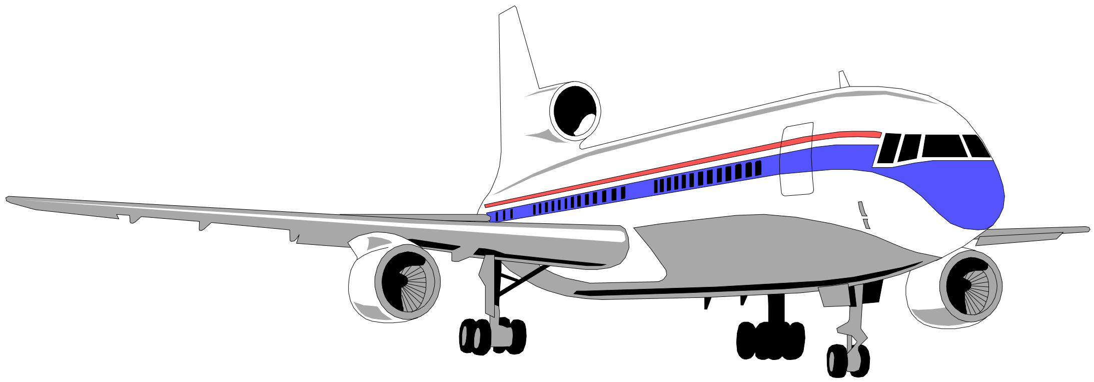
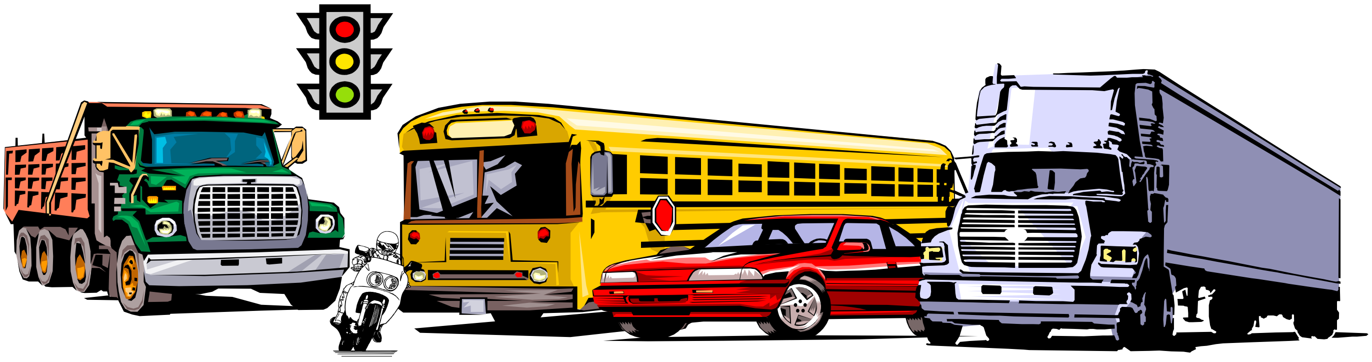


Guidelines for Evaluating the Air Quality Impacts of Transportation Facilities

North Carolina Department of
Environment and Natural Resources

Division of Air Quality
1641 Mail Service Center
Raleigh, NC 27699-1641



September 2007

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APPENDICES

GUIDELINES FOR EVALUATING THE AIR QUALITY IMPACTS OF TRANSPORTATION FACILITIES

1.0 INTRODUCTION

A "Transportation Facility" (i.e. "Complex Source") is defined in the North Carolina general statute (GS 143-213 (22)) as "any facility which is or may be an air pollution source or which will induce or tend to induce development or activities which will or may be air pollution sources, and which shall include, but not be limited to, shopping centers; sports complexes; drive-in theaters; parking lots and garages; residential, commercial, industrial or institutional developments; amusement parks and recreation areas; highways; and any other facilities which will result in increased emissions from motor vehicles".

The purpose of these guidelines is to assist developers, transportation planners, and air quality specialists in demonstrating to the Division of Air Quality (DAQ) that any air pollutant emission associated with a proposed project which falls under rules .0804, or .0805 of the North Carolina Administrative Code (NCAC) Title 15A[1] Subchapter 2D will not contribute to or cause a violation of any North Carolina Ambient Air Quality Standard for carbon monoxide.

The guidelines presented in this document may change at any time as new guidance or air quality modeling techniques become available.

1.1 NORTH CAROLINA ADMINISTRATIVE CODE Title 15A Chapter 2D

The purpose of the Transportation Facility regulations is to set forth requirements of the Commission relating to construction or modification of a Transportation Facility that may result in an ambient air quality standard being exceeded. The pertinent sections of Chapter 2D regarding these requirements are quoted as follows:

> *SECTION .0804 (Airports)* states:
> "Before constructing or modifying any airport facility designed to have at least 100,000 annual aircraft operations, or at least 45 peak-hour aircraft operations (one operation equals one takeoff, or one landing), the owner or developer of the airport facility shall

apply for and have received a permit as described in 15A NCAC 2Q .0600, and shall comply with all terms and conditions therein." Note that airfield operations at military bases are excluded from this requirement under policy established in January 1995.

SECTION .0805 (Parking Facilities) states:

(a) The owner or developer of a transportation facility shall not construct or modify a parking area (and associated buildings) until he has applied for and received a permit under 15A NCAC 2Q .0600 where the parking area is for:

(1) construction of a new or expansion of an existing parking lot or combination of parking lots resulting in a parking capacity of at least 1500 spaces or a potential open parking area of at least 450,000 square feet (1500 spaces at 300 sq. ft. per stall);

(2) modification of an existing parking lot or combination of parking lots with a parking capacity of at least 1500 spaces that will be expanded by at least 500 spaces beyond the last permitted number of spaces;

(3) construction of a new or expansion of an existing parking deck or garage resulting in a parking capacity of at least 750 spaces or a potential parking area of at least 225,000 square feet (750 spaces at 300 s per stall);

(4) modification of an existing parking deck or garage with a parking capacity of at least 750 spaces that will be expanded by at least 250 spaces beyond the last permitted number of spaces;

(5) construction of a new or expansion of an existing combination of parking lots, decks, and garages resulting in a parking capacity of at least 1000 spaces or a potential parking area of at least 300,000 square feet; or

(6) modification of an existing combination of parking lots, decks, and garages with a parking capacity of at least 1000 spaces to be expanded by at least 500 spaces beyond the last permitted number of spaces.

(b) New or modified parking lots, decks, or garages with a parking capacity of 500 or more spaces and existing or proposed parking facilities that:

(1) are directly adjacent to each other and the combined parking capacities are greater than those defined in Paragraph (a) of this Rule, and

(2) use the same public roads or traffic network,

shall be considered one lot or deck. Transportation facilities shall be considered to be directly adjacent if they are within 100 meters of each other in a suburban or rural area or 50 meters of each other in an urban area and if there are no existing physical barriers, such as, buildings or terrain. (*Note: Exclusively for the purpose of establishing if parking lots, decks, or garages are directly adjacent, transportation facilities are to be defined as the parking areas (lots or decks) themselves; therefore distance is measured between the closest parking areas within the proposed development and existing or other proposed parking areas.*)

NOTE: *The following paragraph clarifies DAQ policy concerning the above rule:*

Parking lots, decks, or garages that are connected such that a person may drive from one to another without having to travel on a public street or road shall be considered one lot or deck (see Note under 1.1 (b)(2)). Parking lots, decks, or garages of common ownership separated by a public street or road but within 150 feet of one another and with no existing physical barrier (e.g. buildings, terrain, etc.) will be considered one facility for permit and modeling purposes. Exceptions to this requirement may be made in situations where the Department of Transportation (DOT) authorities require individual facilities to connect parking areas in order to help minimize traffic congestion on public roadways in the vicinity of the facility.

(c) Temporary barriers shall not be used to reduce the capacity of an otherwise affected transportation facility to less than the amount which requires permitting. The design and plan shall clearly show the total parking capacity.

(d) Phased construction shall be evaluated and permitted for a period not to exceed five years from the date of application.

The director may require the owner or developer of the Transportation Facility to conduct air quality monitoring and perform dispersion modeling analyses to predict the impact of proposed construction or modification of a transportation facility on ambient air quality if there is a potential for the ambient air quality standard for carbon monoxide to be exceeded. Additional regulations and expanded rules may be found in 15A NCAC 2D .0800 through .0806.

1.2 NORTH CAROLINA ADMINISTRATIVE CODE Title 15A Chapter 2Q[1]

The purpose of Transportation Facility .0600 Section is to describe the procedures to be followed in applying for and issuing a permit for a transportation facility. Significant paragraphs within each section are included herein for reference. Refer to the complete regulations found in 15A NCAC 2Q .0600 through .0607 for complete information.

SECTION .0601 (Purpose)

(a) The purpose of this Section is to describe the procedures to be followed in applying for and issuing a permit for a transportation facility.

(b) The owner or developer of a transportation facility subject to the requirements of 15A NCAC 2D .0800 shall obtain a construction only permit following the procedures in this Section. An operation permit is not needed.

(c) The owner or developer of a transportation facility required to have a permit under this Section shall not commence construction or modification of a transportation facility until he has applied for and received a construction permit.

SECTION .0603 (Applications)

(a) A transportation facility permit application may be obtained from and shall be filed in writing in accordance with Rule .0104 of this Subchapter.

(b) Applicants shall file transportation facility permit applications at least 90 days before projected date of commencement of construction of a new transportation facility or modification of an existing transportation facility.

(c) A transportation facility permit application containing dispersion modeling analyses that demonstrate compliance with ambient air quality standards or traffic analyses showing a level of service of A, B, C, or D as defined in the current version of the Highway Capacity Manual, using planned roadway and intersection improvements shall include approval for the improvements from the appropriate state or municipal department of transportation.

SECTION .0604 (Public Participation)

(a) Before approving or disapproving a permit to construct or modify a transportation facility, the Director shall provide public notice for comments with an opportunity to request a public hearing on the draft permit.

(b) The public notice shall allow at least 30 days for public comments.

1.3 STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS

The State and Federal ambient air quality standards for carbon monoxide concentration values that are not to be exceeded more than once a year are as follows:

1-hour: 35 ppm or 40 mg/m^3;
8-hour: 9 ppm or 10 mg/m^3;

Any modeled concentration above 35 ppm or 9 ppm is considered a violation of the 1-hour or 8-hour standard. The modeling procedures described in this guideline are not refined enough to distinguish between an exceedance of the standard (occurrence of 1-hour or 8-hour values in excess of the standard) and a violation of the standard (occurrences of two or more exceedances per year of either standard). Therefore, a modeled exceedance of either standard is assumed to represent a predicted violation.

1.4 PERMITTING DEFINITIONS

The following terms, defined in 15A NCAC 2D[1] .0802 and 2Q[1] .0602, are routinely used in Transportation Facility permitting and modeling and are quoted as follows:

(1) Transportation Facility: any building, structure, or installation or any combination thereof which result in associated parking capacities meeting or exceeding those defined for permit requirements. Examples include but are not exclusive to parking lots, parking decks, subdivisions, stadiums, arenas, civic centers, drive-in theaters, parks, industrial complexes, commercial establishments and institutions.

(2) Construction: any activity following land clearing or grading that engages in a program of construction specifically designed for a transportation facility in preparation for the fabrication, erection, or installation of the building components associated with the transportation facility (curbing, footings, conduit, paving, etc).

(3) Modify or Modification: to alter or change the facility resulting in an increase in parking capacity as defined in Rule .0805 or the number of aircraft operations from an airport as defined in Rule .0804.

(4) Owner or developer: any person who owns, leases, develops, or controls a Transportation Facility.

(5) Level of Service (LOS): a qualitative measure describing operational conditions within a traffic stream; generally described in terms of such factors as speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, and safety.

1.5 PERMITTING POLICY

The following Transportation Facility permitting policy items should be considered when evaluating Transportation Facility permit requirements:

(1) Permittee is owner or developer.

(2) A dispersion modeling analysis may be required based on the following information: roadway geometry (multi-lane intersections), high traffic volumes, inadequate LOS (E or F), or occurrence of special events.

(3) Permit applications containing modeling analyses (when required) which demonstrate compliance using proposed roadway and intersection improvements must include approval and documentation from the owner and DOT authority that these improvements will be completed before the opening of the Transportation Facility.

1.6 AIR QUALITY ANALYSIS

A complete air quality analysis may also be required to be submitted with the Transportation Facility permit. Section 2.0 of these guidelines defines the conditions under which an air quality analysis is required. Prior to beginning any Transportation Facility air quality analysis, the project developer or consultant should submit an air quality analysis modeling plan to the DAQ. This plan should be approved by the DAQ prior to beginning the analysis. A meeting with the DAQ to discuss the data, techniques, and assumptions proposed for use in the analysis is strongly suggested. All proposed deviations from the guidelines set forth in this document must be thoroughly documented and justified. After approving the air quality analysis plan, DAQ reserves the right to require additional information to clarify the submitted analysis or to address any issues which were raised by the analysis, particularly in instances where the analysis indicates that any NAAQS may be threatened or violated. The air quality analysis should be completed well before any construction plans are finalized to allow for design changes that may be necessary to mitigate any predicted adverse air quality impacts.

The Transportation Facility permit applications should be filed at least 90 days before the projected date of construction of a new Transportation Facility or modification of an existing Transportation Facility. Review time for permit applications depends upon the complexity of the application and the workload of the permit reviewers. If additional information is needed to complete the review, the total time elapsed between receipt of the application and issuance of the permit can exceed 90 days. After being reviewed by DAQ, all proposed Transportation Facility permit applications must undergo a 30-day public comment period prior to permit issuance. If no comments are received, the permits are usually issued within 15 days after the end of the public comment period. However, if comments are received, a public hearing may be needed or additional analyses may be required, thus delaying permit issuance.

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2.0 TRANSPORTATION FACILITIES

Transportation Facilities required to have an air quality permit are identified in Section 1.1. The permit application may require a complete air quality analysis to demonstrate compliance for carbon monoxide with the National Ambient Air Quality Standards in the year of the proposed project completion.

2.1 PARKING FACILITIES

An air quality analysis is required for any Transportation Facility such as a shopping center, mall, sports arena, auditorium, park & ride transit, transportation depot, etc., which would result in:

(1) any surface parking lot equal to or greater than 1500 vehicle capacity,

OR

(2) any multilevel parking garage equal to or greater than 750 vehicle capacity,

AND

(3) a degradation of the current level-of-service (LOS) at any nearby roadway and intersection to "E" or "F" by the year of completion of the project,

OR

(4) a nearby intersection with a current LOS of "E" or "F".

(5) Any Transportation Facility that supports special event scenarios (i.e. concerts, sporting events, etc.), since the LOS cannot be accurately determined for manually controlled intersections (i.e. police, parking attendants, etc.).

The LOS measures the operating conditions in the intersection and how these conditions affect traffic flow and delay. The Highway Capacity Manual[2] (HCM) defines the LOS as "a measure of driver discomfort, frustration, fuel consumption and increased travel time." In some instances, intersections that operate at LOS "D" or better may have to be modeled due to existing lane configuration and traffic volume or if an ambient monitor near the proposed Transportation Facility shows a recent (within 3 years) violation of the CO standard. Modeling requirements for these intersections will be determined on a case-by-case basis. Modeling for all Transportation Facilities should be expanded to include adjacent parking facilities as well as those within a radius of 150 meters and should include intersection modeling of the nearby (impacted) intersections that may cause or contribute to a potential CO exceedance of the NAAQS. "Nearby" is defined as:

(a) urban or central business district: all intersections within 150 meters or one block, whichever is less, of the proposed transportation facility.

(b) suburban or rural environment: all intersections within 150 meters and all intersections clearly affected by the proposed transportation facility. (NOTE: the main intersection servicing the facility may be located well beyond 150 meters but should still be evaluated).

2.2 AIRCRAFT OPERATIONS

An air quality analysis is required for any airport* expected to have

(1) 100,000 or more annual aircraft operations

<u>OR</u>

(2) 45 or more peak-hour aircraft operations (one operation equals one take-off or one landing).

The air quality analysis includes evaluation of CO emissions from aircraft, support vehicles, and vehicle traffic within and around the airport in addition to modeling parking area emissions and emissions at signalized intersections in the vicinity of the airport that operate at an unacceptable LOS ("E" or "F").

* Military bases are excluded from this requirement.

3.0 ROADWAY AND INTERSECTION MODELING

The first step for evaluation of the air quality impact of a parking facility is to determine the level-of-service (LOS) of intersections affected by the new Transportation Facility. The following section explains the Division of Air Quality's requirements for the LOS analyses. (NOTE: These analyses differ from those required by the North Carolina Department of Transportation).

3.1 LEVEL-OF-SERVICE (LOS) GUIDANCE

A LOS analysis will be required for all intersections impacted by additional traffic generated by the modification or construction of any Transportation Facility. A pre-application meeting is suggested so that intersection and traffic concerns can be discussed. Use the following recommendations in preparation of the LOS analyses:

a) ***Traffic Volumes***

i) Background traffic volumes should be obtained from North Carolina Department of Transportation (NCDOT) or appropriate municipal DOT and should be less than five years old. If no recent data exists, counts should be performed at all intersections affected by the project.

ii) If no specific growth rate is available from the DOT authority, background traffic counts should be increased by at least 3% per year from the year the traffic counts were taken to the year the facility is planned to begin operation.

iii) Background traffic volumes must include traffic from nearby facilities as well as any facilities proposed to be built within one year of the opening of the subject facility.

b) ***Trip Generation***

i) Trips in and out of the facility must be calculated using the most recent edition of the Trip Generation Manual[3].

ii) Generally, for non-retail transportation facilities, a trip generation analysis should be conducted for the AM and PM peak hours during the weekday.

iii) If the facility to be permitted is a retail establishment (shopping center or mall, etc.), the trip generation must be conducted for the Christmas Season, either weekday PM peak or Saturday, whichever time period is expected to result in higher total traffic volumes.

c) LOS Analyses

i) Conduct LOS analyses following NCDOT or municipal DOT guidelines for signal design. Signal timing (phases, all-red times, etc.) must comply with the standards of the NCDOT or the municipality in which the project is located.

ii) Present HCM LOS results regardless of what traffic evaluation software is used.

iii) The LOS analyses must be conducted for the opening year of the facility. If the project has a phased construction and operation plan, conduct a LOS analysis for the opening year of each phase, unless the phases are planned to open less than one year apart. Phased construction will be evaluated and permitted for a period not to exceed 5 years from the date of permit issuance.

iv) LOS analyses must be based on the worst-case total traffic volumes (background and site) and must account for traffic from other nearby traffic generators.

d) Reporting

i) If an acceptable LOS is demonstrated (A, B, C or D) based upon modifications to roadway geometry, traffic flow or signalization, submit written approval and documentation from the owner and DOT authority that these improvements will be completed before the opening of the transportation facility.

ii) If the facility is complex with many parking lots/decks, submit a plan (map and/or table) that separately identifies each parking area with a unique name, number or letter and the number of spaces in each lot.

iii) Along with the LOS analysis summaries, also submit raw traffic counts, assignment and distribution data, trip generation tables, and a detailed description of the project including location and parking area maps. Be sure to clearly identify any laneage modifications, signal improvements, etc. that were considered in the LOS analyses.

If the LOS of all intersections impacted by the project remain at a LOS "D" or better in the year that the proposed transportation facility begins operation, then a permit usually can be granted based upon the LOS determination alone. However, if a LOS "E" or "F" is expected at any of the evaluated intersections in the opening year of the facility, the second step in determining compliance with the NAAQS for CO is to conduct intersection and parking area air quality modeling. The following sections describe the modeling methodologies to determine motor vehicle emission factors and concentrations in the vicinity of the proposed transportation facility.

3.2 EMISSION FACTORS

Carbon monoxide (CO) emission factors for motor vehicles are generated using the MOBILE6[4] emission model (released October 2002) developed by the U.S. Environmental Protection Agency, Office of Transportation and Air Quality. MOBILE6 is a computer program that calculates emission factors for hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and other byproducts of gasoline, diesel, and natural gas fueled highway motor vehicles. Mobile6 represents a significant enhancement to mobile source modeling and supercedes MOBILE5a[5]. A detailed discussion of these enhancements and MOBILE6 can be found in the EPA User's Guide to MOBILE6 (EPA420-R-02-028). The latest model and guidance manual may be downloaded through EPA's Office of Transportation and Air Quality internet site at http://www.epa.gov/otaq/m6.htm.

3.2.1 MOBILE6 Input Parameters

Input parameters for the MOBILE6 model are discussed in detail in the EPA guidance referenced above. The North Carolina recommended MOBILE6 temperature inputs are listed in Appendix A of these guidelines. Contact DAQ for additional guidance and recommendations.

3.3 RECOMMENDED DISPERSION MODELS

The guidance contained in this section is applicable to the modeling of roadways and intersections separately or in combination with each other.

3.3.1 CAL3QHC (Version 2)

The recommended model for the simple roadway and signalized intersection case is CAL3QHC (Version 2)[6]. CAL3QHC is a microcomputer-based model to predict carbon monoxide (CO) and other pollutant concentrations from motor vehicles at roadway intersections. The model includes the CALINE-3 line source dispersion model[7] and a traffic algorithm for estimating vehicular queue lengths at signalized intersections. CAL3QHC requires all the inputs required for CALINE-3 including: roadway geometries, receptor locations, meteorological conditions and vehicular emission rates. In addition, several other parameters are necessary, including signal timing data and information describing the configuration of the intersection being modeled. CAL3QHC can accommodate up to 120 roadway links, 60 receptor locations, and 360 wind angles. The recommended input parameters and an example input file are detailed in Appendix B. For further information on CAL3QHC, refer to the CAL3QHC User's Guide[8] available online at EPA's website http://www.epa.gov/scram001/dispersion_prefrec.htm#cal3qhc. Use of any other modeling techniques must be approved by DAQ in writing. This approval may cause considerable delay to the project due to the time required by the DAQ to evaluate the alternative technique (model). Use of other models may also require the applicant to submit to the DAQ any software and documentation which the DAQ may need to duplicate the applicant's results.

CAL3QHCR is an enhanced version of CAL3QHC that allows processing of up to one year of meteorological data. CAL3QHCR calculates running 8-hour and 1-hour averaged CO concentrations while CAL3QHC only prints maximum hourly averages. Use of CAL3QHCR for intersection modeling will be evaluated on a case-by-case basis.

3.4 RECEPTOR LOCATIONS

Considerable thought must be given to placing receptors at potential areas of routine public access anywhere beyond 3 meters from the traffic lane. Receptors for which 8-hour averages are valid will be subjective and will vary from case to case.

3.4.1 Limited-Access Highways with Fenced Right-of-Way

Locate receptors perpendicular to the end points of each link, 1.8 meters above ground, and at the fence line.

3.4.2 Roadways (Other Than Limited-Access Highways)

Locate receptors perpendicular to the end points of each link, 1.8 meters (6 ft) above ground, and at the following distances from the edge of the outside traffic lane:

(1) actual distance to the nearest sidewalk, parking lot, or building but not less than 3 meters (10 ft). For a building, use actual distance minus 1 meter.

(2) 3 meters for any area where a sidewalk, parking lot, or building could be located or allowed but currently not in place.

(3) the closest distance to which the public has routine access but not less than 3 meters. A 20 meter wide publicly maintained vegetative buffer zone alongside a roadway represents an area not intended for routine public access. In this case, the receptor would be located at a distance of 20 meters. A railroad right-of-way or drainage ditch are other examples of roadside areas which routine public access is not intended.

3.4.3 Intersections

Locate receptors the same as for roadways except that receptors should be placed perpendicular to and along the full length of each queuing link to include the beginning, middle, and end of the queue.

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4.0 PARKING AREA MODELING

This section describes the modeling recommendations for parking areas (lots, garages, etc).

4.1 RECOMMENDED MODEL

The recommended model for both surface and multilevel parking facilities is PAL2.1[8] (Point, Area, Line Source model). The recommended input parameters for PAL2.1 are discussed in the following sections and an example of an input file can be found in Appendix C.

4.1.1 Parking Lot Configuration

For multilevel parking decks, treat each deck as a separate area source with an emission height equal to the height of the deck above ground level. For surface parking lots, use as many rectangular areas as are necessary to represent the shape of the parking lot and any non-emitting areas (building or non-parking spaces) within it. Any driveways or entrances into the parking area should be modeled as a line source in the PAL model.

4.1.2 Emission Rate

For multilevel parking decks and surface lots, compute emission rates following the steps given in Appendix D to this document. For surface parking lots, calculations would be completed only for level one. For non-emitting areas within the parking lot, set the emission rate equal to the negative of the emission rate of the emitting areas.

4.1.3 Initial Dispersion Parameters

Input the initial dispersion parameters as sigma-y_0 = 3 meters and sigma-Z_0 = 1.5 meters.

4.1.4 Detailed PAL inputs

A full description of the input data requirements for PAL is given in the User's Guide for PAL2.1[8]. For some of the inputs common to all types of sources (i.e.

point, area, line, etc.), the DAQ recommended input values are as follows:

a.	Card 2 :	PINA, PINL = .02
b.	Card 3 :	IUZP, IUZA, IUZH, IUZC, IUZS, IUSE = 1
c.	Card 4 :	IURB = 1 (Rural or suburban) = 2 (CBD) IDEP = 1 W = 0.0 VD = 0.0 UHGT = Height of anemometer (10 meters) HMIN = 10.0 (Wind constant below this height) HMAX = 10.0 (Wind constant above this height) UMIN = 1.0
d.	Card 5 :	SYOP = 0.0 SZOP = 0.0 NOTE: If point sources (ie. vents, stacks) are located on or near a building, consider using the following: SYOP = .35 x building width SZOP = .7 x building height
e.	Card 7 :	SYO = 3.0 SZO = 1.0 Sources Use the initial dispersion parameters listed in table 6-5.
f.	Card 8 :	SIYO = 3.0 SIZO = 3.0
g.	Card 9 :	SYOS = 3.0 SZOS = 1.0
h.	Card 10:	SIYA = 3.0 SIZA = 1.0
i.	Card 11:	ZR = 1.8
j.	Card 12:	WTHET = 0 to 360^0 in 10^0 increments refined to 1^0 increments at +/- 10^0 of the radial predicting maximum concentration WU = 1.0 MKST = 4 (CBD/Suburban) = 5 (Rural) WHL = 400 WTA = 273

4.2 RECEPTOR LOCATIONS

4.2.1 Surface Parking Lots

Locate receptors at the edge of the parking lot to include at least one receptor at the diagonal edge, 1.8 m (6 ft) above ground, and at points surrounding an irregularly shaped parking lot that are suspected to represent points of maximum concentration. In most cases, receptors located at the edge of a parking lot such that the wind with the upwind axis from the receptor running through the geometric center of the parking lot will give the highest impact.

4.2.2 Multilevel Parking Decks

Locate receptors at those directions and distances away from the edge of the structure that are suspected to represent points of maximum concentration. However, no receptor should be located within any roadway or intersection emission link.

4.3 CONVERSION FACTOR

Carbon monoxide concentrations from model output are given in grams/cubic meter. To convert to parts per million (ppm) use the following conversion:

$$\mathbf{CO\ (ppm) = C \times (0.02447/28.01) \times 1\ million\ (1 \times 10^6)}$$

where: C = concentration in g/m^3
0.02447 = conversion factor incorporating standard temperature
28.01 = molecular weight of Carbon Monoxide

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5.0 METEOROLOGICAL CONDITIONS

For all types of analyses (roadway, intersection, and parking area), the recommended meteorological parameters for input to the appropriate air quality models are as discussed below.

5.1 Stability Class

For the central business district (CBD) and similar densely built-up areas and large airports (e.g. Charlotte, Greensboro, and Raleigh-Durham), as well as suburban and urban areas use Class D. For rural areas use Class E. The CBD is defined as that portion of a municipality for which the dominant land use is intense business activity. This district is characterized by large numbers of pedestrians, commercial vehicle loadings of goods and people, a heavy demand for parking space, and high parking turnover. The stability class may also be impacted by the time of day analyzed. For the hours between 1 pm to 9 pm, Class D is recommended. However, from 4pm to midnight, an analysis might use Class E (except in CBD).

5.2 Wind Speed

Use a wind speed of 1.0 m/s.

5.3 Wind Direction

Thirty-six wind directions (every 10°) should be used for the initial modeling analysis. The receptor with the maximum concentration should be remodeled with twenty wind directions (every 1°) centered on the maximum wind angle. For example, the initial modeling analysis shows that the maximum concentration at receptor X occurs at 120 degrees, therefore, additional modeling should be conducted for the wind directions varying from 111 to 129 degrees (every 1°) to locate the maximum concentration.

5.4 Mixing Height

Use 1000 meters.

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6.0 RESULTS

The recommended models for roadways, intersections, and parking facilities discussed in previous sections should be used. Parameter settings should be consistent with the guidelines for each model used. Receptors should be located appropriately for each type of traffic facility with concentrations combined at each such receptor for every facility modeled (e.g. intersection and parking deck).

6.1 PERSISTENCE FACTOR

To account for the variation in traffic and meteorological conditions over time, a persistence factor is used to convert the 1-hour worst-case modeling results to a predicted 8-hour average concentration. A discussion and list of the appropriate persistence factors by specific region are given in Appendix E. The 8-hour persistence factors presented in Table E1, were calculated for seven North Carolina regions using 2000-2002 CO monitoring data following the guidance provided in EPA 454/R-92-005 "Guideline for Modeling Carbon Monoxide from Roadway Intersections" [9], section 4.7.2. For areas not within a region with actual monitoring data, an 8-hour persistence factor of 0.79 should be used. If 8-hour concentrations are determined by modeling 8-hour traffic counts in areas not within a region with actual monitoring data, weather variability can be accounted for by using a persistence factor of 0.85.

6.2 BACKGROUND CONCENTRATIONS

1-hour and 8-hour CO background concentrations are added to the maximum modeled 1-hour and 8-hour CO modeled concentrations, the sum of which is then compared to the CO NAAQS to determine facility compliance. 1-hour and 8-hour CO background concentrations were calculated for seven North Carolina regions using 2000-2002 CO monitoring data. A discussion and list of the appropriate background concentrations by specific region are given in Appendix E.

For areas not within a region with actual monitoring data, the average 1-hour and 8-hour background concentrations are used. If local CO monitoring data are available (either DAQ data or DAQ-approved outside data), an area-specific background value may be used.

Representativeness of the data depends on such factors as proximity of the monitor to the source and receptor locations and must be determined on a case-by-case basis.

6.3 COMBINING MAXIMUM CONCENTRATIONS

To determine the total effect of the transportation facility on the ambient air, the results from both modeling exercises (CAL3QHC and PAL) must be combined and added to the appropriate background concentration. In most cases, the impacts of the parking area (PAL) modeling will be smaller than those from the intersection (CAL) modeling, but the combination of the two is the final predicted combination. For a very conservative estimate of the maximum CO concentration, the maximum PAL result may be added to the maximum CAL result (with no regard for the wind directions) and then added to the background concentration. If a potential violation of the NAAQS is found, then the combination of receptors may be further refined to include specific receptor locations with corresponding wind directions. If the combination of the two results, regardless of wind direction, causes a predicted violation of the NAAQS, a more refined receptor grid will need to be included in the modeling.

7.0 AIRPORT MODELING

This section discusses some of the techniques that may be used for estimating emissions and impacts from sources of carbon monoxide from airports. These sources may include passenger vehicles, taxis, buses, aircraft, ground support equipment, auxiliary power units, stationary sources and training fires. Ground support equipment includes, but is not limited to; freight tugs, belt loaders, fuel trucks, air conditioning/heating trucks, water trucks, catering trucks, and lavatory trucks.

7.1 RECOMMENDED MODEL

The Federal Aviation Administration's (FAA) Emissions & Dispersion Modeling System (EDMS) is the recommended model for determining aircraft and ground support vehicles in an airport environment. Additional information concerning the EDMS modeling program can be found at http://www.faa.gov/about/office_org/headquarters_offices/aep/models/edms_model/ .

7.2 RECEPTOR LOCATIONS

Receptors should be located appropriately for each type of source at the airport with concentrations summed at each such receptor for every facility modeled. Generally, receptors should be located at passenger gates, ventilation intakes, and at passenger drop-off points at terminal buildings. Receptors should also be located near intersections and parking facilities following the same guidance discussed in Sections 3.4 and 4.2. To determine the point of maximum concentration for the combination of facilities, additional receptors should be placed based on professional judgment.

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8.0 REPORTING

All modeling analyses should be fully documented to allow for thorough and efficient review. Complete documentation regarding all issues involved in the analysis will usually result in faster reviews, thereby avoiding delays in permit issuance. The permit application package should be submitted at least 90 days before construction at the facility is scheduled to commence and should contain the following information in addition to the permit review fee of $400 made payable to the NC Division of Air Quality:

1. Detailed maps showing project location and layout as well as individual parking areas, line sources, intersections, traffic signal locations, all emission points and receptors, proposed lane additions or modifications, and the grid overlay used in the modeling analysis.

2. Include all data related to any LOS analyses performed for this project as described in Section 3.1, page 13 of this document.

3. Description of the emission calculation procedures used and a specific example of each procedure for any given scenario.

4. Printouts and electronic files of MOBILE6, CAL3QHC and/or PAL input and output. For EDMS, input and output files in electronic format are required.

5. Receptor location descriptions.

6. Tables showing coordinates for all emission sources and receptors.

7. Provide the data and explain all calculations/methods used in analysis.

8. Present the maximum 1-hour and 8-hour concentrations (including background) at each receptor point in tabular format.

9. Completed transportation facility permit application forms. These forms should be completed for each source (lot/deck) in the project.

10. Three copies of the final report including all of the above data should be submitted to the DAQ. Two copies are acceptable if the facility is located in one of the following counties: Chatham, Durham, Edgecombe, Franklin, Granville, Halifax, Johnston, Lee, Nash, Northampton, Orange, Person, Vance, Wake, Warren or Wilson.

DAQ may request additional information necessary for complete evaluation of the analysis.

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9.0 REFERENCES

1. "North Carolina Administrative Code, Title 15A, Department of Environment, Health, and Natural Resources, Chapter 2, Environmental Management", Environmental Management Commission, Raleigh, NC, amended March 8, 1994.

2. Transportation Research Board, Highway Capacity Manual, National Research Council, Washington, DC, 2000.

3. Institute of Transportation Engineers, Trip Generation, An Informational Report, Sixth Edition, ITE, Washington, D.C., 1997.

4. U.S. Environmental Protection Agency, User's Guide to Mobile6 (Chapter 2) (Mobile Source Emissions Model), U.S. EPA, Ann Arbor, MI, 2002.

5. U.S. Environmental Protection Agency, User's Guide to Mobile5a (Mobile Source Emissions Model), EPA 460/3-84-002, U.S. EPA, Ann Arbor, MI, 1993.

6. U.S. Environmental Protection Agency, User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections, EPA-454/R-92-006, US EPA, Research Triangle Park, NC, 1992.

7. Benson, P., CALINE-3 - A Versatile Dispersion Model for Predicting Air Pollutant Levels Near Highways and Arterial Streets, FHWA/CA/TL-79/23, Office of Transportation Laboratory, California DOT, Sacramento, CA, 1979.

8. Peterson, W.B. and E. Diane Rumsy, User's Guide for PAL 2.0, A Gaussian-Plume Algorithm for Point, Area, and Line Sources, EPA/600/8-87/009, Atmospheric Sciences Research Laboratory, Office of Research and Development, U.S. EPA, Research Triangle Park, NC, 1987.

9. U.S. Environmental Protection Agency, Guideline for Modeling Carbon Monoxide From Roadway Intersections, EPA-454/R-92-005, US EPA, OAQPS, Research Triangle Park, NC, 1992.

10. U.S. Environmental Protection Agency, Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Evaluating Indirect Sources, EPA-450/4-78-001, US EPA, Office of Air, Noise, and Radiation, OAQPS, Research Triangle Park, NC, 1978.

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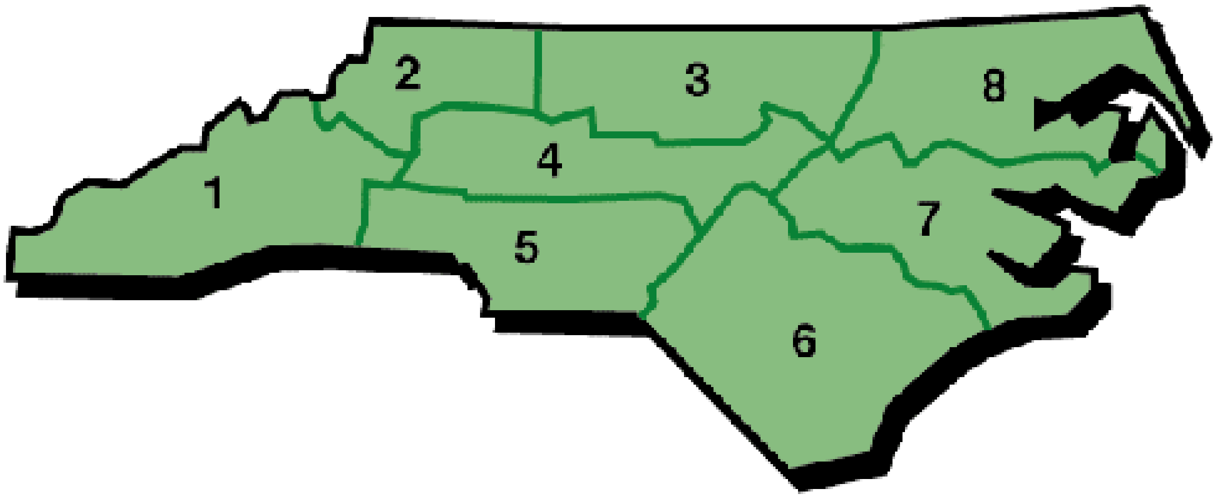
APPENDIX A

<u>MOBILE6 Input Parameters</u>

A.1 TEMPERATURE DATA FOR MOBILE6 MODELING



Climatological Region	Counties	Temperature*
1 Southern Mountains	Buncombe, Burke, Cherokee, Clay, Graham, Haywood, Henderson, Jackson, Macon, Madison, McDowell, Mitchell, Polk, Rutherford, Swain, Transylvania, Yancey	36.5°F
2 Northern Mountains	Alleghany, Ashe, Avery, Caldwell, Surry, Watauga, Wilkes, Yadkin	33.5°F
3 Northern Piedmont	Alamance, Caswell, Durham, Forsyth, Franklin, Granville, Guilford, Orange, Person, Rockingham, Stokes, Vance, Warren	38.1°F
4 Central Piedmont	Alexander, Catawba, Chatham, Davie, Davidson, Iredell, Lee, Randolph, Rowan, Wake	38.9°F
5 Southern Piedmont	Anson, Cabarrus, Cleveland, Gaston, Lincoln, Mecklenburg, Montgomery, Moore, Richmond, Stanly, Union	40.3°F
6 Southern Coastal Plain	Bladen, Brunswick, Columbus, Cumberland, Duplin, Harnett, Hoke, New Hanover, Onslow, Pender, Robeson, Sampson, Scotland	43.5°F
7 Central Coastal Plain	Beaufort, Carteret, Craven, Greene, Hyde, Johnston, Jones, Lenoir, Pamlico, Pitt, Wayne, Wilson	42.8°F
8 Northern Coastal Plain	Bertie, Camden, Chowan, Currituck, Dare, Edgecombe, Gates, Halifax, Hertford, Martin, Nash, Northampton, Pasquotank, Perquimans, Tyrell, Washington	41.6°F

* Climatological Region Map and 1971-2000 Average January Temperature from the National Oceanic and Atmospheric Administration, National Climatic Data Center

APPENDIX B

INPUT REQUIREMENTS FOR CAL3QHC VERSION 2

B.1 INTRODUCTION

CAL3QHC is a versatile dispersion model for predicting air pollutant levels along roadways and intersections and is the recommended model for evaluating the impacts of carbon monoxide at these locations. CAL3QHC is an EPA modified version of CAL3Q - Line Source Dispersion Model. The following section lists and briefly summarizes the input requirements for CAL3QHC. The "format" description of each variable is explained in Table B2.

B.2 CAL3QHC INPUT REQUIREMENTS

LINE #	VARIABLE NAME	FORMAT	COLUMNS	VARIABLE DESCRIPTION
1	JOB	A40	1-40	Current job title.
	ATIM	F4.0	41-44	Averaging time [min].
	ZO	F4.0	45-48	Surface roughness [cm] (fromTable B.3)
	VS	F5.0	49-53	Settling velocity [cm/s].
	VD	F5.0	54-58	Deposition velocity [cm/s].
	NR	I2	59-60	Number of receptors, max=60.
	SCAL	F10.4	61-70	Scale conversion factor [if units are in feet enter 0.3048, if they are in meters enter 1.0].
	IOPT	I1	75	Metric to English conversion in output option. Enter "1" for output in feet. If left blank, the output will be in meters.
	IDEBUG	I1	80	Debugging option. Enter "1" for this option which will cause the input data to be echoed onto the screen. The echoing process stops when an error is detected.
2	RCP	A20	1-20	Receptor name

LINE #	VARIABLE NAME	FORMAT	COLUMNS	VARIABLE DESCRIPTION
	XR	F10.0	21-30	X-coordinate of receptor.
	YR	F10.0	31-40	Y-coordinate of receptor.
	ZR	F10.0	41-50	Z-coordinate of receptor
*** Repeat line 2 for NR (number of receptors) times ***				
3	RUN	A40	1-40	Current run title
	NL	I3	41-43	Number of links, max=120
	NM	I3	44-46	Number of meteorological conditions (unlimited). Each unique wind speed, stability class, mixing height, or wind angle range constitutes a new meteorological condition.
	PRINT2	I2	49-50	Enter "1" for the output that includes the receptor-link matrix tables (Long format), enter "0" for the summary output (Short format).
4	IQ	I3	1-3	Enter "1" for free flow and "2" for queue links.
**** Enter lines 5a and 5b for IQ=2 (queue link). ****				
**** Enter line 5c for IQ=1 (free flow link) ****				
5a	LNK	A20	1-20	Link description
	TYP	A2	21-22	Link type. Enter "AG" for "at grade" or "FL" for "fill", "BR" for "bridge" and "DP" for "depressed".
	XL1	F7.0	23-29	Link X-coordinate for end point 1 at intersection stopping line.
	YL1	F7.0	30-36	Link Y-coordinate for end point 1 at intersection stopping line.
	XL2	F7.0	37-43	Link X-coordinate for end point 2.
5a	YL2	F7.0	44-50	Link Y-coordinate for end point 2.

LINE #	VARIABLE NAME	FORMAT	COLUMNS	VARIABLE DESCRIPTION
	HL	F8.0	51-58	Source height.
	WL	F4.0	59-62	Mixing zone width.
	NLANES	I4	63-66	Number of travel lanes in queue link.
5b	CAVG	I5	6-10	Average total cycle length [s].
	RAVG	I5	16-20	Average red total signal cycle length [s].
	YFAC	F5.1	26-30	Clearance lost time (portion of the yellow phase that is not used by motorist) [s].
	IV	I5	31-35	Approach volume on the queue link [veh/hr].
	IDLFAC	F7.2	36-42	Idle emission factor [g/veh-hr].
	SFR	I4	44-47	Saturation flow rate [veh/hr/lane].
	ST	I1	49	Signal type. Enter "1" for pre-timed, "2" for actuated, "3" for semi-actuated. ***Default is "1."***
	AT	I1	51	Arrival rate. Enter "1" for worst progression, "2" for below average progression, "3" for average progression, "4" for above average progression, "5" for best progression. ***Default is A3".***
5c	LNK	A20	1-20	Link description.
	TYP	A2	21-22	Link type. Enter "AG" for "at grade" or "FL" for "fill," "BR" for "bridge" and "DP" for "depressed".
	XL1	F7.0	23-29	Link X-coordinate for end point 1.
	YL1	F7.0	30-36	Link Y-coordinate for end point 1.
	XL2	F7.0	37-43	Link X-coordinate for end point 2.
	YL2	F7.0	44-50	Link Y-coordinate for end point 2.

LINE #	VARIABLE NAME	FORMAT	COLUMNS	VARIABLE DESCRIPTION
	VPHL	F8.0	51-58	Traffic volume on link [veh/hr].
	EFL	F4.0	59-62	Emission factor [g/veh-mi].
	HL	F4.0	63-66	Source height.
	WL	F4.0	67-70	Mixing zone width.
*** Repeat lines 4 and 5 for NL (number of links) times ***				
6	U	F3.0	1-3	Wind speed [m/s].
	BRG	F4.0	4-7	Wind angle (0-360 degrees, 0=positive Y axis). Enter 0 if angle variation data follow. Enter actual wind angle, if only one wind angle will be used.
	CLAS	I1	8	Stability class.
	MIXH	F6.0	9-14	Mixing height [m].
	AMB	F4.0	15-18	Ambient background concentration [ppm].
	VAR	A1	19	Enter "Y" if angle variation data follow. Enter "N" if only one angle [BRG] will be considered.
	DEGR	I3	20-22	Increment angle [degrees].
	VAI(1)	I3	23-25	Lower boundary of the variation range(First increment multiplier).
	VAI(2)	I3	26-28	Upper boundary of the variation range (Last increment multiplier).
*** Repeat line 6 for each time that new meteorological conditions are to be run ***				

DESCRIPTION OF TYPE OF VARIABLES

VARIABLE FORMAT	TYPE	EXPLANATION *
Ax	CHARACTER	Input a string that has a maximum of "x" number of characters.
Ix	INTEGER	Input an integer that has a maximum of "x" number of digits. The integer should be right justified, e.g., I3:-12.
Fx.y	REAL	Input a real number that consists of a total of "x" digits (including the decimal point). The real number can have up to "x-1" digits to the right of the decimal point, e.g., F8.3:-234.156.

(*) The symbol "-" denotes a blank space.

B.4 SURFACE ROUGHNESS LENGTHS (Z_o) FOR VARIOUS LAND USES

Type of Surface	Z_o (cm)
Smooth desert	0.03
Grass (5 - 6 cm)	0.75
Grass (4 cm)	0.14
Alfalfa (15.2 cm)	2.72
Grass (60 - 70 cm)	11.4
Wheat (60 cm)	22.0
Corn (220 cm)	74.0
Citrus orchard	198.0
Fir forest	283.0
City Land Use	
Single family residential	108.0
Apartment residential	370.0
Office	175.0
Central business district	321.0
Park	127.0

APPENDIX C

SAMPLE PAL INPUT FILE

Card 1 PAL2 MODEL OF AREA SOURCES
Card 2 0.02 0.02 1 2 2 1 1 1
Card 3 1 1 1 1 1 1 1 1
Card 4 1 1 0.0 0.0 10.0 10.0 10.0 1.0

Card 6 (Area Sources)	1 0.0001512 0.0 0.1707 0.0610 0.4054 0.1158
	1 0.0001327 0.0 0.1676 0.1890 0.1067 0.3505
	1 0.0000891 0.0 0.2743 0.2530 0.1128 0.2042
	1 0.0000752 0.0 0.3962 0.1829 0.1524 0.1219
	1 0.0001039 0.0 0.5791 0.0610 0.2774 0.0792
	1 0.0001155 0.0 0.7132 0.2134 0.1128 0.2896
	1 0.0000141 0.0 0.5486 0.2652 0.1360 0.1067
	1 0.0000662 0.0 0.3871 0.3475 0.1433 0.0945
	1 0.0000485 0.0 0.6401 0.5029 0.0671 0.1067
	1 0.0000916 0.0 0.4877 0.4420 0.1524 0.1829
	1 0.0000572 0.0 0.2134 0.5425 0.0762 0.1280
	1 0.0001148 0.0 0.2896 0.6279 0.3353 0.0488
	1 0.0000635 0.0 0.2713 0.6767 0.1645 0.0549
	1 0.0000155 0.0 1.5370 0.6470 0.1800 0.1200
	1 0.0000233 0.0 1.3180 0.3660 0.3300 0.1040
	1 0.0000455 0.0 1.4030 0.2560 0.1340 0.0854
	1 0.0000726 0.0 1.1470 -0.024 0.2320 0.2750
	1 0.0001591 0.0 0.8360 -0.146 0.8240 0.0610
	1 0.0000132 0.0 1.9580 -0.354 0.0600 0.2400
	2 0.0000132 0.0 0.6710 -0.140 0.1400 0.0850
	Includes: parking area source strength, source height, east coordinate, west coordinate, east-west size, and north-south size.

Card 7 (Line Sources)	1 0. 3 0.0305 0.247 0.0305 0.250 3.0 1.5 11.0 0.0 0.03909
	1 0. 3 0.0305 0.250 0.1372 0.2865 3.0 1.5 11.0 0.0 0.03909
	1 0. 2 0.1646 0.3048 0.1585 0.4389 3.0 1.5 7.3 0.0 0.02618
	1 0. 2 0.1585 0.4389 0.1554 0.5791 3.0 1.5 7.3 0.0 0.01833
	1 0. 2 0.1554 0.5791 0.2499 0.7010 3.0 1.5 7.3 0.0 0.01833
	1 0. 2 0.2499 0.7010 0.3962 0.7590 3.0 1.5 7.3 0.0 0.01048
	1 0. 2 0.3962 0.7590 0.5243 0.7254 3.0 1.5 7.3 0.0 0.01048
	1 0. 1 0.5243 0.7254 0.6400 0.6858 3.0 1.5 7.3 0.0 0.00263
	1 0. 1 0.6400 0.6858 0.7407 0.5517 3.0 1.5 7.3 0.0 0.00212

	2 0. 1 0.1676 0.2743 0.1463 0.1219 3.0 1.5 7.3 0.0 0.01291
	Includes: line source height, number of lanes, east & north coordinate of points A & B, initial sigma Y & Z, total width of line source, width of median, and line source emission rate.
Card 11 (Receptors)	1 0.7620 0.1829 1.8 1 0.1829 0.1829 1.8 1 0.5669 0.3322 1.8 1 0.4877 0.4146 1.8 1 0.3597 0.4602 1.8 1 0.4816 0.5486 1.8 1 0.3353 0.6035 1.8 1 0.2591 0.6858 1.8 1 0.7163 0.5486 1.8 1 1.8110 -0.530 1.8 1 1.8420 -0.506 1.8 1 1.8300 -0.475 1.8 1 1.7020 -0.140 1.8 1 1.7080 -0.091 1.8 1 1.7080 -0.024 1.8 1 -0.049 0.1460 1.8 1 -0.049 0.0920 1.8 2 -0.024 0.0430 1.8
	Includes: east coordinate, north coordinate, and receptor height.
Card 12 (Met. Data)	1 000.0 1.0 5 400.0 273.0 1 010.0 1.0 5 400.0 273.0 1 020.0 1.0 5 400.0 273.0 1 030.0 1.0 5 400.0 273.0 1 040.0 1.0 5 400.0 273.0 1 050.0 1.0 5 400.0 273.0 1 060.0 1.0 5 400.0 273.0 1 070.0 1.0 5 400.0 273.0 1 080.0 1.0 5 400.0 273.0 1 090.0 1.0 5 400.0 273.0 1 100.0 1.0 5 400.0 273.0 1 110.0 1.0 5 400.0 273.0 1 120.0 1.0 5 400.0 273.0 1 130.0 1.0 5 400.0 273.0 1 140.0 1.0 5 400.0 273.0 1 150.0 1.0 5 400.0 273.0

	1 160.0 1.0 5 400.0 273.0 2 170.0 1.0 5 400.0 273.0	
Card 13	0	Program Terminate

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APPENDIX D

AREA SOURCE EMISSION RATES FOR MODELING PARKING AREAS USING PAL

D.1. INTRODUCTION

PAL is recommended for modeling parking areas, including multilevel parking garages. Each level, in a multi-level parking deck, can be treated as an individual elevated area source as long as the cumulative effect of emissions at levels closer to the entrance and exit level(s) is accounted for.

D.2. EXAMPLE CALCULATION

The parking source emission strength for input to the PAL model can be estimated in a detailed analysis following Volume 9 [11] or by a simple approximation using the following formulas:

Area Source Emissions:

Idle: $I = (V_p \times E_I \times T_M) / 60 \times 3600$

Travel: $T = (V_p \times E_T \times D) / 5280 \times 3600$

Total Area Emissions $T_E = (\text{Idle} + \text{Travel}) / A$

Line Source Emissions:

Roadway: $R = (V_p \times E_R) / 1609 \times 3600$

Where:

I	= Idle Emission Rate [g/s]
T	= Travel Emission Rate [g/s]
T_E	= Total Area Source Emission Rate [g/s-m^2]
R	= Roadway Emission Rate [g/s-m]
V_p	= Number of vehicles moving during peak hour [veh/hr]
T_M	= Average idling time per vehicle during peak hour [min/veh]
D	= Distance traveled in parking area [ft] (eg. 1/2 width + 2/3 length)
A	= Area of the parking lot [m^2]
E_I	= Idle CO Emission factor from Mobile6 [gm/hr]
E_T	= CO Emission Factor from Mobile6 [gm/mi], based on speed of parking area
E_R	= CO Emission Factor from Mobile 6 [gm/mi], based on speed of roadway

Example: Consider a seven-level parking garage where peak-hour traffic totals 808 vehicles moving in and out the parking garage; the average vehicle speed for each vehicle is 5 mph; the area of each deck is 5865 m^2 (76.6 m each side); and all entrances and exits are on the first level. Calculate the area source strength for all seven levels. Assume 100% cold start operating mode in the year 1997. Assume emission factors are: E_T = 198.6 gm/mile, E_I = 911.7 gm/hr. Since all vehicles moving to or from upper levels must pass through the lower levels, the emissions will be cumulative downward. Using the approximation formula:

For level 1:

$$\text{Idle (I)} = \frac{808 \times 911.7 \times .5}{3600 \times 60} = 1.7 \text{ g/sec}$$

$$\text{Travel (T)} = \frac{808 \times 198.6 \times 293}{3600 \times 5280} = 2.5 \text{ g/sec}$$

$$\text{Total } (T_{E1}) = (1.7 + 2.5) / 5865 = 0.00072 \text{ g/sec-m}^2$$

[Assuming a uniform distribution of vehicles moving on each deck, then:

For level 2: $T_{E2} = (6/7)\, T_{E1} = 0.00061$ g/sec-m^2

For level 3: $T_{E3} = (5/7)\, T_{E1} = 0.00051$ g/sec-m^2, etc.

APPENDIX E

CARBON MONOXIDE BACKGROUND CONCENTRATION AND PERSISTENCE FACTORS IN NORTH CAROLINA

E.1 INTRODUCTION

The models used to predict carbon monoxide (CO) concentrations resulting from mobile source emissions generally give a predicted 1-hour concentration value due to the modeled sources only. In order to determine an 8-hour average concentration for comparison with the 8-hour CO ambient standard, the 1-hour value from the model must first be multiplied by a persistence factor to account for variations in traffic and meteorological conditions over time. Next, a background concentration must be added to the adjusted concentration to account for emissions not explicitly modeled.

E.2 PERSISTENCE FACTOR

For purposes of CO hot-spot analysis, the persistence factor, P, can be defined as:

$$\mathbf{P = E8/E1}$$

where:

E1 = the excess (i.e., excluding background) 1-hour CO concentration value attributable to worst-case traffic and meteorological conditions;

And

E8 = the excess (i.e., excluding background) 8-hour CO concentration averaged over the eight possible 8-hour periods encompassing the E1 hour.

Using actual monitored data, the persistence factor can be approximated as:

$$\mathbf{P = T8/T1}$$

where:

T1 = the total (i.e., including background) 1-hour CO concentration value as above; and

T8 = the total (i.e., including background) 8-hour CO concentration as above.

This approximation is conservative (i.e., overestimates the persistence factor) if the ratio of the 8-hour to 1-hour background values is larger than the ratio of the total values, a likely condition since the background concentration is a more stable quantity. This approximation improves, however, as the excess portion of the total concentration becomes large relative to the background portion, the situation most likely to occur during hours of worst-case traffic and meteorological conditions.

Using the guidance provided in EPA 454/R-92-005 "Guideline for Modeling Carbon Monoxide from Roadway Intersections"[9], section 4.7.2, 8-hour persistence factors were calculated for seven North Carolina regions using 2000-2002 CO monitoring data. Specifically, hourly CO monitoring data for November, December, January, and February for each year were used to determine running 8-hour averages (T8). These data were then sorted and used to determine the 10 highest non-overlapping T8 values. For each of these 10 non-overlapping T8 values, the highest 1-hour (T1) was then determined and used to calculate the appropriate persistence factor ($P_{1..10} = T8_{1..10}/T1_{1..10}$). The 8-hour persistence factor for each region represents the average of the 10 persistence factors calculated.

The results shown in Table E1 indicate that the 8-hour persistence factor for sites not within a region can be estimated as 0.79 for all areas throughout the state. Since the method is based on actual monitored data, this persistence factor implicitly accounts for variations in both traffic and meteorological conditions over time.

E.3 BACKGROUND CONCENTRATION

According to "Guidelines for Air Quality Maintenance Planning and Analysis, Volume 9 (Revised): Evaluating Indirect Sources"[10], background concentration is defined as the concentration of a pollutant at a point that is the result of emissions outside the local vicinity; that is, the concentration at the upwind of the local source. The direct measurement of this concentration is a problem, however, for two reasons. First, since the winds and CO concentrations are highly variable in space and time, it would be necessary to set up continuously operating monitors around the local source in all directions which is an obviously impractical, if not impossible, undertaking. Second, even if such a network of monitors were set up, the erratic nature of the measured concentrations would have to be determined.

Another factor, which has not been considered in the EPA definition but can be an important aspect of background concentration, is the concept of a local background in the time domain. A local background is defined as the residual concentration from previous hours at a local monitoring site. Observations show that the CO concentrations at a microscale monitoring site near a roadway or intersection do not respond quickly to changes in meteorological or traffic conditions. The fact is that what is left over after dispersion of previous emissions constitutes part of the background of the present time.

In many cases, the local background may be as important as the upwind background concentration in predicting whether or not the total CO concentration at a site will exceed the ambient air quality standard. The relative importance of the two depends on the spatial scale of the assumed receptor location and the traffic condition being modeled. The smaller the spatial scale, and the heavier the local traffic, the more important it is to the local background. Consequently, for any CO "hot-spot" analysis, local monitored data, if available, should be used to derive the background concentration. Such data would contain both the space-oriented upwind CO that is dispersed to the hot spot and the time-oriented local residual concentration.

Given that EPA guidance for determining background concentrations was very limited, the NC DAQ had developed a statistically based method to determine 1-hour background concentrations based on the methodology used by the Florida Department of Environmental Regulation to derive statistically stable worst-case 8-hour background concentrations. Using the same CO hourly database as described in the persistence factor calculations (section E.2), this method averaged the hourly data hour-by-hour for each month for each year to develop twelve composite 24-hour sets of concentrations. The twelve 24-hour sets were combined from which the 67^{th} percentile concentration was then computed. The 67^{th} percentile value represented the worst-case 1-hour background concentration. Multiplying the 1-hour background concentration by the appropriate persistence factor derives the worst-case 8-hour background concentration.

Using methods consistent with the EPA "Guideline for Modeling Carbon Monoxide from Roadway Intersections"[9] (EPA 454/R-92-005) for calculating 8-hour persistence factors, the NC DAQ calculated 1-hour background concentrations for seven North Carolina regions using 2000-2002 CO monitoring data. DAQ used several methods to make these calculations; they are as follows:

- ***Method 1:*** Calculate the average hourly CO concentration for each hour for each month for each year (i.e., 24 hours, 4 months, 3 years => 288 "hourly" averages); the maximum hourly average is the 1-hour background concentration.
- ***Method 2:*** Determine the highest hourly concentration for each of the hours for each month for each year (i.e., 24 hours, 4 months, 3 years => 288 "highest" concentrations); the average of the 288 highest concentrations is the 1-hour background concentration.
- ***Method 3:*** Sort the full CO 1-hour data set and compute the 96th percentile.

The results and comparison of each method show that Method 2 produced higher 1-hour background concentrations than Method 1 for each of the seven North Carolina regions. Method 3 produced results higher than Method 2 for four of the seven regions and slightly less than Method 2 (but larger than Method 1) for the remaining three regions. Averaging the 1-hour background concentrations for all regions for each method resulted in Method 3 producing the highest averaged 1-hour background concentration. Due to the overall conservative nature of using Method 3, the relative ease of compiling and evaluating Method 3 data, and the lack of specific guidance from EPA, the NCDAQ has elected to use this method for determining 1-hour background concentrations.

Based on these results, the 1-hour CO background concentration for areas not within a region in North Carolina is estimated as 2.9 ppm. Based on a persistence factor of 0.79, the 8-hour CO background concentration for these same areas in North Carolina is estimated as 2.3 ppm. These values represent the average background concentration and persistence from the regions.

TABLE E1

CO BACKGROUND [(BG) IN PPM]
AND PERSISTENCE FACTORS (P) FOR 2000-2002

County/City	Site Location/Address	Site Average*		Regional Average	
		BG	P	BG	P
Cumberland/Fayetteville	Cumberland Co. ABC Board	2.9	0.78	2.9	0.78
Wake/Raleigh	420 South Person Street	3.8	0.81	2.9	0.79
Forsyth/Winston-Salem	1401 Corporation Parkway	2.8	0.81	2.7	0.80
Forsyth/Winston-Salem	100 SW Stratford Road	2.8	0.73		
Guilford/Greensboro	401 West Wendover Avenue	2.4	0.86		
Mecklenburg/Charlotte	301 N. Tryon Street	2.6	0.82	2.6	0.82
New Hanover/Wilmington	Oleander St. & College Road	2.4	0.73	2.4	0.73
Statewide - for areas not within a region, use the regional averages.				**2.9**	**0.79**

* Use Site Average background and persistence factors only if the project is within approximately two blocks of the monitor site. Otherwise use the regional or statewide averages.

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