Transportation Conformity Guidance for Quantitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas

Appendices

Transportation and Climate Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

EPA United States Environmental Protection Agency

EPA-420-B-15-084
November 2015

APPENDIX A: CLEARINGHOUSE OF WEBSITES, GUIDANCE, AND OTHER TECHNICAL RESOURCES FOR PM HOT-SPOT ANALYSES A-1

APPENDIX B: EXAMPLES OF PROJECTS OF LOCAL AIR QUALITY CONCERN B-1

APPENDIX C: HOT-SPOT REQUIREMENTS FOR PM10 AREAS WITH PRE-2006 APPROVED CONFORMITY SIPS C-1

APPENDIX D: CHARACTERIZING INTERSECTION PROJECTS FOR MOVES D-1

APPENDIX E: [RESERVED] E-1

APPENDIX F: [RESERVED] F-1

APPENDIX G: EXAMPLE OF USING EMFAC2011 FOR A HIGHWAY PROJECT G-1

APPENDIX H: EXAMPLE OF USING EMFAC2011 TO DEVELOP EMISSION FACTORS FOR A TRANSIT PROJECT H-1

APPENDIX I: ESTIMATING LOCOMOTIVE EMISSIONS I-1

APPENDIX J: ADDITIONAL REFERENCE INFORMATION ON AIR QUALITY MODELS AND DATA INPUTS J-1

APPENDIX K: EXAMPLES OF DESIGN VALUE CALCULATIONS FOR PM HOT-SPOT ANALYSES K-1

APPENDIX L: CALCULATING 24-HOUR PM2.5 DESIGN VALUES USING A SECOND TIER APPROACH J-1

Appendix A:
Clearinghouse of Websites, Guidance, and Other Technical Resources for PM Hot-spot Analyses

A.1 INTRODUCTION

This appendix is a centralized compilation of documents and websites referenced in the guidance, along with additional technical resources that may be of use when completing quantitative PM hot-spot analyses. Refer to the appropriate sections of the guidance for complete discussions on how to use these resources in the context of completing a quantitative PM hot-spot analysis. The references listed are current as of this writing; readers are reminded the check for the latest versions when using them for a particular PM hot-spot analysis.

A.2 TRANSPORTATION CONFORMITY AND CONTROL MEASURE GUIDANCE

The EPA hosts an extensive library of transportation conformity guidance online at: www.epa.gov/otaq/stateresources/transconf/policy.htm (unless otherwise noted). See in particular guidance under the heading, "Emission Models and Conformity" as well as guidance under the heading, "Quantifying Benefits of Control Measures in SIPs and Conformity." The following specific guidance documents, in particular, may be useful references when implementing PM hot-spot analyses:

- The most recent version of the MOVES policy guidance, e.g., "Policy Guidance on the Use of MOVES2014 for State Implementation Plan Development, Transportation Conformity, and Other Purposes." This document describes how and when to use the latest version of MOVES for SIP development, transportation conformity determinations, and other purposes. The most recent version(s)[1] of the MOVES technical guidance, e.g., "MOVES2014 Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity." This document provides guidance on appropriate input assumptions and sources of data for the use of MOVES in SIP submissions and regional emissions analyses for transportation conformity purposes.

- EPA and FHWA, "Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations," EPA-420-B-08-901 (December 2008).

[1] More than one version may be available at the same time because of the new emission model grace period in the conformity regulation at 40 CFR 93.111. During the grace period, more than one version of a model may be used for conformity.

- "Guidance for Developing Transportation Conformity State Implementation Plans," EPA-420-B-09-001 (January 2009).

- EPA-verified anti-idle technologies (including technologies that pertain to trucks) can be found at: www.epa.gov/smartway/forpartners/technology.htm.

- For additional information about quantifying the benefits of retrofitting and replacing diesel vehicles and engines for conformity determinations, see EPA's website for the most recent guidance on this topic: www.epa.gov/otaq/stateresources/transconf/policy.htm.

FHWA's transportation conformity site has additional conformity information, including examples of quantitative PM hot-spot analyses. Available at: www.fhwa.dot.gov/environment/air_quality/conformity/practices/.

A.3 MOVES MODEL TECHNICAL INFORMATION AND USER GUIDES

MOVES, any future versions of the model, the latest user guides, and technical information can be found at www.epa.gov/otaq/models/moves/index.htm, including the following:[2]

- The most recent version of the User Guide, which walks users through various MOVES examples and provides an overview of menu items and options.

- The most recent version of the User Interface Reference Manual, which provides details on using the MOVES interface commands, and menu options.

- The most recent version of the Software Design Reference Manual, which provides background on configuring and installing MOVES and describes MOVES code structure.

Policy documents and Federal Register announcements related to the MOVES model can be found on the EPA's website at: www.epa.gov/otaq/stateresources/transconf/policy.htm#models.

Guidance on using the MOVES model at the project level, as well as illustrative examples of using MOVES for quantitative PM hot-spot analyses, can be found in Section 4 of the guidance, in Appendix D, and within EPA's Project Level Training for Quantitative PM Hot-Spot Analyses, which can be downloaded from www.epa.gov/otaq/stateresources/transconf/training3day.htm.

[2] Note that older model versions and their accompanying documentation can also be found on this EPA web site, under the link on the left for "Previous MOVES versions."

A.4 EMFAC2011 MODEL TECHNICAL INFORMATION, USER GUIDES, AND OTHER GUIDANCE

EMFAC2011, its user guides, and any future versions of the model can be downloaded from the California Air Resources Board website at: www.arb.ca.gov/msei/categories.htm .

Policy documents and Federal Register announcements related to the EMFAC model can be found on the EPA's website at: www.epa.gov/otaq/stateresources/transconf/policy.htm#models.

Supporting documentation for EMFAC, including the technical memorandum "Revision of Heavy Heavy-Duty Diesel Truck Emission Factors and Speed Correction Factors" cited in Section 5 of this guidance, can be found at www.arb.ca.gov/msei/supportdocs.htm#onroad.

Instructions on using the EMFAC model at the project level, as well as examples of using EMFAC for quantitative PM hot-spot analyses, can be found in Section 5 of the guidance, in Appendices G and H, and within EPA's Project Level Training for Quantitative PM Hot-Spot Analyses, which can be downloaded from www.epa.gov/otaq/stateresources/transconf/training3day.htm. (Be sure to download the California version of the training course.)

A.5 DUST EMISSIONS METHODS AND GUIDANCE

Information on calculating emissions from paved roads, unpaved roads, and construction activities can be found in AP-42, Chapter 13 (Miscellaneous Sources). AP-42 is EPA's compilation of data and methods for estimating average emission rates from a variety of activities and sources from various sectors. Refer to EPA's website to access the latest versions of AP-42 sections and for more information about AP-42 in general: www.epa.gov/ttn/chief/ap42/index.html.

Guidance on calculating dust emissions for PM hot-spot analyses can be found in Section 6 of the guidance.

A.6 LOCOMOTIVE EMISSIONS GUIDANCE

The following guidance documents, unless otherwise noted, can be found on or through the EPA's locomotive emissions website at: www.epa.gov/otaq/locomotives.htm:

- "Procedure for Emission Inventory Preparation - Volume IV: Mobile Sources," Chapter 6. Available online at: http://www.epa.gov/otaq/models/nonrdmdl/r92009.pdf. Note that the emissions factors listed in Volume IV have been superseded by the April 2009 publication listed below for locomotives certified to meet EPA standards.

- "Emission Factors for Locomotives," EPA-420-F-09-025 (April 2009). Available online at: www.epa.gov/otaq/regs/nonroad/locomotv/420f09025.pdf .

- "Control of Emissions from Idling Locomotives," EPA-420-F-08-014 (March 2008).

- "Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Implementation Plans," EPA-420-B-04-002 (January 2004). Available online at: www.epa.gov/cleandiesel/documents/420b0937.pdf .

- EPA-verified anti-idle technologies (including technologies that pertain to locomotives) can be found at: www.epa.gov/smartway/forpartners/technology.htm

Guidance on calculating locomotive emissions for PM hot-spot analyses can be found in Section 6 of the guidance and in Appendix I.

A.7 AIR QUALITY DISPERSION MODEL TECHNICAL INFORMATION AND USER GUIDES

The latest version of "Guideline on Air Quality Models" (Appendix W to 40 CFR Part 51) (dated 2005 as of this writing) can be found on EPA's SCRAM website at: www.epa.gov/scram001/guidance_permit.htm.

Both AERMOD and CAL3QHCR models and related documentation can be obtained through EPA's Support Center for Regulatory Air Models (SCRAM) web site at: www.epa.gov/scram001. In particular, the following guidance may be useful when running these models:

- AERMOD Implementation Guide

- AERMOD User Guide ("User's Guide for the AMS/EPA Regulatory Model – AERMOD")

- CAL3QHCR User Guide ("User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for Predicting Pollutant Concentrations Near Roadway Intersections")

- MPRM User Guide

- AERMET User Guide

Information on locating and considering air quality monitoring sites can be found in 40 CFR Part 58 (Ambient Air Quality Surveillance), particularly in Appendices D and E to that part.

Guidance on selecting and using an air quality model for quantitative PM hot-spot analyses can be found in Sections 7 and 8 of the guidance and in Appendix J. Illustrative examples of using an air quality model for a PM hot-spot analysis can be found within EPA's Project Level Training for Quantitative PM Hot-Spot Analyses, which can be downloaded from www.epa.gov/otaq/stateresources/transconf/training3day.htm.

A.8 TRANSPORTATION DATA AND MODELING CONSIDERATIONS

The following is a number of technical resources on transportation data and modeling which may help implementers determine the quality of their inputs and the sensitivity of various data.

A.8.1 Transportation model improvement

The FHWA Travel Model Improvement Program (TMIP) provides a wide range of services and tools to help planning agencies improve their travel analysis techniques. Available online at: www.fhwa.dot.gov/planning/tmip/ .

A.8.2 Speed

"Evaluating Speed Differences between Passenger Vehicles and Heavy Trucks for Transportation-Related Emissions Modeling." Available online at: www.ctre.iastate.edu/reports/truck_speed.pdf.

A.8.3 Project level planning

"National Cooperative Highway Research Program (NCHRP) Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design" describes methods, data sources, and procedures for producing travel forecasts for highway project-level analyses. This report provides an update to NCHRP Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design. Available online at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_765.pdf.

A.8.4 Traffic analysis

Traffic Analysis Toolbox website: http://ops.fhwa.dot.gov/trafficanalysistools/.

"Traffic Analysis Toolbox Volume I: Traffic Analysis Tools Primer." Federal Highway Administration, FHWA-HRT-04-038 (June 2004). Available online at: http://ops.fhwa.dot.gov/trafficanalysistools/tat_vol1/vol1_primer.pdf.

The Highway Capacity Manual Application Guidebook. Transportation Research Board, Washington, D.C., 2003. Available online at: http://hcmguide.com/.

The Highway Capacity Manual 2010. Transportation Research Board, Washington, D.C., 2010. Not available online; purchase information available at: www.trb.org/Main/Blurbs/164718.aspx. As of this writing, the 2010 edition is most current; the most recent version of the manual, and the associated guidebook, should be consulted when completing PM hot-spot analyses.

Appendix B:
Examples of Projects of Local Air Quality Concern

B.1 INTRODUCTION

This appendix gives additional guidance on what types of projects may be projects of local air quality concern requiring a quantitative PM hot-spot analysis under 40 CFR 93.123(b)(1). However, as noted elsewhere in this guidance, PM_{10} nonattainment and maintenance areas with approved conformity SIPs that include PM_{10} hot-spot provisions from previous rulemakings must continue to follow those approved conformity SIP provisions until the SIP is revised; see Appendix C for more information.

B.2 EXAMPLES OF PROJECTS THAT REQUIRE PM HOT-SPOT ANALYSES

EPA noted in the March 2006 final rule that the examples below are considered to be the most likely projects that would be covered by 40 CFR 93.123(b)(1) and require a $PM_{2.5}$ or PM_{10} hot-spot analysis (71 FR 12491).[1]

Some examples of projects of local air quality concern that would be covered by 40 CFR 93.123(b)(1)(i) and (ii) are:

- A project on a new highway or expressway that serves a significant volume of diesel truck traffic, such as facilities with greater than 125,000 annual average daily traffic (AADT) and 8% or more of such AADT is diesel truck traffic;
- New exit ramps and other highway facility improvements to connect a highway or expressway to a major freight, bus, or intermodal terminal;
- Expansion of an existing highway or other facility that affects a congested intersection (operated at Level-of-Service D, E, or F) that has a significant increase in the number of diesel trucks; and,
- Similar highway projects that involve a significant increase in the number of diesel transit busses and/or diesel trucks.

Some examples of projects of local air quality concern that would be covered by 40 CFR 93.123(b)(1)(iii) and (iv) are:

- A major new bus or intermodal terminal that is considered to be a "regionally significant project" under 40 CFR 93.101[2]; and,

[1] EPA also clarified 93.123(b)(1)(i) in the January 24, 2008 final rule (73 FR 4435-4436).

[2] 40 CFR 93.101 defines a "regionally significant project" as "a transportation project (other than an exempt project) that is on a facility which serves regional transportation needs (such as access to and from the area outside of the region, major activity centers in the region, major planned developments such as new retail malls, sports complexes, etc., or transportation terminals as well as most terminals themselves) and would normally be included in the modeling of a metropolitan area's transportation network, including at a minimum all principal arterial highways and all fixed guideway transit facilities that offer an alternative to regional highway travel."

- An existing bus or intermodal terminal that has a large vehicle fleet where the number of diesel buses increases by 50% or more, as measured by bus arrivals.

A project of local air quality concern covered under 40 CFR 93.123(b)(1)(v) could be any of the above listed project examples.

B.3 EXAMPLES OF PROJECTS THAT DO NOT REQUIRE PM HOT-SPOT ANALYSES

The March 2006 final rule also provided examples of projects that would not be covered by 40 CFR 93.123(b)(1) and would not require a $PM_{2.5}$ or PM_{10} hot-spot analysis (71 FR 12491).

The following are examples of projects that are not a local air quality concern under 40 CFR 93.123(b)(1)(i) and (ii):

- Any new or expanded highway project that primarily services gasoline vehicle traffic (i.e., does not involve a significant number or increase in the number of diesel vehicles), including such projects involving congested intersections operating at Level-of-Service D, E, or F;
- An intersection channelization project or interchange configuration project that involves either turn lanes or slots, or lanes or movements that are physically separated. These kinds of projects improve freeway operations by smoothing traffic flow and vehicle speeds by improving weave and merge operations, which would not be expected to create or worsen PM NAAQS violations; and,
- Intersection channelization projects, traffic circles or roundabouts, intersection signalization projects at individual intersections, and interchange reconfiguration projects that are designed to improve traffic flow and vehicle speeds, and do not involve any increases in idling. Thus, they would be expected to have a neutral or positive influence on PM emissions.

Examples of projects that are not a local air quality concern under 40 CFR 93.123(b)(1)(iii) and (iv) would be:

- A new or expanded bus terminal that is serviced by non-diesel vehicles (e.g., compressed natural gas) or hybrid-electric vehicles; and,
- A 50% increase in daily arrivals at a small terminal (e.g., a facility with 10 buses in the peak hour).

Appendix C:
Hot-Spot Requirements for PM_{10} Areas with Pre-2006 Approved Conformity SIPs

C.1 INTRODUCTION

This appendix describes what projects require a quantitative PM_{10} hot-spot analysis in those limited cases where a state's approved conformity SIP is based on pre-2006 conformity requirements.[1] The March 10, 2006 final hot-spot rule defined the current federal conformity requirements for what projects require a PM hot-spot analysis (i.e., only certain highway and transit projects that involve significant levels of diesel vehicle traffic or any other project identified in the PM SIP as a local air quality concern).[2] However, there are some PM_{10} nonattainment and maintenance areas where PM_{10} hot-spot analyses are required for different types of projects, as described further below.

This appendix will be relevant for only a limited number of PM_{10} nonattainment and maintenance areas with pre-2006 approved conformity SIPs. This appendix is not relevant for any $PM_{2.5}$ nonattainment or maintenance areas, since the current federal $PM_{2.5}$ hot-spot requirements apply in all such areas. Project sponsors can use the interagency consultation process to verify applicable requirements before beginning a quantitative PM_{10} hot-spot analysis.

C.2 PM_{10} AREAS WHERE THE PRE-2006 HOT-SPOT REQUIREMENTS APPLY

Prior to the March 2006 final rule, the federal conformity rule required some type of hot-spot analysis for all non-exempt federally funded or approved projects in PM_{10} nonattainment and maintenance areas. These pre-2006 requirements are in effect for those states with an approved conformity SIP that includes the pre-2006 hot-spot requirements.

In PM_{10} areas with approved conformity SIPs that include the pre-2006 hot-spot requirements, a quantitative PM_{10} hot-spot analysis is required for the following types of projects:

- Projects which are located at sites at which PM_{10} NAAQS violations have been verified by monitoring;
- Projects which are located at sites which have vehicle and roadway emission and dispersion characteristics that are essentially identical to those of sites

[1] A "conformity SIP" includes a state's specific criteria and procedures for certain aspects of the transportation conformity process (40 CFR 51.390).
[2] See Section 2.2 and Appendix B of this guidance and the preamble of the March 2006 final rule (71 FR 12491-12493).

with verified violations (including sites near one at which a violation has been monitored); and

- New or expanded bus and rail terminals and transfer points which increase the number of diesel vehicles congregating at a single location.

This guidance should be used to complete any quantitative PM_{10} hot-spot analyses.

In addition, a <u>qualitative</u> PM_{10} hot-spot analysis is required in the pre-2006 hot-spot requirements for all other non-exempt federally funded or approved projects. For such analyses, consult the 2006 EPA-FHWA qualitative hot-spot guidance.[3]

These pre-2006 hot-spot requirements continue to apply in PM_{10} areas with approved conformity SIPs that include them until the state acts to change the conformity SIP. The conformity rule at 40 CFR 51.390 states that conformity requirements in approved conformity SIPs "remain enforceable until the state submits a revision to its [conformity SIP] to specifically remove them and that revision is approved by EPA."

C.3 REVISING A CONFORMITY SIP

EPA strongly encourages affected states to revise pre-2006 provisions and take advantage of the streamlining flexibilities provided by the current Clean Air Act. EPA's January 2008 final conformity rule significantly streamlined the requirements for conformity SIPs in 40 CFR 51.390.[4] As a result, conformity SIPs are now required to include only three provisions (consultation procedures and procedures regarding written commitments) rather than all of the provisions of the federal conformity rule.

EPA recommends that states with pre-2006 PM_{10} hot-spot requirements in their conformity SIPs act to revise them to reduce the number of projects where a hot-spot analysis is required. In affected PM_{10} areas, the current conformity rule's PM_{10} hot-spot requirements at 40 CFR 93.123(b)(1) and (2) will be effective only when a state either:

- Withdraws the existing provisions from its approved conformity SIP and EPA approves this SIP revision, or
- Revises its approved conformity SIP consistent with the requirements found at 40 CFR 93.123(b) and EPA approves this SIP revision.

[3] "Transportation Conformity Guidance for Qualitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas," EPA420-B-06-902, found on EPA's website at: www.epa.gov/otaq/stateresources/transconf/policy/420b06902.pdf.

[4] "Transportation Conformity Rule Amendments to Implement Provisions Contained in the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU); Final Rule," 73 FR 4420.

Affected states should contact their EPA Regional Office to proceed with one of these two options. For more information about conformity SIPs, see EPA's "Guidance for Developing Transportation Conformity State Implementation Plans (SIPs)," EPA-420-B-09-001 (January 2009); available online at: www.epa.gov/otaq/stateresources/transconf/policy/420b09001.pdf.

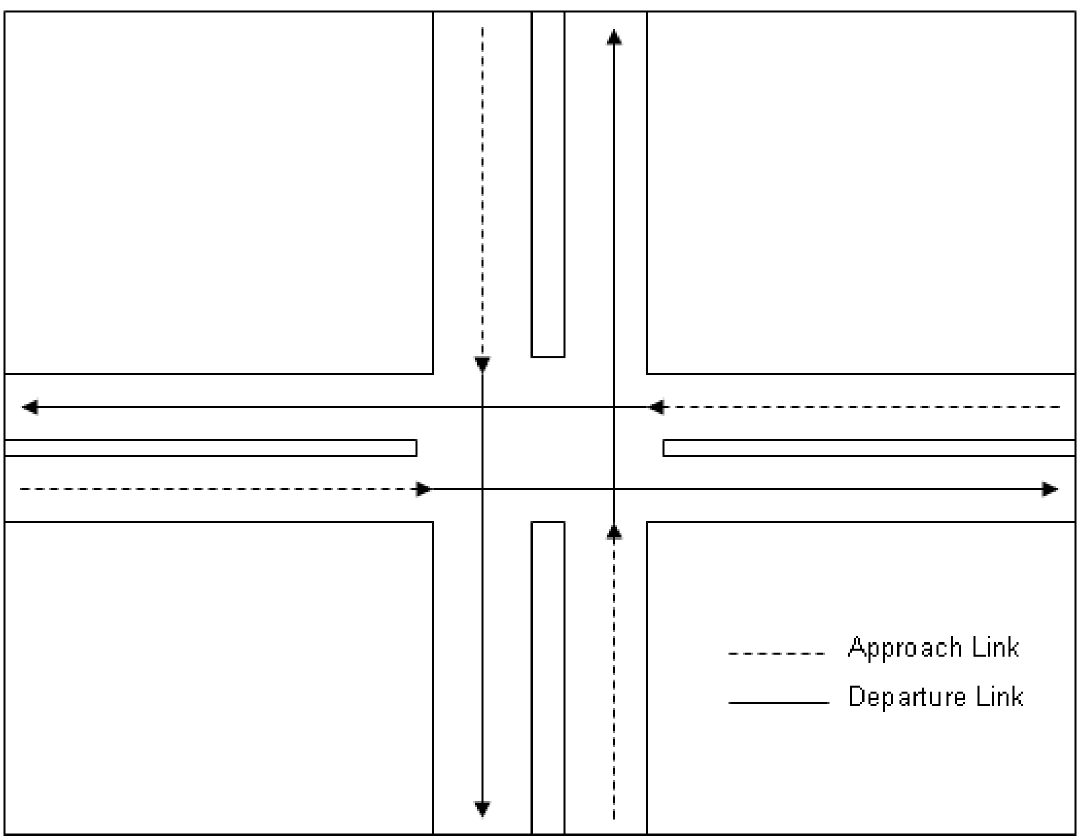
Appendix D:
Characterizing Intersection Projects for MOVES

D.1 INTRODUCTION

This appendix expands upon the discussion in Section 4.2 on how best to characterize links when modeling an intersection project using MOVES. The MOVES emissions model allows users to represent intersection traffic activity with a higher degree of sophistication compared to previous models. This appendix provides several options to describe vehicle activity to take advantage of the capabilities MOVES offers to complete more accurate PM hot-spot analyses of intersection projects. MOVES is the approved emissions model for PM hot-spot analyses in areas outside of California.

Exhibit D-1 is an example of a simple signalized intersection showing the links developed by a project sponsor to represent the two general categories of vehicle activity expected to take place at this intersection (approaching the intersection and departing the intersection).

Exhibit D-1. Example of Approach and Departure Links for a Simple Intersection



When modeling an intersection, each approach link or departure link can be modeled as one or more links in MOVES depending on the option chosen to enter traffic activity. This guidance suggests three possible options for characterizing activity on each approach and departure link (such as those shown in Exhibit D-1):

- Option 1: Using average speeds
- Option 2: Using link drive schedules
- Option 3: Using Op-Mode distributions

While Option 1 may need to be relied upon more during the initial transition to using MOVES, as more detailed data are available to describe vehicle activity, users are encouraged to consider using the Options 2 and 3 to take full advantage of the capabilities of MOVES.

Once a decision has been made on how to characterize links, users should continue to develop the remaining MOVES inputs as discussed in Section 4 of the guidance.

D.2 OPTION 1: USING AVERAGE SPEEDS

The first option is for the user to estimate the average speeds for each link in the intersection based on travel time and distance. Travel time should account for the total delay attributable to traffic signal operation, including the portion of travel when the light is green and the portion of travel when the light is red. The effect of a traffic signal cycle on travel time includes deceleration delay, move-up time in a queue, stopped delay, and acceleration delay. Using the intersection example given in Exhibit D-1, each approach link would be modeled as one link to reflect the higher emissions associated with vehicle idling through lower speeds affected by stopped delay; each departure link would be modeled as one link to reflect the higher emissions associated with vehicle acceleration through lower speeds affected by acceleration delay.

Project sponsors can determine congested speeds by using appropriate methods based on best practices for highway analyses. Some resources are available through FHWA's Travel Model Improvement Program (TMIP).[1] Methodologies for computing intersection control delay are provided in the Highway Capacity Manual.[2] All assumptions, methods, and data underlying the estimation of average speeds and delay should be documented as part of the PM hot-spot analysis.

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[1] See FHWA's TMIP website: http://tmip.fhwa.dot.gov/.

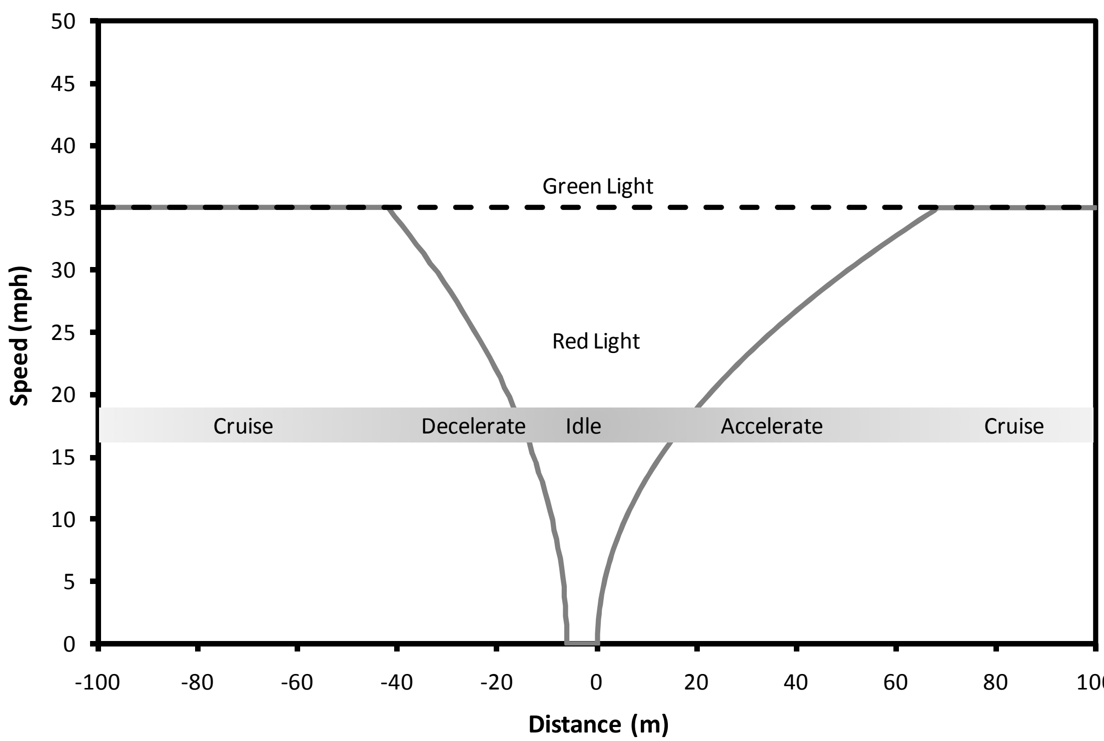
[2] Users should consult the most recent version of the Highway Capacity Manual. As of the release of this guidance, the latest version is the *Highway Capacity Manual 2010*, which can be obtained from the Transportation Research Board (see http://www.trb.org/Main/Blurbs/164718.aspx for details).

D.3 OPTION 2: USING LINK DRIVE SCHEDULES

A more refined approach is to enter vehicle activity into MOVES as a series of link drive schedules to represent individual segments of cruise, deceleration, idle, and acceleration of a congested intersection. A link drive schedule defines a speed trajectory to represent the entire vehicle fleet via second-by-second changes in speed and highway grade. Unique link drive schedules can be defined to describe types of vehicle activity that have distinct emission rates, including cruise, deceleration, idle, and acceleration.

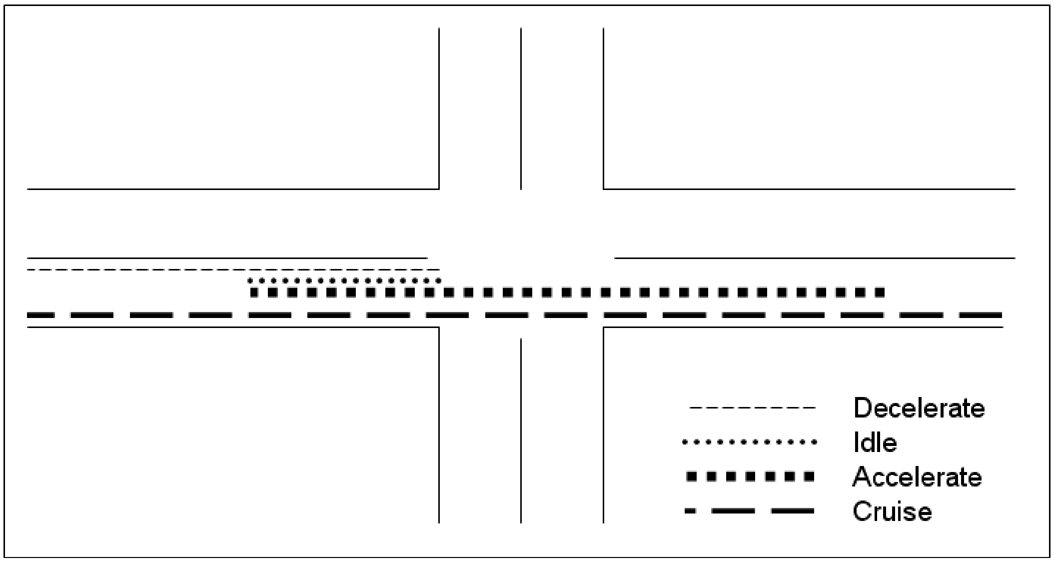
Exhibit D-2 illustrates why using this more refined approach can result in a more detailed emissions analysis. This exhibit shows the simple trajectory of a single vehicle approaching an intersection during the red signal phase of a traffic light cycle. This trajectory is characterized by several distinct phases (a steady cruise speed, decelerating to a stop for the red light, idling during the red signal phase, and accelerating when the light turns green). In contrast, the trajectory of a single vehicle approaching an intersection during the green signal phase of a traffic light cycle is characterized by a more or less steady cruise speed through the intersection.

Exhibit D-2. Example Single Vehicle Speed Trajectory Through a Signalized Intersection



For the example intersection in Exhibit D-1, link drive schedules representing the different operating modes of vehicle activity on the approach and departure links can be determined. For approach links, the length of a vehicle queue is dependent on the number of vehicles subject to stopping at a red signal. Vehicles approaching a red traffic signal decelerate over a distance extending from the intersection stop line back to the stopping distance required for the last vehicle in the queue. The average stopping distance can be calculated from the average deceleration rate and the average cruise speed. Similarly, for the departure links, vehicles departing a queue when the light turns green accelerate over a distance extending from the end of the vehicle queue to the distance required for the first vehicle to reach the cruise speed, given the rate of acceleration and cruise speed. Exhibit D-3 provides an illustration of how the different vehicle operating modes may be apportioned spatially near this signalized intersection.

Exhibit D-3. Example Segments of Vehicle Activity Near a Signalized Intersection



There are other considerations with numerous vehicles stopping and starting at an intersection over many signal cycles during an hour. For instance, heavy trucks decelerate and accelerate at slower rates than passenger cars. Drivers tend not to decelerate at a constant rate, but through a combination of coasting and light and heavy braking. Acceleration rates are initially higher when starting from a complete stop at an intersection, becoming progressively lower to make a smooth transition to cruise speed.

In the case of an uncongested intersection, the rates of vehicles approaching and departing the intersection are in equilibrium. Some vehicles may slow, and then speed up to join the dissipating queue without having to come to a full stop. Once the queue clears, approaching vehicles during the remainder of the green phase of the cycle will cruise through the intersection virtually unimpeded.

In the case of a congested intersection, the rate of vehicles approaching the intersection is greater than the rate of departure, with the result that no vehicle can travel through without stopping; vehicles approaching the traffic signal, whether it is red or green, will have to come to a full stop and idle for one or more cycles before departing the intersection. The latest Highway Capacity Manual is a good source of information for vehicle operation through signalized intersections. All assumptions, methods, and data underlying the development of link drive schedules should be documented as part of the PM hot-spot analysis.

The MOVES emission factors for each segment of vehicle activity obtained via individual link drive schedules are readily transferable to either AERMOD or CAL3QHCR, as discussed further in Section 7 of the guidance. There will most likely be a need to divide the cruise and the acceleration segments to account for differences in approach and departure traffic volumes.

Note: For both free-flow highway and intersection links, users may directly enter output from traffic simulation models in the form of second-by-second individual vehicle trajectories. These vehicle trajectories for each road segment can be input into MOVES using the Link Drive Schedule Importer and defined as unique LinkIDs. There are no limits in MOVES as to how many links can be defined; however, model run times increase as the user defines more links. A representative sampling of vehicles can be used to model higher volume segments by adjusting the resulting sum of emissions to account for the higher traffic volume. For example, if a sampling of 5,000 vehicles (5,000 links) was used to represent the driving patterns of 150,000 vehicles, then the sum of emissions would be adjusted by a factor of 30 to account for the higher traffic volume (i.e., 150,000 vehicles/5,000 vehicles). Since the vehicle trajectories include idling, acceleration, deceleration, and cruise, separate roadway links do not have to be explicitly defined to show changes in driving patterns. The sum of emissions from each vehicle trajectory (LinkID) represents the total emission contribution of a given road segment.

D.4 OPTION 3: USING OP-MODE DISTRIBUTIONS

A third option is for a user to generate representative Op-Mode distributions for approach and departure links by calculating the fraction of fleet travel times spent in each mode of operation. For any given signalized intersection, vehicles are cruising, decelerating, idling, and accelerating. Op-Mode distributions can be calculated from the ratios of individual mode travel times to total travel times on approach links and departure links. This type of information could be obtained from Op-Mode distribution data from (1) existing intersections with similar geometric and operational (traffic) characteristics, or (2) output from traffic simulation models for the proposed project or similar projects. Acceleration and deceleration assumptions, methods, and data underlying the activity-to-Op-Mode calculations should be documented as part of the PM hot-spot analysis.

The following methodology describes a series of equations to assist in calculating vehicle travel times on approach and departure links. Note that a single approach and single departure link should be defined to characterize vehicles approaching, idling at, and departing an intersection (e.g., there is no need for an “idling link,” as vehicle idling is captured as part of the approach link).

D.4.1 Approach links

When modeling each approach link, the fraction of fleet travel times in seconds (s) in each mode of operation should be determined based on the fraction of time spent cruising, decelerating, accelerating, and idling:

Total Fleet Travel Time (s) = Cruise Time + Decel Time + Accel Time + Idle Time

The cruise travel time can be represented by the number of vehicles cruising multiplied by the length of approach divided by the average cruise speed:

Cruise Time (s) = Number of Cruising Vehicles * (Length of Approach (mi) ÷ Average Cruise Speed (mi/hr)) * 3600 s/hr

The deceleration travel time can be represented by the number of vehicles decelerating multiplied by the average cruise speed divided by the average deceleration rate:

Decel Time (s) = Number of Decelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Decel Rate (mi/hr/s))

The acceleration travel time occurring on an approach link can be similarly represented. However, to avoid double-counting acceleration activity that occurs on the departure link, users should multiply the acceleration time by the proportion of acceleration that occurs on the approach link (Accel Length Fraction on Approach):

Accel Time (s) = Number of Accelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Accel Rate (mi/hr/s)) * Accel Length Fraction on Approach

The idle travel time can be represented by the number of vehicles idling multiplied by the average stopped delay (average time spent stopped at an intersection):

Idle Time (s) = Number of Idling Vehicles * Average Stopped Delay (s)

Control delay (total delay caused by an intersection) may be used in lieu of average stopped delay, but control delay includes decelerating and accelerating travel times, which should be subtracted out (leaving only idle time).

After calculating the fraction of time spent in each mode of approach activity, users should select the appropriate MOVES Op-Mode corresponding to each particular type of activity (see Section 4.5.7 for more information). The operating modes in MOVES typifying approach links include:

- Cruise/acceleration (OpModeID 11-16, 22-25, 27-30, 33, 35, 37-40);
- Low and moderate speed coasting (OpModeID 11, 21);
- Braking (OpModeID 0, 501);

- Idling (OpModeID 1); and
- Tire wear (OpModeID 400-416).

The relative fleet travel time fractions can be allocated to the appropriate Op-Modes in MOVES. The resulting single Op-Mode distribution accounts for relative times spent in the different driving modes (cruise, deceleration, acceleration, and idle) for the approach link. A simple example of deriving Op-Mode distributions for a link using this methodology is demonstrated in Step 3 of Appendix F for a bus terminal facility.

D.4.2 Departure links

When modeling each departure link, the fraction of fleet travel times spent in each mode of operation should be determined based on the fraction of time spent cruising and accelerating:

Total Fleet Travel Time (s) = Cruise Time + Accel Time

The cruise travel time can be represented by the number of vehicles cruising multiplied by the travel distance divided by the average cruise speed:

Cruise Time (s) = Number of Cruising Vehicles * (Length of Departure (mi) ÷ Average Cruise Speed (mi/hr)) * 3600 s/hr

The acceleration travel time occurring during the departure link can be represented by the number of vehicles accelerating multiplied by the average cruise speed divided by the average acceleration rate. However, to avoid double-counting acceleration activity that occurs on the approach link, users should multiply the resulting acceleration time by the proportion of acceleration that occurs on the departure link (Accel Length Fraction on Departure):

Accel Time (s) = Number of Accelerating Vehicles * (Average Cruise Speed (mi/hr) ÷ Average Accel Rate (mi/hr/s)) * Accel Length Fraction on Departure

After calculating fraction of time spent in each mode of departure activity, users should select the appropriate MOVES Op-Mode corresponding to each particular type of activity (see Section 4.5.7 for more information). The operating modes typifying departure links include:

- Cruise/acceleration (OpModeID 11-16, 22-25, 27-30, 33, 35, 37-40); and
- Tire wear (OpModeID 401-416).

The relative fleet travel time fractions can be allocated to the appropriate Op-Modes. The resulting single Op-Mode distribution accounts for relative times spent in the different driving modes (cruise and acceleration) for the departure link.

Appendix E:
Example Quantitative PM Hot-spot Analysis of a Highway Project using MOVES and CAL3QHCR

Note: EPA has removed the example in Appendix E because it has been superseded by the example analyses found in EPA's quantitative PM hot-spot analysis course. The course materials, including the presentation of the example analysis and all of the files necessary to repeat the analysis are available for download at: www.epa.gov/otaq/stateresources/transconf/training3day.htm .

Appendix F:
Example Quantitative PM Hot-spot Analysis of a Transit Project using MOVES and AERMOD

Note: EPA has removed the example in Appendix F because it has been superseded by the example analyses found in EPA's quantitative PM hot-spot analysis course. The course materials, including the presentation of the example analysis and all of the files necessary to repeat the analysis are available for download at: www.epa.gov/otaq/stateresources/transconf/training3day.htm.

Appendix G:
Example of Using EMFAC2011 for a Highway Project

G.1 Introduction

The purpose of this appendix is to demonstrate the procedures described in Section 5 of the guidance on using EMFAC2011 to generate emission factors for air quality modeling. The following example, based on a hypothetical, simplified highway project, illustrates the modeling steps required for users to run the EMFAC2011-PL tool to develop project-specific PM running exhaust emission factors using the "simplified approach" described in Section 5.5 of the guidance.

As discussed in the guidance, application of the simplified approach and use of the EMFAC2011-PL tool is only appropriate when the project-specific fleet age distribution does not differ from the EMFAC2011 defaults and the project does not include start or idling emissions. See Appendix H for an example of using the detailed approach to modify a default age distribution.

Users will be able to generate running emission factors (in grams/vehicle-mile) in a single EMFAC2011-PL run; multiple links and calendar years can also be handled within one run. This example does not include the subsequent air quality modeling; refer to Appendix E for an example of how to run an air quality model for a highway project for PM hot-spot analyses.

G.2 Project Characteristics

The hypothetical highway project is located in Sacramento County, California. For illustrative purposes, the project is characterized by a single link with an average link travel speed for all traffic equal to 65 mph.[1] Project-specific age distributions do not differ from the EMFAC2011 defaults, so a simplified modeling approach using the EMFAC2011-PL tool will be used to develop a link-specific $PM_{2.5}$ emission rate.

The project's first full year of operation is assumed to be the year 2013. Through the interagency consultation process, it is determined that 2015 should be the analysis year (based on the project's emissions and background concentrations). The build scenario 2015 traffic data for this highway project shows that 25% of the total project VMT is from trucks and 75% from non-trucks. This truck/non-truck fleet mix will be used to post-process the EMFAC-PL output.

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[1] These are simplified data to illustrate the use of EMFAC2011; this example does not, for instance, separate data by peak vs. off-peak periods, divide the project into separate links, or consider additional analysis years, all of which would likely be required for an actual project.

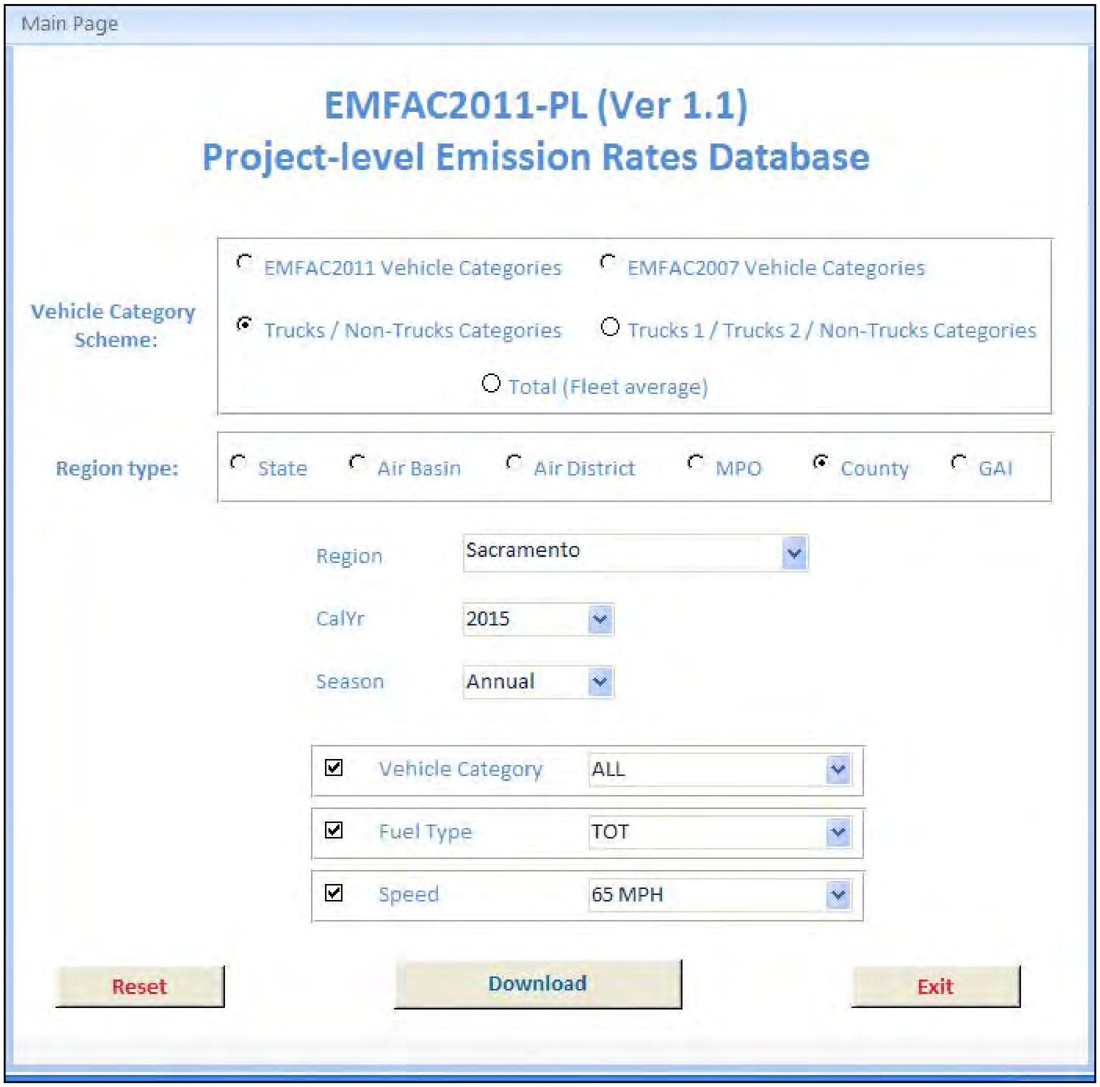
G.3 DESCRIBING THE SCENARIO USING THE EMFAC2011-PL TOOL

Based on the project characteristics, it is first necessary to describe the modeling scenario in the EMFAC2011-PL interface (see Exhibits G-1 and G-2).

Exhibit G-1. Basic Inputs in EMFAC2011-PL for the Hypothetical Highway Project

Step	Input Category	Input Data	Note
1	Vehicle Category Scheme	Truck / Non-Truck Categories	Provides rates for truck/non-truck categories
2	Region type	County	Per Section 5.5.2 of the guidance
3	Region	Sacramento	Select from drop-down list
4	CalYr	2015	Select from drop-down list
5	Season	Annual	Select from drop-down list
6	Vehicle Category	ALL	Provides rates for HD and LD
7	Fuel Type	TOT	Does not generate separate rates for gasoline and diesel
8	Speed	65 MPH	Select from drop-down list

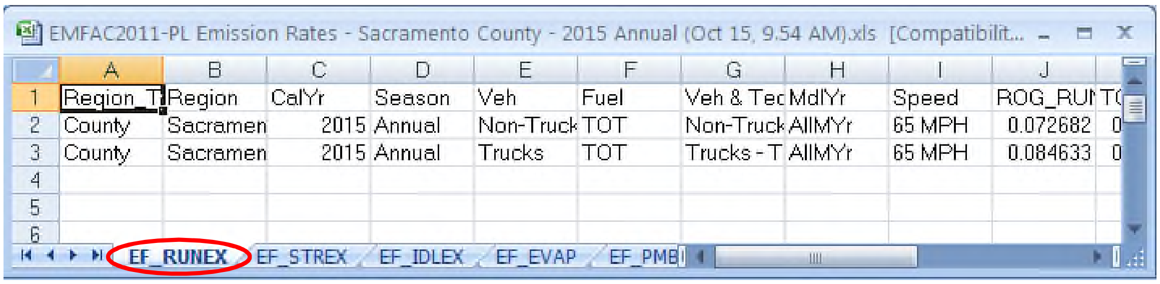
Exhibit G-2. EMFAC2011-PL GUI Showing Selections Made for the Hypothetical Highway Project



G.4 Calculating a Link-Specific Emission Rate from EMFAC2011-PL Output

After running EMFAC2011-PL, an output Excel file (Exhibit G-3) is produced in the EMFAC2011-PL folder. From this file, emission rates are appropriately processed to calculate a single link emission rate appropriate for dispersion modeling. This process is described below.

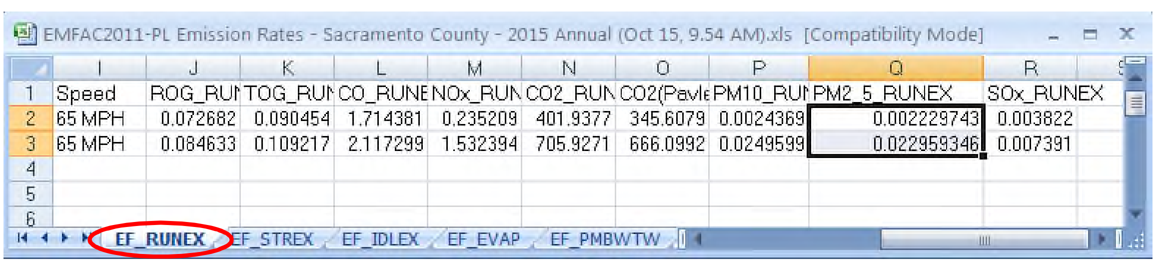
Exhibit G-3. EMFAC2011-PL Output File



	A	B	C	D	E	F	G	H	I	J
1	Region_T	Region	CalYr	Season	Veh	Fuel	Veh & Tec	MdlYr	Speed	ROG_RUI
2	County	Sacramen	2015	Annual	Non-Truck	TOT	Non-Truck	AllMYr	65 MPH	0.072682
3	County	Sacramen	2015	Annual	Trucks	TOT	Trucks - T	AllMYr	65 MPH	0.084633

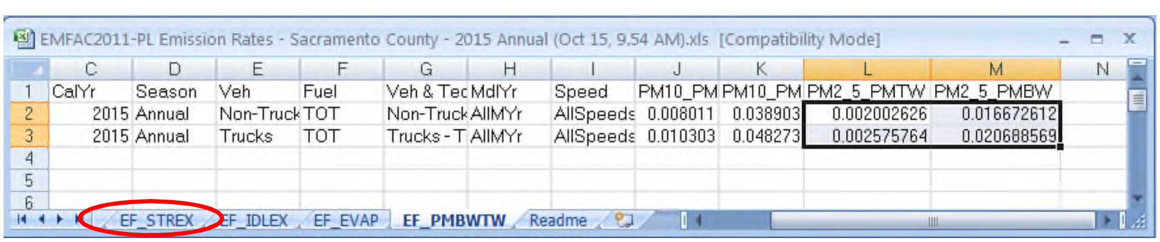
The next step is to extract the relevant emission rates for post-processing in a separate Excel worksheet. For running emissions, the Total $PM_{2.5}$ emission factor (EF) is calculated as the sum of the running exhaust EF (Exhibit G-4), the brake wear EF, and the tire wear EF (Exhibit G-5).

Exhibit G-4. Running Exhaust Rates



	I	J	K	L	M	N	O	P	Q	R
1	Speed	ROG_RUI	TOG_RUI	CO_RUNE	NOx_RUN	CO2_RUN	CO2(Pavle	PM10_RUI	PM2_5_RUNEX	SOx_RUNEX
2	65 MPH	0.072682	0.090454	1.714381	0.235209	401.9377	345.6079	0.0024369	0.002229743	0.003822
3	65 MPH	0.084633	0.109217	2.117299	1.532394	705.9271	666.0992	0.0249599	0.022959346	0.007391

Exhibit G-5. Brake Wear and Tire Wear Rates



	C	D	E	F	G	H	I	J	K	L	M
1	CalYr	Season	Veh	Fuel	Veh & Tec	MdlYr	Speed	PM10_PM	PM10_PM	PM2_5_PMTW	PM2_5_PMBW
2	2015	Annual	Non-Truck	TOT	Non-Truck	AllMYr	AllSpeeds	0.008011	0.038903	0.002002626	0.016672612
3	2015	Annual	Trucks	TOT	Trucks - T	AllMYr	AllSpeeds	0.010303	0.048273	0.002575764	0.020688569

These rates are then summed separately for Trucks and Non-Truck categories (shown in Exhibit G-6).

Exhibit G-6. Calculation of Truck and Non-Truck Total $PM_{2.5}$ EF

	Running Exhaust EF	**Tire wear EF**	**Break wear EF**	**Total $PM_{2.5}$ EF**
Non-trucks	0.0022297	0.0020026	0.0166726	**0.020905**
Trucks	0.0229593	0.0025758	0.0206886	**0.046224**

From the calculated Total $PM_{2.5}$ EF, the truck and non-truck rates are then weighted together based on the relative VMT for each vehicle type. In this example, trucks account for 25% of VMT while non-trucks account for 75% of VMT. Exhibit G-7 demonstrates how the EFs are weighted to calculate a single link emission rate.

Exhibit G-7. Calculation of Total $PM_{2.5}$ Link Emission Rate

	Total Emission Rate	VMT adjustment	Weighted Emission Rate
Non-trucks	0.020905	0.75	0.0156788
Trucks	0.046224	0.25	0.011556
			0.027235

This completes the use of the EMFAC2011-PL tool to determine emissions factors for this project using the simplified approach. The total running link emission factor of 0.027235 grams per vehicle-mile can be now be used in combination with link length and link volume as inputs into the selected air quality model, as discussed in Section 7 of the guidance.

Appendix H:
Example of Using EMFAC2011 to Develop Emission Factors for a Transit Project

H.1 INTRODUCTION

The purpose of this appendix is to illustrate the modeling steps required for users to develop PM idling emission factors for a hypothetical bus terminal project using EMFAC2011. It also shows how to generate emission factors from EMFAC2011 for a project that involves a limited selection of vehicle classes (e.g., urban buses) and an age distribution that differs from the EMFAC2011 defaults.[1] Because the project age distribution differs from the EMFAC2011 defaults, use of the simplified approach and EMFAC2011-PL tool is not appropriate. Instead, the detailed approach described in Section 5.6 of the guidance will be used.

This example uses the “Emfac” mode in EMFAC2011-LDV to generate grams per vehicle-hour (g/veh-hr) emission factors stored in the “Summary Rate” output file (.rts file) suitable for use in the AERMOD air quality model. This example does not include the subsequent air quality modeling; refer to Appendix F for an example of how to run AERMOD for a transit project for PM hot-spot analyses.

The assessment of a bus terminal or other non-highway project can involve modeling two different categories of emissions: (1) the idle and/or start emissions at the project site, and (2) the running exhaust emissions on the links approaching and departing the project site. As discussed in Section 5.7.4, EMFAC2011-LVD allows users to generate emission factors for all of these in a single run. This appendix walks through the steps to model idle emissions for this hypothetical project. Users will be able to generate idle emission factors in a single EMFAC2011-LDV model run; multiple calendar years can also be handled within one model run. As described in the main body of this section, each run will be specific to either PM_{10} or $PM_{2.5}$; however, this example is applicable to both. This example is intended to help project sponsors understand how to create representative idle emission factors based on the best available information supplied by EMFAC2011, thus providing an example of how users may have to adapt the information in EMFAC2011 to their individual project circumstances.

To estimate idle emissions at a terminal project, the main task will involve modifying the default vehicle populations and VMT distribution, by vehicle, fuel, and age distribution embedded in EMFAC2011 to reflect the project-specific bus fleet.

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[1] This is a highly simplified example showing how to employ EMFAC2011 to calculate idle emission factors for use in air quality modeling. An actual project would be expected to be significantly more complex.

H.2 PROJECT CHARACTERISTICS

A PM_{10} hot-spot analysis is conducted for a planned bus terminal project in Sacramento County, California. The project's first full year of operation is assumed to be the year 2013. Through the interagency consultation process, it is determined that 2015 should be the analysis year (based on the project's emissions and background concentrations). The PM analysis is focused on idle emissions from buses operated in the terminal. Additionally, all buses in this example operate using diesel fuel and are ten years old (age 10).

It is determined that the appropriate EMFAC2011 vehicle category for the urban transit buses included in the project is "UBUS-DSL," which is a type found in the EMFAC2011-LDV module (see Section 5.6.2 of the guidance). Therefore, we will be applying the EMFAC2011-LDV procedure described in Section 5.7 of the guidance.

H.3 PREPARING EMFAC2011 BASIC INPUTS

Based on the project characteristics, basic inputs and default settings in EMFAC2011-LDV are first specified (see Exhibit H-1). These basic inputs are similar to those specified for highway projects. To generate idle emission factors for urban transit buses (UBUS-DSL) from EMFAC2011-LDV, a speed bin of 5 mph must be selected in the EMFAC2011-LDV interface.

Exhibit H-1. Basic Inputs in EMFAC2011-LDV for the Hypothetical Highway Project

Step	Input Category	Input Data	Note
1	Geographic Area	County → Sacramento	Select from drop-down list
	Calculation Method	Use Average	Default (not visible in the EMFAC2011-LDV user interface)
2	Calendar Years	2015	Select from drop-down list
3	Season or Month	Annual	Select from drop-down list
4	Scenario Title	Use default	Define default title in the EMFAC2011-LDV user interface
5	Model Years	Use default	Include all model years
6	Vehicle Classes	Use default	Include all vehicle classes
7	I/M Program Schedule	Use default	Include all pre-defined I/M program parameters
8	Temperature	60F	Delete all default temperature bins and input 60
9	Relative Humidity	70%RH	Delete all default relative humidity bins and input 70
10	Speed	Use default	Include speed bin of 5 mph
11	Emfac Rate Files	Summary Rates (RTS)	Select from EMFAC2011-LDV user interface
12	Output Particulate	PM_{10}	Select from EMFAC2011-LDV user interface

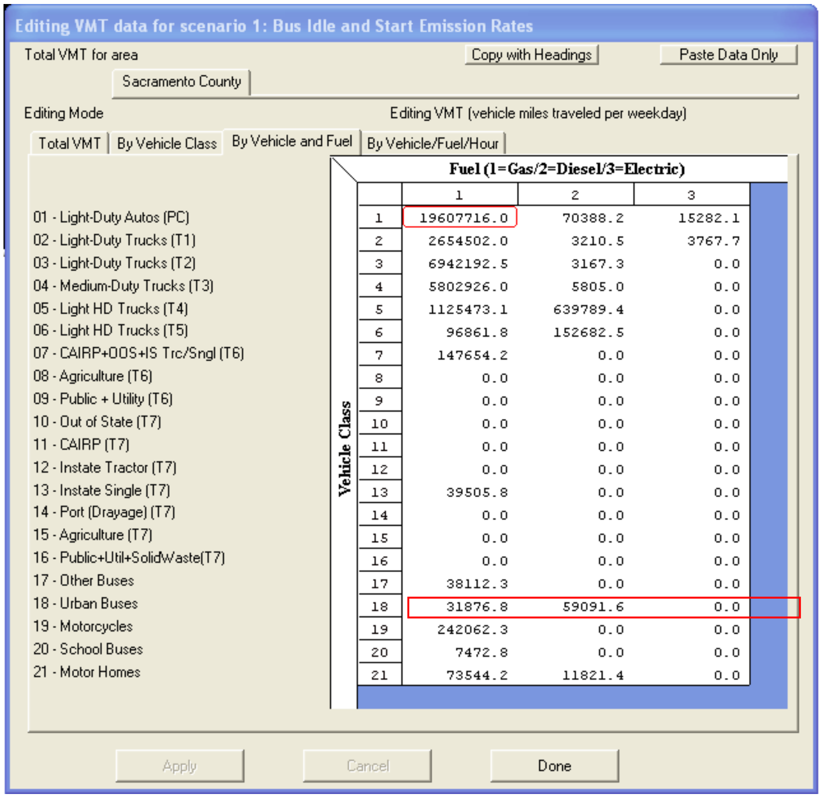
H.4 EDITING EMFAC2011-LDV DEFAULT VMT AND POPULATION TO REFLECT PROJECT-SPECIFIC BUS FLEET

To generate idle emission factors that reflect the bus terminal project data, vehicle population and VMT by vehicle class must be modified in the EMFAC2011-LDV user interface. The EMFAC2011 module has data limitations regarding idle emissions: among the available vehicle classes in EMFAC2011-LDV, idle emission factors are available only for the LHDT1, LHDT2, MHDT, HHDT, School Buses, and Other Buses vehicle types. Although EMFAC2011-LDV does not explicitly provide idle emission factors for the "UBUS-DSL" class (the class most typically associated with urban transit buses), as described in Section 5.7.4 of the guidance, the 5 mph emission factors may be used to represent transit buses by multiplying the rate (grams/vehicle-mile) by 5 miles per hour, resulting in a grams/veh-hour rate.

Since the fuel use and age distribution of the bus fleet are known, it is necessary to edit the EMFAC2011-LDV program constants (defaults) to reflect this information. First, VMT "By Vehicle and Fuel" will be edited to reflect entirely diesel Urban Bus operation by changing gasoline Urban Bus VMT to "1" (because "0" will cause an error). Next, Population "By Vehicle and Fuel" will be edited to reflect entirely diesel Urban Bus operation by changing the number of gasoline Urban Buses to "1". Finally, the Population "By Vehicle/Fuel/Age" will be edited to reflect the known Urban Bus age distribution by preserving the number of Urban Buses "age 10", and changing the number of buses of all other ages to "0" (note this must be done by exporting the default age distribution to Excel, as explained in Exhibit H-4).

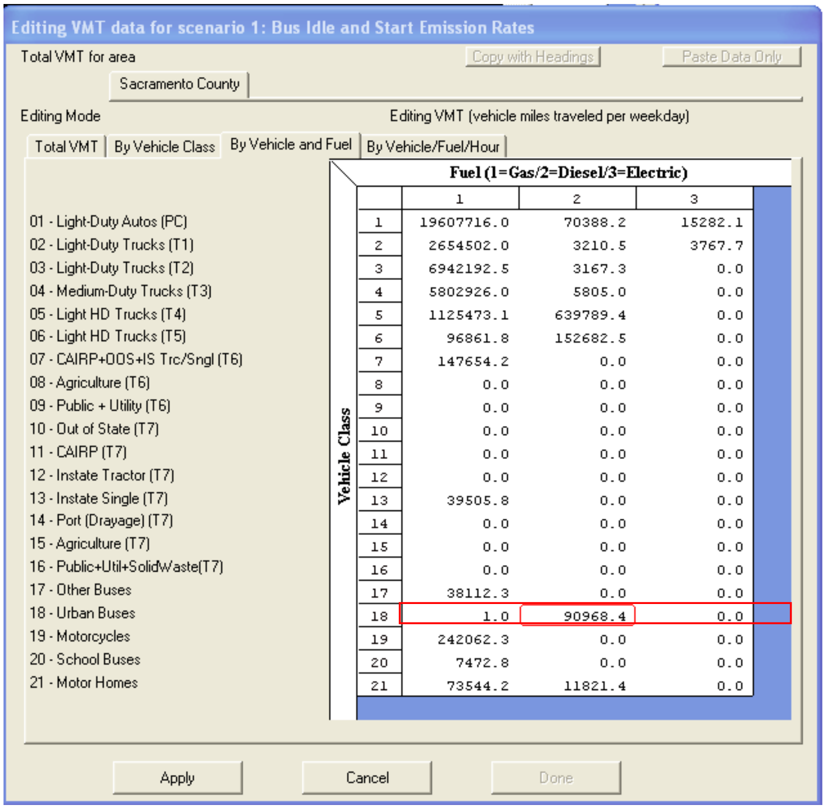
As shown in Figure H-2, VMT is edited to reflect only diesel operation by Urban Buses. For this example bus terminal, a very low value ("1") is entered into the interface for gasoline Urban Buses to represent the project-specific fuel data.

Exhibit H-2. Changing EMFAC2011-LDV Default VMT to Reflect Project-Specific Fuel Use



Vehicle Class		Fuel (1=Gas/2=Diesel/3=Electric) 1	2	3
01 - Light-Duty Autos (PC)	1	19607716.0	70388.2	15282.1
02 - Light-Duty Trucks (T1)	2	2654502.0	3210.5	3767.7
03 - Light-Duty Trucks (T2)	3	6942192.5	3167.3	0.0
04 - Medium-Duty Trucks (T3)	4	5802926.0	5805.0	0.0
05 - Light HD Trucks (T4)	5	1125473.1	639789.4	0.0
06 - Light HD Trucks (T5)	6	96861.8	152682.5	0.0
07 - CAIRP+OOS+IS Trc/Sngl (T6)	7	147654.2	0.0	0.0
08 - Agriculture (T6)	8	0.0	0.0	0.0
09 - Public + Utility (T6)	9	0.0	0.0	0.0
10 - Out of State (T7)	10	0.0	0.0	0.0
11 - CAIRP (T7)	11	0.0	0.0	0.0
12 - Instate Tractor (T7)	12	0.0	0.0	0.0
13 - Instate Single (T7)	13	39505.8	0.0	0.0
14 - Port (Drayage) (T7)	14	0.0	0.0	0.0
15 - Agriculture (T7)	15	0.0	0.0	0.0
16 - Public+Util+SolidWaste(T7)	16	0.0	0.0	0.0
17 - Other Buses	17	38112.3	0.0	0.0
18 - Urban Buses	18	31876.8	59091.6	0.0
19 - Motorcycles	19	242062.3	0.0	0.0
20 - School Buses	20	7472.8	0.0	0.0
21 - Motor Homes	21	73544.2	11821.4	0.0

Default EMFAC2011-LDV data before modification

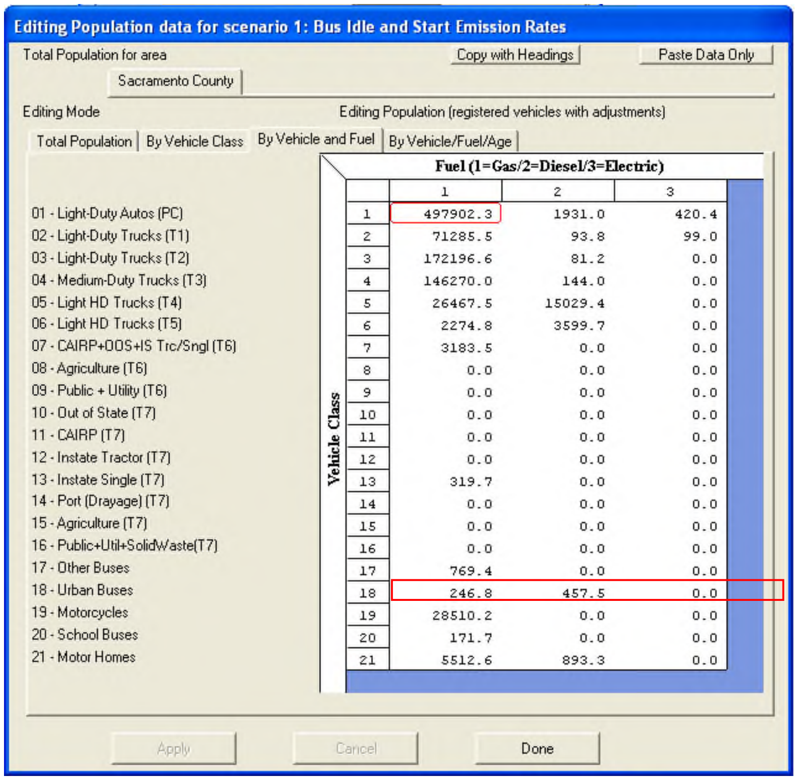


Vehicle Class		1	2	3
01 - Light-Duty Autos (PC)	1	19607716.0	70388.2	15282.1
02 - Light-Duty Trucks (T1)	2	2654502.0	3210.5	3767.7
03 - Light-Duty Trucks (T2)	3	6942192.5	3167.3	0.0
04 - Medium-Duty Trucks (T3)	4	5802926.0	5805.0	0.0
05 - Light HD Trucks (T4)	5	1125473.1	639789.4	0.0
06 - Light HD Trucks (T5)	6	96861.8	152682.5	0.0
07 - CAIRP+OOS+IS Trc/Sngl (T6)	7	147654.2	0.0	0.0
08 - Agriculture (T6)	8	0.0	0.0	0.0
09 - Public + Utility (T6)	9	0.0	0.0	0.0
10 - Out of State (T7)	10	0.0	0.0	0.0
11 - CAIRP (T7)	11	0.0	0.0	0.0
12 - Instate Tractor (T7)	12	0.0	0.0	0.0
13 - Instate Single (T7)	13	39505.8	0.0	0.0
14 - Port (Drayage) (T7)	14	0.0	0.0	0.0
15 - Agriculture (T7)	15	0.0	0.0	0.0
16 - Public+Util+SolidWaste(T7)	16	0.0	0.0	0.0
17 - Other Buses	17	38112.3	0.0	0.0
18 - Urban Buses	18	1.0	90968.4	0.0
19 - Motorcycles	19	242062.3	0.0	0.0
20 - School Buses	20	7472.8	0.0	0.0
21 - Motor Homes	21	73544.2	11821.4	0.0

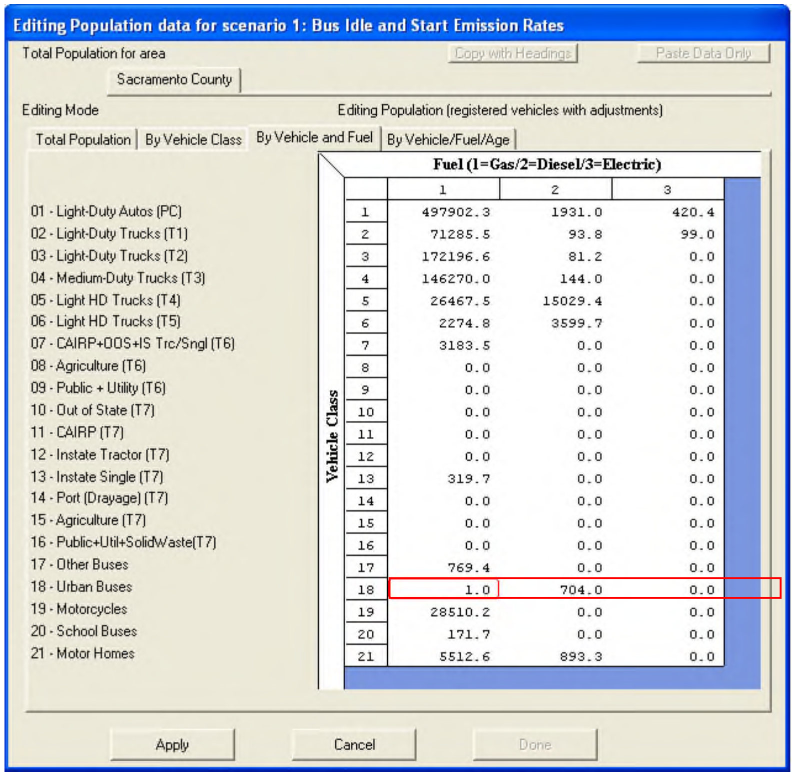
Modified EMFAC2011-LDV data

Next, in Exhibit H-3 the default EMFAC2011-LDV vehicle population is similarly edited to reflect an entirely diesel-fueled bus fleet.

Exhibit H-3. Changing EMFAC2011-LDV Default Population to Reflect Project-Specific Fuel Use



Default EMFAC2011-LDV data before modification

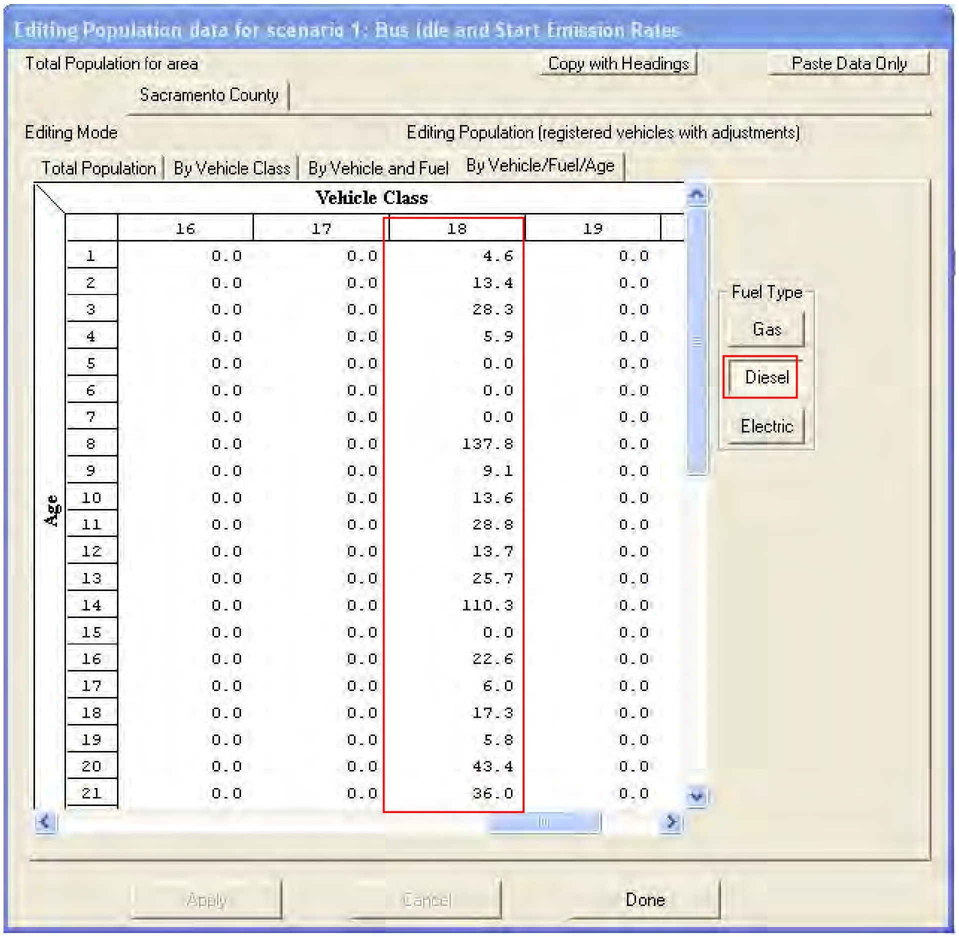


Vehicle Class		1	2	3
01 - Light-Duty Autos (PC)	1	497902.3	1931.0	420.4
02 - Light-Duty Trucks (T1)	2	71285.5	93.8	99.0
03 - Light-Duty Trucks (T2)	3	172196.6	81.2	0.0
04 - Medium-Duty Trucks (T3)	4	146270.0	144.0	0.0
05 - Light HD Trucks (T4)	5	26467.5	15029.4	0.0
06 - Light HD Trucks (T5)	6	2274.8	3599.7	0.0
07 - CAIRP+OOS+IS Trc/Sngl (T6)	7	3183.5	0.0	0.0
08 - Agriculture (T6)	8	0.0	0.0	0.0
09 - Public + Utility (T6)	9	0.0	0.0	0.0
10 - Out of State (T7)	10	0.0	0.0	0.0
11 - CAIRP (T7)	11	0.0	0.0	0.0
12 - Instate Tractor (T7)	12	0.0	0.0	0.0
13 - Instate Single (T7)	13	319.7	0.0	0.0
14 - Port (Drayage) (T7)	14	0.0	0.0	0.0
15 - Agriculture (T7)	15	0.0	0.0	0.0
16 - Public+Util+SolidWaste(T7)	16	0.0	0.0	0.0
17 - Other Buses	17	769.4	0.0	0.0
18 - Urban Buses	18	1.0	704.0	0.0
19 - Motorcycles	19	28510.2	0.0	0.0
20 - School Buses	20	171.7	0.0	0.0
21 - Motor Homes	21	5512.6	893.3	0.0

Modified EMFAC2011-LDV data

Finally, in Exhibit H-4, it is necessary to export the default age distribution for modification in Excel. The Urban Bus type has a default age distribution that does not match the project. To change the default, zeros ("0") are entered for all ages except "Age10" to reflect a fleet that is entirely 10 year-old buses. The table is copied and pasted back into the EMFAC2011-LDV module.

Exhibit H-4. Changing EMFAC2011-LDV Default Age Distribution to Reflect Project-Specific Bus Roster



	A	B	C	D	E	F	G	H	I	J	K
1	Sacramento County Diesel P	Age01	Age02	Age03	Age04	Age05	Age06	Age07	Age08	Age09	Age1(
2	01 - Light-Duty Autos (PC)	133.4758	137.1166	152.1877	158.1884	173.6059	179.5487	103.6043	4.97377	0	
3	02 - Light-Duty Trucks (T1)	6.95752	7.152435	7.606674	6.278053	8.160515	5.866775	0	0	0	
4	03 - Light-Duty Trucks (T2)	4.866089	9.060982	10.413	5.814407	4.593681	6.801266	0	0	0	6.659
5	04 - Medium-Duty Trucks (T3	8.03714	7.291153	8.159173	7.372656	7.056864	5.781903	44.25079	3.721883	3.715413	2.745
6	05 - Light HD Trucks (T4)	707.3047	684.5059	650.1201	577.6885	531.6475	465.5589	110.2175	491.8519	599.908	1337.
7	06 - Light HD Trucks (T5)	171.5688	161.188	160.5263	150.7287	129.66	109.6431	53.12713	256.6604	243.032	419.9
8	07 - CAIRP+OOS+IS Trc/Sngl (	0	0	0	0	0	0	0	0	0	
9	08 - Agriculture (T6)	0	0	0	0	0	0	0	0	0	
10	09 - Public + Utility (T6)	0	0	0	0	0	0	0	0	0	
11	10 - Out of State (T7)	0	0	0	0	0	0	0	0	0	
12	11 - CAIRP (T7)	0	0	0	0	0	0	0	0	0	
13	12 - Instate Tractor (T7)	0	0	0	0	0	0	0	0	0	
14	13 - Instate Single (T7)	0	0	0	0	0	0	0	0	0	
15	14 - Port (Drayage) (T7)	0	0	0	0	0	0	0	0	0	
16	15 - Agriculture (T7)	0	0	0	0	0	0	0	0	0	
17	16 - Public+Util+SolidWaste(	0	0	0	0	0	0	0	0	0	
18	17 - Other Buses	0	0	0	0	0	0	0	0	0	
19	18 - Urban Buses	4.634178	13.41263	28.27333	5.890194	0	0	0	137.847	9.056062	13.58
20	19 - Motorcycles	0	0	0	0	0	0	0	0	0	
21	20 - School Buses	0	0	0	0	0	0	0	0	0	
22	21 - Motor Homes	30.27832	28.08069	25.44299	22.05225	19.21754	19.0921	8.860383	44.64226	56.58108	70.4
23											
24											

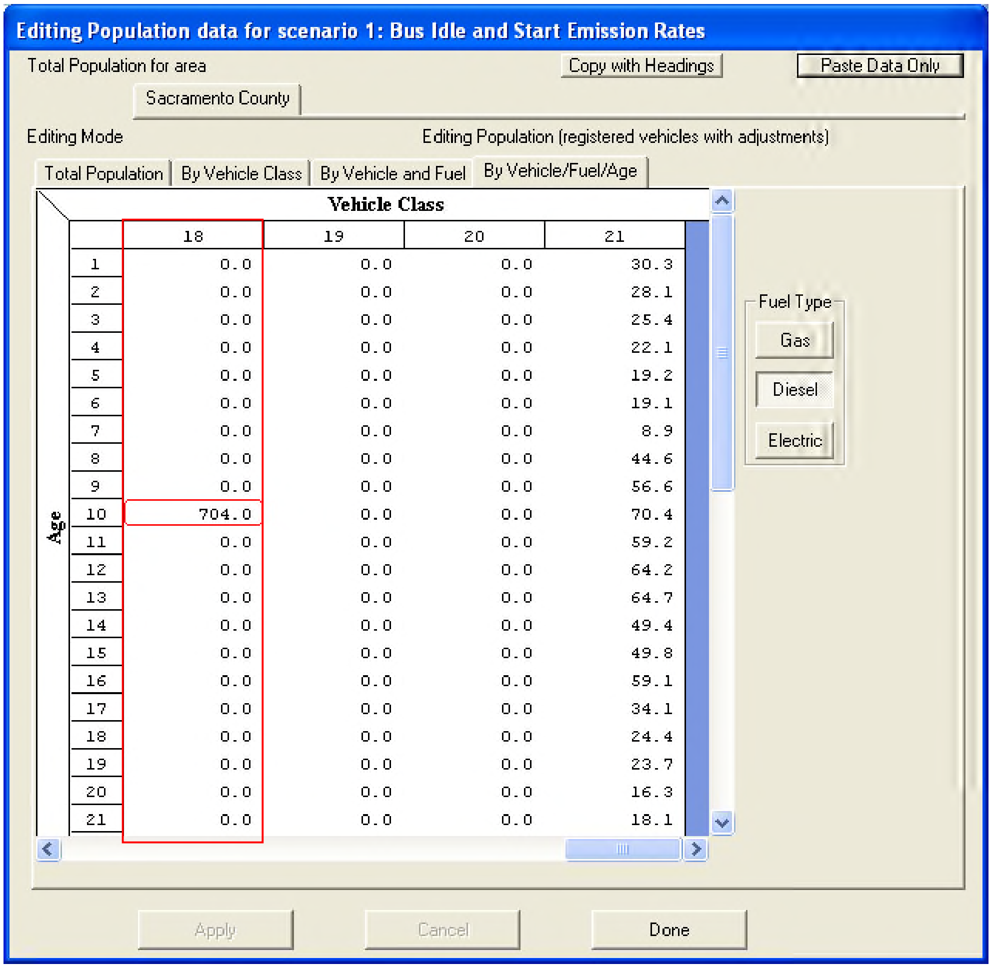
Sheet1 Sheet2 Sheet3

Default EMFAC2011-LDV age distribution before modification

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Sacramen	Age01	Age02	Age03	Age04	Age05	Age06	Age07	Age08	Age09	Age10	Age11	Age12
2	01 - Light-	133.4758	137.1166	152.1877	158.1884	173.6059	179.5487	103.6043	4.97377	0	0	0	
3	02 - Light-	6.95752	7.152435	7.606674	6.278053	8.160515	5.866775	0	0	0	0	0	
4	03 - Light-	4.866089	9.060982	10.413	5.814407	4.593681	6.801266	0	0	0	6.659657	7.168968	
5	04 - Mediu	8.03714	7.291153	8.159173	7.372656	7.056864	5.781903	44.25079	3.721883	3.715413	2.745002	0	1.775
6	05 - Light I	707.3047	684.5059	650.1201	577.6885	531.6475	465.5589	110.2175	491.8519	599.908	1337.003	1116.968	1365.
7	06 - Light I	171.5688	161.188	160.5263	150.7287	129.66	109.6431	53.12713	256.6604	243.032	419.9518	341.9187	183.
8	07 - CAIRP	0	0	0	0	0	0	0	0	0	0	0	
9	08 - Agricu	0	0	0	0	0	0	0	0	0	0	0	
10	09 - Public	0	0	0	0	0	0	0	0	0	0	0	
11	10 - Out o	0	0	0	0	0	0	0	0	0	0	0	
12	11 - CAIRP	0	0	0	0	0	0	0	0	0	0	0	
13	12 - Instat	0	0	0	0	0	0	0	0	0	0	0	
14	13 - Instat	0	0	0	0	0	0	0	0	0	0	0	
15	14 - Port (I	0	0	0	0	0	0	0	0	0	0	0	
16	15 - Agricu	0	0	0	0	0	0	0	0	0	0	0	
17	16 - Public	0	0	0	0	0	0	0	0	0	0	0	
18	17 - Other	0	0	0	0	0	0	0	0	0	0	0	
19	18 - Urban	0	0	0	0	0	0	0	0	0	704	0	
20	19 - Motor	0	0	0	0	0	0	0	0	0	0	0	
21	20 - Schoo	0	0	0	0	0	0	0	0	0	0	0	
22	21 - Motor	30.27832	28.08069	25.44299	22.05225	19.21754	19.0921	8.860383	44.64226	56.58108	70.4305	59.19204	64.17
23													
24													

Sheet1 Sheet2 Sheet3

Modified age distribution



Age	18	19	20	21
1	0.0	0.0	0.0	30.3
2	0.0	0.0	0.0	28.1
3	0.0	0.0	0.0	25.4
4	0.0	0.0	0.0	22.1
5	0.0	0.0	0.0	19.2
6	0.0	0.0	0.0	19.1
7	0.0	0.0	0.0	8.9
8	0.0	0.0	0.0	44.6
9	0.0	0.0	0.0	56.6
10	704.0	0.0	0.0	70.4
11	0.0	0.0	0.0	59.2
12	0.0	0.0	0.0	64.2
13	0.0	0.0	0.0	64.7
14	0.0	0.0	0.0	49.4
15	0.0	0.0	0.0	49.8
16	0.0	0.0	0.0	59.1
17	0.0	0.0	0.0	34.1
18	0.0	0.0	0.0	24.4
19	0.0	0.0	0.0	23.7
20	0.0	0.0	0.0	16.3
21	0.0	0.0	0.0	18.1

Modified EMFAC2011-LDV data

H.6 PROCESSING IDLE EMISSION FACTORS

Urban Buses ("UBUS") is the vehicle class best representing transit buses in this hypothetical bus terminal project. After the EMFAC2011-LDV run is completed, the project-specific idle exhaust emission factors are presented in Table 1 of the output Summary Rates file (.rts file) as shown in Exhibit H-5.

Exhibit H-5. EMFAC2011-LDV Output

sacramento_transit.rts - Notepad

File Edit Format View Help

Pollutant Name: PM10 Temperature: 70F Relative Humidity: 70%

Speed MPH	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
0	0.000	0.000	0.088	0.000	0.000	0.000	0.018
5	0.009	0.011	0.021	0.034	0.106	0.001	0.013
10	0.006	0.007	0.015	0.023	0.077	0.001	0.009
15	0.004	0.005	0.012	0.016	0.058	0.001	0.006
20	0.003	0.004	0.009	0.011	0.045	0.001	0.005
25	0.002	0.003	0.007	0.009	0.036	0.001	0.004
30	0.002	0.002	0.006	0.008	0.030	0.000	0.003
35	0.002	0.002	0.005	0.007	0.026	0.000	0.003
40	0.001	0.002	0.005	0.007	0.023	0.001	0.002
45	0.001	0.002	0.004	0.007	0.022	0.001	0.002
50	0.001	0.002	0.004	0.007	0.021	0.001	0.002
55	0.001	0.002	0.004	0.008	0.021	0.001	0.002
60	0.002	0.002	0.004	0.010	0.021	0.001	0.002
65	0.002	0.002	0.004	0.011	0.023	0.001	0.003

As discussed, the Urban Bus type does not have an explicit idle emission rate. Therefore, the 5 mph emission rate will be used to represent idle operation. As highlighted in Exhibit H-5, the PM_{10} 5 mph exhaust emission factor for the Urban Buses is 0.106 grams/veh-mile. In order to produce a grams/veh-hour emission factor for use in AERMOD, this emission factor (0.106 grams/vehicle-mile) is multiplied by 5 miles per hour. The resulting rate is 0.53 grams/veh-hour. Note that buses typically do not idle for the entire hour, so this rate should be applied to the actual number of bus idle-hours (i.e., [grams/vehicle-hour] x [idling time of each vehicle in fraction of an hour] x [number of vehicles]) expected in the project area to produce an updated grams/hour rate.

This completes the use of EMFAC2011-LDV for determining idle emission factors for this project. The grams/hour idle rate can now be input into AERMOD as discussed in Section 7 of the guidance.

Appendix I:
Estimating Locomotive Emissions

I.1 INTRODUCTION

This appendix describes how to quantify locomotive emissions when they are a component of a transit or freight terminal or otherwise a source in the project area being modeled. Note that state or local air quality agencies may have experience modeling locomotive emissions and therefore could be of assistance when quantifying these emissions for a PM hot-spot analysis.

Generally speaking, locomotive emissions can be estimated in the following manner:

1. Determine where in the project area locomotive emissions should be estimated.

2. Determine when to analyze emissions.

3. Describe the locomotive activity within the project area, including:
    - The locomotives present in the project area (the "locomotive roster"); and
    - The percentage of time each locomotive spends in various throttle settings (the "duty cycle").

4. Calculate locomotive emissions using either:
    - Horsepower rating and load factors, or
    - Fuel consumption data.[1]

The estimated locomotive emission rates that result from this process would then be used for air quality modeling. The interagency consultation process must be used to evaluate and choose the model and associated method and assumptions used for quantifying locomotive emissions for PM hot-spot analyses (40 CFR 93.105(c)(1)(i)).

I.2 DETERMINING WHERE IN THE PROJECT AREA LOCOMOTIVE EMISSIONS SHOULD BE ESTIMATED

Under certain circumstances, it is appropriate to model different locations within the project area as separate sources to characterize differences in locomotive type and/or activity appropriately. This step is analogous to dividing a highway project into links (as described in Sections 4.2 and 5.2 of the guidance) and improves the accuracy of emissions modeling and subsequent air quality modeling. For example, in an intermodal terminal, emissions from a mainline track (which will have a large percentage of higher

[1] These are the two methods described in this appendix; others may be possible. See Appendix I.5 for details.

speed operations with little idling) should be estimated separately from the associated passenger or freight terminal (which would be expected to experience low speed operations and significant idling).

The following activities are among those typically undertaken by locomotives and are candidates for being modeled as separate sources if they occur at different locations within the project area:

- Idling within the project area;
- Trains arriving into, or departing from, the project area (e.g., terminal arrival and departure operations);
- Testing, idling, and service movements in maintenance areas or sheds;
- Switching operations;
- Movement of trains passing through, but not stopping in, the project area.

The project area may also be divided into separate sources if it includes several different locomotive rosters (see Appendix I.4.1, below)

I.3 DETERMINING WHEN TO ANALYZE EMISSIONS

The number of hours and days that have to be analyzed depends on the range of activity expected to occur within the project area. For rail projects where activity varies from hour to hour, day to day, and possibly month to month, it is recommended that, at a minimum, project sponsors calculate emissions based on 24 hours of activity for both a typical weekday and weekend day and for four representative quarters of the analysis year when comparing emissions to all $PM_{2.5}$ NAAQS.[2] For projects in areas that violate only the 24-hour PM_{10} or $PM_{2.5}$ NAAQS, the project sponsor may choose to model only one quarter, in appropriate cases. See Section 3.3.4 of the guidance for further information.

These resulting emission rates should be applied to AERMOD and used to calculate design values to compare with the applicable PM NAAQS as described in Sections 7 through 9 of the guidance.

I.4 DESCRIBING THE LOCOMOTIVE ROSTERS AND DUTY CYCLES

Before calculating locomotive emission rates, it is necessary to know what locomotives are present in the locations being analyzed in the project area (see Appendix I.2, above) and what activities these locomotives are undertaking at these locations. This data will impact how emissions are calculated.

[2] If there is no difference in activity between weekday and weekend activity, it may not be necessary to examine weekend day activity separately. Similarly, if there is no difference in activity between quarters, emission rates can be determined for one quarter, which can then be used to represent every quarter of the analysis year.

I.4.1 Locomotive rosters

Because emissions can vary significantly depending on a locomotive's make, model, engine, and year of engine manufacture (or re-manufacture), it is important to know what locomotives are expected to be operating within the project area. Project sponsors should develop a "locomotive roster" (i.e., a list of each locomotive's make, model, engine, and year) for the locomotives that will be operating within the specific project area being analyzed. The more detailed the locomotive roster, the more accurate the estimated emissions will be.

In some cases, it will be necessary to develop more than one locomotive roster to reflect the operations in the project area accurately (for example, switcher locomotives may be confined to one portion of a facility and therefore may be represented by their own roster). In these situations, users should model areas with different rosters as separate sources to account for the variability in emissions (see Appendix I.2).

I.4.2 Locomotive duty cycles

Diesel locomotive engine power is controlled by "notched" throttles; idling, braking, and moving the locomotive is conducted by placing the throttle in one of several available "notch settings."[3] A locomotive's "duty cycle" is a description of how much time, on average, the locomotive spends in each notch setting when operating. Project sponsors should use the latest locally-generated or project-specific duty cycles whenever possible; this information may be available from local railway authorities or the state or local air agency.[4] The default duty cycles for line-haul and switch locomotives, found in Tables 1 and 2 of 40 CFR 1033.530 (EPA's regulations on controlling emissions from locomotives), should be used only if they adequately represent the locomotives that will be present in the project area and no local or project-specific duty cycles are available.

I.5 CALCULATING LOCOMOTIVE EMISSIONS

Once a project's locomotive rosters and respective duty cycles have been determined, locomotive emissions can then be calculated for each part of the project area using either (1) horsepower rating and load factors, or (2) fuel consumption data. These two methods are summarized below. Unless otherwise determined through consultation, only one method should be used for a given project.

[3] A diesel locomotive typically has eight notch settings for movement (run notches), in addition to one or more idle or dynamic brake notch settings. Dynamic braking is when the locomotive engine, rather than the brake, is used to control speed.

[4] The state or local air agency may have previously developed locally-appropriate duty cycles for emissions inventory purposes.

I.5.1 Finding emission factors

Regardless of method chosen, locomotive emissions factors will be needed for the analysis. Locomotive emission factors depend on the type of engine, the power rating of the locomotive (engine horsepower), and the year of engine manufacture (or re-manufacture). Default PM_{10} emission factors for line-haul and switch locomotives can be obtained from Tables 1 and 2 of EPA's "Emission Factors for Locomotives," EPA-420-F-09-025 (April 2009).[5] These PM_{10} emission factors are in grams/horsepower-hour and can easily be converted to $PM_{2.5}$ emission factors. However, these are simply default values; locomotive-specific data may be available from manufacturers and should be used whenever possible. In addition, see Appendix I.5.4 for other variables that must be considered when determining the appropriate locomotive emission factors.

Note that the default locomotive emission factors promulgated by EPA may change over time as new information becomes available. The April 2009 guidance cited above contains the latest emission factors as of this writing. Project sponsors should consult the EPA's website at: www.epa.gov/otaq/locomotives.htm for the latest locomotive default emission factors and related guidance.

I.5.2 Calculating emissions using horsepower rating and load factors

One way locomotive emissions can be calculated is to use $PM_{2.5}$ or PM_{10} locomotive emission factors, the horsepower rating of the engines found on the locomotive roster, and engine load factors (which are calculated from the duty cycle).

<u>Calculating Engine Load Factors</u>

The horsepower of the locomotive engines, including the horsepower used in each notch setting, should be available from the rail operator or locomotive manufacturer. Locomotive duty cycle data (see Appendix I.4.2) can then be used to determine how much time each locomotive spends in each notch setting, including braking and idling. An engine's "load factor" is the percent of maximum available horsepower it uses over the course of its duty cycle. In other words, a load factor is the weighted average power used by the locomotive divided by the engine's maximum rated power.[6] Load factors can be calculated by summing the actual horsepower-hours of work generated by the engine in a given period of time and dividing it by the engine's maximum horsepower and the hours during which the engine was being used, with the result expressed as a percentage. For example, if a 4000 hp engine spends one hour at full power (generating 4000 hp-hrs) and one hour at 50 percent power (generating 2000 hp-hrs), its load factor would be 75

[5] Table 1 of EPA's April 2009 document includes default emission factors for higher power cycles representative of general line-haul operation; Table 2 includes emission factors for lower power cycles used for switching operations. The April 2009 document also includes information on how to convert PM_{10} emission factors for $PM_{2.5}$ purposes. Note that Table 6 (PM_{10} Emission Factors) should not be used for PM hot-spot analyses, since these factors are national fleet averages rather than emission factors for any specific project.

[6] "Weighted average power" in this case is the average power used by the locomotive weighted by the time spent in each notch, as explained further below.

percent (6000 hp-hrs ÷ 4000 hp ÷ 2 hrs). Note that, in this example, it would be equivalent to calculate the load factor using the percent power values instead: ((100% * 1 hr) + (50% * 1 hr) ÷ 2 hrs = 75%). To simplify emission factor calculations, it is recommended that locomotive activity be generalized into the operational categories of "moving" and "idling," with separate load factors calculated for each.

An engine's load factor is calculated by completing the following steps:

<u>Step 1</u>. Determine the number of notch settings the engine being analyzed has and the horsepower used by the engine in each notch setting.[7] Alternatively, as described above, the percent of maximum power available in each notch could instead be used.

<u>Step 2</u>. Identify the percentage of time the locomotive being analyzed spends in each notch setting based on its duty cycle (see Appendix I.4.2).

<u>Step 3</u>. To make emission rate calculations easier, it is useful to calculate two separate load factors for an engine: one for when the locomotive is idling and one for when it is moving.[8] Therefore, the percentage of time the locomotive spends in each notch (from Step 2) needs to be adjusted so that all idling and all moving notches are considered separately. For example, if a locomotive has just one idle notch setting, it spends 100% of its idling time in that setting, even if it only idles during part of its duty cycle. While calculating the time spent idling will usually be simple, for the non-idle (moving) notch settings some additional adjustment to the locomotive's duty cycle percentages will be required to determine the time spent in each moving notch as a fraction of total time spent moving, disregarding any time spent idling.

For example, say a locomotive spends 30% of its time idling and 70% of its time moving over the course of its duty cycle and that 15% of this total time (idling and moving together) is spent in notch 2. When calculating the moving load factor, this percentage needs to be adjusted to determine what fraction of just the 70% of time spent moving is spent in notch 2. In this example, 15% of the total duty cycle spent in notch 2 would equal 21.4% (15% * 100% ÷ 70%) of the locomotive's time when it is not at idle; that is, whenever it is moving, this locomotive spends 21.4% of its time in notch 2. This calculation is repeated for each moving notch setting. The result will be the fraction of time spent in each notch when considering idle and moving modes of operation separately.

<u>Step 4</u>. The next step is to calculate what fraction of maximum available horsepower is being used based on the time spent in each notch setting as was calculated in Step 3. This is determined by summing the product of the percentage of time spent in each notch (calculated in Step 3) by the horsepower generated by the engine at that notch setting (determined in Step 1). For example, if the locomotive with a rated engine power of

[7] For locomotives that are equipped with multiple dynamic braking notches and/or multiple idle notches, it may be necessary to assume a single dynamic braking notch and a single idle notch, depending on what information is available about the particular engine.
[8] In this case, "moving" refers to all non-idle notch settings: that is, dynamic braking and all run notches.

3000 hp spends 21.4% of its moving time in notch 2 and 78.6% of its moving time in notch 6, and is known to generate 500 hp while in notch 2 and 2000 hp while in notch 6, then its weighted average power would be 1679 hp (107 hp (500 hp * 0.214) + 1572 hp (2000 hp * 0.786) = 1679 hp).

Step 5. The final step is to determine the load factors. This is done by dividing the weighted average horsepower (calculated in Step 4) by the maximum engine horsepower. For idling, this should be relatively simple. For example, if there is one idle notch setting and it is known that a 4000 hp engine uses 20 hp when in its idle notch, then its idle load factor will be 0.5% (20 hp ÷ 4000 hp). To determine the load factor for all power notches, the weighted horsepower calculated in Step 4 should be divided by the total engine horsepower. For example, if the same 4000 hp engine is determined to use an average of 1800 hp while in motion (as determined by adjusting the horsepower by the time spent in each "moving" notch setting in Step 4), then the moving load factor would be 45% (1800 hp ÷ 4000 hp).

The resulting idling and moving load factors represent the average amount of the total engine horsepower the locomotive is using when idling and moving, respectfully. These load factors can then be used to modify PM emission factors and generate emission rates as described below.

Generating Emission Rates Based on Load Factors

As noted above, EPA's "Emission Factors for Locomotives" provides emission factors in grams/brake horsepower-hour. This will also likely be the case with any specific emission factors obtained from manufacturer's specifications. These units can be converted into grams/second (g/s) emission rates by using the load factor on the engines and the time spent in each operating mode, as described below.

The first step is to adjust the PM emission factors to reflect how the engine will actually be operating.[9] This is done by multiplying the appropriate PM emission factor by the idling and moving load factors calculated for that particular engine.[10] Next, to determine the emission rate, this adjusted emission factor is further multiplied by the amount of time the locomotive spends idling and moving while in the project area.[11]

For example, if the PM emission factor known to be 0.18 g/bhp-hr, the engine being analyzed has an idling load factor of 0.5%, and the locomotive is anticipated to idle 24 minutes per hour in the project area, then the resulting emission rate would be 0.035 grams/hour (0.18 g/bhp-hr * 0.5% * 0.4 hours).

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[9] Because combustion characteristics of an engine vary by throttle notch position, it is appropriate to adjust the emission factor to reflect the average horsepower actually being used by the engine.
[10] Project sponsors are reminded to check www.epa.gov/otaq/locomotives.htm to ensure the latest default emission factors for idle and moving emissions are being used.
[11] Note that this may or may not match up with the idle and moving time as described by the duty cycle used to calculate the load factors, depending on how project-specific that duty cycle is.

Emission rates need to be converted into g/s for use by AERMOD, as described further in Sections 7 through 9 of the guidance. These calculations should be repeated until the entire locomotive roster is represented in each part of the project area being analyzed.

Appendix I.7 provides an example of calculating g/s locomotive emission rates using this methodology.

I.5.3 Calculating emissions using fuel consumption data

Another method to calculate locomotive emissions involves using fuel consumption data. Chapter 6.3 of EPA's "Procedure for Emission Inventory Preparation -- Volume IV: Mobile Sources" (reference information provided in Appendix I.6, below) is a useful reference and should be consulted when using this method.

Note that, for this method, it may be useful to scale down data already available to the project sponsor. For example, if rail car miles/fuel consumption is known for trains operating in situations identical to those being estimated in the project area, this data can be used to estimate fuel consumption rates for a defined track length within the project area.

<u>Calculating Average Fuel Consumption</u>

Locomotive fuel consumption is specific to a particular locomotive engine and the throttle (notch) setting it is using. Data on the fuel consumption of various engines at different notch settings can often be obtained from the locomotive or engine manufacturer's specifications. When only partial data is available (e.g., only data for the lowest and highest notch settings are known), interpolation combined with best available engineering judgment can be used to determine fuel consumption at the intermediate notch settings.

A locomotive's average fuel consumption can be calculated by determining how long each locomotive is expected to spend in each notch setting based on its duty cycle (see Appendix I.4.2). This data can be aggregated to generate an average fuel consumption rate for each locomotive type. See Chapter 6.3 of Volume IV for details on how to generate this data based on a specific locomotive roster and duty cycle.

Once the average fuel consumption rates have been determined, they should be multiplied by the appropriate emission factors to determine a composite average hourly emission rate for each engine in the roster. Since the objective is to determine an average fuel consumption rate for the entire locomotive roster, this calculation should be repeated for each engine on the roster at each location analyzed.

If several individual sources will be modeled at different sections of the project area as described in Appendix I.2, train schedule data should be consulted to determine the hours of operation of each locomotive within each section of the project area. Hourly emission rates per locomotive should then be multiplied by the number of hours the locomotive is operating, for each hour of the day in each section of the project area to provide average hourly emission rates for each section of the project. These should then be converted to grams/second for use in AERMOD, as described further in Sections 7 through 9 of the guidance.

Examples of calculating locomotive emissions using this method can be found in Chapter 6 of Volume IV.

I.5.4 Factors influencing locomotive emissions and emission factors

The following considerations will influence locomotive emissions regardless of the method used and should be examined when determining how to characterize locomotives for emissions modeling or when choosing the appropriate emission factors:

- Project sponsors should be aware of the emission reductions that would result from remanufacturing existing locomotives (or replacing existing locomotives with new locomotives) that meet EPA's Tier 3 or Tier 4 emission standards when they become available. The requirements that apply to existing and new locomotives were addressed in EPA's 2008 rulemaking entitled "Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 liters Per Cylinder" (73 FR 37095). Beginning in 2012 all locomotives will be required to use ultra-low sulfur diesel fuel (69 FR 38958). Additionally, when existing locomotives are remanufactured, certified remanufacture systems will have to be installed to reduce emissions. Beginning in 2011, new locomotives must meet tighter Tier 3 emission standards. Finally, beginning in 2015 even more stringent Tier 4 emission standards for new locomotives will begin to be phased in.

- For locomotives manufactured before 2005, a given locomotive may be in one of three possible configurations, depending on when it was last remanufactured: (1) uncertified; (2) certified to the standards in 40 CFR Part 92; or (3) certified to the standards in 40 CFR Part 1033. Each of these configurations should be treated as a separate locomotive type when conducting a PM hot-spot analysis.

- Emissions from locomotives certified to meet Family Emission Limits (FELs) may differ from the emission standard identified on the engine's Emission Control Information label. Rail operators will know if their locomotives participate in this program. Any locomotives in the project area participating in this program should be identified so that the actual emissions from the particular locomotives being analyzed are considered in the analysis, rather than the family emissions level listed on their FEL labels.

I.6 AVAILABLE RESOURCES

These resources and websites should be checked prior to beginning any PM hot-spot analysis to ensure that the latest data (such as emission factors) are being used:

- "Emission Factors for Locomotives," EPA-420-F-09-025 (April 2009). Available online at: www.epa.gov/otaq/locomotives.htm.

- Chapter 6 of "Procedure for Emission Inventory Preparation - Volume IV: Mobile Sources." Available online at: www.epa.gov/otaq/models/nonrdmdl/r92009.pdf . Note that, as of this writing, the emission factors listed in Volume IV have been superseded by the April 2009 publication listed above for locomotives certified to meet current EPA standards.[12]

- "Control of Emissions from Idling Locomotives," EPA-420-F-08-014, March 2008. Available online at: www.epa.gov/otaq/regs/nonroad/locomotv/420f13050.pdf.

- See Section 10 of the guidance for additional information regarding potential locomotive emission control measures.

I.7 EXAMPLE OF CALCULATING LOCOMOTIVE EMISSION RATES USING HORSEPOWER RATING AND LOAD FACTOR ESTIMATES

The following example demonstrates how to estimate locomotive emissions using the engine horsepower rating/load factor method described in Appendix I.5.2.

The hypothetical proposed project in this example includes the construction of an intermodal terminal in an area that is designated as nonattainment for both the 1997 annual $PM_{2.5}$ NAAQS and the 2006 24-hour $PM_{2.5}$ NAAQS. The terminal in this example is to be completed and operational in 2013. The hot-spot analysis is performed for 2015, because it is determined through interagency consultation that this will be the year of peak emissions, when considering the project's emissions and the other emissions in the project area.

In this example, the operational schedule anticipates that 32 locomotives will be in the project area over a 24-hour period, with 16 locomotives in the project area during the peak hour. Based on the schedule, it is further determined that while in the project area each train will spend 540 seconds idling and 76 seconds moving.

The locomotive $PM_{2.5}$ emissions are calculated based on horsepower rating and load factors.

[12] Although the emission factors have been superseded, the remainder of the Volume IV guidance remains in effect.

I.7.1 Calculate idle and moving load factors

As described in I.5.2, the project sponsor uses a series of steps to calculate load factors. These steps are described below and the results from each step are shown in table form in Exhibit I-1.

Step 1: The project sponsor first needs some information about the locomotives expected to be operating at the terminal in the analysis year.

For each locomotive, the horsepower used by the locomotive in each notch setting as well as under dynamic braking and at idle must be determined. For the purpose of this example it is assumed that all of the locomotives that will serve this terminal are very similar: all use the same horsepower under each of operating conditions, and all have only one idle and dynamic braking notch setting. The horsepower generated at each notch setting is obtained from the engine specifications (see second column of Exhibit I-1). In this case, the rated engine horsepower is 4000 hp (generated at notch 8).

Step 2: The next step is to determine the average amount of time that the locomotives spend in each notch and expressing the results as a percentage of the locomotive's total operating time. In this example, it is determined that, based on their duty cycle, the locomotives that will service this terminal spend 38% of their time idling and 62% of their time in motion in one of the eight run notch settings or under dynamic braking. The percentage of time spent in each notch is shown in the third column of Exhibit I-1.

Step 3: To make emission factor calculations easier, it is decided to calculate separate idling and moving load factors. The next step, then, is for the project sponsor to calculate the actual percentage of time that the locomotives spend in each notch, treating idling and moving time separately. This is done by excluding the time spent idling and recalculating the percentage of time spent in the other notches (i.e., dynamic braking and each of the eight notch settings) so that the total time spent in non-idle notches adds to 100%. The results are shown in the fourth column of Exhibit I-1.

Step 4: The next step is to calculate the weighted average horsepower for this engine using the horsepower generated in each notch and the percentage of time spent in each notch as adjusted in Step 3. For locomotives that are idling, this is simply the horsepower used at idle. For the other notches, the actual horsepower for each notch is determined by multiplying the horsepower generated in a given notch (determined in Step 1) by the actual percentage of time that the locomotive is in that notch, as adjusted (calculated in Step 3). The results are shown in the fifth column of Exhibit I-1.

Step 5: The final step in this part of the analysis is to determine the idle and moving load factors. The idle load factor is just the horsepower generated at idle divided by the maximum engine horsepower, with the result expressed as a percentage. To determine the moving load factor, the weighted average horsepower for all non-idle notches (calculated in Step 4) is divided by the maximum engine horsepower, with the result expressed as a percentage. The final column of Exhibit I-1 shows the results of these calculations, with the idling and moving load factors highlighted.

Exhibit I-1. Calculating Locomotive Load Factors

Notch Setting	**Step 1: Horsepower (hp) used in notch**	**Step 2: Average % time spent in notch**	**Step 3: Reweighted time spent in each notch** (adjusted so that non-idle notches add to 100%)	**Step 4: Time-weighted hp used, based on time spent in notch**	**Step 5: Load factors (idle and moving)**
Idling load factor:					
Idle	14	38.0%	100.0%	14.0	0.4%
Moving load factor:					
Dynamic Brake	136	12.5%	20.2%	27.5	
1	224	6.5%	10.5%	23.5	
2	484	6.5%	10.5%	50.8	
3	984	5.2%	8.4%	82.7	
4	1149	4.4%	7.1%	81.6	
5	1766	3.8%	6.1%	107.8	
6	2518	3.9%	6.3%	158.6	
7	3373	3.0%	4.8%	161.9	
8	4,000	16.2%	26.1%	1,044.0	
Total		62.0%	100.0%	1,752.4	43.8%

I.7.2 Using the load factors to calculate idle and moving emission rates

Now that the idle and moving load factors have been determined, the gram/second (g/s) emission rates can be calculated for the idling and moving locomotives.

First, the project sponsor would determine how many locomotives are projected to be idling and how many are projected to be in motion during the peak hour of operation and over a 24-hour period. As previously noted, it is anticipated that 32 locomotives will be in the project area over a 24-hour period, with 16 locomotives in the project area during the peak hour. It was further determined that, while in the project area, each train will spend 540 seconds idling and 76 seconds moving.

For the purpose of this example, it has been assumed that each locomotive idles for the same amount of time and is in motion for the same amount of time. Note that, in this case, the number of locomotives considered "moving" will be double the actual number of locomotives present in order to account for the fact that each locomotive moves twice through the project area (as it arrives and departs the terminal).

Next, the project sponsor would determine the $PM_{2.5}$ emission factor to be used in this analysis for 2015. These emission factors can be determined from the EPA guidance titled "Emission Factors for Locomotives."

Table 1 of "Emission Factors for Locomotives" presents PM_{10} emission factors in terms of grams/brake horsepower-hour (g/bhp-hr) for line haul locomotives that are typically used by commuter railroads. Emission factors are presented for uncontrolled locomotives, locomotives manufactured to meet Tier 0 through Tier 4 emission standards, and locomotives remanufactured to meet more stringent emission standards. It's important to determine the composition of the fleet of locomotives that will use the terminal in the year that is being analyzed so that the emission factors in Table 1 can be used in the calculations. This information would be available from the railway operator.

In this example, we are assuming that all of the locomotives meet the Tier 2 emission standard. However, an actual PM hot-spot analysis would likely have a fleet of locomotives that meets a combination of these emission standards. The calculations shown below would have to be repeated for each different standard that applies to the locomotives in the fleet.

The final step in these calculations is to use the information shown in Exhibit I-1 and the other project data collected to calculate the $PM_{2.5}$ emission rates for idling and moving locomotives during both the peak hour and over a 24-hour basis.[13]

<u>Calculating Peak Hour Idling Emissions</u>

The following calculation would be used to determine the idling emission rate during the peak hour of operation:[14]

$PM_{2.5}$ Emission Rate = (16 trains/hr) * (1 hr/3,600 s) * (540 s/train) * (4,000 hp) * (0.004) * (0.18 g/bhp-hr) * (1 hr/3,600 s) * (0.97)
$PM_{2.5}$ Emission Rate = 0.0019 g/s

Where:

- Trains per hour = 16 (number of trains present in peak hour)
- Idle time per train = 540 s (from anticipated schedule)
- Locomotive horsepower = 4,000 hp (from engine specifications)
- Idle load factor = 0.004 (0.4%, calculated in Exhibit I-1)
- Tier 2 Locomotive Emission Factor = 0.18 g/bhp-hr (from "Emission Factors for Locomotives")
- Ratio of $PM_{2.5}$ to PM_{10} = 0.97 (from "Emission Factors for Locomotives")

[13] Peak hour emission rates will not be necessary for all analyses; however, for certain projects that involve very detailed air quality modeling analyses, peak hour emission rates may be necessary to more accurately reflect the contribution of locomotive emissions to air quality concentrations in the project area.
[14] Note that, for the calculations shown here, any units expressed in hours or days need to be converted to seconds since a g/s emission rate is required for AERMOD.

Calculating 24-hour Moving Emissions

Similarly, the following equation would be used to calculate the moving emission rate for the 24-hour period:

$PM_{2.5}$ Emission Rate = (64 trains/day) * (76 s/train) * (1 day/86,400 s) * (4,000 hp) * (0.438) * (0.18 g/bhp-hr) * (1hr/3,600 s) * (0.97)
$PM_{2.5}$ Emission Rate = 0.0048 g/s

Where:

- Trains per day = 64 (double the actual number of trains present over 24 hours to account for each train moving twice through the project area)
- Moving time per train = 76 s (from anticipated schedule)
- Locomotive horsepower = 4,000 hp (from engine specifications)
- Moving load factor = 0.438 (43.8%, calculated in Exhibit I-1)
- Tier 2 Locomotive Emission Factor = 0.18 g/bhp-hr (from "Emission Factors for Locomotives")
- Ratio of $PM_{2.5}$ to PM_{10} = 0.97 (from "Emission Factors for Locomotives")

A summary of the variables used in the above equations and the resulting emission rates can be found in Exhibit I-2, below.

Exhibit I-2. $PM_{2.5}$ Locomotive Emission Rates

Operational Mode	Number of Locomotives		Time/ Train	$PM_{2.5}$ Emission Factor	Calculated Peak Hour Emission Rate	Calculated 24-hour Emission Rate
	Peak hour	24 hours	(s)	(g/bhp-hr)	(g/s)	(g/s)
Idle	16	32	540	0.18	0.0019	0.00016
Moving	32	64	76	0.18	0.057	0.0048

These peak and 24-hour emission rates can now be used in air quality modeling for the project area, as described in Sections 7 through 9 of the guidance.

Note that, since this area is designated as nonattainment for both the 1997 annual $PM_{2.5}$ NAAQS and the 2006 24-hour $PM_{2.5}$ NAAQS, the results of the analysis will be compared to both NAAQS (see Section 3.3.4 of the guidance). Since the area is in nonattainment of the annual $PM_{2.5}$ NAAQS, all four quarters will need to be included in the analysis to estimate a year's worth of emissions. If there is no change in locomotive activity across quarters, the emission rates calculated here could be used for each quarter of the year (see Appendix I.3).

Appendix J:
Additional Reference Information on Air Quality Models and Data Inputs

J.1 INTRODUCTION

This appendix supplements Section 7's discussion of air quality models. Specifically, this appendix describes how to configure AERMOD and CAL3QHCR for PM hot-spot analysis modeling, as well as additional information on handling the data required to run the models for these analyses. This appendix is not intended to replace the user guides for air quality models, but discuss specific model inputs, keywords, and formats for PM hot-spot modeling. This appendix is organized so that it references the appropriate discussions in Section 7 of the guidance.

J.2 SELECTING AN APPROPRIATE AIR QUALITY MODEL

The following discussion supplements Section 7.3 of the guidance and describes how to appropriately configure AERMOD and CAL3QHCR when completing a PM hot-spot analysis. Users should also refer to the model user guides, as appropriate.

J.2.1 Using AERMOD for PM hot-spot analyses

There are no specific commands unique to transportation projects that are necessary when using AERMOD. By default, AERMOD produces output for particulate matter in units of micrograms per cubic meter of air ($\mu g/m^3$). All source types in AERMOD require that emissions are specified in terms of emissions per unit time, although AREA-type sources also require specification of emissions per unit time per unit area. AERMOD has no specific traffic queuing mechanisms. Emissions output from MOVES, EMFAC, AP-42, and other types of methods should be formatted as described in the AERMOD User Guide.[1]

J.2.2 Using CAL3QHCR for PM hot-spot analyses

CAL3QHCR is an extension of the CAL3QHC model that allows the processing of a full year of hourly meteorological data, the varying of traffic-related inputs by hour of the week, and calculation of long-term average concentrations. It also will display the five highest concentration days for the time period being modeled. Emissions output from MOVES, EMFAC, AP-42, and other emission methods should be formatted as described

[1] Extensive documentation is available describing the various components of AERMOD, including user guides, model formulation, and evaluation papers. See EPA's SCRAM website for AERMOD documentation: www.epa.gov/scram001/dispersion_prefrec.htm#aermod.

in the CAL3QHCR User Guide.[2] In addition, the following guidance is provided when using CAL3QHCR for a PM hot-spot analysis:

Specifying the Right Pollutant

When using CAL3QHCR for PM hot-spot analyses, the MODE keyword must be used to specify analyses for PM so that concentrations are described in micrograms per cubic meter of air ($\mu g/m^3$) rather than parts per million (ppm).

Entering Emission Rates

MOVES emission rates for individual roadway links are based on the Op-Mode distribution associated with each link and are able to include emissions resulting from idling. MOVES-based emission factors that incorporate relevant idling time and other delays should be entered in CAL3QHCR using the EFL keyword. Therefore, within CAL3QHCR, the IDLFAC keyword's emission rates should be set to zero, because the effects of idling are already included within running emissions. (Note that if a non-zero emission rate is used in CAL3QHCR, the model will treat idling emission rates separately from running emission rates.) The same recommendation applies when using emission rates calculated by EMFAC.

Assigning Speeds

Although the user guide for CAL3QHCR specifies that the non-queuing links should be assigned speeds in the absence of delay caused by traffic signals, the user should use speeds that reflect delay when using CAL3QHCR for a hot-spot analysis. Since MOVES emission factors already include the effects of delay (i.e., Op-Mode distributions that are user-specified or internally calculated include the effects of delay), the speeds used in CAL3QHCR links will already reflect the relevant delay on the link over the appropriate averaging time. The same recommendation applies when using EMFAC.

Using the Queuing Algorithm

When applying CAL3QHCR for the analysis of highway and intersection projects, its queuing algorithm should not be used.[3] This includes the CAL3QHCR keywords NLANE, CAVG, RAVG, YFAC, IV, and IDLFAC. As discussed in Sections 4 and 5, idling vehicle emissions should instead be accounted for by properly specifying links for emission analysis and reflecting idling activity in the activity patterns used for MOVES or EMFAC modeling.

[2] The CAL3QHCR user guide and other model documentation can be found on EPA's SCRAM website: www.epa.gov/scram001/dispersion_prefrec.htm#cal3qhc.

[3] CAL3QHCR's algorithm for estimating the length of vehicle queues associated with intersections is based on the *1985 Highway Capacity Manual*, which is no longer current. Furthermore, a number of other techniques are now available that can be used to estimate vehicle queuing around intersections.

J.3 CHARACTERIZING EMISSION SOURCES

The following discussion supplements Section 7.4 of the guidance and describes in more detail how to characterize sources in AERMOD and CAL3QHCR, including the physical characteristics, location, and timing of sources. This discussion assumes the user is familiar with handling data in these models, including the use of specific keywords. For additional information, refer to the AERMOD and CAL3QHCR user guides and EPA's quantitative PM hot-spot analysis training course, available for download at http://www.epa.gov/otaq/stateresources/transconf/projectlevel-hotspot.htm#training .

J.3.1 Physical characteristics and locations of sources in AERMOD

The following discussion gives guidance on how to best characterize a source. AERMOD includes different commands (keywords) for area, volume, and point sources. When modeling roadway links, experience in the field has shown that area sources may be easier to characterize correctly compared to volume sources. It is acceptable to use either area or volume sources to simulate roadways in AERMOD. Users may want to be particularly mindful of making errors when using volume sources.[4]

Modeling Area Sources

AERMOD can represent rectangular, polygon-shaped, and circular area sources using the AREA, AREAPOLY, AREACIRC, or LINE keywords.[5] Sources that may be modeled as area sources may include areas within which emissions occur relatively evenly, such as a single link modeled using MOVES or EMFAC. Evenly-distributed ground-level sources might also be modeled as area sources. EPA recommends that the LINE source keyword be used for modeling roadway sources as it greatly simplifies defining the physical location and orientation of sources.

AERMOD requires the following information when modeling an area source using the LINE source keyword:

- The emission rate per unit area (mass per unit area per unit time);
- The coordinates of midpoint of the ends (X_1,Y_1, X_2,Y_2)
- The width of the source in meters;
- The initial vertical dimension of the area source plume and initial vertical dispersion coefficient; and
- The release height above the ground.

To estimate the width of the source, one of the following options should be used:

[4] For additional information on issues related to applying volume sources, see slides 16-19 in EPA's "PM Hot-spot Modeling: Lessons Learned in the Field" presentation found on: http://www.epa.gov/otaq/stateresources/transconf/projectlevel-hotspot.htm#training

[5] Sources defined by the LINE keyword are still area sources and are equivalent to rectangular AREA sources.

a) The width of the traveled way, typically 3.7 m (12 ft) per lane for a high-speed, high volume roadway and 3.3 m (11 ft) per lane for an arterial/collector; or
b) The width of the traveled way (all travel lanes) + 6 meters.[6]

A typical approach is to assume the initial vertical dimension is about 1.7 times the average vehicle height, to account for the effects of vehicle-induced turbulence. For light-duty vehicles, this is about 2.6 meters, using an average vehicle height of 1.53 meters or 5 feet. For heavy-duty vehicles, this is about 6.8 meters, using an average vehicle height of 4.0 meters. Since most road links will consist of a combination of light-duty and heavy-duty traffic, the initial vertical dimension should be a combination of their respective values. There are two options available to estimate initial vertical dimension:

a) Estimate the initial vertical dimension using an emissions-weighted average. For example, if light-duty and heavy-duty vehicles contribute 40% and 60% of the emissions of a given volume source, respectively, the initial vertical dimension would be (0.4 * 2.6) + (0.6 * 6.8) = 5.1 meters.
b) Alternatively, the initial vertical dimension may be estimated using a traffic volume weighted approach based on light-duty and heavy-duty vehicle fractions.

The AERMOD User Guide recommends that the initial vertical dispersion coefficient (σ_{zo}), termed *Szinit* in AERMOD, be estimated by dividing the initial vertical dimension by 2.15. For typical light-duty vehicles, this corresponds to a *Szinit* (σ_{zo}) of 1.2 meters. For typical heavy-duty vehicles, the initial value of *Szinit* (σ_{zo}) is 3.2 meters.

The source release height (*Relhgt*), which is the height at which wind effectively begins to affect the plume, may be estimated as the midpoint of the initial vertical dimension. In other words, *Relhgt* is the initial vertical dimension multiplied by 0.5. As noted above, most road links will consist of a combination of light-duty and heavy-duty traffic. For each roadway source, the source release height (*Relhgt*) should be based on the same initial vertical dimension used for calculated its *Szinit*, as described above.

Another way of dealing with *Szinit* and/or release height (*Relhgt*) parameters that change as a result of different fractions of light-duty and heavy-duty vehicles is to create two overlapping versions of each roadway source, corresponding to either light-duty and heavy-duty traffic. These two sources could be superimposed in the same space, but would have emission rates and *Szinit* and *Relhgt* parameters that are specific to light-duty or heavy-duty traffic.

Also, AERMOD allows *Szinit*, and *Relhgt* to change by hour of the day, which may be considered if the fraction of heavy-duty vehicles is expected to significantly change

[6] Option (a) is based on the AASHTO "Green Book," A Policy on Geometric Design of Highways and Streets, available from AASHTO's on-line bookstore (https://bookstore.transportation.org/collection_detail.aspx?ID=110); Option (b) is based on the Haul Road Workgroup Final Report (December 2011), found on the web at http://www.epa.gov/ttn/scram/reports/Haul_Road_Workgroup-Final_Report_Package-20120302.pdf.

throughout a day. Users should consult the latest information on AERMOD when beginning a PM hot-spot analysis.

Groups of idling vehicles may also be modeled as one or more area sources. In those cases, the initial vertical dimension of the source, dispersion coefficients, and release heights should be calculated assuming that the vehicles themselves are inducing no turbulence. Source characterization should be based on the type of vehicles idling, e.g., if the vehicles idling are primarily heavy-duty trucks, then the release height would be 4 meters.

Modeling Volume Sources

Another option for modeling sources in a PM hot-spot analysis is to use volume sources. When modeling highway and intersection links, experience in the field has shown that area sources may be easier to characterize compared to volume sources. Project sponsors using volume sources should seek the assistance of their EPA Region through the interagency consultation process, based on 40 CFR 93.105(c)(1)(i). Consulting with EPA on parameters that will be used to describe the sources may save time in avoiding errors.

Examples of project sources that may be modeled with volume sources could include areas designated for truck or bus queuing or idling (e.g., off-network links in MOVES), driveways and pass-throughs in transit or freight terminals, and locomotive emissions.[7] AERMOD can also approximate a highway using a series of adjacent volume sources (see the AERMOD User Guide for suggestions), but as noted above, EPA recommends using area sources rather than volume sources to represent highways. Certain nearby sources that have been selected to be modeled may also be appropriately treated as a volume source (see Section 8 of the guidance for more information on considering background concentrations from other sources).

When using volume sources, users need to provide the following information:

- The emission rate (mass per unit time, such as g/s);
- The initial lateral dispersion coefficient determined from the initial lateral dimension (width) of the volume;
- The initial vertical dispersion coefficient determined from the initial vertical dimension (height) of the volume; and
- The source release height of the volume source center, (i.e., meters above the ground).

Within AERMOD, the volume source algorithms are applicable to line sources with some initial plume depth (e.g., highways, rail lines).[8] See the above discussion on area sources for guidance on defining release height and initial vertical dispersion coefficients.

[7] See Section 6 and Appendix I for information regarding calculating locomotive emissions.
[8] The vehicle-induced turbulence around roadways with moving traffic suggests that prior to transport downwind, a roadway plume has an initial size; that is, the emissions from the tailpipe are stirred because the vehicle is moving and therefore the plume “begins” from a three-dimensional volume, rather than from a point source (the tailpipe).

The goal of using volume sources to represent a roadway is to create a uniform emissions characterization. Ensure that volume sources are not spaced too widely along the roadway. Adjacent volume sources should overlap and the distance between them should be equal to the width of the source, as described in the AERMOD user's guide. Any other approximation of roadways with volume sources will result in adjacent receptors being over or under-estimated depending on their proximity to the center of the volume source.

To specify the initial lateral dispersion coefficient (σ_{yo}), referred to as *Syinit* in AERMOD, the AERMOD User Guide recommends dividing the initial width by 2.15. This is to ensure that the overlapping distributions from adjacent volume sources simulate a line source of emissions.

Groups of idling vehicles may also be modeled as one or more volume sources. In those cases, the initial dimensions of the source, dispersion coefficients, and release heights should be calculated assuming that the vehicles themselves are inducing no turbulence. Source characterization should be based on the type of vehicles idling, e.g., if the vehicles idling are primarily heavy-duty trucks, then the release height would be 4 meters.

In addition, when the source-receptor spacing in AERMOD is shorter than the distance between adjacent volume sources, AERMOD may produce aberrant results. Therefore, ensure that no receptors are placed within a distance of (2.15 x *Syinit* + 1 meter) of the center of a volume source, known as the "receptor exclusion zone." As a practical recommendation, when using volume sources to simulate a roadway where receptors are placed five meters from the edge of the roadway, the width of a volume source should be less than eight meters. This will ensure that no receptors fall within the receptor exclusion zone. If the width of the roadway is larger than eight meters, it is recommended that additional volume sources be defined (e.g., separate each lane of traffic), or area sources be used.

Modeling Point Sources

It may be appropriate to model some emission sources as fixed point sources, such as exhaust fans or stacks on a bus garage or terminal building. If a source is modeled with the POINT keyword in AERMOD, the model requires:

- The emission rate (mass per unit time);
- The release height above the ground;
- The exhaust gas exit temperature;
- The stack gas exit velocity; and,
- The stack inside diameter in meters.

These parameters can often be estimated using the plans and engineering diagrams for ventilation systems.

For projects with emissions on or near rooftops, such as bus terminals or garages, building downwash should also be modeled for the relevant sources. The potential for building downwash should also be addressed for nearby sources whose emissions are on or near rooftops in the project area. Building downwash occurs when air moving over a building mixes to the ground on the "downwind" side of the building. AERMOD includes algorithms to model the effects of building downwash on plumes from nearby or adjacent point sources. Consult the AERMOD User Guide for additional detail on how to enter building information.

J.3.2 Placement and sizing of sources within AERMOD

There are several general considerations with regard to placing and sizing sources within AERMOD.

First, area, volume, and point sources should be placed in the locations where emissions are most likely to occur. For example: if buses enter and exit a bus terminal from a single driveway, the driveway should be modeled using one or more discrete volume or area sources in the location of that driveway, rather than spreading the emissions from that driveway across the entire terminal yard.

Second, for emissions from the sides or tops of buildings (as may be found from a bus garage exhaust fan), it may be necessary to use the BPIPPRIME utility in AERMOD to appropriately capture the characteristics of these emissions (such as downwash).

Third, the initial dimensions and other parameters of each source should be as realistic as is feasible. Chapter 3 of the AERMOD User Guide includes recommendations for how to appropriately characterize the shape of area and volume sources.

Finally, if nearby sources are to be included in air quality modeling (see discussion in Section 8 of the guidance), a combination of all these source types may be needed to appropriately represent their emissions within AERMOD. For instance, evenly-distributed ground-level sources might also be modeled as area sources, while a nearby power plant stack might be modeled as a point source.

J.3.3 Timing of emissions in AERMOD

Within AERMOD, emissions that vary across a year should be described with the EMISFACT keyword (see Section 3.3.5 of the AERMOD User Guide). The number of quarters that need to be analyzed may vary based on a particular PM hot-spot analysis. See Section 2.5 of the guidance for more information on when PM emissions need to be evaluated, and Sections 4 and 5 of the guidance on determining the number of MOVES and EMFAC runs.

The *Qflag* parameter under EMISFACT may be used with a secondary keyword to describe different patterns of emission variations throughout a year. Note that AERMOD defines seasons in the following manner: winter (December, January, February), spring (March, April, May), summer (June, July, August), and fall (September, October, November). Emission data obtained from MOVES or EMFAC should be appropriately matched with the relevant time periods in AERMOD. For example, if four MOVES or EMFAC runs are completed (one for each quarter of a year), there are emission estimates corresponding to four months of the year (January, April, July, October) and peak and average periods within each day. In such a circumstance, January runs should be used to represent all AERMOD winter months (December, January, February), April runs for all spring months (March, April, May), July runs for all summer months (June, July, August), and October for all fall months (September, October, November).

If separate weekend emission rates are available, season-specific weekday runs should be used for the Monday-Friday entries; weekend runs would be assigned to the Saturday and Sunday entries. The peak/average runs for each day should be mapped to the AERMOD entry hours corresponding to the relevant time of day from the traffic analysis. *Qflag* can be used to represent emission rates that vary by season, hour of day, and day of the week. Consult the AERMOD User Guide for details.

J.3.4 Physical characteristics and locations of sources in CAL3QHCR

CAL3QHCR characterizes highway and intersection projects as line sources. The geometry and operational patterns of each roadway link are described using the following variables, which in general may be obtained from engineering diagrams and design plans of the project:[9]

- The coordinates (X, Y) of the endpoints of each link;[10]
- The width of the "highway mixing zone" (see below);
- The type of link ("at grade," "fill," "bridge," or "depressed");
- The height of the roadway relative to the surrounding ground (not to exceed ±10 meters);[11] and
- The hourly flow of traffic (vehicles per hour).

CAL3QHCR treats the area over each roadway link as a "mixing zone" that accounts for the area of turbulent air around the roadway resulting from vehicle-induced turbulence. The width of the mixing zone is an input to the model. Users should specify the width of a link in CAL3QHCR as the width of the traveled way (traffic lanes, not including

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[9] Traffic engineering plans and diagrams may include information such as the number, width, and configuration of lanes, turning channels, intersection dimensions, and ramp curvature, as well as operational estimates such as locations of weave and merge sections and other descriptions of roadway geometry that may be useful for specifying sources.

[10] In CAL3QHCR, the Y-axis is aligned due north.

[11] The CALINE3 dispersion algorithm in CAL3QHCR is sensitive to the height of the road. In particular, the model treats bridges and above-grade "fill" roadways differently. It also handles below-grade roadways with height of less than zero (0) meters as "cut" sections. Information on the topological features of the project site is needed to make such a determination. Note that in the unusual circumstance that a roadway is more than ten meters below grade, CALINE3 has not been evaluated, so CAL3QHCR is not recommended for application. In this case, the relevant EPA Regional Office should be consulted for determination of the most appropriate model.

shoulders) plus three meters on either side. Users should treat divided highways as two separate links. See Section 7.6 of the guidance for more information on placing receptors.

J.3.5 Timing of emissions in CAL3QHCR

The CAL3QHCR User Guide describes two methods for accepting time-varying emissions and traffic data; these are labeled the "Tier I" and "Tier II" approaches.[12] Project-level PM hot-spot modeling should use the Tier II method, which can accommodate different hourly emission patterns for each day of the week. Most emissions data will not be so detailed, but the Tier II approach can accommodate emissions data similar to that described in Sections 4 and 5 of the guidance. The CAL3QHCR Tier I approach should not be used, as it employs only one hour of emissions and traffic data and therefore cannot accommodate the emissions data required in a PM hot-spot analysis.

Through the IPATRY keyword, CAL3QHCR allows up to seven 24-hour profiles representing hour-specific emission, traffic, and signalization (ETS) data for each day of the week. Depending on the number of MOVES runs, the emission factors should be mapped to the appropriate hours of the day. For example, peak traffic emissions data for each day would be mapped to the CAL3QHCR entry hours corresponding to the relevant times of day (in this case, the morning and afternoon peak traffic periods). If there are more MOVES runs than the minimum specified in the Section 4, they should be modeled and linked to the correct days and hours using IPATRY.

As described in Section 7 of the guidance, the number of CAL3QHCR runs required for a given PM hot-spot analysis will vary based on the amount of meteorological data available.

J.4 INCORPORATING METEOROLOGICAL DATA

This discussion supplements Section 7.5 of the guidance and describes in more detail how to handle meteorological data in AERMOD and CAL3QHCR. Section 7.2.3 of Appendix W to 40 CFR Part 51 provides the basis for determining the urban/rural status of a source. Consult the AERMOD Implementation Guide for instructions on what type of population data should be used in making urban/rural determinations.

J.4.1 Specifying urban or rural sources in AERMOD

As described in Section 7 of the guidance, AERMOD employs nearby population as a surrogate for the magnitude of differential urban-rural heating (i.e., the urban heat island

[12] This nomenclature is unrelated to EPA's motor vehicle emission standards and the design value calculation options described in Section 9 of this guidance.

effect). When modeling urban sources in AERMOD, users should use the URBANOPT keyword to enter this data.

When considering urban roughness lengths, users should consult the AERMOD Implementation Guide. Any application of AERMOD that utilizes a value other than 1 meter for the urban roughness length should be considered a non-regulatory application and would require appropriate documentation and justification as an alternate model (see Section 7.3.3 of the guidance).

For urban applications using representative National Weather Service (NWS) meteorological data, consult the AERMOD Implementation Guide. For urban applications using NWS data, the URBANOPT keyword should be selected, regardless of whether the NWS site is located in a nearby rural or urban setting. When using site-specific meteorological data in urban applications, consult the AERMOD Implementation Guide.

J.4.2 Specifying urban or rural sources in CAL3QHCR

CAL3QHCR requires that users specify the run as being rural or urban using the "RU" keyword.[13] Users should make the appropriate entry depending if the source is considered urban or rural as described in Section 7.5.5 of the guidance.

J.5 MODELING COMPLEX TERRAIN

This discussion supplements Section 7.5 of the guidance and describes in more detail how to address complex terrain in AERMOD and CAL3QHCR. In most situations, the project area should be modeled as having flat terrain. Additional detail on how this should be accomplished in each model is found below. However, in some situations a project area may include complex terrain, such that sources and receptors included in the model are found at different heights.

J.5.1 AERMOD

This guidance reflects the AERMOD Implementation Guide as of March 19, 2009. Analysts should consult the most recent AERMOD Implementation Guide for the latest guidance on modeling complex terrain.

For most highway and transit projects, the analyst should apply the non-DFAULT option in AERMOD and assume flat, level terrain. In the AERMOD input file, the FLAT option should be used in the MODELOPT keyword. This recommendation is made to avoid underestimating concentrations in two circumstances likely to occur with the low-elevation, non-buoyant emissions from transportation projects. First, in DFAULT mode, AERMOD will tend to underestimate concentrations from low-level, non-buoyant

[13] Specifying urban modeling with the "RU" keyword converts stability classes E and F to D.

sources where there is up-sloping terrain with downwind receptors uphill since the DFAULT downwind horizontal plume will pass below the actual receptor elevation. Second, in DFAULT mode, AERMOD will tend to underestimate concentrations when a plume is terrain-following. Therefore, the FLAT option should be selected in most cases.

There may be some cases where significant concentrations result from nearby elevated sources. In these cases, interagency consultation should be used on a case-by-case basis to determine whether to include terrain effects and use the DFAULT option. In those cases, AERMAP should be used to prepare input files for AERMOD; consult the AERMOD and AERMAP user guides and the latest AERMOD Implementation Guide for information on obtaining and processing relevant terrain data.

J.5.2 CAL3QHCR

CAL3QHCR does not handle complex terrain. No action is therefore required.

J.6 RUNNING THE MODEL AND OBTAINING RESULTS

This discussion supplements Section 7.7 of the guidance and describes in more detail how to handle data outputs in AERMOD and CAL3QHCR. AERMOD and CAL3QHCR produce different output file formats, which must be post-processed in different ways to enable calculation of design values as described in Section 9.3 of the guidance. This guidance is applicable regardless of how many quarters are being modeled.

J.6.1 AERMOD output

AERMOD requires that users specify the type and format of output files in the main input file for each run. See Section 3.7 of the AERMOD User Guide for details on the various output options. Output options should be specified to enable the relevant design value calculations required in Section 9.3. Note that many users will have multiple years of meteorological data, so multiple output files may be required (unless the meteorological files have been joined prior to running AERMOD – which is recommended for most analyses).

For the annual $PM_{2.5}$ design value calculations described in Section 9.3.2, averaging times should be specified that allow calculation of the annual average concentrations at each receptor. For example, when using five years of meteorological data, the ANNUAL averaging time should be specified using the AVERTIME keyword in the CO pathway. For the OU pathway, a POSTFILE keyword should be defined to obtain the annual average concentrations at each receptor.

For the 24-hour $PM_{2.5}$ design value calculations described in Section 9.3.3, the RECTABLE keyword should be used to obtain the average 98^{th} percentile concentration at each receptor. The eighth high value should be requested, because this would be the 98^{th} percentile concentration for the year, that is, of 365 values. In conjunction with defining PM2.5 in the POLLUTID keyword of the Control pathway, the concentrations generated in the output will be an average across N-years of meteorological data. If five years of meteorological data were used, the output will be calculated as the average 98th percentile value, and can be added directly to the 98th percentile background concentration to determine the 24-hr PM2.5 design value for a first tier approach (described in Section 9 and Appendix K).

See Appendix L for information on using AERMOD for a second tier design value approach.

For the 24-hour PM_{10} calculations, the RECTABLE keyword may be used to obtain the sixth highest 24-hour concentrations over the entire modeling period (assuming five years of meteorological data were used). The output will be calculated as the sixth high value at each receptor and can be added directly to the appropriate background concentration (i.e., fourth-, third-, second-highest, or highest, based on Exhibit 9-6) to determine the 24-hr PM_{10} design value (described in Section 9 and Appendix K).

J.6.2 CAL3QHCR output

For each year of meteorological data and quarterly emission inputs, CAL3QHCR reports the five highest 24-hour concentrations and the quarterly average concentrations in its output file.

For calculating annual $PM_{2.5}$ design values using CAL3QHCR output, some post-processing is required. CAL3QHCR's output file refers to certain data under the display: **"**THE HIGHEST ANNUAL AVERAGE CONCENTRATIONS." If four quarters of emission data are separately run in CAL3QHCR, each quarter's outputs listed under "THE HIGHEST ANNUAL AVERAGE CONCENTRATIONS" are actually quarterly-average concentrations. As described in Section 7, per year of meteorological data, CAL3QHCR should be run for as many quarters as analyzed using MOVES and EMFAC, as CAL3QHCR accepts only a single quarter's emission factors per input file.

Calculating 24-hour $PM_{2.5}$ design values under a first tier approach is described in Section 9.3.3. To get annual average modeled concentrations for a first tier approach (Step 1), the third-highest 24-hour concentrations in each quarter and year of meteorological data should be identified. Within each year of meteorological data, the eighth-highest 24-hour concentration from the 12 values (the top three for each of four quarters) at each receptor should be identified. For a first tier approach, at each receptor, the eighth-high concentration (98th percentile from 365 values) from each year of meteorological data should be averaged together. See Appendix L for information on using CAL3QHCR for a second tier design value approach.

When calculating 24-hour PM_{10} design values, it is necessary to estimate the sixth-highest concentration in each year if using five years of meteorological data. For each period of meteorological data, CAL3QHCR outputs the six highest 24-hour concentrations. To estimate the sixth-highest concentration, for each receptor, the six highest 24-hour concentrations from each quarter and year of meteorological data should be arrayed together and ranked. From all quarters and years of meteorological data, the sixth-highest concentration should be identified. These concentrations, at each receptor can be added directly to the appropriate monitor value for the 24-hour background concentration from three years of monitoring data, based on Exhibit 9-6 (as described in Section 9 and Appendix K).

Appendix K:
Examples of Design Value Calculations for PM Hot-spot Analyses

K.1 INTRODUCTION

This appendix supplements Section 9's discussion of calculating and applying design values for PM hot-spot analyses. While this guidance can apply to any PM NAAQS, this appendix provides examples of how to calculate design values for the PM NAAQS in effect at the time the guidance was issued (the 1997 annual $PM_{2.5}$ NAAQS, the 2006 and 1997 24-hour $PM_{2.5}$ NAAQS, and the 1987 24-hour PM_{10} NAAQS). The design values in this appendix are calculated using the steps described in Section 9.3. Readers should reference the appropriate sections of the guidance as needed for more detail on how to complete each step of these analyses.

These illustrative example calculations demonstrate the basic procedures described in the guidance and therefore are simplified in the number of receptors considered and other details that would occur in an actual PM hot-spot analysis. Where users would have to repeat steps for additional receptors, it is noted. These examples are organized according to the build/no-build analysis steps that are described in Sections 2 and 9 of this guidance.

The final part of this appendix provides mathematical formulas that describe the design value calculations discussed in Section 9 and this appendix.

K.2 PROJECT DESCRIPTION AND CONTEXT FOR ALL EXAMPLES

For the following examples, a PM hot-spot analysis is being done for an expansion of an existing highway with a significant increase in the number of diesel vehicles (40 CFR 93.123(b)(1)(i)). The highway expansion will serve an expanded freight terminal. The traffic at the terminal will increase as a result of the expanded highway project's increase in truck traffic, and therefore the freight terminal is projected to have higher emissions under the build scenario than under the no-build scenario. The freight terminal is not part of the project; however, it is a nearby source that will be included in the air quality modeling, as described further below.

The air quality monitor selected to represent background concentrations from other sources is a Federal Equivalent Method (FEM) monitor that is 300 meters upwind of the project. The monitor is on a 1-in-3 day sampling schedule. In this example, the three most recent years of monitoring data are from 2008, 2009, and 2010. Since 2008 is a leap year (366 days), for this example, there are 122 monitored values in that year and 121 values for both 2009 and 2010 (365 days each).[1]

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[1] Note that the number of air quality monitoring measurements may vary by year. For example, with 1-in-3 measurements, there could be 122 or 121 measurements in a year with 365 days. Or, there may be fewer

However, through interagency consultation, it is determined that the freight terminal's emissions are not already captured by this air quality monitor. AERMOD has been selected as the air quality model to estimate PM concentrations produced by the project (the highway expansion) and the nearby source (the freight terminal).[2] There are five years of representative off-site meteorological data being used in this analysis.

As discussed in Section 2.4, a project sponsor could consider mitigation and control measures at any point in the process. However, since the purpose of these examples is to show the design value calculations, in this appendix such measures are not considered until after the calculations are done.

K.3 EXAMPLE: ANNUAL $PM_{2.5}$ NAAQS

K.3.1 General

This example illustrates the approach to calculating design values for comparison to the annual $PM_{2.5}$ NAAQS, as described in Section 9.3.2. The annual $PM_{2.5}$ design value is the average of three consecutive years' annual averages. The design value for comparison is rounded to the nearest tenth of a $\mu g/m^3$ (nearest 0.1 $\mu g/m^3$). For example, 15.049 rounds to 15.0, and 15.050 rounds to 15.1.[3]

Each year's annual average concentrations include contributions from the project, any nearby sources modeled, and background concentrations. For air quality monitoring purposes, the annual $PM_{2.5}$ NAAQS is met when the three-year average concentration is less than or equal to the current annual $PM_{2.5}$ NAAQS (i.e., 15.0 $\mu g/m^3$):

Annual $PM_{2.5}$ design value = ([Y1] average + [Y2] average + [Y3] average) ÷ 3

Where:
[Y1] = Average annual $PM_{2.5}$ concentration for the first year of air quality monitoring data
[Y2] = Average annual $PM_{2.5}$ concentration for the second year of air quality monitoring data
[Y3] = Average annual $PM_{2.5}$ concentration for the third year of air quality monitoring data

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actual monitored values if sampling was not conducted on some scheduled days or the measured value was invalidated due to quality assurance concerns. The actual number of samples with valid data should be used.

[2] EPA notes that CAL3QHCR could not be used in this particular PM hot-spot analysis, since air quality modeling included the project and a nearby source. See Section 7.3 of the guidance for further information.

[3] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the tenths place should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.

For this example, the project described in Appendix K.2 is located in an annual $PM_{2.5}$ NAAQS nonattainment area. This example illustrates how an annual $PM_{2.5}$ design value could be calculated at the same receptor in the build and no-build scenarios, based on air quality modeling results and air quality monitoring data. In an actual PM hot-spot analysis, design values would be calculated at additional receptors, as described further in Section 9.3.2.

K.3.2 Build scenario

For the build scenario, the $PM_{2.5}$ impacts from the project and from the nearby source are estimated with AERMOD at all receptors.[4]

Steps 1-2. Because AERMOD is used for this project, Step 1 is skipped. The receptor with the highest average annual concentration, using five years of meteorological data, is identified directly from the AERMOD output. This receptor's average annual concentration is 3.603 $\mu g/m^3$.

Step 3. Based on the three years of measurements at the background air quality monitor, the average monitored background concentrations in each quarter is determined. Then, for each year of background data, the four quarters are averaged to get an average annual background concentration (last column of Exhibit K-1). These three average annual background concentrations are averaged, and the resulting value is 11.582 $\mu g/m^3$, as shown in Exhibit K-1:

Exhibit K-1. Background Concentrations

Background Concentrations	Q1	Q2	Q3	Q4	Average Annual
2008	13.013	17.037	8.795	8.145	11.748
2009	14.214	14.872	7.912	7.639	11.159
2010	11.890	16.752	9.421	9.287	11.838
3-year average:					11.582

Step 4. The 3-year average annual background concentration (from Step 3) is added to the average annual modeled concentration from the project and nearby source (from Step 2):

$$11.582 + 3.603 = 15.185$$

Step 5. Rounding to the nearest 0.1 $\mu g/m^3$ produces a design value of 15.2 $\mu g/m^3$.

[4] As noted above, there is a single nearby source that is projected to have higher emissions under the build scenario than the no-build scenario as a result of the project and its impacts are not expected to be captured by the monitor chosen to provide background concentrations. Therefore, emissions from the project and this nearby source are both included in the AERMOD output.

In this example, the concentration at the highest receptor is estimated to exceed the 1997 annual $PM_{2.5}$ NAAQS of 15.0 μg/m^3.

Steps 6-8: Since the design value in Step 5 is greater than the NAAQS, design value calculations are then completed for all receptors in the build scenario, and receptors with design values above the NAAQS are identified. After this is done, the no-build scenario is modeled for comparison.

K.3.3 No-build scenario

The no-build scenario (i.e., the existing highway and freight terminal without the proposed highway and freight terminal expansion), is modeled at all of the receptors in the build scenario, but design values are only calculated in the no-build scenario at receptors where the design value for the build scenario is above the annual $PM_{2.5}$ NAAQS (from Steps 6-8 above).

Step 9. For this example, the receptor with the highest average annual concentration in the build scenario is used to illustrate the no-build scenario design value calculation. The average annual concentration modeled at this receptor in the no-build scenario is 3.521 μg/m^3.

Step 10. The background concentrations from the representative monitor are unchanged from the build scenario, so the average annual modeled concentration of 3.521 is added to the 3-year average annual background concentrations of 11.528 μg/m^3 from Step 3:

$$11.582 + 3.521 = 15.103$$

Step 11. Rounding to the nearest 0.1 μg/m^3 produces a design value of 15.1 μg/m^3.

In this example, the design value at the receptor in the build scenario (15.2 μg/m^3) is greater than the design value at the same receptor in the no-build scenario (15.1 μg/m^3).[5] In an actual PM hot-spot analysis, design values would also be compared between build and no-build scenarios at all receptors in the build scenario that exceeded the annual $PM_{2.5}$ NAAQS. The interagency consultation process would then be used to discuss next steps, e.g., appropriateness of receptors. Refer to Sections 9.2 and 9.4 for additional details.

If it is determined that conformity requirements are not met at all appropriate receptors, the project sponsor should then consider additional mitigation or control measures, as discussed in Section 10. After measures are selected, a new build scenario that includes the controls should be modeled and new design values calculated. Design values for the no-build scenario shown above would not need to be recalculated since the no-build scenario would not change.

[5] Values are compared after rounding. As long as the build design value is no greater than the no-build design value after rounding, the project would meet conformity requirements at a given receptor, even if the pre-rounding build design value is greater than the pre-rounding no-build design value.

K.4 EXAMPLE: 24-HOUR $PM_{2.5}$ NAAQS

K.4.1 General

This example illustrates a first tier approach to calculating design values for comparison with the 24-hour $PM_{2.5}$ NAAQS. As discussed in Section 9, while either approach is acceptable, EPA recommends beginning with a first tier approach as there are very few cases where a second tier approach would not produce a more conservative design value. See Appendix L for information on using a second tier approach.

The 24-hour design value is the average of three consecutive years' 98th percentile $PM_{2.5}$ concentration of 24-hour values for each of those years. For air quality monitoring purposes, the NAAQS is met when that three-year average concentration is less than or equal to the currently applicable 24-hour $PM_{2.5}$ NAAQS for a given area's nonattainment designation (35 $\mu g/m^3$ for nonattainment areas for the 2006 $PM_{2.5}$ NAAQS and 65 $\mu g/m^3$ for nonattainment areas for the 1997 $PM_{2.5}$ NAAQS).[6] The design value for comparison to any 24-hour $PM_{2.5}$ NAAQS is rounded to the nearest 1 $\mu g/m^3$ (i.e., decimals 0.5 and greater are rounded up to the nearest whole number, and any decimal lower than 0.5 is rounded down to the nearest whole number). For example, 35.499 rounds to 35 $\mu g/m^3$, while 35.500 rounds to 36.[7]

For this example, the project described in Appendix K.2 is located in a nonattainment area for the 2006 24-hour $PM_{2.5}$ NAAQS. This example presents the first tier build scenario results for a single receptor to illustrate how the calculations should be made based on air quality modeling results and air quality monitoring data. In an actual PM hot-spot analysis, design values would be calculated at additional receptors, as described further in Section 9.3.3.

K.4.2 Build scenario

$PM_{2.5}$ contributions from the project and the nearby source are estimated together with AERMOD in each of four quarters using meteorological data from five consecutive years, using a 24-hour averaging time. As discussed in Appendix K.2 above, the one nearby source (the freight terminal) was included in air quality modeling.
Under a first tier analysis, the average 98th percentile modeled 24-hour concentrations at a given receptor are added to the average 98th percentile 24-hour background concentrations, regardless of the quarter in which they occur. The average 98th percentile

[6] There are only two $PM_{2.5}$ areas where conformity currently applies for both the 1997 and 2006 24-hour NAAQS. While both 24-hour NAAQS must be considered in these areas, in practice if the more stringent 2006 24-hour $PM_{2.5}$ NAAQS is met, then the 1997 24-hour $PM_{2.5}$ NAAQS is met as well.
[7] A sufficient number of decimal places (3-4) should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding should only occur during final design value calculations, pursuant to Appendix N to 40 CFR Part 50.

modeled 24-hour concentrations are produced by AERMOD, using five years of meteorological data in one run.

Step 1. The receptor with the highest average 98th percentile modeled 24-hour concentration is identified. This was obtained directly from the AERMOD output.[8] For this example, the data from this receptor is shown in Exhibit K-2. Exhibit K-2 shows the 98th percentile 24-hour concentration for each year of meteorological data used.. The average concentration of these outcomes, 3.710 μg/m³ (highlighted in Exhibit K-2), is the highest, compared to the averages at all of the other receptors.

Exhibit K-2. Modeled 98th Percentile $PM_{2.5}$ Concentrations from Project and Nearby Source

Year	98th Percentile $PM_{2.5}$ Concentration
Met Year 1	3.413
Met Year 2	2.846
Met Year 3	3.671
Met Year 4	4.951
Met Year 5	3.667
Average	3.710

Step 2. The average 98th percentile 24-hour background concentration for a first tier analysis is calculated using the 98th percentile 24-hour concentrations of the three most recent years of monitoring data from the representative air quality monitor selected (see Appendix K.2). Since the background monitor is on a 1-in-3 day sampling schedule, it made either 122 or 121 measurements per year during the three most recent years. According to Exhibit 9-5, with this number of monitored values per year, the 98th percentile is the third highest concentration. Exhibit K-3 depicts the top eight monitored concentrations (in μg/m³) of the monitor throughout the years employed for estimating background concentrations.

[8] If CAL3QHCR were being used, some additional processing of model output would be needed. Refer to Section 9.3.3.

Exhibit K-3. Top Eight Monitored Concentrations in the Three Most Recent Years

Rank	Year 1	Year 2	Year 3
1	34.123	33.537	35.417
2	31.749	32.405	31.579
3	31.443	31.126	31.173
4	30.809	30.819	31.095
5	30.219	30.487	30.425
6	30.134	29.998	30.329
7	30.099	29.872	30.193
8	28.481	28.937	28.751

The third-ranked concentration of each year (highlighted in Exhibit K-3) is the 98th percentile value. These are averaged:

$(31.443 + 31.126 + 31.173) \div 3 = 31.247\ \mu g/m^3$.

Step 3. Then, the 98th percentile average 24-hour modeled concentration for this receptor (from Step 1) is added to the average 98th percentile 24-hour background concentration (from Step 2):

$3.710 + 31.247 = 34.957\ \mu g/m^3$.

Rounding to the nearest whole number results in a 24-hour $PM_{2.5}$ design value of 35 $\mu g/m^3$.

This concentration is equal to the 2006 24-hour $PM_{2.5}$ NAAQS (35 $\mu g/m^3$), and therefore this analysis demonstrates that conformity is met.

If the project had not passed the initial build comparison, the project sponsor has two options:

1. Repeat the first tier analysis for the no-build scenario at all receptors that exceeded the NAAQS in the build scenario. If the calculated design value for the build scenario is less than or equal to the design value for the no-build scenario at all of these receptors, then the project conforms;[9] or
2. Conduct a second tier approach – See Appendix L.

K.5 EXAMPLE: 24-HOUR PM_{10} NAAQS

K.5.1 General

This example illustrates calculating design values for comparison with the 24-hour PM_{10} NAAQS, as described in Section 9.3.4. The 24-hour PM_{10} design value is based on the expected number of 24-hour exceedances of 150 μg/m^3, averaged over three consecutive years. For air quality monitoring purposes, the NAAQS is met when the number of exceedances is less than or equal to 1.0. The 24-hour PM_{10} design value is rounded to the nearest 10 μg/m^3. For example, 155.500 rounds to 160, and 154.999 rounds to 150.[10]

The 24-hour PM_{10} design value is calculated at each air quality modeling receptor by directly adding the sixth-highest modeled 24-hour concentration (if using five years of meteorological data) to the appropriate monitor value for the 24-hour background concentration (from three years of monitored data), based on Exhibit 9-6.

For this example, the project described in Appendix K.2 is located in a nonattainment area for the 24-hour PM_{10} NAAQS. This example presents build scenario results for a single receptor to illustrate how the calculations should be made based on air quality modeling results and air quality monitoring data.

K.5.2 Build Scenario

Step 1. From the air quality modeling results from the build scenario, the sixth-highest 24-hour concentration is identified at each receptor. These sixth-highest concentrations are the sixth highest that are modeled at each receptor, regardless of year of meteorological data used.[11] AERMOD was configured to produce these values.

Step 2. The sixth-highest modeled concentrations (i.e., the concentrations at Rank 6) are compared across receptors, and the receptor with the highest value at Rank 6 is identified. For this example, the highest sixth-highest 24-hour concentration at any receptor is 15.218 μg/m^3. (That is, at all other receptors, the sixth-highest concentration is less than 15.218 μg/m^3.) Exhibit K-4 shows the six highest 24-hour concentrations at this receptor.

[10] This rounding convention comes from Appendix K to 40 CFR Part 50. A sufficient number of decimal places (3-4) in modeling results should be retained during intermediate calculations for design values, so that there is no possibility of intermediate rounding or truncation affecting the final result. Rounding to the nearest 10 ug/m^3 should only occur during final design value calculations, pursuant to Appendix K to 40 CFR Part 50. Monitoring values typically are reported with only one decimal place.

[11] The six highest concentrations could occur anytime during the five years of meteorological data. They may be clustered in one or two years, or they may be spread out over several, or even all five, years of the meteorological data.

Exhibit K-4. Receptor with the Highest Sixth-Highest 24-Hour Concentration (Build Scenario)

Rank	Highest 24-Hour Concentrations
1	17.012
2	16.709
3	15.880
4	15.491
5	15.400
6	15.218

Step 3. In this example, the background monitor collects data every third day (1-in-3 sampling) and has a total of 360 daily readings in the most recent three year period. The appropriate 24-hour background concentration from the three most recent years of monitoring data is identified based on Exhibit 9-6. The information in Exhibit 9-6 has been repeated in Exhibit K-5 below, along with the highest four values from the background monitor:

Exhibit K-5: Highest Values from the Chosen Background Monitor (360 Readings in the Most Recent Three Year Period)

Number of Background Concentration Values from the Monitor	Monitor Value Used for Design Value Calculation	Highest Values from the Chosen Background Monitor
< 347	Highest Monitor Value	112.490
348 - 695	Second Highest Value	86.251
696 - 1042	Third Highest Value	75.821
1043 - 1096	Fourth Highest Value	75.217

Because the monitor has 360 readings in the most recent three-year period, the second-highest 24-hour background concentration is used for the design value calculation. The second-highest value is 86.251 $\mu g/m^3$.

Step 4. The sixth-highest 24-hour modeled concentration of 15.218 $\mu g/m^3$ from the highest receptor (from Step 2) is added to the second-highest 24-hour background concentration of 86.251 $\mu g/m^3$ (from Step 3):

$$15.218 + 86.251 = 101.469$$

Step 5. This sum is rounded to the nearest 10 $\mu g/m^3$, which results in a design value of 100 $\mu g/m^3$.

This result is then compared to the 24-hour PM_{10} NAAQS. In this case, the concentration calculated at all receptors is less than the 24-hour PM_{10} NAAQS of 150 $\mu g/m^3$, therefore the analysis shows that the project conforms. However, if the design value for this receptor had been greater than 150 μg/m^3, the remainder of the steps in Section 9.3.4 would be completed. That is, build scenario design values for each receptor would be calculated (Steps 6-7 in Section 9.3.4) and, for all those that exceed the NAAQS, the no-build design values would also be calculated (Steps 8-10 in Section 9.3.4). The build and no-build design values would then be compared.[12]

[12] Values are compared after rounding. As long as the build design value is no greater than the no-build design value after rounding, the project would meet conformity requirements at a given receptor, even if the pre-rounding build design value is greater than the pre-rounding no-build design value.

Appendix L:
Calculating 24-hour $PM_{2.5}$ Design Values
Using a Second Tier Approach

L.1 INTRODUCTION

As described in Section 9, design values for the 24-hr $PM_{2.5}$ NAAQS may be calculated using either a first tier or second tier approach. Generally, the first tier approach involves adding the 98th percentile monitored data directly to each receptor's 98th percentile modeled concentrations. The second tier approach requires developing a 98th percentile background concentration for each quarter. Those values are then read into the AERMOD input file and used to calculate an appropriate 98th percentile design value for each receptor – done entirely within the model. EPA believes that most analyses should be done with a first tier approach, as described in Section 9 and demonstrated in Appendix K. The first tier approach requires much less processing of monitoring data and modeled concentrations. However, users may choose to follow the second tier approach to meet conformity requirements if through interagency consultation it is determined that a first tier approach is overly conservative. The second tier process includes the following general steps:

1) Calculate quarterly 98th percentile values from the monitoring data
2) Add quarterly background concentrations to AERMOD input file
3) Run AERMOD to generate 98th percentile concentrations at each receptor

This process differs from the methodology described for the first tier approach, as well as $PM_{2.5}$ annual and PM_{10} design value calculations. Notably, background is handled first, then added into the AERMOD input file. AERMOD will automatically generate the appropriate 98th percentile design value.

Note that CAL3QHCR cannot be used in a second tier approach. The model only produces the highest <u>six</u> values for each quarter; and to accurately calculate the 98th percentile across four quarters, it is necessary to obtain the highest <u>eight</u> values in each quarter. Any analysis done with a second tier design value approach should use AERMOD.

The remainder of Appendix L describes an example of a second tier design value approach, as well as the steps involved with adding background concentrations to an AERMOD input file.

L.2 PREPARING MONITORING DATA

This appendix provides an illustrative example of the calculations and data sorting recommendations for the background monitoring data to be used in a second tier modeling approach.[1] In this example, it was determined through interagency consultation that the impacts from the project's $PM_{2.5}$ emissions were most prominent during the cool season and were not temporally correlated with background $PM_{2.5}$ levels that were typical highest during the warm season. So, combining the modeled and monitored contributions through a first tier approach was determined to be potentially overly conservative.

The example provided is from an idealized Federal Reference Method (FRM) $PM_{2.5}$ monitoring site that operates on a daily (1-in-1 day) frequency with 100% data completeness. In this case, the annual 98th percentile concentration is the 8th highest concentration of the year. In most cases, the FRM monitoring site will likely operate on a 1-and-3 day frequency and will also likely have missing data due to monitor maintenance or collected data not meeting all of the quality assurance criteria. Please reference Section 9 (Exhibit 9.5) and Appendix N to 40 CFR Part 50 to determine the appropriate 98th percentile rank of the monitored data based on the monitor sampling frequency and valid number of days sampled during each year. The appropriate seasonal (or quarterly) background concentrations to be included as input to the AERMOD model per a second tier approach are as follows:

Step 1 – Start with the most recent three years of representative background $PM_{2.5}$ ambient monitoring data that are being used to develop the monitored background $PM_{2.5}$ design value. In this example, the three years are labeled Year 1, Year 2, and Year 3.

Step 2 – For each year, determine the appropriate rank for the daily 98th percentile $PM_{2.5}$ concentration. Again, this idealized example is from a 1-in-1 day monitor with 100% data completeness. So, the 8th highest concentration of each year is the 98th percentile $PM_{2.5}$ concentration. The 98th percentile $PM_{2.5}$ concentration for Year 1 is highlighted in Exhibit L-1. The full concentration data from Year 2 and Year 3 are not shown across the steps in this Appendix for simplicity, but would be similar to that of Year 1.

Step 3 – Remove from further consideration in this analysis the $PM_{2.5}$ concentrations from each year that are greater than the 98th percentile $PM_{2.5}$ concentration. In the case presented for a 1-in-1 day monitor, the top 7 concentrations are removed. If the monitor were a 1-in-3 day monitor, only the top 2 concentrations would be removed. The resultant dataset after the top 7 concentrations have been removed from further consideration in this analysis for Year 1 is presented in Exhibit L-2.

Step 4 – For each year, divide the resultant annual dataset of the monitored data equal to or less than the 98th percentile $PM_{2.5}$ concentration into each season (or quarter). For Year 1, the seasonal subsets are presented in Exhibit L-3.

Step 5 – Determine the maximum $PM_{2.5}$ concentration from each of the seasonal (or quarterly) subsets created in Step 4 for each year. The maximum $PM_{2.5}$ concentration from each season for Year 1 is highlighted in both Exhibits L-3 and L-4.

[1] This example has been adapted from the 2014 Guidance for $PM_{2.5}$ Permit Modeling, available at: http://www.epa.gov/ttn/scram/guidance/guide/Guidance_for_PM25_Permit_Modeling.pdf

Step 6 – Average the seasonal (or quarterly) maximums from Step 5 across the three years of monitoring data to create the four seasonal background $PM_{2.5}$ concentrations to be included as inputs to the AERMOD model. These averages for the Year 1, Year 2, and Year 3 dataset used in this example are presented in Exhibit L-4. As noted above, the full concentration data only from Year 1 is shown in the exhibits in this appendix for simplicity, but the seasonal maximums from Years 2 and 3 presented in Exhibit L-4 were determined by following the previous five steps, similar to that of Year 1.

Exhibit L-1. Year 1 Daily $PM_{2.5}$ Concentrations

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	25.1	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	28.9	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	27.6	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	26.5	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	27.9	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	29.1	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	29.3	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration (highlighted green value) = 25.1

Exhibit L-2: Year 1 Daily $PM_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile

Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.	Date	Conc.
1-Jan	10.4	16-Feb	15.1	2-Apr	10.5	18-May	11.1	3-Jul	17.1	18-Aug	18.7	3-Oct	12.3	18-Nov	4.4
2-Jan	5.4	17-Feb	11.8	3-Apr	8.2	19-May	7.7	4-Jul	19.8	19-Aug	21.5	4-Oct	19.5	19-Nov	8.2
3-Jan	10.0	18-Feb	3.4	4-Apr	9.7	20-May	13.6	5-Jul	14.3	20-Aug	20.1	5-Oct	23.7	20-Nov	11.1
4-Jan	16.4	19-Feb	4.5	5-Apr	6.9	21-May	12.1	6-Jul	11.5	21-Aug	18.4	6-Oct	19.8	21-Nov	5.3
5-Jan	11.2	20-Feb	4.8	6-Apr	6.3	22-May	10.0	7-Jul	14.3	22-Aug	16.7	7-Oct	21.7	22-Nov	8.9
6-Jan	11.1	21-Feb	11.9	7-Apr	7.9	23-May	13.3	8-Jul	12.2	23-Aug	13.8	8-Oct	12.2	23-Nov	14.0
7-Jan	10.2	22-Feb	20.1	8-Apr	9.8	24-May	11.2	9-Jul	11.1	24-Aug	19.0	9-Oct	5.1	24-Nov	12.7
8-Jan	11.4	23-Feb	11.4	9-Apr	16.5	25-May	17.7	10-Jul	9.7	25-Aug	17.6	10-Oct	10.2	25-Nov	9.7
9-Jan	8.1	24-Feb	19.3	10-Apr	13.3	26-May	14.2	11-Jul	16.4	26-Aug	15.4	11-Oct	10.7	26-Nov	12.8
10-Jan	9.4	25-Feb	18.2	11-Apr	11.0	27-May	15.4	12-Jul	21.5	27-Aug	12.6	12-Oct	5.6	27-Nov	16.6
11-Jan	5.7	26-Feb	12.8	12-Apr	8.8	28-May	13.9	13-Jul	RC	28-Aug	12.1	13-Oct	5.9	28-Nov	17.2
12-Jan	8.9	27-Feb	5.5	13-Apr	6.3	29-May	9.3	14-Jul	11.7	29-Aug	10.1	14-Oct	9.7	29-Nov	16.6
13-Jan	18.1	28-Feb	9.7	14-Apr	5.1	30-May	14.5	15-Jul	18.9	30-Aug	17.2	15-Oct	12.8	30-Nov	4.5
14-Jan	11.0	29-Feb	12.1	15-Apr	7.9	31-May	20.5	16-Jul	RC	31-Aug	19.9	16-Oct	16.4	1-Dec	7.5
15-Jan	11.8	1-Mar	9.6	16-Apr	8.2	1-Jun	15.3	17-Jul	RC	1-Sep	19.4	17-Oct	12.0	2-Dec	10.6
16-Jan	10.7	2-Mar	5.6	17-Apr	14.7	2-Jun	11.5	18-Jul	12.8	2-Sep	18.2	18-Oct	7.9	3-Dec	16.7
17-Jan	10.0	3-Mar	12.5	18-Apr	22.5	3-Jun	17.9	19-Jul	6.2	3-Sep	24.0	19-Oct	6.6	4-Dec	12.5
18-Jan	15.6	4-Mar	7.1	19-Apr	12.8	4-Jun	21.1	20-Jul	20.1	4-Sep	15.4	20-Oct	8.1	5-Dec	7.3
19-Jan	18.0	5-Mar	4.9	20-Apr	6.9	5-Jun	17.9	21-Jul	RC	5-Sep	12.4	21-Oct	12.2	6-Dec	10.4
20-Jan	6.6	6-Mar	9.9	21-Apr	7.5	6-Jun	17.6	22-Jul	16.9	6-Sep	12.5	22-Oct	4.6	7-Dec	13.4
21-Jan	7.4	7-Mar	11.2	22-Apr	6.0	7-Jun	15.0	23-Jul	12.8	7-Sep	15.8	23-Oct	6.1	8-Dec	10.5
22-Jan	13.5	8-Mar	5.5	23-Apr	9.1	8-Jun	22.3	24-Jul	7.9	8-Sep	23.4	24-Oct	4.6	9-Dec	9.3
23-Jan	16.0	9-Mar	8.8	24-Apr	10.3	9-Jun	RC	25-Jul	15.7	9-Sep	11.5	25-Oct	4.5	10-Dec	6.5
24-Jan	9.4	10-Mar	11.0	25-Apr	12.0	10-Jun	21.6	26-Jul	24.9	10-Sep	6.0	26-Oct	10.5	11-Dec	3.0
25-Jan	12.6	11-Mar	12.1	26-Apr	12.5	11-Jun	19.4	27-Jul	22.2	11-Sep	11.8	27-Oct	6.4	12-Dec	3.5
26-Jan	13.6	12-Mar	9.7	27-Apr	11.3	12-Jun	21.2	28-Jul	17.5	12-Sep	10.7	28-Oct	4.6	13-Dec	10.2
27-Jan	16.1	13-Mar	15.1	28-Apr	7.6	13-Jun	RC	29-Jul	19.1	13-Sep	7.6	29-Oct	5.6	14-Dec	17.6
28-Jan	10.0	14-Mar	21.6	29-Apr	7.4	14-Jun	15.6	30-Jul	21.1	14-Sep	7.5	30-Oct	7.6	15-Dec	12.4
29-Jan	10.4	15-Mar	16.6	30-Apr	11.4	15-Jun	14.8	31-Jul	18.0	15-Sep	7.1	31-Oct	11.2	16-Dec	9.7
30-Jan	6.9	16-Mar	7.9	1-May	12.6	16-Jun	17.8	1-Aug	16.3	16-Sep	7.7	1-Nov	16.2	17-Dec	7.0
31-Jan	4.9	17-Mar	9.6	2-May	10.0	17-Jun	12.6	2-Aug	19.3	17-Sep	11.3	2-Nov	17.3	18-Dec	7.9
1-Feb	5.4	18-Mar	10.3	3-May	11.2	18-Jun	10.5	3-Aug	17.9	18-Sep	16.8	3-Nov	18.3	19-Dec	6.9
2-Feb	7.1	19-Mar	8.4	4-May	10.4	19-Jun	15.0	4-Aug	25.1	19-Sep	14.8	4-Nov	8.9	20-Dec	8.1
3-Feb	10.9	20-Mar	4.9	5-May	15.7	20-Jun	22.7	5-Aug	RC	20-Sep	8.0	5-Nov	5.8	21-Dec	4.9
4-Feb	12.1	21-Mar	8.7	6-May	16.1	21-Jun	18.7	6-Aug	19.1	21-Sep	10.8	6-Nov	8.6	22-Dec	7.7
5-Feb	17.1	22-Mar	13.3	7-May	16.8	22-Jun	15.2	7-Aug	14.0	22-Sep	14.5	7-Nov	15.0	23-Dec	7.7
6-Feb	10.3	23-Mar	12.2	8-May	14.5	23-Jun	16.8	8-Aug	10.8	23-Sep	21.2	8-Nov	8.3	24-Dec	10.5
7-Feb	4.0	24-Mar	10.3	9-May	11.7	24-Jun	15.1	9-Aug	15.0	24-Sep	8.6	9-Nov	10.0	25-Dec	6.5
8-Feb	9.7	25-Mar	11.9	10-May	9.0	25-Jun	20.7	10-Aug	21.7	25-Sep	1.2	10-Nov	12.8	26-Dec	7.6
9-Feb	11.5	26-Mar	20.1	11-May	6.7	26-Jun	23.0	11-Aug	14.3	26-Sep	16.0	11-Nov	11.8	27-Dec	13.3
10-Feb	3.0	27-Mar	22.5	12-May	7.9	27-Jun	17.8	12-Aug	14.7	27-Sep	12.1	12-Nov	14.8	28-Dec	6.4
11-Feb	5.5	28-Mar	18.2	13-May	8.3	28-Jun	12.4	13-Aug	13.0	28-Sep	18.0	13-Nov	14.5	29-Dec	3.7
12-Feb	18.9	29-Mar	10.8	14-May	12.2	29-Jun	12.7	14-Aug	13.5	29-Sep	17.8	14-Nov	7.7	30-Dec	4.7
13-Feb	17.6	30-Mar	6.4	15-May	13.1	30-Jun	8.9	15-Aug	17.5	30-Sep	16.4	15-Nov	3.6	31-Dec	4.4
14-Feb	11.2	31-Mar	3.3	16-May	8.8	1-Jul	7.1	16-Aug	23.9	1-Oct	12.3	16-Nov	4.6		
15-Feb	14.4	1-Apr	7.8	17-May	8.2	2-Jul	13.8	17-Aug	18.4	2-Oct	8.2	17-Nov	7.8		

Annual 98th Percentile Concentration (highlighted green value) = 25.1

RC = Above 98th Percentile and Removed from Consideration (highlighted peach values)

Exhibit L-3. Year 1 Daily $PM_{2.5}$ Concentrations Less Than or Equal to the 98th Percentile by Quarter

Season / Quarter 1			
Date	**Conc.**	**Date**	**Conc.**
1-Jan	10.4	16-Feb	15.1
2-Jan	5.4	17-Feb	11.8
3-Jan	10.0	18-Feb	3.4
4-Jan	16.4	19-Feb	4.5
5-Jan	11.2	20-Feb	4.8
6-Jan	11.1	21-Feb	11.9
7-Jan	10.2	22-Feb	20.1
8-Jan	11.4	23-Feb	11.4
9-Jan	8.1	24-Feb	19.3
10-Jan	9.4	25-Feb	18.2
11-Jan	5.7	26-Feb	12.8
12-Jan	8.9	27-Feb	5.5
13-Jan	18.1	28-Feb	9.7
14-Jan	11.0	29-Feb	12.1
15-Jan	11.8	1-Mar	9.6
16-Jan	10.7	2-Mar	5.6
17-Jan	10.0	3-Mar	12.5
18-Jan	15.6	4-Mar	7.1
19-Jan	18.0	5-Mar	4.9
20-Jan	6.6	6-Mar	9.9
21-Jan	7.4	7-Mar	11.2
22-Jan	13.5	8-Mar	5.5
23-Jan	16.0	9-Mar	8.8
24-Jan	9.4	10-Mar	11.0
25-Jan	12.6	11-Mar	12.1
26-Jan	13.6	12-Mar	9.7
27-Jan	16.1	13-Mar	15.1
28-Jan	10.0	14-Mar	21.6
29-Jan	10.4	15-Mar	16.6
30-Jan	6.9	16-Mar	7.9
31-Jan	4.9	17-Mar	9.6
1-Feb	5.4	18-Mar	10.3
2-Feb	7.1	19-Mar	8.4
3-Feb	10.9	20-Mar	4.9
4-Feb	12.1	21-Mar	8.7
5-Feb	17.1	22-Mar	13.3
6-Feb	10.3	23-Mar	12.2
7-Feb	4.0	24-Mar	10.3
8-Feb	9.7	25-Mar	11.9
9-Feb	11.5	26-Mar	20.1
10-Feb	3.0	27-Mar	22.5
11-Feb	5.5	28-Mar	18.2
12-Feb	18.9	29-Mar	10.8
13-Feb	17.6	30-Mar	6.4
14-Feb	11.2	31-Mar	3.3
15-Feb	14.4		
Seasonal / Quarterly Maximum			**22.5**

Season / Quarter 2			
Date	**Conc.**	**Date**	**Conc.**
1-Apr	7.8	17-May	8.2
2-Apr	10.5	18-May	11.1
3-Apr	8.2	19-May	7.7
4-Apr	9.7	20-May	13.6
5-Apr	6.9	21-May	12.1
6-Apr	6.3	22-May	10.0
7-Apr	7.9	23-May	13.3
8-Apr	9.8	24-May	11.2
9-Apr	16.5	25-May	17.7
10-Apr	13.3	26-May	14.2
11-Apr	11.0	27-May	15.4
12-Apr	8.8	28-May	13.9
13-Apr	6.3	29-May	9.3
14-Apr	5.1	30-May	14.5
15-Apr	7.9	31-May	20.5
16-Apr	8.2	1-Jun	15.3
17-Apr	14.7	2-Jun	11.5
18-Apr	22.5	3-Jun	17.9
19-Apr	12.8	4-Jun	21.1
20-Apr	6.9	5-Jun	17.9
21-Apr	7.5	6-Jun	17.6
22-Apr	6.0	7-Jun	15.0
23-Apr	9.1	8-Jun	22.3
24-Apr	10.3	9-Jun	RC
25-Apr	12.0	10-Jun	21.6
26-Apr	12.5	11-Jun	19.4
27-Apr	11.3	12-Jun	21.2
28-Apr	7.6	13-Jun	RC
29-Apr	7.4	14-Jun	15.6
30-Apr	11.4	15-Jun	14.8
1-May	12.6	16-Jun	17.8
2-May	10.0	17-Jun	12.6
3-May	11.2	18-Jun	10.5
4-May	10.4	19-Jun	15.0
5-May	15.7	20-Jun	22.7
6-May	16.1	21-Jun	18.7
7-May	16.8	22-Jun	15.2
8-May	14.5	23-Jun	16.8
9-May	11.7	24-Jun	15.1
10-May	9.0	25-Jun	20.7
11-May	6.7	26-Jun	23.0
12-May	7.9	27-Jun	17.8
13-May	8.3	28-Jun	12.4
14-May	12.2	29-Jun	12.7
15-May	13.1	30-Jun	8.9
16-May	8.8		
Seasonal / Quarterly Maximum			**23.0**

Season / Quarter 3			
Date	**Conc.**	**Date**	**Conc.**
1-Jul	7.1	16-Aug	23.9
2-Jul	13.8	17-Aug	18.4
3-Jul	17.1	18-Aug	18.7
4-Jul	19.8	19-Aug	21.5
5-Jul	14.3	20-Aug	20.1
6-Jul	11.5	21-Aug	18.4
7-Jul	14.3	22-Aug	16.7
8-Jul	12.2	23-Aug	13.8
9-Jul	11.1	24-Aug	19.0
10-Jul	9.7	25-Aug	17.6
11-Jul	16.4	26-Aug	15.4
12-Jul	21.5	27-Aug	12.6
13-Jul	RC	28-Aug	12.1
14-Jul	11.7	29-Aug	10.1
15-Jul	18.9	30-Aug	17.2
16-Jul	RC	31-Aug	19.9
17-Jul	RC	1-Sep	19.4
18-Jul	12.8	2-Sep	18.2
19-Jul	6.2	3-Sep	24.0
20-Jul	20.1	4-Sep	15.4
21-Jul	RC	5-Sep	12.4
22-Jul	16.9	6-Sep	12.5
23-Jul	12.8	7-Sep	15.8
24-Jul	7.9	8-Sep	23.4
25-Jul	15.7	9-Sep	11.5
26-Jul	24.9	10-Sep	6.0
27-Jul	22.2	11-Sep	11.8
28-Jul	17.5	12-Sep	10.7
29-Jul	19.1	13-Sep	7.6
30-Jul	21.1	14-Sep	7.5
31-Jul	18.0	15-Sep	7.1
1-Aug	16.3	16-Sep	7.7
2-Aug	19.3	17-Sep	11.3
3-Aug	17.9	18-Sep	16.8
4-Aug	25.1	19-Sep	14.8
5-Aug	RC	20-Sep	8.0
6-Aug	19.1	21-Sep	10.8
7-Aug	14.0	22-Sep	14.5
8-Aug	10.8	23-Sep	21.2
9-Aug	15.0	24-Sep	8.6
10-Aug	21.7	25-Sep	1.2
11-Aug	14.3	26-Sep	16.0
12-Aug	14.7	27-Sep	12.1
13-Aug	13.0	28-Sep	18.0
14-Aug	13.5	29-Sep	17.8
15-Aug	17.5	30-Sep	16.4
Seasonal / Quarterly Maximum			**25.1**

Season / Quarter 4			
Date	**Conc.**	**Date**	**Conc.**
1-Oct	12.3	16-Nov	4.6
2-Oct	8.2	17-Nov	7.8
3-Oct	12.3	18-Nov	4.4
4-Oct	19.5	19-Nov	8.2
5-Oct	23.7	20-Nov	11.1
6-Oct	19.8	21-Nov	5.3
7-Oct	21.7	22-Nov	8.9
8-Oct	12.2	23-Nov	14.0
9-Oct	5.1	24-Nov	12.7
10-Oct	10.2	25-Nov	9.7
11-Oct	10.7	26-Nov	12.8
12-Oct	5.6	27-Nov	16.6
13-Oct	5.9	28-Nov	17.2
14-Oct	9.7	29-Nov	16.6
15-Oct	12.8	30-Nov	4.5
16-Oct	16.4	1-Dec	7.5
17-Oct	12.0	2-Dec	10.6
18-Oct	7.9	3-Dec	16.7
19-Oct	6.6	4-Dec	12.5
20-Oct	8.1	5-Dec	7.3
21-Oct	12.2	6-Dec	10.4
22-Oct	4.6	7-Dec	13.4
23-Oct	6.1	8-Dec	10.5
24-Oct	4.6	9-Dec	9.3
25-Oct	4.5	10-Dec	6.5
26-Oct	10.5	11-Dec	3.0
27-Oct	6.4	12-Dec	3.5
28-Oct	4.6	13-Dec	10.2
29-Oct	5.6	14-Dec	17.6
30-Oct	7.6	15-Dec	12.4
31-Oct	11.2	16-Dec	9.7
1-Nov	16.2	17-Dec	7.0
2-Nov	17.3	18-Dec	7.9
3-Nov	18.3	19-Dec	6.9
4-Nov	8.9	20-Dec	8.1
5-Nov	5.8	21-Dec	4.9
6-Nov	8.6	22-Dec	7.7
7-Nov	15.0	23-Dec	7.7
8-Nov	8.3	24-Dec	10.5
9-Nov	10.0	25-Dec	6.5
10-Nov	12.8	26-Dec	7.6
11-Nov	11.8	27-Dec	13.3
12-Nov	14.8	28-Dec	6.4
13-Nov	14.5	29-Dec	3.7
14-Nov	7.7	30-Dec	4.7
15-Nov	3.6	31-Dec	4.4
Seasonal / Quarterly Maximum			**23.7**

Seasonal/Quarterly Maximum Concentration (highlighted blue values)

RC = Above 98th Percentile and Removed from Consideration (highlighted peach values)

Exhibit L-4: Resulting Average of Seasonal (or Quarterly) Maximums from Year 1 for Inclusion into AERMOD

Seasonal / Quarterly Average Highest Monitored Concentration
(From Annual Datasets Equal To and Less Than the 98th Percentile)

	Q1	**Q2**	**Q3**	**Q4**
Year 1	22.5	23.0	25.1	23.7
Year 2	21.1	20.7	21.2	19.8
Year 3	20.7	22.6	23.5	20.7
Average	**21.433**	**22.100**	**23.267**	**21.400**

Note, the complete datasets for Year 2 and Year 3 are not shown in this appendix but would follow the same steps as for Year 1.

L.3 RUNNING AERMOD

After calculating the seasonal 98th percentile background concentrations, the four average seasonal values (shown in the last row of Exhibit L-4) can be added to the AERMOD input file. There are four important steps to follow when creating an input file consistent with the second tier design value approach.

1) AERMOD must be run with five years of concatenated met data (assuming the use of an off-site monitor). This allows for the calculation of the 98th percentile value across all years of data.

2) Ensure that "PM2.5" is listed for the POLLUTID keyword in the CO pathway. This will trigger calculations in AERMOD that automatically average across five years of meteorological data to determine the 98th percentile concentration at each receptor.

3) Add a line in the SO pathway with the keyword BACKGRND, followed by SEASON. This will allow the definition of four seasonal values. For the example shown above in Appendix L.2, the appropriate line in AERMOD would be:

SO BACKGRND SEASON 21.433 22.100 23.267 21.400

   Also, ensure that BACKGRND is added to the SRCGROUP line of the SO pathway.

4) Finally, since the 98th percentile of 365 days is the eighth highest day, use the RECTABLE keyword of the OU pathway to define the "8th" highest value to report.

After running AERMOD, the RECTABLE generated will report 98th percentile concentrations, averaged across five years of meteorological data, for each receptor. These values can be compared directly to the NAAQS, or in the case of a build/no-build analysis, the values at the same receptor in the build scenario.