Microscale Carbon Monoxide Impact Assessment for the Atlantic Steel Development Project

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INTRODUCTION

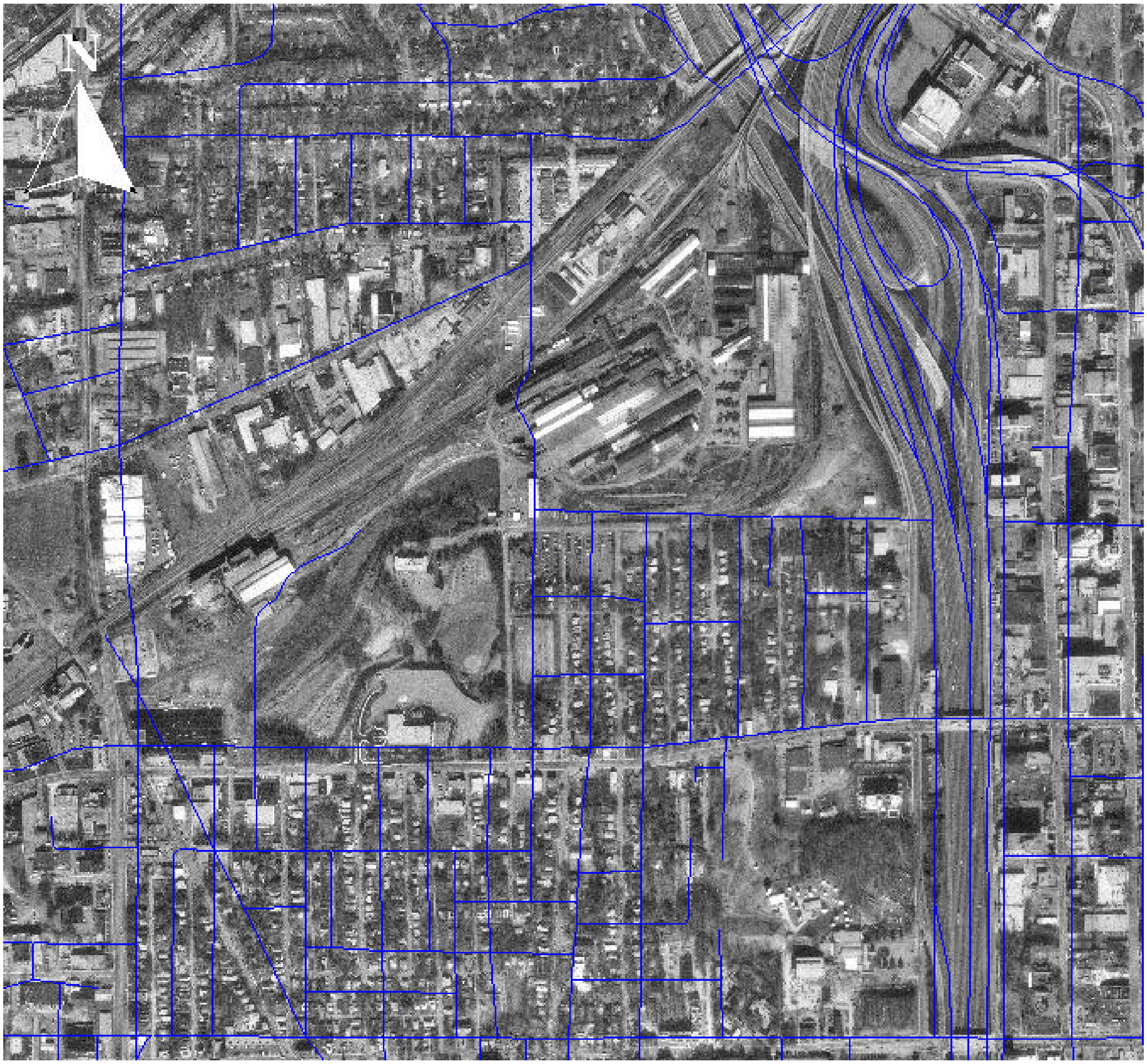
Hagler Bailly Services, Inc., is under contract to the US Environmental Protection Agency to evaluate the environmental impacts of redeveloping the Atlantic Steel site in Midtown Atlanta. As part of the modeling of the development impacts, EPA required assistance in evaluating whether the proposed development would produce new CO hotspots in the surrounding neighborhood. To provide that support, the contractor assembled a microscale modeling team made up of staff from the Georgia Institute of Technology who served as project subcontractors. Drs. Randall Guensler and Michael Rodgers led the research team and directed the research and modeling tasks summarized in this document.

The Atlantic Steel project is a major urban development located in downtown Atlanta. Freeway access to the area is proposed from I-75 between Howell Mill road and 14th Street. Because the project will yield a significant increase in number of trips generated and attracted to the local area, and vehicle miles of travel on arterial roads and freeways, it is necessary to undertake an analysis of the local air quality impacts expected to result from the development. For federal agency approvals to be issued, the project must not create a violation of the ambient air quality standards for carbon monoxide. Figure 1 illustrates the proposed project location near the Georgia Institute of Technology.

The research team developed the modeling framework using a variety of off-the-shelf modeling tools. The MOBILE5a emission rate model and CALINE4 line source dispersion model served as the analytical tools of choice for this project. A geographic information system (GIS) was employed to link standard regional travel demand model results with the line source analyses. PERL scripts and FORTRAN programming was employed to link corridor travel simulation model results with the line source analyses. Data input files were provided by Hagler Bailly Services, Inc., Moreland Altobelli, Inc., the Georgia Department of Transportation, Atlanta Regional Commission, and Georgia Institute of Technology. The GIS graphics for network and model documentation were developed and links and receptor sites were coded for input to the CALINE4 model. The team reviewed aggregate model outputs and developed appropriate volumes and speeds for microscale analyses. The team also developed and documented all required meteorological parameters and emission rates for use in analyses.

The research team developed new program code to feed the outputs of a variety of vehicle activity and emission rate models into CALINE4 analyses. The new model code was non-invasive, in that the standard models were not modified. Instead, the team developed code that would allow standard models and output data files to be called and run for any desired conditions. The new code allowed the modeling team to run analyses for hundreds of roadway links and receptor sites, predicting worst-case pollutant concentrations throughout the project region. The model code predicts and displays the worst-case wind angle for each receptor in the region. Standardized graphical output reports were prepared for receptors and links, and vectors illustrate the wind direction for worst-case concentrations at receptors. The team also selected additional receptor sites for modeling based on their familiarity with the local region and their professional judgment.

Figure 1 - Atlantic Steel Project Location and Current Roadway Infrastructure



The microscale analyses were based upon the CORSIM traffic simulation model, run for the years 1998, 2005, and 2025. The CORSIM analyses were prepared by Moreland Altobelli, Inc. using system constraints provided from 4-step travel demand model runs prepared by Hagler Bailly Services, Inc (TRANPLAN model runs for the years 2000 and 2015). The microscale modeling team made no changes to any of the TRANPLAN or CORSIM runs.

The research team determined that the project is extremely unlikely to create a violation of ambient air quality standards for carbon monoxide in the foreseeable future. Analyses were developed for worst case morning and evening January conditions when traffic volumes are high, temperatures are cold, and meteorological conditions limit pollutant dispersion. All predicted peak one-hour carbon monoxide concentrations were less than 12 ppm under worst-case conditions. The one-hour carbon monoxide standard is 35 ppm. Analyses were conservative, with assumptions designed to over-predict pollutant concentrations. Given the temporal distribution of vehicle activity, decreased traffic volumes, increased travel speeds, lower emission rates, and increased pollutant dispersion after the peak hour, it is also extremely unlikely that the project will create a violation of the 8-hour standard for carbon monoxide (9ppm).

MISCROSCALE EMISSIONS MODELING

Microscale carbon monoxide impact assessment should be performed for worst-case conditions in the area of transportation projects to ensure that an adequate margin of health safety is provided for individuals expected to work or play in the area. Ambient air quality standards are expressed in units of potential personal exposure or concentration over an averaging time (35 parts per million of CO over a one-hour period, and 9 parts per million of CO over an 8-hour average period). Hence, analyses should examine concentrations expected result over 1-hour and 8-hour period in areas where the population is expected to work, rest, or play for periods in excess of one hour. For transportation projects, microscale line source dispersion models are used to predict the concentrations of carbon monoxide in areas near the implemented project.

To ensure that potential violations of ambient air quality standards are identified before a highway-related project proceeds, microscale line source dispersion models are used to predict the downwind concentrations from planned projects. To provide a margin of safety in analyses designed to predict maximum concentrations, worst-case traffic and meteorological conditions are employed. These worst case conditions are designed to provide a margin of safety for individuals who can be expected to live, work, or play in the area. If the analyses do not predict violations of ambient air quality standards under worst case conditions, the transportation system is not expected to yield air quality standard violations under typical operating conditions.

DEVELOPMENT OF TRAFFIC VOLUMES AND AVERAGE VEHICLE SPEEDS

As more and more vehicles use the roadway, traffic volumes (in vehicles/lane/hour) increase rapidly. When traffic volumes begin to approach 2100 to 2300 vehicles/lane/hour on freeways, travel speeds begin to drop rapidly. Roadway capacity (about 2400 vehicles/lane/hour on freeways) is achieved at about 35 mph. If travel demand surpasses roadway capacity, traffic flow enters what is known as congested flow conditions. Traffic densities continue to increase, vehicles begin stop-and-go driving conditions, and travel speeds drop so rapidly that traffic flow cannot be sustained at capacity levels. As congestion worsens, traffic flow drops and emission rates per vehicle-mile of travel increase. Similar relationships also exist on arterial roadways. Traffic volume estimates for roadways in microscale analyses are usually based upon either the outputs of traditional 4-step travel demand models or upon monitored traffic data (with applied growth factors). Average speeds are usually based upon post-processed travel demand model outputs, traffic simulation model outputs, or generalized relationships for an urban area based upon empirical studies.

Downwind concentrations from a roadway source are in direct proportion to the traffic volumes and vehicle emission rates. Doubling the traffic volume or source strength will roughly double the predicted increase in emissions concentrations (relative to background concentrations) under any given set of meteorological conditions. Because the net mass emissions from a roadway are a function of traffic volume and emission rate, it is important that both parameters be represented as accurately as possible.

This section outlines the methods employed to estimate the traffic volumes and average speeds for the roadway links analyzed in each of the present and future Atlantic Steel scenarios analyzed. The prime contractor provided model output results from two different transportation modeling approaches: 1) TRANPLAN, a standard four-step travel demand model used to predict future traffic conditions at the regional level, and 2) CORSIM, a simulation model designed to analyze traffic impacts at the corridor level. Hagler Bailly Services, Inc. prepared TRANPLAN model runs for the years 2000 and 2015. Moreland Altobelli, Inc. used the TRANPLAN outputs to prepare CORSIM traffic simulation model runs for the years 1998, 2005, and 2025. The microscale modeling team was tasked with estimating the carbon monoxide impacts of the future development using the detailed traffic simulation model outputs. The following subsections describe how each data set was handled to prepare input files for microscale analyses.

TRANPLAN Traffic Volumes and Speeds

The microscale modeling team prepared a spatial representation of the TRANPLAN network and developed a vehicle activity data set that could be used to verify the outputs of the traffic simulation model (which would in turn be used in CALINE4 analyses). The team proceeded as follows:

1. The binary loaded-network TRANPLAN files for the years 2000 and 2015 Atlanta were converted to ASCII loaded-networks using the TRANPLAN ‘netcard.exe’ utility program.
2. The ASCII network files were converted to an ARC/INFO (GIS product by ESRI) file, using custom software developed by Georgia Tech, and subsequently projected to Stateplane coordinates (NAD 1983, Meters, Georgia West).
3. The two network files were joined to create a single GIS file containing both 2000 and 2015 estimated speeds, capacities, and daily volumes. The network spatial structure was verified (the files were identical in spatial structure except for the addition of links representing proposed post-project infrastructure changes). The 2015 network contained new links that dump project-generated trips on to Northside Drive on the west, State Street to the south, and Spring Street to the east.
4. The combined network file was then ‘conflated’ to a Georgia Department of Transportation spatially-accurate (1:24,000) road database. ‘Conflation’ is a term used to describe the transferring of attributes from one line file to another. The TRANPLAN network is designed for correct link connectivity, not for accurate spatial representation (shape points were not included between network connections). For accurate CO modeling, it is important to accurately transfer the estimated travel characteristics to an accurate spatial road network.
5. Coordinates for each node were assigned within ARC/INFO and written as attributes to each road segment as ‘from’ and ‘to’ coordinates.
6. A custom GIS software routine developed by Georgia Tech assigned roadway widths (traveled way). The 1994 Digital Ortho Quarter Quadrangle aerial photos were analyzed to

provide roadway traveled way data and an additional 3 meters was added to each side of the lane to establish the appropriate CALINE4 mixing zone widths.

7. The final road database containing ~200 road segments was written to a DBASE IV file. For each roadway link, the file attributes included x, y coordinates for link origin and destination, link capacity, daily traffic volume, peak hour average speeds, and roadway width. An excel spreadsheet was created from the database file so that peak-hour traffic volumes could be inserted and an ASCII output file appropriate for CALINE processing could be developed.
8. Daily traffic volumes were converted to peak hour volumes using information obtained from the Atlanta Regional Commission (Bachman, 1997). Peak hour factors for 7am and 7pm were set at 18% and 10% of daily traffic volumes, respectively (see Figure 2). These values should overestimate traffic volumes during these periods. For freeways, arterials, connectors, and local roads, when demand exceeded capacity, capacity volumes were assigned for the hour (it is impossible to process more traffic through the link than the capacity level). For freeways, the hourly volumes at capacity are probably underestimates. The research team believes that greater traffic volumes than predicted by TRANPLAN can be handled without significant drops in travel speed (capacity appears underestimated at 35 mph). Furthermore, the average speeds predicted by the TRANPLAN model are significantly lower than actually occur on the freeways. Hence, the microscale modeling team does not believe that the TRANPLAN model outputs should be used directly in the CALINE analyses. The assumed low average speeds significantly overestimate emission rates and will result in much higher predicted downwind concentrations than would occur at this site.
9. Each step was reviewed and verified to identify potential process errors.

TRANPLAN link coordinates, traffic volumes, and average speeds are contained in Appendix 1. An example of the loaded network can be seen in Figures 3 and 4, which provide coded link numbers and relative traffic volumes (by line thickness).

Figure 2 - Temporal Distribution of Onroad Activity

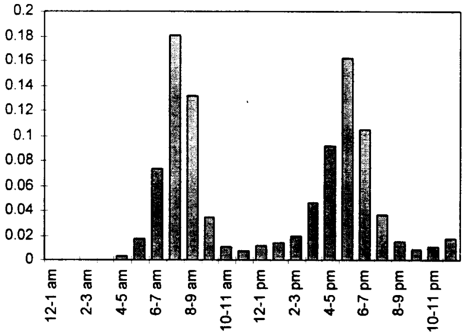


Figure 3 - Loaded TRANPLAN Network

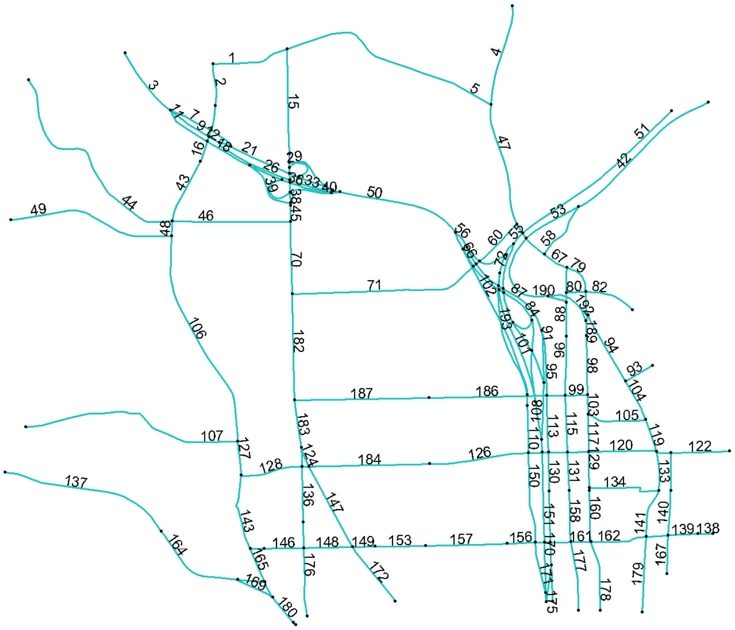
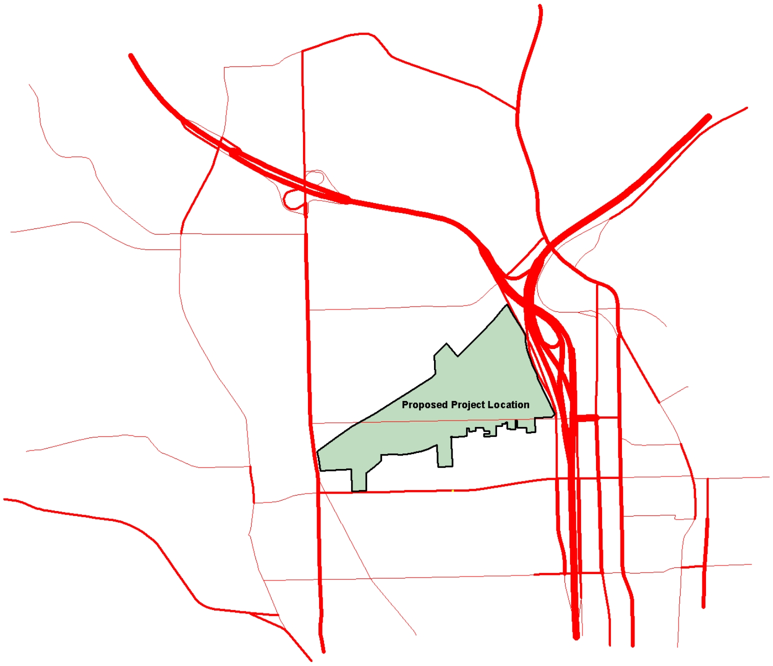


Figure 4 - TRANPLAN Network Loaded with Traffic Volumes (line width indicates relative traffic volume)



TRANPLAN Modeling Limitations

The TRANPLAN network for 2015 post-development suggested that 37,252 trips would be generated over a 24-hour weekday period. The majority of these trips were assigned to a link that heads west to Northside drive. Only 35% were assigned to the link that heads across I-75/85 to Spring Street, and 0% were assigned to State Street that heads south. Further, the assigned speed for the new road segment headed towards Northside Drive is greater than 70 mph, while the surrounding links are all in the 30 mph and less range. These coding issues may result in overestimated congestion levels on some links and underestimated congestion levels on other links.

Average travel speeds on most local roads have not been verified with an independent data source. Current conditions could be validated through monitoring of local traffic in the morning and evening peak hours using laser guns.

The TRANPLAN network shows the freeway overpass at 16th street rather than 17th street as shown in the CORSIM analyses. This will not impact traffic volume and speed predictions, but may impact the spatial allocation of emissions in microscale air quality modeling.

Moreland Altobelli, Inc. used the TRANPLAN outputs to prepare inputs to the CORSIM traffic simulation model developed for the study area (described in the next section). The TRANPLAN predictions serve as input volumes to simulation sections. The accuracy of the input volume transfer from TRANPLAN to CORSIM was not analyzed on a link-by-link basis by the microscale modeling team. As will be discussed later, there is reason to believe that the total input volumes are low. However, as will also be discussed later, the microscale modeling team does not believe that the lower traffic volumes will result in different conclusions with respect to compliance with CO standards.

CORSIM Traffic Volumes and Speeds

FHWA's CORridor SIMulation (CORSIM) model is a microscopic traffic simulation model used to predict the interaction of traffic on a computerized version of the roadway network. A network of interacting links (or roads) is coded in the model and traffic flows in and out of the network boundaries (typically taken from travel demand model outputs) are provided as input model. The CORSIM model then simulates the interactions of vehicles with network controls (signal timing) and with other vehicles (using driver behavior, car following, and lane changing theory). CORSIM combines the NETSIM model for surface streets and the FRESIM model for freeways. Traffic assignment to various routes through the network is based upon user-optimization assumptions (that users try to minimize their travel time). CORSIM is typically used to evaluate the potential traffic impacts of geometric design and signal timing improvements. A variety of other transportation strategies (such as rapid accident detection and response) are analyzed using CORSIM. More information on the CORSIM model can be found at http://www.fhwa-tsis.com/.

Moreland Altobelli, Inc., developed CORSIM modeling runs for the years 1998, 2005, and 2025. The CORSIM model employs a spatial representation of the roadway network. As such, the x, y coordinates of all roadway links are contained in the CORSIM input files provided for the various scenarios by Moreland Altobelli, Inc. The *TRAFVU* software package allows users to view and print CORSIM network links and model outputs. Figures 5 and 6 are the *TRAFVU* network prints for the baseline (1998) and future development (2005 and 2025) years. Notice that the future development years include the 17th street bridge crossing and coded freeway ramp system.

Initial traffic volumes into the network were based upon travel demand model outputs that were provided to Moreland Altobelli, Inc. by Hagler Bailly Services, Inc. The microscale modeling team double-checked these input files to ensure that proper coding was employed. The input data and assumptions were reviewed for accuracy and reasonableness for the existing conditions scenario (1998). Model output was also examined to ensure that the model had been calibrated correctly. Additionally, future scenarios (2005 and 2025) were analyzed for reasonable output.

Figure 5 - CORSIM Year 1998 Network

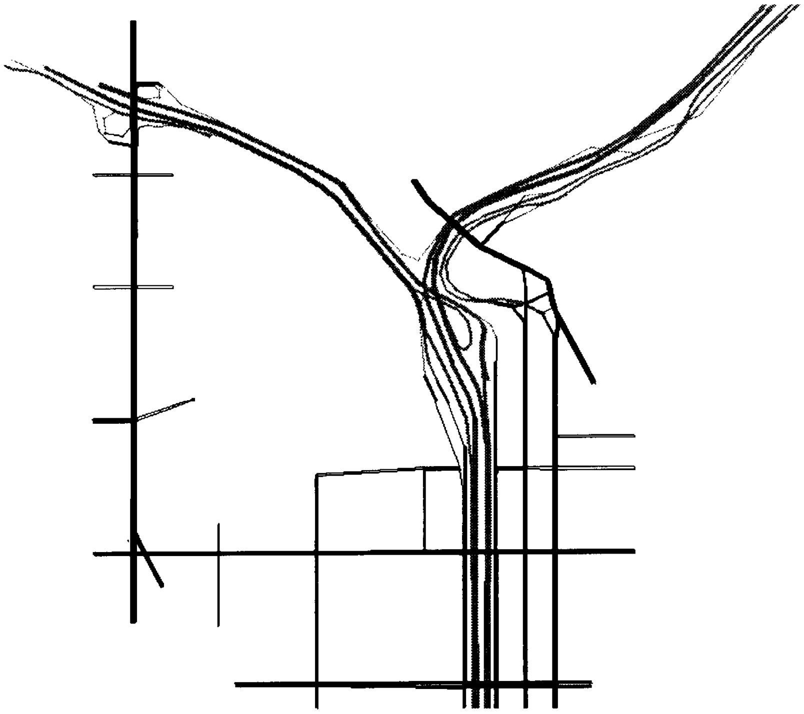
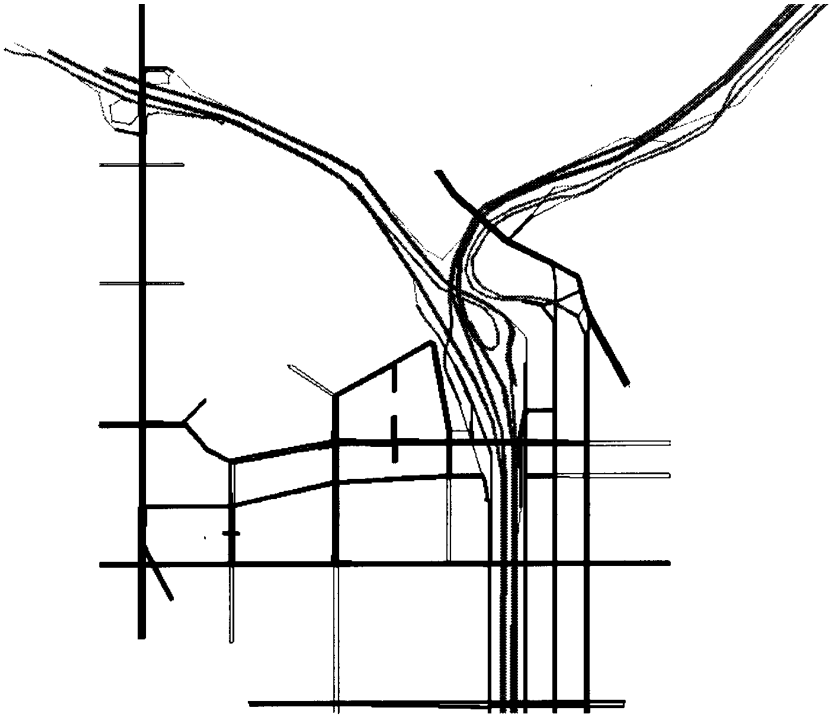


Figure 6 - CORSIM Year 2005 and 2025 Networks



Network Coding

The Atlantic Steel Development CORSIM files were reviewed for network accuracy. The base year transportation network (1998) was compared against a geographic information system (GIS) map for spatial accuracy. The GIS database map is based on a geometrically corrected TIGER file street database. The network was examined for various spatial details. First, the CORSIM network was compared against the GIS database to ensure that no discrepancies existed between the two. All major and most minor roads were represented in the CORSIM network and no significant deviations from the street database were apparent. The lengths of several non-freeway network links were compared against the street database and all actual and network lengths were found to be in agreement. One-way streets were checked to ensure that they were indeed coded as one-way streets. The only major one-way streets are Spring Street, a major southbound arterial, and West Peachtree, a major northbound arterial. Both were coded consistently.

The coded geometry of several intersections in the study network (number of lanes, presence of turning lanes and general intersection geometry) was compared to field data. All of the intersections reviewed were represented correctly in the CORSIM network. The only discrepancy is representation of grades. No grades were noted in the coded network as part of each link's geometry. In reality, a 9% grade is found on the N/S streets along Northside drive between Bishop and Bellemeade. Grades of varying degrees are found on other intersection approaches in the study area but were not accounted for in the model. Grade would affect free-flow speed and capacity. However, it is unlikely that this will have a significant impact on volume or speed outputs.

Although, there was no way to examine the geometric and spatial accuracy of the future scenarios, they were viewed TRAFVU, to make sure no obvious errors in the geometry of the network or unreasonable activity were present. No significant problems were noted and the spatial representation provided by Moreland Altobelli, Inc., is assumed to accurately reflect the project design.

CORSIM defaults were used for vehicle types, lane widths, and various other factors. No evidence suggests that this will negatively impact model output. The network was also viewed in TRAFVU and checked to identify potential visible errors, such spillback on links where spillback would not be expected, vehicles traveling the wrong way on one-way links, etc. No visible problems were noted.

Freeflow speeds for non-freeway links appear reasonable. All non-freeway links are coded between 30 and 40 mph. This assumption is reasonable given that higher volumes and short to medium distances between traffic signals characterize all of the links.

A freeflow speed of 55 mph was specified for all freeway segments. Given the excessive speeds noted in the Atlanta area, the freeflow speed assumption is low. A more reasonable estimate of freeflow speed would be around 70 mph. If traffic were flowing at freeflow speeds, the CO emissions would be underestimated using 55mph maximums (given the nature of speed-emission relationship in MOBILE5a). Fortunately, the conditions of concern in microscale modeling are morning or evening peak hour conditions when traffic flow is high and average speeds are significantly below freeflow values.

Nevertheless, improper coding of freeway link freeflow speeds also affects the CORSIM average speed predictions under more congested conditions. The impact is complex, because CORSIM employs car-following theory. That is, a car attempts to accelerate to freeflow speeds until it encounters a vehicle moving at slower speeds, at which time the car follows the lead vehicle. Hence, impacts of freeflow coding cascade through the system in a nonlinear fashion. The effects of freeflow coding differences will vary from link to link.

Signal timing cycle lengths were examined for several intersections and compared against actual signal timing collected in the field. Field data were collected either in 1997 or 1998. Table 1, below, compares actual and coded network timings. The green time for the major approach is shown as well as the signal cycle. Most of the timing plans are similar except for West Peachtree and 14th street, which has a much shorter green for the NB movement than that taken in the field. For the PM peak period, the Northbound approach has significant volumes since it is a 5 lane one-way segment. A shorter than actual green time for this result may result in reduced capacity, reducing travel speeds. This assumption will likely increase system emission rates and over-predict emissions from this link.

A potential flaw in the CORSIM network is that no pedestrian activity was indicated. Pedestrian activity exists in the downtown section including areas east of I-85 around 14th and Spring, 10th and Spring, 14th and West Peachtree, and 10th and West Peachtree. Pedestrian activity may influence capacity and average speeds. Pedestrian activity could be significant for both present conditions and the future development since the development is being designed to encourage pedestrian activity. Sections of 10th Street near Georgia Tech are also expected to experience pedestrian activity since a number of students park in the Homepark area and then walk to campus across 10th Street. In other portions of the study area, marginal pedestrian activity is expected including segments along 14th Street and Northside Drive.

Table 1: Comparison of Actual and Coded Intersection Timing

Intersection	Time Period	Green Time		Cycle Length	
		Field	CORSIM	Field	CORSIM
Spring & 16th Street SB	AM	40	60	80	90
West Peachtree & 14th NB	AM	70	40	100	120
Spring & 14th Street SB	AM	68	50	100	120
Northside & Deering NB & SB	AM	45	50	90	100
Northside & Deering NB & SB	PM	45	50	90	100

Average Speeds

CORSIM output files were examined to determine whether average speed estimates were reasonable. The existing scenario (1998) data were checked and links with speeds lower than 12 mph flagged. Once links with low average speeds were identified, their locations were compared with the network map to determine whether low reported speeds made sense logistically for these locations. All links identified as such, were either in locations were congestion was likely to occur or along links with short distances between traffic signals. These factors would be expected to cause lower than normal speeds.

CORSIM output for the AM and PM periods of the two future scenarios were also examined for excessively low or high speeds. Average speeds for non-freeway and freeway links were calculated by time period and compared across scenarios. Results are presented in Table 2. Average speeds vary only marginally from existing conditions. The only significant change is speed is that the PM average freeway link speed decreases from 39 mph in 1998 to 33 mph in 2005. The average speed then increases to 37 mph for the 2025 scenario (but should probably have decreased).

Table 2: Average Speeds by Link Category and Time Period

Scenario	Freeway Links		Non-Freeway Links	
	AM	PM	AM	PM
1998	40 mph	39 mph	19 mph	17 mph
2005	41 mph	33 mph	19 mph	18 mph
2025	39 mph	37 mph	17 mph	16 mph

The CORSIM analysis results did not depart significantly from expected average speeds. The microscale modeling team analyzed data that were collected by the Georgia Department of Transportation along the freeway corridor in question for the months of January and February 1999. The data are collected and processed using Autoscope machine vision systems in the Atlanta Traffic Operations center. Average freeway speeds are recorded in five-minute bins for each station along the route between the Brookwood interchange and North Avenue. The average of the minimum reported freeway speeds (in 5-minute bins) from all I75/85 Stations was calculated from the data. The average of the minimum reported freeway speeds along the northbound route was 50 mph between 6am and 7am, and 43 mph between 7am and 8am. The average of the minimum reported freeway speeds along the southbound route was 50 mph between 6am and 7am, and 31 mph between 7am and 8am. Given the serious congestion levels in the Atlanta region, these speeds might appear high to someone living outside the region. It is important to remember, however, that the most serious traffic bottlenecks in the region already restrict traffic flow into these freeway segments. Hence, traffic in this central freeway segment moves fairly smoothly unless there is a freeway incident that spills congestion queues into the study area. The CORSIM average 1998 average speeds may be a few mph higher than expected, but would not significantly impact the resulting microscale analyses.

Arterial Volumes

After checking for input errors, model output was examined to ensure that the model had been calibrated correctly. Actual turning movement counts were available for several intersections in the study area collected during a Georgia Tech research project between 1997 and 1998. After calculating approach arterial volumes from field data, actual versus model output arterial volumes were compared. Details are provided below in Table 3. As shown, volumes are comparable. The differences that exist may be attributed to daily fluctuations in traffic volumes. The only location of concern is West Peachtree at 15th street. A field data count yielded an hourly volume of 336 vehicles/hour (vph) for the morning peak period. The coded link for the same area in the CORSIM network was assigned a volume of 1896, a difference of 464%. West Peachtree is a 5-lane roadway heading north out of the downtown area. A volume of almost 2000 vehicles per hour seems unlikely for morning traffic in the reverse direction of peak traffic flow. With the exception of West Peachtree and 15th, the model appears to be giving reasonable volume outputs. However, the high CORSIM output volumes for West Peachtree represent a very conservative assumption in an air quality analysis which will over-predict emissions and pollutant concentrations.

Table 3: Comparison of Field and Network Coded Traffic Volumes

Location	Time Period	Field Counts	CORSIM	Percent Difference
Northside & Deering NB	AM	756	837	11%
Northside & Deering SB	AM	1446	1452	>1%
Northside & Deering WB	AM	214	198	-7%
Spring & 14th Street SB	AM	2105	2010	-5%
Spring & 16th Street SB	AM	1898	1956	3%
West Peachtree & 15th NB	**AM**	**336**	**1896**	**464%**
Northside & Deering NB	PM	1530	1734	13%
Northside & Deering SB	PM	1116	1068	-4%
Northside & Deering WB	PM	332	321	-3%
West Peachtree & 10th EB	PM	1396	1107	-21%
West Peachtree & 10th NB	PM	2164	2598	20%
West Peachtree & 10th WB	PM	928	1257	35%

Freeway Volumes

The freeway links tend to impact the CO concentration at any receptor site in the project area to a greater extent than arterials and local roads. Hence, the microscale modeling team compared the hourly traffic volumes predicted by CORSIM to those actually experienced in this corridor. To assess the adequacy of freeway traffic volume estimates, the microscale modeling team contacted Mark Demidovich of the Georgia Department of Transportation Traffic Operations Center. Although average speeds for the freeway links of concern were already available to the team via Internet access to a proprietary database, GDOT does not maintain a similar volumes database with public access. Mr. Demidovich provided traffic volumes and average speeds for the North Avenue station for December 8, 1998.

The monitored traffic volumes appear to be much higher than are currently being predicted by the CORSIM model. The maximum predicted CORSIM traffic volume at any station was 7,700 vehicles per hour (at about 22 mph average speed) at North Avenue. Traffic monitoring data indicate that the system handles more than 13,000 vehicles per hour at about 40 mph at this station. This analysis indicates: 1) the CORSIM entry volumes (feeding into the simulation) are currently set too low, and 2) Atlanta drivers are behaving akin to Los Angeles drivers with respect to gap acceptance. For the CORSIM model to predict the volumes and speeds correctly for this area, significant model calibration needs to be performed. As indicated earlier, the average speeds predicted by CORSIM are conservative and provide higher emission rates than would the higher speed estimates from monitoring data. However, the CORSIM traffic volume predictions on the freeway may be underestimated by as much as 60%.

CORSIM Model Shortcomings

The calibration findings indicate that the sponsor should undertake improved CORSIM modeling for the project. Improvements should be made to: 1) simulation entry volumes (based upon actual counts), 2) free flow speed settings, 3) pedestrian interactions, and probably 4) driver/vehicle aggressiveness settings (used in car-following equations). The 1998 CORSIM model runs should then be validated using current ground counts and speeds at various stations.

Use of CORSIM Traffic Volumes and Speeds in Microscale Analyses

Because the transportation network is spatially coded into the CORSIM input file, the x, y coordinates of the roadway links can be readily identified. A Perl script was developed to process the various CORSIM input files for each year and pull from the input files all relevant roadway link parameters. The CORSIM output files contain the predicted traffic volumes and average speeds for each network link that result from the simulation run. Another Perl script was developed to process the output files for these variables. Unfortunately, roadway widths are not employed in CORESIM modeling and are not contained in either the input nor output files. Because matching the roadway geometry of the TRANPLAN and CORSIM data files was too resource intensive (a conflation process would need to be employed) roadway widths for CALINE analyses were based upon the number of lanes multiplied by standard lane width parameters for various roadway types. An additional 3 meters was added to each side of the lane to establish the appropriate CALINE4 mixing zone width.

DEVELOPMENT OF MOTOR VEHICLE EMISSION RATES:

The approved emission rate model for use in microscale transportation analyses is the US Environmental Protection Agency's MOBILE5a model. Motor vehicle emission rates are a function of vehicle fleet characteristics, onroad operating conditions, environmental conditions, fuel characteristics, and the implementation of various regional motor vehicle emissions control programs (such as inspection and maintenance). The MOBILE5a model provides the modeling tool to predict changes in vehicle emission rates (grams/mile) as a function of changes in these conditions over time and across regions. The MOBILE5a model is designed for use in regional modeling efforts, but is also the only approved model for use in estimating vehicle emission rates along transportation corridors and for microscale air quality impact assessment.

Emission rates were developed by the microscale modeling team by running the MOBILE5a model for each scenario, using standard MOBILE5a input files provided to by USEPA regional staff. These standard files are maintained by the region and reflect Atlanta-specific vehicle fleet characteristics, fuel specifications, and inspection and maintenance program requirements. Ambient temperatures and onroad vehicle operating conditions that applied in each of the modeled scenarios were developed based upon review of local environmental parameters (discussed in the next section) and review of the travel demand and simulation model runs (discussed in the previous section). The modification of each local area parameter for use in the scenarios is summarized in Appendix 2. To predict emission rates for various average speeds, each scenario was modeled in MOBILE5a in average speed increments of 2.5 mph. Appendix 3 contains the average speed vs. vehicle emission rate matrices for each scenario, ad were used to provide emission rate inputs to microscale dispersion model runs.

DEVELOPMENT OF METEOROLOGICAL PARAMETERS:

The dispersion modeling requires inputs of realistic “near worst case” meteorological parameters to determine if violation of National Ambient Air Quality Standards (NAAQS) are likely. These inputs include wind speed and direction, temperature, humidity and mixing height. Since the most likely violations are of the carbon monoxide standard during the winter months, January conditions were selected for the analysis. Because no environmental data are available for the property itself, the research team employed data from the best available sources. Each data source was selected to represent local conditions and proximal data sources were employed whenever possible. In some cases, extrapolations account for seasonal differences or differences in topography between the sampling site and the property in question. The parameters selected for use in the analysis are provided in the various tables included in this section. The data sources, extrapolations, and impacts on CO modeling are also discussed.

Wind Conditions:

To assess the wind speed conditions at the site, meteorological data were analyzed from two urban Photochemical Assessment Monitoring Sites (PAMS) sites in the Atlanta area. The Tucker site is located in suburban northeast Atlanta. The South Dekalb site located east Atlanta. Data were considered for January conditions from 1995 to 1999 for both sites. Both sites were located within 20 km of the Atlantic Steel property and should be useful for assessing meso- and synoptic-scale wind conditions. More localized data are available from short-term studies on the Georgia Tech campus (~3 km south of the site) during the summers of 1992, 1995 and 1996. The Georgia Tech data were compared to the Tucker and South Dekalb data for the same time periods to assess the importance of smaller scale circulation patterns.

Mean Wind Speed

As expected for an urban site located away from urban canyons, the Georgia Tech data show slightly lower mean and median wind speeds for comparable periods than do the other sites. Because data from both PAMS sites indicate wind speeds at or below 1 meter/sec for more than 10 % of the time during the January period, the lower limit of accuracy for the dispersion model (1 m/sec) was used for all model runs.

Wind Speed Variability

Wind speed variability is derived from observation of the standard deviation of wind speeds over short (seconds to minutes) while the mean winds are derived from hourly averages. These data are considered unreliable if the wind speed is persistently low and at or near the limit-of-detection of the measurements. Thus for modeling purposes the standard deviation of the wind measurements is assumed to be 50% of the measurement (or modeling) limit or 0.5 meters/sec. This value is somewhat higher than that measured at the Tucker site of 0.26 meters/sec as would be expected due to the large number of “zero” reading at the Tucker site.

Wind Direction:

Wind direction data are those from the Tucker and South Dekalb PAMS sites and are for reference only since the dispersion model calculates a worst-case wind direction.

Wind Direction Variability:

Data from the Tucker PAMS site for January 1995 and January 1997 (when high time resolution data are available). These indicate a standard deviation of wind direction of 27.4 degrees for a five-minute averaging period based on one-second data. Since this is quite close to the default value or 25 degrees, the default value was used.

Wind Variable Summary:

All of the parameters in Table 4 are one to five percentile worst-case, except wind direction (median). Since wind speed is <1 m/sec for more than 10 % of the time during January the lower limit of model accuracy (1 m/sec) was used.

Table 4 - Summary of Site-Specific Wind Conditions for CALINE4 analyses

Time of Day (24 hr clock)	Wind Speed (meters/sec)	Wind Direction (degrees)	Mixing Height (meters)	Wind Variability (Std. Dev.)
1:00	1*	320	20	25 degrees
7:00	1*	285	22	25 degrees
13:00	1	235	160	25 degrees
19:00	1*	270	36	25 degrees

* A minimum wind speed of 1 meter/second is assigned due to dispersion model limitations

Temperature and Humidity

The temperature data employed in the analyses are the NOAA climatological data for "mean coldest January day" for Atlanta, GA scaled to the mean diurnal temperature profile recorded at the Tucker PAMS site and rounded to the nearest degree. Relative humidity data are the 90'th percentile for non-saturated (fog) conditions for the Tucker, GA PAMS site from 1992-1997. Table 5 summarizes the appropriate ambient temperatures used in MOBILE5a and CALINE4 modeling.

Table 5 - Summary of CALINE4 Input Temperatures

Time of Day (24 hr clock)	Temperature (Celsius)	Relative Humidity*
1:00	-10	0.9
7:00	-10	0.9
13:00	-3	0.65
19:00	-5	0.75

Dispersion Mixing Height

Mixing heights were estimated from Southern Oxidants Study data, scaled for seasonal differences. During studies in August-September 1991, July-August 1992, September 1995 and July-August 1996 approximately 65 complete tethersonde profiles of wind, temperature and dew point were recorded on the Georgia Tech campus approximately 3 km south of the site. Based on these profiles, mean boundary layer breakup time was estimated to be two hours after sunrise (~8:30 am in January) with 80% of full boundary layer height achieved 3.5 hours after sunrise (~ 10 am in January). The data periods used to evaluate each time period are given in Table 6 below.

Table 6 - Mixing Height Seasonal Adjustments

Reference Time	Profile times (actual measurement periods)	Mean Mixing Height (meters)	Seasonal Adjustment	Model Mixing Height (meters)
1:00	22:00-6:00	25	0.78	20
7:00	6:00-9:00	28	0.78	22
13:00	9:00-18:00	160	1.0	160
19:00	18:00-22:00	36	1.0	36

Because the primary data sources occur in July-September and the evaluation period is for January, seasonal adjustment is required. Adjustments are made to the 1:00 and 7:00 samples based on the ratio of the mean mixing height for February and May from a rural site in west-central Georgia (Garrettson, 1997) collected by the same tethersonde equipment. Since these measurements were made only during the evening and early morning, no corrections are applied to the daytime values. While this may represent some over-estimate of mixing height during this period, it has little practical significance due to the much lower mixing height predicted for the early morning period. These nocturnal and early morning mixing heights (20 and 22 meters) are in generally good agreement, however, with early estimates by Rodgers (1986) of between 16 and 30 meters for December conditions near the same site.

Surface Roughness

Surface Roughness was estimated using the procedure of Oke (1987) and Garratt (1977). The Logarithmic tethersonde wind profiles from the Georgia Tech campus were extrapolated to zero wind speed to produce a zero wind height. Based on this procedure, calculated zero wind heights on the Georgia Tech campus ranged from ~0 to 51 meters with an average of 18.2 meters. Zero plane displacement at the measurement site (defined as 2/3 of mean effective canopy height (Sutton (1953)) is between 14.5 and 16.8 meters, yielding an estimated surface roughness of between 1.4 and 3.7 meters. In 1991, additional data were collected at another nearby site as part of the Southern Oxidants Study Atlanta Pilot Study a tall scaffold (h=25 meters). At this more open site data were collected at five elevations (1, 3, 6, 10 and 25 meters). These data yield an estimated zero plane height of 2.9 meters with a zero plane displacement of approximately 1 meter. Surface roughness can also be inferred by empirical relationships to Mean Effective Canopy Height (MECH). Guidance from the CAL3QHC model suggests a roughness length of 15 % of MECH. Assuming that the final site plan will be dominated by buildings of height H=50 meters with an average separation (D) of 125 meters (i.e. H/D=0.4), we calculate a MECH of ~25 meters (Oke, 1978). This would correspond to a surface roughness of 3.75 meters. In practice there is likely to be a zero plane displacement of 10-15 meters and thus a surface roughness of 1.5 to 2.25 meters. These results are summarized in Table 7.

Table 7 - Estimates of Surface Roughness Length

Method	Zero Wind Level (meters)	Zero Plane Displacement (meters)	Surface Roughness (meters)	Range (meters)
Tethersonde	18.2	15.6 (14.5-16.8)	2.6	1.4-3.7
Tower	2.9	1.0	1.9	1.6-2.2
Semi-empirical	25 (MECH)	10 (0-18)	2.3	1.1-3.8
AVERAGE			**2.3**	**1.1-3.8**

Based on these results the surface roughness used in the dispersion calculations has been set to 2.3 meters (230 cm).

Background CO Concentrations

Ambient measurements of CO are very limited in the vicinity of the development site. The closest CO measurements to the site were conducted during the Georgia Tech/U.S.EPA Olympic Measurement program near the Olympic Natatorium on the Georgia Tech Campus preceding and following the Olympic games during the summer of 1996. (Measurements during the Olympics were not analyzed as being unrepresentative). These measurements give an average CO concentration of 1.27 ppmv (Grodzinsky, 1998; Pearson, J.R., 1999). These data were scaled to the ratio of winter to summer CO concentrations recorded at the Tucker PAMS site (1.6x) to yield an estimated downtown background concentration of approximately 2.0 ppmv.

MODELING PROCEDURE AND RESULTS

One set of modeling analyses, based upon a traffic simulation model, was completed for the years 1998, 2005, and 2025. For each analysis set, separate runs were made for morning and evening peak conditions (7am and 7pm). Hence, six separate scenarios are reported.

To provide the graphical output for this project, each scenario analysis requires the computation of pollutant concentration contributions from each roadway link (350+) to each receptor site (a grid of 400 receptors) for 10 wind angles (36-degree increments). Thus, each scenario run involves more than 1.4 million dispersion computations. As such, the modeling routine is computationally resource intensive. Each raw scenario requires approximately 54 hours of analysis before predictions can be plotted.

The research team developed a link screening criteria based upon pollutant flux (grams of carbon monoxide per square meter of pavement). All links contributing less than 0.5 grams/hour/meter^2 of pavement were eliminated from the analyses because they do not significantly contribute to ambient pollutant concentrations at receptor sites. This assumption was validated by running one of the modeled scenarios using only those links with a pollutant flux of less than 0.5 grams/hour/meter^2. The results demonstrated that the net contribution to pollutant concentration at all receptor sites was less than 1ppm. The analytical results indicate that a pollutant flux minimum may be a good criteria to include in tools that can be used for rapid screening analysis of proposed projects. The research team is undertaking additional research in this area to develop an optimized cutpoint for use in such analytical tool development.

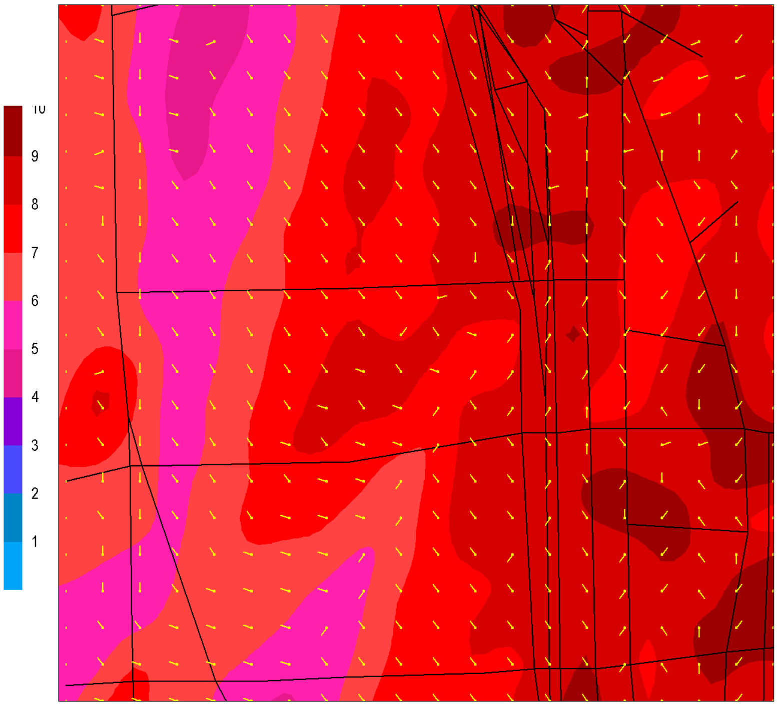
To improve the processing routine, more than half of the low volume, low emission rate links were eliminated from the analysis using the screening criteria. Before running the model, the background concentration was increased from 2ppm to 3 ppm to ensure that elimination of these minor links would not result in artificially low predictions. With the screening criteria in place, scenario analyses run in less than 24 hours.

A large ASCII output file is generated from each modeling run. The file contains a summary table of: worst case wind angle, maximum predicted CO concentration for each receptor site, and contributions from each link in the system (the standard CALINE4 output format for receptors, except that the files are very wide due to the large number of receptors analyzed). This file is then input to a graphics program developed in PERL to summarize the outputs. An isopleth chart is developed illustrating the concentration of pollutants in a topographic map format. In addition, a wind angle diagram illustrates the worst case wind angle for each receptor site in a wind rose format.

Results for the Receptor Grid

The model outputs for the year 2000 CORSIM scenario are presented in Figures 7 and 8. Figure 7 provides the topographic view of maximum pollutant concentration at each point in space. The stated maximum for each receptor location in the region can result from different wind directions and is a function of roadway geometry and emissions flux from the roadway (a function of traffic volume, emission rate, and road area). Figure 7 also illustrates the wind angle for each receptor point in space under which worst-case CO concentrations results. The graphic outputs from all 10 modeling runs are presented in Appendix 4.

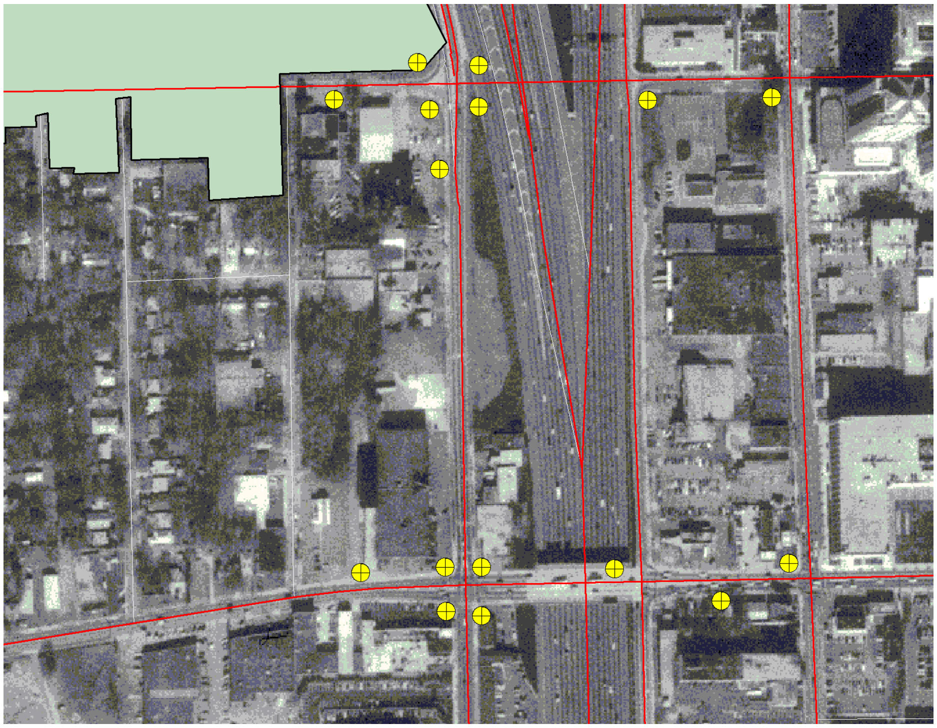
Figure 7 – Graphic Output of CALINE4 Model Run for the Year 2005 CORSIM Scenario, Illustrating Worst-Case CO Concentrations (ppm) and Wind Directions



Specific Receptor Analyses

To ensure that the receptor grid modeling approach identifies worst-case conditions, the microscale modeling team performed a second set of analytical runs using specific receptor sites of interest. Worst-case runs were performed for the CORSIM 1998 a.m. and p.m. runs (which yielded the highest CO concentrations). Receptors were placed at 3m distance from the intersections with the highest traffic volumes, to ensure that the previous grid placement did not overlook a potentially significant location (See Figure 8). One receptor was even placed on the freeway overpass (which is not required by FHWA and EPA modeling guidance). Wind angle was refined to 2-degree increments to ensure that the larger worst case wind angle increments in the receptor grid runs did not overlook a significantly elevated CO concentration prediction between wind angles. In both scenario analyses, the maximum predicted 1-hour concentration for any receptor never exceeded 9.9 ppm.

Figure 8 – Specific Receptor Locations in the Refined CALINE4 Model Run for the Year 1998 CORSIM Scenario (Maximum Predicted Concentrations did not Exceed 9.9 ppm).



CONCLUSIONS

The research team determined that the project is extremely unlikely to create a violation of ambient air quality standards for carbon monoxide in the foreseeable future. Analyses were developed for worst case morning and evening January conditions when traffic volumes are high, temperatures are cold, and meteorological conditions limit pollutant dispersion. All predicted peak one-hour carbon monoxide concentrations for all scenarios were less than 12 ppm under worst-case conditions.

The CORSIM traffic volume predictions for freeways may be underestimated by as much as 60% under the current model runs. The underestimation of traffic volumes by CORSIM impacts predicted CO emissions. Increasing traffic volumes on freeways by 60% will increase predicted CO concentrations. The increase in predicted CO concentrations is likely to be in the 3-5 ppm range. Hence the maximum predicted concentrations for the gridded receptor network should still not exceed 15 ppm.

The one-hour carbon monoxide standard is 35 ppm. Analyses were very conservative, with assumptions designed to over-predict pollutant concentrations. Given the temporal distribution of vehicle activity, decreased traffic volumes, increased travel speeds, lower emission rates, and increased pollutant dispersion after the peak hour, it is also extremely unlikely that the project will create a violation of the 8-hour standard for carbon monoxide (9ppm).

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