WORST CASE ANGLE)
      POLLUTANT: CO

 IV.  MODEL RESULTS (WORST CASE WIND ANGLE )

              *       * PRED  *                 CONC/LINK
              *  BRG  * CONC  *                   (PPM)
 RECEPTOR     * (DEG) * (PPM) *   A    B    C    D    E    F    G    H
--------------*-------*-------*----------------------------------------
 1. RECPT   1 *   39. *   8.3 *  0.6  0.8  0.1  1.4  1.0  0.6  0.4  0.2
 2. RECPT   2 *  317. *   8.8 *  0.2  0.9  0.0  0.2  0.4  0.8  1.5  0.1
 3. RECPT   3 *  256. *   7.9 *  0.2  1.3  0.9  0.2  0.3  0.3  0.4  0.5


              * CONC/LINK
              *   (PPM)
 RECEPTOR     *   I    J
 -------------*----------
 1. RECPT   1 *  0.2  0.1
 2. RECPT   2 *  0.3  1.3
 3. RECPT   3 *  0.5  0.3
```

fin