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

Public Draft

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

Public Draft

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

EPA United States Environmental Protection Agency

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Table of Contents

List of Exhibits

List of Appendices

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Section 1: Introduction

1.1 PURPOSE OF THIS GUIDANCE

This guidance describes how to complete quantitative hot-spot analyses for certain highway and transit projects in $PM_{2.5}$ and PM_{10} nonattainment and maintenance areas. This guidance describes conformity requirements for hot-spot analyses, and provides technical guidance on estimating project emissions with the Environmental Protection Agency's (EPA's) MOVES2010 model, California's EMFAC2007 model, and other methods. It also outlines how to apply air quality models for PM hot-spot analyses and includes additional references and examples. However, the guidance does not change the specific transportation conformity rule requirements for quantitative PM hot-spot analyses, such as what projects require these analyses. EPA has coordinated with the Department of Transportation (DOT) in developing this guidance.

Transportation conformity is required under Clean Air Act section 176(c) (42 U.S.C. 7506(c)) to ensure that federally supported highway and transit project activities are consistent with ("conform to") the purpose of a state air quality implementation plan (SIP). Conformity to the purpose of the SIP means that transportation activities will not cause new air quality violations, worsen existing violations, or delay timely attainment of the relevant national ambient air quality standards (NAAQS) and interim milestones. EPA's transportation conformity rule (40 CFR 51.390 and Part 93) establishes the criteria and procedures for determining whether transportation activities conform to the SIP. Conformity applies to transportation activities in nonattainment and maintenance areas for transportation-related pollutants, including $PM_{2.5}$ and PM_{10}.

1.2 TIMING OF QUANTITATIVE PM HOT-SPOT ANALYSES

On March 10, 2006, EPA published a final rule establishing transportation conformity requirements for analyzing the local PM air quality impacts of transportation projects (71 FR 12468). The conformity rule requires a qualitative PM hot-spot analysis to be performed until EPA releases guidance on how to conduct quantitative PM hot-spot analyses and announces in the Federal Register that such requirements are in effect (40 CFR 93.123(b)).[1] EPA also stated in the March 2006 final rule that quantitative PM hot-spot analyses would not be required until EPA released an appropriate motor vehicle emissions model for these project-level analyses.[2]

[1] For more information on qualitative PM hot-spot analyses, see "Transportation Conformity Guidance for Qualitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas," EPA420-B-06-902 (March 2006); available online at: www.epa.gov/otaq/stateresources/transconf/policy/420b06902.pdf. The qualitative PM hot-spot requirements under 40 CFR 93.123(b)(2) will no longer apply in any $PM_{2.5}$ and PM_{10} nonattainment and maintenance areas once quantitative requirements are in effect. At that time, the 2006 EPA/FHWA qualitative PM hot-spot guidance will be superseded by EPA's quantitative PM hot-spot guidance.

[2] See EPA's March 2006 final rule for further information (71 FR 12498-12502).

Quantitative PM hot-spot analyses will be required after the end of the conformity grace period for applying motor vehicle emissions models for such analyses. To that end, EPA will soon approve its new motor vehicle emissions model (MOVES2010) for use in project-level transportation conformity determinations, including PM and carbon monoxide (CO) hot-spot analyses.[3] EPA plans to establish a two-year grace period before MOVES is required in quantitative PM and CO hot-spot analyses. EPA will publish a Federal Register notice of availability to approve MOVES2010 (and EMFAC2007 in California) for PM hot-spot analyses, and the effective date of that notice will constitute the start of the two-year conformity grace period. EPA has issued policy guidance on when these models will be required for PM hot-spot analyses and other purposes.[4]

1.3 DEFINITION OF A HOT-SPOT ANALYSIS

A hot-spot analysis is defined in 40 CFR 93.101 as an estimation of likely future localized pollutant concentrations and a comparison of those concentrations to the relevant NAAQS. A hot-spot analysis assesses the air quality impacts on a scale smaller than an entire nonattainment or maintenance area, including, for example, congested highways or transit terminals. Such an analysis of the area substantially affected by the project is a means of demonstrating that Clean Air Act conformity requirements are met for the relevant NAAQS in the "project area." When a hot-spot analysis is required, it is included within a project-level conformity determination.

1.4 PROJECTS REQUIRING A PM HOT-SPOT ANALYSIS

PM hot-spot analyses are required for projects of local air quality concern, which include certain highway and transit projects that involve significant levels of diesel vehicle traffic or any other project identified in the $PM_{2.5}$ or PM_{10} SIP as a localized air quality concern.[5] See Section 2.2 of the guidance for further information on the specific types of projects that require PM hot-spot analyses. A PM hot-spot analysis is not required for projects that are not of local air quality concern. For these projects, state and local project sponsors should document in their project-level conformity determinations that the requirements of the Clean Air Act and 40 CFR 93.116 are met without a hot-spot analysis, since such projects have been found not to be of local air quality concern under

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[3] EPA plans to issue a separate guidance document on how to use MOVES for CO project-level analyses (including CO hot-spot analyses for conformity purposes), consistent with EPA's "Guideline for Modeling Carbon Monoxide from Roadway Intersections," November 1992 (EPA-454/R-92-005). This guidance will be available when MOVES is approved for project-level conformity analyses at the following website: www.epa.gov/otaq/stateresources/transconf/policy.htm#models.

[4] "Policy Guidance on the Use of MOVES2010 for State Implementation Plan Development, Transportation Conformity, and Other Purposes," EPA-420-B-09-046 (December 2009); available online at: www.epa.gov/otaq/stateresources/transconf/policy.htm#models.

[5] See the preamble of the March 2006 final rule for further information regarding how and why EPA defined projects of local air quality concern (71 FR 12491-12493).

40 CFR 93.123(b)(1). See Appendix B of this guidance for examples of projects that are most likely to be of local air quality concern, as well as examples of projects that are not (and do not require a PM hot-spot analysis). This guidance does not alter the types of projects that require a PM hot-spot analysis.

Note that additional projects may need hot-spot analyses in some PM_{10} nonattainment and maintenance areas with approved conformity SIPs which are based on the federal PM_{10} hot-spot requirements that existed before the amendments contained in the March 2006 final rule.[6] EPA strongly encourages states with these types of approved conformity SIPs to revise their conformity SIPs to take advantage of the streamlining flexibilities provided by the current Clean Air Act.[7] See Appendix C for further details on how these types of approved conformity SIPs can affect what projects are required to have PM hot-spot analyses. Project sponsors should use the interagency consultation process to verify the requirements before beginning a quantitative PM_{10} hot-spot analysis.

1.5 OTHER PURPOSES FOR THIS GUIDANCE

This guidance addresses how to complete a quantitative PM hot-spot analysis for transportation conformity purposes. However, certain sections of this guidance, such as Sections 4 or 5 for estimating project-level emissions using MOVES or EMFAC, may also be consulted when completing air quality analyses for transportation projects for other purposes.

1.6 ORGANIZATION OF THIS GUIDANCE

The remainder of this guidance is organized as follows:

- Section 2 provides an overview of transportation conformity requirements for PM hot-spot analyses.
- Section 3 describes the general process for conducting PM hot-spot analyses.
- Sections 4 and 5 describe how to estimate vehicle emissions from a project using the latest approved emissions model, either MOVES (for all states other than California) or EMFAC (for California).
- Section 6 discusses how to estimate emissions from road dust, construction dust, and from other sources, if necessary.
- Section 7 describes how to determine the appropriate air quality dispersion model and select model inputs.
- Section 8 covers how to determine background concentrations, including nearby source emissions in the project area.

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[6] A "conformity SIP" includes a state's specific criteria and procedures for certain aspects of the transportation conformity process (40 CFR 51.390).

[7] 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.

- Section 9 describes how to calculate the appropriate design values and determine whether or not the project conforms.
- Section 10 describes some mitigation and control measures that could be considered, if necessary.

The following appendices for this guidance may also help state and local agencies conduct PM hot-spot analyses:

- Appendix A is a clearinghouse of information and resources external to this guidance which may be useful when completing PM hot-spot analyses.
- Appendix B gives examples of projects of local air quality concern.
- Appendix C discusses what projects need a hot-spot analysis if a state's approved conformity SIP is based on pre-2006 requirements.
- Appendix D demonstrates how to characterize links in an intersection when running MOVES.
- Appendices E and F are abbreviated PM hot-spot analysis examples (using MOVES) for a highway and transit project, respectively.
- Appendices G and H are examples on how to configure and run EMFAC for a highway and transit project, respectively.
- Appendix I describes guidance on estimating locomotive emissions in the project area.
- Appendix J includes details on how to input data and run air quality models for a PM hot-spot analysis as well as prepare outputs for design value calculations.
- Appendix K has examples of how to calculate design values and determine transportation conformity.

Except where indicated, this guidance applies equally for the annual $PM_{2.5}$ NAAQS, the 24-hour $PM_{2.5}$ NAAQS, and the 24-hour PM_{10} NAAQS.

1.7 ADDITIONAL INFORMATION

For specific questions concerning a particular nonattainment or maintenance area, please contact the transportation conformity staff person responsible for your state at the appropriate EPA Regional Office. Contact information for EPA Regional Offices can be found at: www.epa.gov/otaq/stateresources/transconf/contacts.htm.

General questions about this draft guidance can be directed to Meg Patulski at EPA's Office of Transportation and Air Quality, patulski.meg@epa.gov, (734) 214-4842.

1.8 GUIDANCE AND EXISTING REQUIREMENTS

This guidance does not create any new requirements. The Clean Air Act and the regulations described in this document contain legally binding requirements. This guidance is not a substitute for those provisions or regulations, nor is it a regulation in itself. Thus, it does not impose legally binding requirements on EPA, DOT, states, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA retains the discretion to adopt approaches on a case-by-case basis that may differ from this guidance but still comply with the statute and applicable regulations. This guidance may be revised periodically without public notice. As noted above, EPA plans to describe in its upcoming Federal Register notice the two-year conformity grace period for MOVES2010 and EMFAC2007 for PM hot-spot analyses, and when the requirements for quantitative PM hot-spot analyses in 40 CFR 93.123(b) will take effect.

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Section 2: Transportation Conformity Requirements

2.1 INTRODUCTION

This section outlines the transportation conformity requirements for quantitative PM hot-spot analyses. This section describes general statutory and regulatory requirements, specific analytical requirements, and the different types of agencies that are involved in developing hot-spot analyses.

2.2 OVERVIEW OF STATUTORY AND REGULATORY REQUIREMENTS

Clean Air Act section 176(c)(1) is the statutory requirement that must be met by all projects in nonattainment and maintenance areas that are subject to transportation conformity. Section 176(c)(1)(B) states that federally-supported transportation projects must not "cause or contribute to any new violation of any standard in any area; increase the frequency or severity of any existing violation of any standard in any area; or delay timely attainment of any standard or any required interim emission reductions or other milestones in any area."

Section 93.109(b) of the conformity rule outlines the requirements for project-level conformity determinations.[8] For example, PM hot-spot analyses must be based on the latest planning assumptions available at the time the analysis begins (40 CFR 93.110). Also, the design concept and scope of the project must be consistent with that included in the conforming transportation plan and transportation improvement program (TIP) or regional emissions analysis (40 CFR 93.114).

Section 93.123(b)(1) of the conformity rule defines the projects that require a $PM_{2.5}$ or PM_{10} hot-spot analysis as:

> "(i) New highway projects that have a significant number of diesel vehicles, and expanded highway projects that have a significant increase in the number of diesel vehicles;
>
> (ii) Projects affecting intersections that are at Level-of-Service D, E, or F with a significant number of diesel vehicles, or those that will change to Level-of-Service D, E, or F because of increased traffic volumes from a significant number of diesel vehicles related to the project;

[8] In general, when a hot-spot analysis is required, it is done when a project-level conformity determination is completed. Conformity determinations are typically developed during the National Environmental Policy Act (NEPA) process, although conformity requirements are separate from NEPA-related requirements. There can also be limited cases when conformity requirements apply after the initial NEPA process has been completed.

(iii) New bus and rail terminals and transfer points that have a significant number of diesel vehicles congregating at a single location;

(iv) Expanded bus and rail terminals and transfer points that significantly increase the number of diesel vehicles congregating at a single location; and

(v) Projects in or affecting locations, areas, or categories of sites which are identified in the $PM_{2.5}$ or PM_{10} applicable implementation plan or implementation plan submission, as appropriate, as sites of violation or possible violation."

A PM hot-spot analysis is not required for projects that are <u>not</u> of local air quality concern. See Section 1.4 for more background on projects that require PM hot-spot analyses.

Section 93.123(c) of the conformity rule includes the general requirements for all PM hot-spot analyses. A PM hot-spot analysis must:

- Estimate the total emissions burden of direct $PM_{2.5}$ or PM_{10} emissions that may result from the implementation of the project(s), summed together with future background concentrations;
- Include the entire transportation project, after identifying the major design features that will significantly impact local concentrations;
- Use assumptions that are consistent with those used in regional emissions analyses for inputs that are required for both analyses (e.g., temperature, humidity);
- Assume the implementation of mitigation or control measures only where written commitments for such measures have been obtained; and
- Consider emissions increases from construction-related activities if they occur only during the construction phase and last more than five years at any individual site.

Finally, the interagency consultation process must be used to develop project-level conformity determinations to meet all applicable conformity requirements for a given project.

2.3 INTERAGENCY CONSULTATION AND PUBLIC PARTICIPATION REQUIREMENTS

The interagency consultation process is an important tool for completing project-level conformity determinations and hot-spot analyses. Interagency consultation must also be used to develop a process to evaluate and choose associated methods and assumptions to be used in PM hot-spot analyses (40 CFR 93.105(c)(1)(i)). The agencies that may be involved in the interagency consultation process include the project sponsor, state and local transportation and air quality agencies, EPA, and DOT. The roles and responsibilities of various agencies for meeting the transportation conformity requirements are addressed in 40 CFR 93.105 or in a state's approved conformity SIP.

See Section 2.9 for further information on the agencies involved in interagency consultation.

The conformity rule requires agencies completing project-level conformity determinations to establish a proactive public involvement process that provides opportunity for public review and comment (40 CFR 93.105(e)). The NEPA public involvement process can be used to satisfy this public participation requirement. If a project-level conformity determination that includes a PM hot-spot analysis is performed after NEPA is completed, a public comment period must still be provided to support that determination.

2.4 HOT-SPOT ANALYSES ARE BUILD/NO-BUILD ANALYSES

The conformity rule requires that the emissions from the proposed project, when considered with background concentrations, will not produce a new violation of the NAAQS, increase the frequency or severity of existing violations, or delay timely attainment of the NAAQS or any required interim reductions or milestones.[9] As described in Section 1.4, the hot-spot analysis examines the area substantially affected by the project (i.e., the "project area").

In general, a hot-spot analysis compares the air quality concentrations with the proposed project (the build scenario) to the air quality concentrations without the project (the no-build scenario).[10] A build/no-build analysis is necessary for each analysis year(s) chosen (see Section 2.8). It is always necessary to complete emissions and air quality modeling on the build scenario and compare these results to the relevant PM NAAQS. However, it will not always be necessary to conduct emissions and air quality modeling for the no-build scenario, as described further below.

In order to properly scope the level of analysis and prevent unnecessary work, EPA suggests the following approach when completing a PM hot-spot analysis:

- First, model the build scenario and account for background concentrations in accordance with this guidance. If the design values for the build scenario are less than or equal to the relevant NAAQS, the project is considered to conform and no further modeling is required (i.e., there is no need to model the no-build scenario).

- If the build scenario results in design values greater than the NAAQS, then the no-build scenario will also need to be modeled. The no-build scenario will model the air quality impacts of sources without the proposed project. The modeling results of the build and no-build scenarios should be combined with background concentrations as appropriate. If the design values for the build scenario are less

[9] See 40 CFR 93.116(a). See also November 24, 1993 conformity rule for background on EPA's intentions for hot-spot analyses (58 FR 62212-62213).
[10] Please note that a build/no-build analysis for project-level conformity determinations is different than the build/no-build interim emissions test for regional emissions analyses in 40 CFR 93.119.

> than or equal to the design values for the no-build scenario, then the project meets the conformity rule's hot-spot requirements. If not, then the project does not meet conformity requirements without further mitigation or control measures. If such measures are considered, additional modeling will need to be completed and new design values calculated to ensure that the build is less than or equal to the no-build scenario.

The project sponsor can decide to use the suggested approach above or a different approach (e.g., conduct the no-build analysis first, calculate design values at all build and no-build scenario receptors). This guidance can accommodate whatever approach is used for a given PM hot-spot analysis. In general, assumptions should be consistent between the build and no-build scenarios for a given analysis year, except for traffic volumes and other project activity changes or changes in nearby sources that are expected to occur due to the project (e.g., increased activity at a nearby marine port or intermodal terminal due to a new freight corridor highway). Project sponsors should document the build/no-build analysis in the project-level conformity determination, including the assumptions, methods, and models used for each analysis year(s).

The interagency consultation process should be used to determine if new NAAQS violations or increases in the frequency or severity of existing violations are anticipated based on the hot-spot analysis. 40 CFR 93.101 already defines when a new or worsened air quality violation is determined to occur:

> "*Cause or contribute to a new violation* for a project means:
> (1) To cause or contribute to a new violation of a standard in the area substantially affected by the project or over a region which would otherwise not be in violation of the standard during the future period in question, if the project were not implemented; or
> (2) To contribute to a new violation in a manner that would increase the frequency or severity of a new violation of a standard in such area."
>
> "*Increase the frequency or severity* means to cause a location or region to exceed a standard more often or to cause a violation at a greater concentration than previously existed and/or would otherwise exist during the future period in question, if the project were not implemented."

A build/no-build analysis is typically based on design value comparisons done on a receptor-by-receptor basis. However, there may be certain cases where a "new" violation at one receptor (in the build scenario) is relocated from a different receptor (in the no-build scenario). As discussed in the preamble to the November 24, 1993 transportation conformity rule, EPA believes that "a seemingly new violation may be considered to be a relocation and reduction of an existing violation only if it were in the area substantially affected by the project and if the predicted [future] design value for the "new" site would be less than the design value at the "old" site without the project – that is, if there would be a net air quality benefit" (58 FR 62213). Since 1993, EPA has made this interpretation only in limited cases with CO hot-spot analyses where there is a clear relationship between a proposed project and a possible relocated violation (e.g., a reduced CO NAAQS violation is relocated from one corner of an intersection to another due to traffic-related changes from an expanded intersection). The interagency consultation process should be used to discuss any potential relocated violations in PM hot-spot analyses. See Section 9 for further information regarding how conformity would be determined in such a case.

2.5 EMISSIONS CONSIDERED IN PM HOT-SPOT ANALYSES

2.5.1 General requirements

PM hot-spot analyses include only directly emitted $PM_{2.5}$ or PM_{10} emissions. $PM_{2.5}$ and PM_{10} precursors are not considered in PM hot-spot analyses.[11]

2.5.2 PM emissions from motor vehicle exhaust, brake wear, and tire wear

Exhaust, brake wear, and tire wear emissions from on-road vehicles must always be included in a project's $PM_{2.5}$ or PM_{10} hot-spot analysis. See Sections 4 and 5 for how to quantify these emissions using MOVES (outside California) or EMFAC (within California).

2.5.3 $PM_{2.5}$ emissions from re-entrained road dust

Re-entrained road dust must be considered in $PM_{2.5}$ hot-spot analyses only if EPA or the state air agency has made a finding that such emissions are a significant contributor to the $PM_{2.5}$ air quality problem in a given nonattainment or maintenance area (40 CFR 93.102(b)(3) and 93.119(f)(8)).[12]

- <u>If a $PM_{2.5}$ area has no adequate or approved SIP budgets for the $PM_{2.5}$ NAAQS</u>, re-entrained road dust is not included in a hot-spot analysis unless the EPA Regional Administrator or state air quality agency determines that re-entrained road dust is a significant contributor to the $PM_{2.5}$ nonattainment problem and has so notified the metropolitan planning organization (MPO) and DOT.

- <u>If a $PM_{2.5}$ area has adequate or approved SIP budgets</u>, re-entrained road dust would have to be included in a hot-spot analysis only if such budgets include re-entrained road dust.

Please refer to your EPA Regional Office for information on whether a finding of significance for re-entrained road dust has been made for a given $PM_{2.5}$ area. See Section

[11] See 40 CFR 93.102(b) for the general requirements for applicable pollutants and precursors in conformity determinations. Section 93.123(c) provides additional information regarding certain PM emissions for hot-spot analyses. See EPA's March 2006 final rule preamble for additional background (71 FR 12496-8).

[12] See the July 1, 2004 final conformity rule for further information (69 FR 40004).

6 for further information regarding how to estimate re-entrained road dust for $PM_{2.5}$ hot-spot analyses, if necessary.

2.5.4 PM_{10} emissions from re-entrained road dust

Re-entrained road dust must be included in all PM_{10} hot-spot analyses. Because road dust dominates PM_{10} inventories, EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses.[13] See Section 6 for further information regarding how to estimate re-entrained road dust for PM_{10} hot-spot analyses.

2.5.5 PM emissions from construction-related activities

Emissions from construction-related activities are not required to be included in PM hot-spot analyses if such emissions are considered temporary as defined in 40 CFR 93.123(c)(5) (i.e., emissions which occur only during the construction phase and last five years or less at any individual site). Construction emissions would include any direct PM emissions from construction-related dust and exhaust emissions from construction vehicles and equipment.

For most projects, construction emissions would not be included in $PM_{2.5}$ or PM_{10} hot-spot analyses (because in most cases, the construction phase is less than five years at any one site). However, there may be limited cases where a large project is constructed over a longer time period, and non-temporary construction emissions must be included when an analysis year is chosen during project construction. See Section 6 for further information regarding how to estimate transportation-related construction emissions for PM hot-spot analyses, if necessary.

2.6 NAAQS CONSIDERED IN PM HOT-SPOT ANALYSES

The Clean Air Act and transportation conformity regulations require that conformity be met for all transportation-related NAAQS for which an area has been designated nonattainment or maintenance. Therefore, a project-level conformity determination must address all applicable NAAQS for a given pollutant.[14]

Accordingly, results from a quantitative hot-spot analysis will need to be compared to all relevant $PM_{2.5}$ and PM_{10} NAAQS in effect for the area undertaking the analysis.[15] For example, in an area designated nonattainment or maintenance for only the 1997 annual $PM_{2.5}$ NAAQS or only the 2006 24-hour $PM_{2.5}$ NAAQS, the hot-spot analysis would have to address only that respective $PM_{2.5}$ NAAQS. If an area is designated nonattainment or

[13] See the March 2006 final rule for further background (71 FR 12496-98).
[14] See EPA's March 2006 final rule (71 FR 12468-12511).
[15] This guidance is written for the $PM_{2.5}$ and PM_{10} NAAQS in effect at the time of writing (see the EPA Green Book, available online at www.epa.gov/oar/oaqps/greenbk/index.html). However, the guidance may also accommodate future PM NAAQS that can be implemented in a similar manner.

maintenance for the 1997 annual $PM_{2.5}$ NAAQS and the 2006 24-hour $PM_{2.5}$ NAAQS, the hot-spot analysis would have to address both NAAQS.

2.7 BACKGROUND CONCENTRATIONS

As required by 40 CFR 93.123(c)(1) and discussed in Section 2.2, a PM hot-spot analysis must analyze the total emissions burden which results from the implementation of a project, summed with future background concentrations. By definition, background concentrations do not include emissions from the project itself. Background concentrations include the emission impacts of all other sources in the project area, including any nearby sources (e.g., locomotives at an intermodal terminal). Section 8 provides further information on how background concentrations can be determined.

2.8 APPROPRIATE TIME FRAME AND ANALYSIS YEARS

Section 93.116(a) of the conformity rule requires that PM hot-spot analyses must consider either the full time frame of an area's transportation plan or, in an isolated rural nonattainment or maintenance area, the 20-year regional emissions analysis.[16]

Conformity requirements are met if areas demonstrate that no new or worsened violations occur in the year(s) of highest expected emissions – which includes the project's emissions in addition to background concentrations.[17] Areas should analyze the year(s) within the transportation plan or regional emissions analysis, as appropriate, during which:

- Peak emissions from the project are expected; and
- A new NAAQS violation or worsening of an existing violation would most likely occur due to the cumulative impacts of the project and background concentrations in the project area.[18]

In some cases, modeling the last year of the transportation plan or the year of project completion may not be sufficient to satisfy this requirement. For example, if a project is opened in two stages and the entire two-stage project is being approved, the interagency consultation process may result in a decision to analyze two years: one to examine the impacts of the first stage of the project and another to examine the impacts of the completed project. The interagency consultation process should be used to select an appropriate analysis year or years to demonstrate the project conforms over the entire

[16] Although Clean Air Act section 176(c)(7) and 40 CFR 93.106(d) allow the election of changes to the time horizons for transportation plan and TIP conformity determinations, these changes to do not affect the time frame and analysis requirements for hot-spot analyses.
[17] If such a demonstration can be made, then EPA believes it is reasonable to assume that no adverse impacts would occur in any other years within the time frame of the transportation plan or regional emissions analysis.
[18] See EPA's July 1, 2004 final conformity rule (69 FR 40056-40058).

time frame of the transportation plan and regional emissions analysis, per 40 CFR 93.105(c)(1)(i) and 93.116.

2.9 AGENCY ROLES AND RESPONSIBILITIES

The typical roles and responsibilities of agencies implementing the PM hot-spot analysis requirements are described below. Further details are provided throughout later sections of this guidance.

2.9.1 Project sponsor

The project sponsor is typically the agency responsible for implementing the project (e.g., a state department of transportation, regional or local transit operator, or local government). The project sponsor is the lead agency for developing the PM hot-spot analysis, meeting interagency consultation and public participation requirements, and documenting the final hot-spot analysis in the project-level conformity determination.

2.9.2 DOT

DOT is responsible for making project-level conformity determinations. PM hot-spot analyses and conformity determinations would generally be included in documents prepared to meet NEPA requirements.[19] It is possible for DOT to make a project-level conformity determination outside of the NEPA process (for example, if conformity requirements apply after NEPA has been completed but additional federal action on the project is required). DOT is also an active member of the interagency consultation process for conformity determinations.

2.9.3 EPA

EPA is responsible for promulgating transportation conformity regulations and provides policy and technical assistance to federal, state, and local conformity implementers. EPA is an active member of the interagency consultation process for conformity determinations. In addition, EPA reviews submitted SIPs, and provides policy and technical support for air quality modeling, monitoring, and other issues.

2.9.4 State and local transportation and air agencies

State and local transportation and air quality agencies are part of the interagency consultation process and assist in modeling of transportation activities, emissions, and air quality. These agencies are likely to provide data required to perform a PM hot-spot analysis, although the conformity rule does not specifically define the involvement of

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[19] As noted above, transportation conformity requirements are separate from NEPA-related requirements, although conformity determinations are typically developed during the NEPA process and reviewed in parallel.

these agencies in project-level conformity determinations. For example, the state or local air quality agency operates the air quality monitoring network, processes meteorological data, uses air quality models for air quality planning purposes (such as SIP development and modeling applications for other purposes). MPOs often conduct emissions modeling, maintain regional population forecasts, and project future traffic conditions relevant for project planning. The interagency consultation process can be used to discuss the role of the state or local air agency, the MPO, and other agencies in project-level conformity determinations, if such roles are not already defined in the state's conformity SIP.

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Section 3: Overview of a Quantitative PM Hot-Spot Analysis

3.1 INTRODUCTION

This section provides an overview of the process for conducting a quantitative PM hot-spot analysis. This section may be particularly helpful to those who are looking for a general understanding of this process. All individual elements or steps presented here are covered in more depth and with more technical information throughout the remainder of the guidance. The general steps required to complete a quantitative PM hot-spot analysis are depicted in Exhibit 3-1 (following page) and summarized in this section.

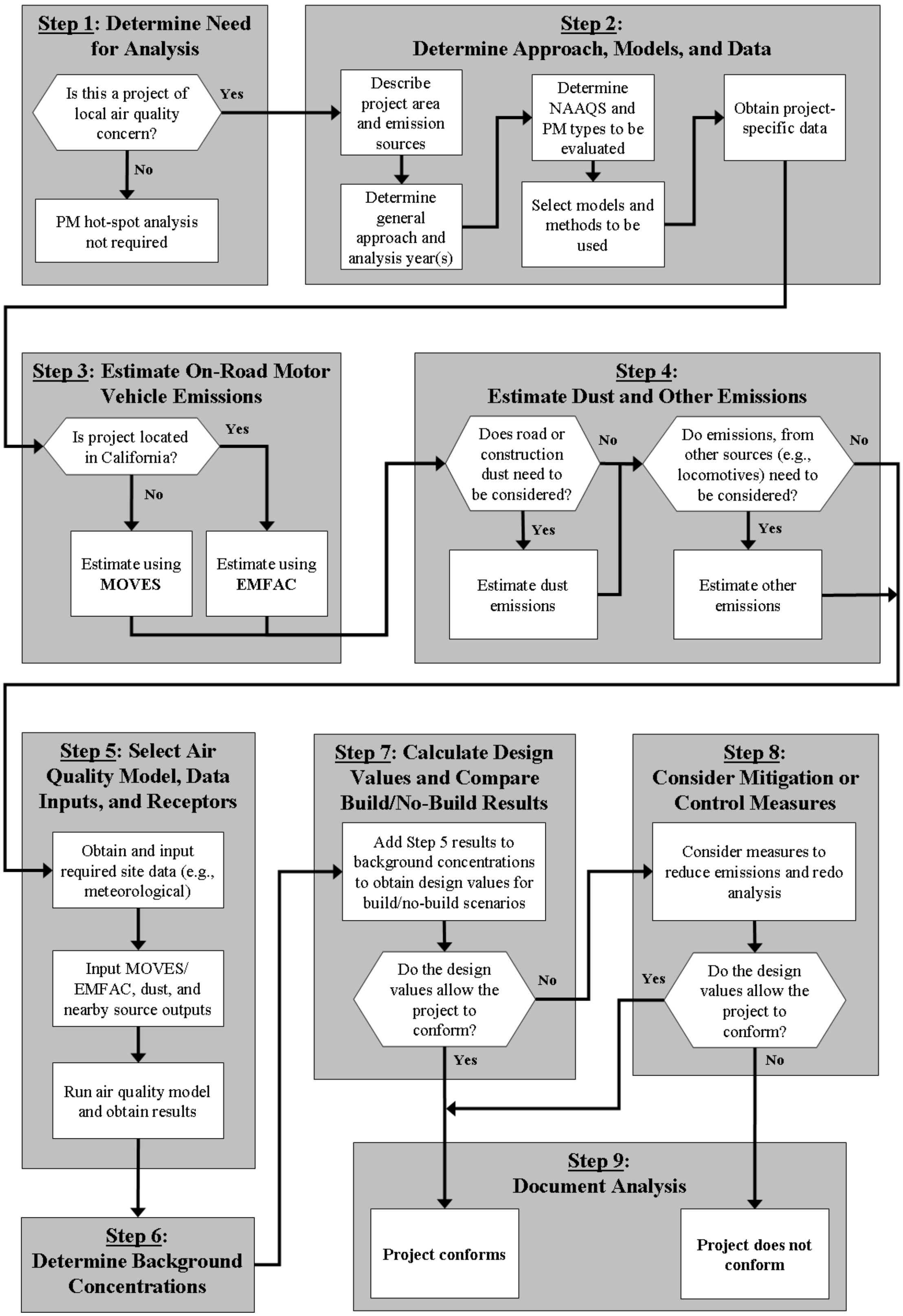
Note that the interagency consultation process is an essential part of developing PM hot-spot analyses. As a number of fundamental aspects of the analysis need to be determined through consultation, it is recommended that these discussions take place at the earliest opportunity and well in advance of beginning any modeling. In addition, early consultation allows potential data sources for the analysis to be more easily identified.

3.2 DETERMINE NEED FOR A PM HOT-SPOT ANALYSIS (STEP 1)

The conformity rule requires a PM hot-spot analysis only for projects of local air quality concern. See Section 1.4 and Appendix B regarding how to determine if the project is of local air quality concern according to the conformity rule and through the interagency consultation process.

As stated earlier, if the project is not of local air quality concern, then the project meets 40 CFR 93.116 requirements for PM without a hot-spot analysis. For this type of project, project sponsors should briefly document in the project-level conformity determination that the requirements of the Clean Air Act and 40 CFR 93.116 are met without a hot-spot analysis, since such projects have been found not to be of local air quality concern under 40 CFR 93.123(b). Note that all other project-level conformity requirements must continue to be met.

Exhibit 3-1. Overview of the Quantitative Hot-spot Analysis Process



3.3 DETERMINE APPROACH, MODELS, AND DATA (STEP 2)

3.3.1 General

There are several decisions that need to be made before beginning a PM hot-spot analysis, including:

- The geographic area to be covered by the analysis (the "project area") and emission sources to be modeled;
- The general approach and analysis year(s) for emissions and air quality modeling;
- The applicable PM NAAQS to be evaluated;
- The type of PM emissions to be modeled for different sources;
- The emissions and air quality models and methods to be used;
- The project-specific data to be used; and
- The schedule for conducting the analysis and points of consultation.

Further details on these decisions are provided below.

3.3.2 Determining the geographic area and emission sources to be covered by the analysis

The geographic area to be covered by a PM hot-spot analysis (the "project area") is to be determined on a case-by-case basis through the interagency consultation process. PM hot-spot analyses must examine the air quality impacts of the relevant PM NAAQS in the area substantially affected by the project (40 CFR 93.123(c)(1)). To meet this and other conformity requirements, it is necessary to define the project, determine where it is to be located, and determine whether any other emission sources are also located in the project area.[20] In addition to emissions from the proposed highway or transit project,[21] there may be other nearby sources of emissions (e.g., a freight rail terminal) that need to be estimated and considered along with other background concentrations. There may be other sources in the project area that are determined through the interagency consultation process to be insignificant to project emissions (e.g., a service drive or small employee parking lot). See Sections 4 through 6 for how to estimate emissions from the proposed project, and Sections 6 through 8 for when and how to include nearby source emissions as well as other background concentrations.

Hot-spot analyses must include the entire project (40 CFR 93.123(c)(2)). However, it may be appropriate in some cases to focus the PM hot-spot analysis only on the locations of highest air quality concentrations. For example, for large projects, it may be necessary to analyze multiple locations that are expected to have the highest air quality concentrations, and consequently, the most likely new or worsened PM NAAQS violations.

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[20] See more in the March 24, 2010 final conformity rule entitled "Transportation Conformity Rule $PM_{2.5}$ and PM_{10} amendments," 75 FR 14281; found online at: www.epa.gov/otaq/stateresources/transconf/conf-regs.htm.

[21] 40 CFR 93.101 defines "highway project" and "transit project" for transportation conformity purposes.

3.3.3 Deciding the general analysis approach and analysis year(s)

As stated in Section 2.4, there are several approaches for completing a build/no-build analysis for a given project. For example, a project sponsor may want to start by completing the build scenario first to see if a new or worsened PM NAAQS violation is predicted (and if not, then modeling the no-build scenario would be unnecessary). In contrast, a project sponsor could start with the no-build scenario first if a future PM NAAQS violation is anticipated in both the build and no-build scenarios.

It is also necessary to select one or more analysis years within the time frame of the transportation plan or regional emissions analysis when emissions from the project, any nearby sources, and background are expected to be highest. Analysis year(s) should be determined through the interagency consultation process. See Section 2.8 for more information on selecting analysis year(s).

3.3.4 Determining which PM NAAQS to be evaluated

As stated in Section 2.6, PM hot-spot analyses need to be evaluated only for the NAAQS for which an area has been designated nonattainment or maintenance. In addition, there are aspects of modeling that can be affected by whether a NAAQS is an annual or a 24-hour PM NAAQS. For example, a hot-spot analysis for the annual $PM_{2.5}$ NAAQS would involve data and modeling throughout a given analysis year (i.e., all four quarters of the analysis year).[22]

A hot-spot analysis for the 24-hour $PM_{2.5}$ or PM_{10} NAAQS would also involve data and modeling throughout an analysis year, except when future NAAQS violations and peak emissions in the project area are expected to occur in only one quarter of the future analysis year(s). In such cases, a project sponsor could choose to complete emissions and air quality modeling for only that quarter if agreed to through the interagency consultation process. For example, a PM_{10} nonattainment or maintenance area may only have PM_{10} NAAQS violations during the first quarter of the year (January-March), when PM emissions from other sources, such as wood smoke, are also highest. In such an area, if the highest emissions from the project area are also expected to occur in this same quarter, then the project sponsor could complete the PM hot-spot analysis for only that quarter (if agreed to through interagency consultation).

Note: It may be difficult to determine whether 24-hour $PM_{2.5}$ NAAQS violations will occur in only one quarter, due to the number of $PM_{2.5}$ emission sources in a given project area that can occur throughout the year. In such cases, it is important to analyze all quarters to ensure that any new or worsened PM NAAQS violation can be identified through modeling.

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[22] Calendar quarters in this guidance are defined in the following manner: Q1 (January-March), Q2 (April-June), Q3 (July-September), and Q4 (October-December).

3.3.5 Deciding on the type of PM emissions to be modeled

The interagency consultation process should be used to determine what types of directly emitted $PM_{2.5}$ or PM_{10} are relevant for estimating the emissions in the project area. See Section 2.5 for further information on what types of directly emitted PM must be included in hot-spot analyses and Sections 4 through 6 and Section 8 on when and how to quantify PM emissions.

3.3.6 Determining the models and methods to be used

The interagency consultation process must be used to determine the emissions and air quality models and methods used in the PM hot-spot analysis (40 CFR 93.105(c)(1)(i)). The latest approved emissions models must be used in PM hot-spot analyses (40 CFR 93.111). See Sections 3.4 through 3.6 as well as the subsequent sections of the guidance they refer to for specific information about models and methods that apply.

Note: It is important to select an air quality model to be used in the PM hot-spot analysis early in the process, since this information is necessary to prepare emissions model outputs for air quality modeling purposes. See Section 7 for further information on when AERMOD or CAL3QHCR are recommended air quality models for PM hot-spot analyses.

3.3.7 Obtaining the project-specific data to be used

The transportation conformity rule requires that the latest planning assumptions available at the time that the analysis begins be used in conformity determinations (40 CFR 93.110). In addition, the regulation states that hot-spot analysis assumptions must be consistent with those assumptions used in the regional emissions analysis for any inputs which are required for both analyses (40 CFR 93.123(c)(3)).

The project sponsor should use project-specific data for both emissions and air quality modeling, whenever possible, though default inputs may be appropriate in some cases. The use of project-specific versus default data is discussed further in Sections 4 through 8.

The following are examples of data needed to run MOVES or EMFAC, as described in Sections 4 and 5:

- Traffic data sufficient to characterize each link in the project area;
- Starts per hour and number of vehicles idling during each hour for off-network links/sources;
- Vehicle types and age distribution expected in the project area; and
- Temperature and humidity data for each month and hour included in the analysis.

Depending on the air quality model to be used, the following are examples of data that will likely be needed, as described in Sections 7 through 9:

- Surface meteorological data from monitors that measure the atmosphere near the ground;
- Upper air data describing the vertical temperature profile of the atmosphere;
- Data describing surface characteristics near the surface meteorological monitors;
- Nearby population data; and
- Information necessary for determining locations of air quality modeling receptors.

To complete the PM hot-spot analysis, areas will also need data on background concentrations from nearby or other emission sources in the project area, as described in Section 8.

3.4 ESTIMATE ON-ROAD MOTOR VEHICLE EMISSIONS (STEP 3)

There are two approved motor vehicle emissions models available for estimating the project's exhaust, brake wear, and tire wear emissions. See Section 4 for more on estimating these PM emissions with EPA's MOVES model. Section 5 describes how to apply EMFAC for estimating these emissions for projects in California.

3.5 ESTIMATE DUST AND OTHER EMISSIONS (STEP 4)

Section 2.5 provides more information about when re-entrained road dust and/or construction emissions are included in $PM_{2.5}$ and PM_{10} hot-spot analyses. Section 6 describes methods for estimating these emissions.

There may be other sources of emissions that also need to be estimated, and included in air quality modeling. Section 8 provides further information regarding how to account for these emissions in a PM hot-spot analysis. Appendix I provides further information for estimating locomotive emissions.

3.6 SELECT AN AIR QUALITY MODEL, DATA INPUTS AND RECEPTORS (STEP 5)

An air quality model estimates PM concentrations at specific points in the project area known as "receptors." Emissions that result from the project (including those from vehicles, dust, and construction from Steps 3 and 4) as well as any other nearby emission sources (e.g., locomotives) must be input into the selected air quality model, which predicts how emissions are dispersed based on meteorological and other input data. There are two air quality models (AERMOD and CAL3QHCR) recommended for use in PM hot-spot analyses. Basic information about these models, including how to select a model for a particular project and the data needed to run them, is found in Section 7 and Appendix J.

3.7 DETERMINE BACKGROUND CONCENTRATIONS (STEP 6)

The PM hot-spot analysis must also account for background PM concentrations in the project area to account for emissions that are not related to the project or nearby sources. Section 8 provides further information on selecting representative background concentrations.

3.8 CALCULATE DESIGN VALUES AND COMPARE BUILD AND NO-BUILD SCENARIO RESULTS (STEP 7)

In general, the PM concentrations estimated from air quality modeling (in Step 5) are then combined with background concentrations (in Step 6) at the receptor locations for both the build and no-build scenarios. The resulting statistic is referred to as a design value; how it is specifically calculated depends on the form of the NAAQS. If the design value in the build scenario is <u>less than or equal to</u> the relevant PM NAAQS at appropriate receptors, then the project meets conformity requirements. In the case where the design value is <u>greater than</u> the NAAQS in the build scenario, a project could still meet conformity requirements if the design values in the build scenario were <u>less than or equal to</u> the design values in the no-build scenario at appropriate receptors. See Section 2.4 and Section 9 for further details on build/no-build approaches and implementation.

3.9 CONSIDER MITIGATION OR CONTROL MEASURES (STEP 8)

Where a project does not meet conformity requirements, a project sponsor may consider mitigation or control measures to reduce emissions in the project area. If mitigation or control measures are considered, additional modeling will need to be completed and new design values calculated to ensure that conformity requirements are met. See Section 10 for more information on possible measures for consideration.

3.10 DOCUMENT THE PM HOT-SPOT ANALYSIS (STEP 9)

The PM hot-spot analysis should include sufficient documentation to justify the conclusion that a proposed project meets conformity rule requirements per 40 CFR 93.116 and 93.123.

Hot-spot analysis documentation should include, at a minimum:

- A description of the proposed project, including where the project is located, the project's scope (e.g., adding an interchange, widening a highway, expanding a major bus terminal), when the project is expected to be open to traffic, travel activity projected for the analysis year(s), and what part of 40 CFR 93.123(b)(1) is applicable;[23]

- A description of the analysis year(s) examined;
- Emissions modeling, including the emissions model used (e.g., MOVES), modeling inputs and results, and how the project was characterized in terms of links;
- Modeling inputs and results for estimating re-entrained road dust, construction emissions, and other nearby source emissions, as applicable to a particular PM hot-spot analysis;
- Air quality modeling data, including the air quality model used, modeling inputs and results, and description of the receptors employed in the analysis;
- A description of the assumptions used to determine background concentrations;
- A discussion of any mitigation or control measures that will be implemented, the methods and assumptions used to quantify their expected effects, and associated written commitments; and
- A conclusion for how the proposed project meets 40 CFR 93.116 and 93.123 conformity requirements for the $PM_{2.5}$ and/or PM_{10} NAAQS.

Documentation should consistently describe the sources of data used in preparing emissions and air quality modeling inputs. This documentation should also describe any other critical assumptions that have the potential to affect predicted concentrations. Documentation of PM hot-spot analyses would be included in the project-level conformity determination.

[23] This information could reference the appropriate sections of any NEPA document prepared for the project.

Section 4: Estimating Project-level PM Emissions Using MOVES

4.1 Introduction

This section of the guidance describes how to use MOVES to estimate PM exhaust, brake wear, and tire wear emissions for PM hot-spot analyses outside of California. This section focuses on determining what the appropriate project-level inputs are and how MOVES should be run to provide the necessary information to complete air quality modeling.[24]

MOVES2010 is a computer model designed by EPA to estimate emissions from cars, trucks, buses and motorcycles. MOVES2010 replaces MOBILE6.2, EPA's previous emissions model.[25] MOVES is based on an extensive review of in-use vehicle data collected and analyzed since the release of MOBILE6.2. MOVES estimates PM emissions to account for speed and temperature variations and models emissions at a high resolution. As a result, users can now incorporate a much wider array of vehicle activity data for each roadway link, as well as start and idle activity in transit or other terminal projects.

Exhibit 4-1 (following page) shows the necessary steps for applying the MOVES model for project-level PM hot-spot analyses.

This section presumes users already have a basic understanding of how to run MOVES, either by attending MOVES training or reviewing the MOVES User Guide.[26] MOVES includes a default database of meteorology, fleet, activity, fuel, and control program data for the entire United States. The data included in this database come from a variety of sources and are not necessarily the most accurate or up-to-date information available at the local level for a particular project. This section describes when the use of that default database is appropriate for PM hot-spot analysis, as well as when available local data must be used (40 CFR 93.110 and 93.123(c)).

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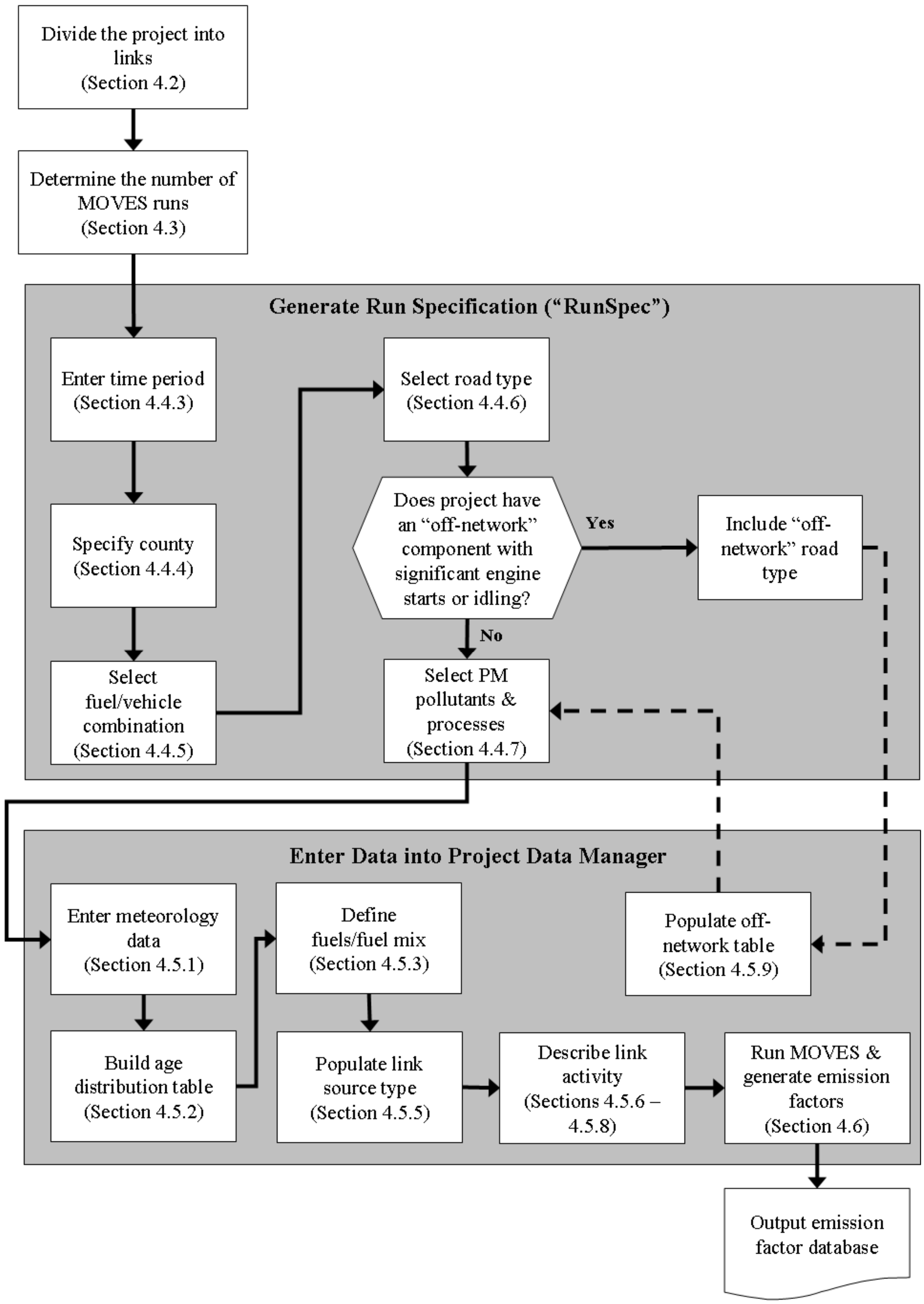
[24] Technical guidance on using MOVES for regional emissions inventories can be found in "Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity," EPA-420-B-10-023 (April 2010); available online at: www.epa.gov/otaq/stateresources/transconf/policy.htm.

[25] EPA stated in the preamble to the March 2006 final rule that finalizing the MOVES emissions model was critical before quantitative PM hot-spot analyses are required, due to the limitations of applying MOBILE6.2 for PM at the project level. See EPA's March 2006 final rule for further information (71 FR 12498-12502).

[26] The MOVES model, User Guide, and supporting documentation are available online at: www.epa.gov/otaq/models/moves/index.htm.

Exhibit 4-1. Steps for Using MOVES in a Quantitative PM Hot-spot Analysis



Note: The steps in this exhibit and in the accompanying text describe how to use MOVES at the project-level for a PM hot-spot analysis.

As discussed in Section 2.4, project sponsors should conduct emissions and air quality modeling for the project build scenario first. If this scenario does not exceed the NAAQS, then it is not necessary to model the no-build scenario. Following this approach will allow users to avoid unnecessary emissions and air quality modeling. Finally, Section 4 describes how to use MOVES to estimate emissions from a highway or transit project that requires a PM hot-spot analysis ("the project"); this section could also be used to estimate emissions for any other highway and transit facilities in the project area, when necessary.

4.2 CHARACTERIZING A PROJECT IN TERMS OF LINKS

Prior to entering data into MOVES, users need to first identify the project type and the associated emission processes (running, start, and idle exhaust) to be modeled. This guidance distinguishes between two types of transportation projects: (1) highway and intersection projects, and (2) transit or other terminal projects:

- For highway and intersection projects, running exhaust, crankcase, brake wear, and tire wear emissions are the main focus.
- For transit and other terminal projects, start, crankcase, and extended idle emissions are typically needed, and in some cases these projects will also need to address cruise, approach and departure running exhaust emissions on affected links.

The goal of defining a project's links is to accurately capture emissions where they occur. Within MOVES, a link represents a segment of road or an "off-network" location where a certain type of vehicle activity occurs.[27] Generally, the links specified for a project should include segments with similar traffic/activity conditions and characteristics. From the link-specific activity and other inputs, MOVES calculates emissions from every link of a project for a given time period (or run). In MOVES, running emissions, including periods of idling at traffic signals, are defined in the Links Importer (see Section 4.5.6), while starts and extended periods of idling (e.g., truck idling at a freight terminal) are defined in the Off-Network Importer (see Section 4.5.9).

4.2.1 Highway and intersection projects

<u>General</u>

A PM hot-spot analysis fundamentally depends on the availability of accurate data on roadway link speed and traffic volumes for build and no-build scenarios.[28] Thus, local

[27] "Off-network" in the context of MOVES refers to an area of activity not occurring on a roadway. Examples of a MOVES off-network link include parking lots and freight or bus terminals.

[28] Project sponsors should document available traffic data sets, their sources, key assumptions, and the methods used to develop build and no-build scenario inputs for MOVES. Documentation should include differences between how build and no-build traffic projections are obtained. For projects of local air quality concern, there will always be differences in traffic volumes and other activity changes between the

traffic data should be used to characterize each link sufficiently. It is recommended that the user divide a project into separate links to allow sufficient resolution at different vehicle traffic and activity patterns; characterizing this variability in emissions within the project area will assist in air quality modeling (see Section 7).

For analyses with MOVES, a minimum of both an average speed and traffic volume is required for each link. If that is the only information available, MOVES uses default assumptions of vehicle activity patterns (called drive cycles) for that average speed and type of roadway to estimate emissions. Those default drive cycles use different combinations of vehicle activity (acceleration, deceleration, cruise, and/or idle) depending on the speed and road type. For example, if the link average speed is 30 mph and it is an urban street, MOVES uses a default drive cycle that includes a high proportion of acceleration, deceleration, and idle activity as would be expected on an urban street with frequent stops. If the average speed is 60 mph and it is a rural freeway, MOVES uses a default drive cycle that assumes a higher proportion of cruise activity, smaller proportions of acceleration and deceleration activity, and little or no idle activity.

As described further in Section 4.5.7, users should take advantage of the full capabilities of MOVES for estimating emissions on different highway and intersection project links. Although average speeds and travel volumes are typically available for most transportation projects and may need to be relied upon during the transition to using MOVES, users can develop and use more precise data through the MOVES Operating Mode Distribution Importer or Link Drive Schedule Importer, as described further below. When more detailed data are available to describe the pattern of changes in vehicle activity (proportion of time in acceleration, deceleration, cruise, or idle activity) over a length of road, MOVES is capable of calculating these specific emission impacts. EPA encourages users to consider these options for highway and intersection projects, especially as MOVES is implemented further into the future, or for more advanced MOVES applications.

<u>Free-flow Highway Links</u>

The links defined in MOVES should capture the expected physical layout of a project and representative variations in vehicle activity. The simplest example is a single, one directional, four-lane highway that could be characterized as just one link. More sophisticated analyses may break up traffic flow on that single link into multiple links of varying operating modes or drive cycles that may have different emission factors depending on the relative acceleration, cruise, or deceleration activity on each segment of that link. In general, the definition of link will depend on how much the type of vehicle activity (acceleration, deceleration, cruise or idle) changes over a length of roadway, the level of detail of available data, and the modeling approach used with MOVES. For a highway lane where vehicle behavior is fairly constant, the length of the link could be longer and the use of detailed activity data will have a smaller impact on results. In

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build and no-build scenarios, and these differences must be accounted for in the data that is used in the PM hot-spot analysis.

MOVES, activity on free-flow highway links can be defined by an average speed, link drive schedule, or operating mode ("Op-Mode") distribution (discussed in Section 4.5.7).

<u>Intersection Links</u>

If the project analysis involves intersections, the intersections need to be treated separately from the free-flow links that connect to those intersections. Although road segments between intersections may experience free-flow traffic operations, the approaches and departures from the intersections will likely involve acceleration, deceleration, and idling activity not present on the free-flow link. For intersection modeling, the definition of link length will depend on the geometry of the intersection, how that geometry affects vehicle activity, and the level of detail of available activity information. Guidance for defining intersection links are given in Appendix D, but the definition of links used for a particular project will depend of the specific details of that project and the amount of available activity information.[29]

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 that 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 (as described in Appendix D). The sum of emissions from each vehicle trajectory (LinkID) represents the total emission contribution of a given road segment.

4.2.2 Transit and other terminal projects

For off-network sources such as a bus terminal or intermodal freight terminal, the user should have information on starts per hour and number of vehicles idling during each hour. This activity will likely vary from hour to hour. It is recommended that the user divide such a project into separate links to appropriately characterize variability in emission density within the project area (as discussed in Section 7). In this case, each "link" describes an area with a certain number of vehicle starts per hour, or a certain number of vehicles idling during each hour.

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[29] As discussed in Section 7, the use of the CAL3QHCR queuing algorithm for intersection idle queues is not recommended. Rather, idling vehicles should be represented in combination with decelerating, accelerating, and free-flow traffic on an approach segment of an intersection.

Some transit and other terminal projects may have significant running emissions similar to free-flow highway projects (such as buses and trucks coming to and from an intermodal terminal). These emissions can be calculated by defining one or more unique running links as described in Section 4.2.1 and Appendix D (that is, in addition to any other roadway links associated with the project). These running link emissions can then be aggregated with the emissions from starts and idling from non-running activity on the transit or other terminal link outside of the MOVES model to generate the necessary air quality model inputs.

Long duration idling (classified in MOVES as Operating Mode ID "200") can only be modeled in MOVES for long-haul combination trucks. Idling for other vehicles and shorter periods of idling for long-haul combination trucks should be modeled as a project link with an operating mode distribution that consists only of idle operation (Op-Mode 1). This can be specified in the Links table by inputting the vehicle population and specifying an average speed of "0" mph.

Note: The user may choose to exclude sources such as a separate service drive, separate small employee parking lot, or other minor sources that are determined through interagency consultation to be insignificant to project emissions.

4.3 DETERMINING THE NUMBER OF MOVES RUNS

4.3.1 General

Before running MOVES to calculate emission factors, users should first determine the number of unique scenarios that can sufficiently describe activity variation in a project. In most projects traffic volume, average speed, idling, fleet mix, and the corresponding emission factors will likely vary from hour to hour, day to day, and month to month. However, it is unlikely that data are readily available to capture such finite changes. Project sponsors may have activity data collected at a range of possible temporal resolutions. The conformity rule requires the latest activity data available at the time of the analysis to be used in a quantitative hot-spot analysis (40 CFR 93.110).[30] Depending on the sophistication of the activity data analysis for a given project, these data may range from a daily average-hour and peak-hour value to hourly estimates for all days of the year. EPA encourages the development of sufficient travel activity data to capture the expected ranges of traffic conditions for the build and no-build scenarios. The number of MOVES runs should be based on the best available activity data and the PM NAAQS involved.[31] Exhibit 4-2 includes EPA's recommendations for PM hot-spot analyses:

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[30] See "EPA and DOT Joint Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations," EPA420-B-08-901 (December 2008); available online at: www.epa.gov/otaq/stateresources/transconf/policy/420b08901.pdf.

[31] The conformity rule requires the latest activity data available at the time of the analysis to be used (40 CFR 93.110).

Exhibit 4-2. Typical Number of MOVES Runs for an Analysis Year

Applicable NAAQS	Build Scenario	No-build Scenario[32]
Annual $PM_{2.5}$ NAAQS only	16	16
24-hour $PM_{2.5}$ NAAQS only	16 (4 in certain cases)	16 (4 in certain cases)
24-hour PM_{10} NAAQS only	16 (4 in certain cases)	16 (4 in certain cases)
Annual and 24-hour PM NAAQS[33]	16	16

Hot-spot analyses for the annual $PM_{2.5}$ NAAQS should include 16 unique MOVES runs (i.e., four runs for different time periods for each of four calendar quarters). Therefore, for a typical build/no-build analysis, a total of 32 runs would be needed (16 for each scenario). Hot-spot analyses for only the 24-hour $PM_{2.5}$ or PM_{10} NAAQS should also be completed with the 16 MOVES runs, except in cases where potential PM NAAQS violations are expected to occur in only one quarter of the calendar year. In such cases, the user may choose to model only that quarter with four MOVES runs for each scenario. See Section 3.3 for further details for when fewer MOVES runs is appropriate for the 24-hour PM NAAQS; this decision should be determined through interagency consultation.

The product of the MOVES analysis is a year's (or quarter's) worth of hour-specific emission factors for each project link that will be applied to the appropriate air quality model (discussed in Section 7) and compared to the relevant PM NAAQS (discussed in Section 9). The following subsections provide further information for determining MOVES runs for all PM NAAQS, based on the level of available travel activity data.

4.3.2 For projects with typical travel activity data

Traffic forecasts for highway and intersection projects are often completed for annual average daily traffic volumes, with an allocation factor for a daily peak-hour volume. This data can be used to conduct an analysis with MOVES that is representative for all hours of the year. To complete 16 MOVES runs as outlined above, the user should run MOVES for four months: January, April, July, and October; and four weekday time periods: morning peak (AM), midday (MD), evening peak (PM), and overnight (ON).[34] The AM and PM peak periods should be run with peak-hour traffic activity; MD and ON periods should be run with average-hour activity. The most reasonable methods in accordance with good practice should be used to obtain the allocation factors and diurnal

[32] There are some cases where the no-build scenario and associated emissions and air quality modeling is not necessary. See Section 2.4 for further information.
[33] Such a situation would include cases where a project is located in a nonattainment/maintenance area for both the annual $PM_{2.5}$ NAAQS and either a 24-hour $PM_{2.5}$ NAAQS or the 24-hour PM_{10} NAAQS.
[34] If it is determined through interagency consultation that only four MOVES runs are required for a PM hot-spot analysis for a 24-hour PM NAAQS, four runs would be done for the same weekday time periods, except only for one quarter (i.e., January, April, July, or October).

distribution of traffic and the methods must be decided in accordance with interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

The results for each of the four hours can then be extrapolated to cover the entire day. For example, the peak-hour volume can be used to represent activity conditions over a three-hour morning (AM) and three-hour evening (PM) period. The remaining 18 hours of the day can be represented by the average-hour activity. These 18 hours would be divided into a midday (MD) and overnight (ON) scenario.

The following is one suggested approach for an analysis employing the average-hour/peak-hour traffic scenario based on an examination of national-scale data:

- Morning peak (AM) emissions based on traffic data and meteorology occurring between 6 a.m. and 9 a.m.;
- Midday (MD) emissions based on data from 9 a.m. to 4 p.m.;
- Evening peak (PM) emissions based on data from 4 p.m. to 7 p.m.; and
- Overnight (ON) emissions based on data from 7 p.m. to 6 a.m.

If there are local or project-specific data to suggest that the AM or PM peak traffic periods will occur in different hours than the default values suggested here, or over a longer or shorter period of time, that information should be documented and the hours representing each time period adjusted accordingly. Additionally, users should independently determine peak periods for the build and no-build scenarios, and should not assume that each scenario is identical, as determined through interagency consultation.

The emission factors for each month's runs should be used for the other months within the quarter. The months suggested for the minimum number of MOVES runs correspond to the first month of each quarter. For instance, January emissions should be assumed to represent February and March emissions, April should be used to represent May and June emissions, and so forth.[35]

4.3.3 For projects with additional travel activity data

Some project sponsors may have developed traffic or other activity data to show variations in volume and speed across hours, days, or months. Additionally, if users are modeling a transit or other terminal project, traffic volumes, starts, and idling estimates are likely to be readily available for each hour of the day. Under either of these circumstances, users have the option of applying the methodology described above (using average-hour and peak-hour as representative for all hours of the year) if it is determined through the interagency consultation process that using the additional data would not significantly impact the emissions modeling results. Alternatively, additional MOVES runs could be generated to produce a unique emission factor for additional activity data (i.e., each period of time for which specific activity data are available).

[35] Rather than use the middle month of the first quarter (February), January is used because it is typically the coldest month of the year and therefore has the highest PM emission rates.

4.4 DEVELOPING BASIC RUN SPECIFICATION INPUTS

Once the user has defined the project conceptually in terms of links and determined the number of MOVES runs, the next step in using MOVES for project-level analyses is to develop a run specification ("RunSpec"). The RunSpec is a computer file in XML format that can be edited and executed directly or with the MOVES Graphical User Interface (GUI). MOVES requires the user to set up a RunSpec to define the place and time of the analysis as well as the vehicle types, road types, fuel types, and the emission-producing processes and pollutants that will be included in the analysis. The headings in this subsection describe each set of input options needed to create the RunSpec as defined in the navigation panel of the MOVES GUI. In order to create a project-level RunSpec, the user must go down the navigation panel filling in the appropriate data for each of the menu items listed in the panel. Those menu items are:

- Description
- Scale
- Time Spans
- Geographic Bounds
- Vehicles/Equipment
- Road Type
- Pollutants and Processes
- Manage Input Data Sets
- Strategies
- Output
- Advanced Performance Features

Additional information on each menu item can be found in the MOVES User Guide available on EPA's website (www.epa.gov/otaq/models/moves/index.htm). The appropriate sections of the user guide are referenced when describing the RunSpec creation process below.

4.4.1 Description

(MOVES User Guide Section 2.2.1)

This menu item allows the user to enter a description of the RunSpec using up to 5,000 characters of text. Entering a complete description of the RunSpec is important to help keep track of multiple MOVES runs that may be needed for a PM hot-spot analysis and to provide supporting documentation for the regulatory submission.

4.4.2 Scale

(MOVES User Guide Section 2.2.2)

The Scale menu item in MOVES allows the user to select different scales or domains for the MOVES analysis. All MOVES runs for project-level analysis must be done using the

"Project" domain in the "Scale" panel. Selecting the "Project" domain is necessary to allow MOVES to accept detailed activity input at the link level.[36]

Users should select either "Inventory" or "Emission Rates" as output depending on the air quality model being used:

- When using AERMOD, a grams/hour emission factor is needed. Users should select "Inventory", which produces results for total emissions on each link; this is equivalent to a grams/hour/link emission factor.
- When using CAL3QHCR, the "Emission Rates" option should be selected to produce link specific grams/vehicle-mile emission factors.

This guidance explains the steps of post-processing both "Inventory" and "Emission Rate" results to produce the desired emission factors in Section 4.6.

4.4.3 Time Spans

(MOVES User Guide Section 2.2.3)

The Time Spans menu item is used to define the specific time period covered in the MOVES run. The Time Spans panel is divided into five sections, which allow the user to select the time aggregation level, year, month, day, and hour included in the run.

For the project domain, the MOVES model processes one hour, of one day, of one month, of one year for each run; that is, each MOVES run represents one specific hour. The user should enter the desired time period in the MOVES Time Span panel for estimating $PM_{2.5}$ and/or PM_{10} emissions for the relevant NAAQS in a given nonattainment or maintenance area. Time aggregation should be set to "hour" which indicates no pre-aggregation. The "day" selection should be set to "weekday" or "weekend," but not both. Most users will be defining activity for a typical weekday. The year, month, and hour should be set to specifically describe each MOVES run. For instance, one run might be: 2015, January, 8:00 to 8:59 a.m. (the start and end hours set to 8:00 to 8:59 a.m., respectively). The user may choose to build a batch file to automate the process of running multiple scenarios.

4.4.4 Geographic Bounds

(MOVES User Guide Section 2.2.4)

The Geographic Bounds menu item allows the user to define the specific county that will be modeled. The MOVES database includes county codes and descriptive information for all 3,222 counties in the United States. Specifying a county in MOVES determines certain default information for the analysis. Users should select the specific county where the project is located. Only a single county (or single custom domain) can be included in a MOVES run at the project level. If a project spans multiple counties, users have three options:

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[36] Running MOVES using the "County" or "National" domains would not allow for detailed link level input or output that is needed for PM hot-spot analyses.

- If the county-specific local data is the same for all the counties, select the county in which the majority of the project area is located;
- If not, separate the project into multiple parts, each of which is in a separate county, and do a separate MOVES run for each part; or
- Use the custom domain option to model one unique area that represents all the project counties.

4.4.5 Vehicles/Equipment

(MOVES User Guide Section 2.2.5)

The Vehicles/Equipment menu item and panel is used to specify the vehicle types that are included in the MOVES run. MOVES allows the user to select from among 13 "source use types" (the terminology that MOVES uses to describe vehicle types) and four different fuels. Some fuel/source type combinations do not exist (e.g., diesel motorcycles), and therefore, are not included in the MOVES database. PM hot-spot analyses must include all vehicle types that are expected to operate in the project area. Users should select the appropriate fuel and vehicle type combinations in the On Road Vehicle Equipment panel to reflect the full range of vehicles that will operate in the project area. In general, users should simply select all vehicle and fuel types, unless data are available showing that some vehicles or fuels are not used in the project area.

4.4.6 Road Type

(MOVES User Guide Section 2.2.6)

The Road Type panel is used to define the types of roads that are included in the project. MOVES defines five different road types:

- Rural Restricted Access – a rural highway that can be accessed only by an on-ramp;
- Rural Unrestricted Access – all other rural roads (arterials, connectors, and local streets);
- Urban Restricted Access – an urban highway that can be accessed only by an on-ramp;
- Urban Unrestricted Access – all other urban roads (arterials, connectors, and local streets); and
- Off-Network – any location where the predominant activity is vehicle starts and idling (parking lots, truck stops, rest areas, freight or bus terminals).

MOVES uses these road types to determine the default drive cycle on a particular link. For example, MOVES uses drive cycles for unrestricted access road types that assume stop-and-go driving, including multiple accelerations, decelerations, and short periods of idling. For restricted access road types, MOVES uses drive cycles that include a higher fraction of cruise activity with much less time spent accelerating or idling.

For project-level analyses, the extent upon which MOVES uses these default drive cycles will depend on how much additional information the user can supply for the link. The process of choosing default or local drive cycles is described in Sections 4.2 and 4.5.7.

However, even if the user will be supplying detailed, link-specific drive cycle information or an Op-Mode distribution, road type is a necessary input in the RunSpec and users should select one or more of the five road types that correspond to the road types of the links that will be included in the project area. The determination of rural or urban road types should be based on the Highway Performance Monitoring System (HPMS) functional classification of the road type.

Additionally, any project that includes significant numbers of engine starts or significant amounts of extended idling for heavy-duty vehicles needs to include the "Off-Network" road type to properly account for emissions from that activity. More details on describing inputs to describe engine start and idling activity are given in Section 4.5.9.

4.4.7 Pollutants and Processes

(MOVES User Guide Section 2.2.7)

The Pollutant and Processes panel is used to select both the types of pollutants and the emission processes that produce them. For $PM_{2.5}$ or PM_{10} emissions, MOVES calculates emissions for several pollutant species:

- Organic Carbon (OC)
- Elemental Carbon (EC)
- Sulfate Particulate
- Brake Wear Particulate
- Tire Wear Particulate

In addition, MOVES divides emissions by pollutant process. For a PM hot-spot analysis, the categories are:

- Running Exhaust
- Start Exhaust
- Extended Idle Exhaust
- Crankcase Running Exhaust
- Crankcase Start Exhaust
- Crankcase Extended Idle Exhaust
- Brake Wear
- Tire Wear

For a $PM_{2.5}$ hot-spot analysis, the user should select "Primary Exhaust $PM_{2.5}$ - Total" (or "Primary Exhaust PM_{10} - Total" if it is a PM_{10} hot-spot analysis), which is an aggregate of each of the pollutant species (OC, EC, and sulfate) for each process. For MOVES to run, the user must also select each individual PM species (i.e., "Primary $PM_{2.5}$ - Organic Carbon," "Primary $PM_{2.5}$ - Elemental Carbon," "Primary $PM_{2.5}$ - Sulfate Particulate," or the PM_{10} equivalents). In addition, if the analysis has road links with running emissions, users must also select "Primary $PM_{2.5}$ - Brake Wear Particulate" and "Primary $PM_{2.5}$ - Tire Wear Particulate" (or their PM_{10} equivalents) as brake wear and tire wear are not included in the exhaust totals.

The user should calculate total PM from the MOVES output table results for each link using the formulas described below:

For highway links (roads, intersections, ramps, etc.) where output was specified as a grams/vehicle-mile emission factor ("Emission Rates" output), the aggregate total PM emission factor (i.e., the sum of all PM emission factors for a link) needs to be calculated using the formula:

$$PM_{aggregate\ total} = (PM_{total\ running}) + (PM_{total\ crankcase\ running}) + (brake\ wear) + (tire\ wear)$$

For transit and other terminal project activity (starts and extended idle) where output was selected as grams/hour ("Inventory" output), the aggregate total PM emission factor (i.e., the sum of all PM emission factors for a link) needs to be calculated using the formula:

$$PM_{aggregate\ total} = (PM_{total\ starts}) + (PM_{total\ crankcase\ starts}) + (PM_{total\ ext.\ idle}) + (PM_{total\ crankcase\ ext.\ idle})$$

For transit and other terminal project links that contain starts and extended idling as well as running emissions, and output was selected as "Inventory" output (grams/hour/link), the aggregate total PM emission factor for each link needs to be calculated using the formula:

$$PM_{aggregate\ total} = (PM_{total\ running}) + (PM_{total\ crankcase\ running}) + (PM_{total\ starts}) + (PM_{total\ crankcase\ starts}) + (PM_{total\ ext.\ idle}) + (PM_{total\ crankcase\ ext.\ idle}) + (brake\ wear) + (tire\ wear)$$

4.4.8 Manage Input Data Sets

(MOVES User Guide Section 2.2.8)

Most analyses will not use the Manage Input Data Sets panel. One possible application is to specify user-supplied databases to be read by the model during execution of a run. However, for project-level analysis in MOVES, the Project Data Manager, described below, serves this same function while providing for the creation of data table templates and for the review of default data. EPA specifically developed the Project Data Manager for project analyses and recommends using it to create and specify user supplied database tables, instead of the Manage Input Databases panel.

4.4.9 Strategies

(MOVES User Guide Section 2.2.9)

In MOVES, the Strategies panel can be used to model alternative control strategies that affect the composition of the vehicle fleet. The MOVES model has two alternative control strategies built into the Strategies panel:

- The Alternative Vehicle Fuels and Technologies (AVFT) strategy allows users to modify the fraction of alternative fueled vehicles and advanced technology vehicles in each model year.

- The On-Road Retrofit strategy allows the user to enter information about diesel trucks and buses that have been retrofitted with emission control equipment.

In general, most PM hot-spot analyses would not include any inputs to the Strategies panel. However, there are some exceptions. For example, a bus terminal project might include plans to mitigate emissions by retrofitting the bus fleet that will operate at that terminal with control equipment that reduces PM emissions. In that case, the user would specify the details of the retrofit project using the On-Road Retrofit strategy panel. The latest guidance on retrofit programs can be located at the EPA's conformity website: www.epa.gov/otaq/stateresources/transconf/policy.htm. Strategies that affect vehicle activity, such as implementing a truck idle reduction plan, should be handled in the Off-Network Importer and Links Importer.

See Section 10 for further information regarding the inclusion of mitigation and/or control measures in PM hot-spot analyses.

4.4.10 Output

(MOVES User Guide Section 2.2.10)

Selecting Output in the Navigation panel provides access to two additional panels: General Output and Output Emissions Detail. Each of these allows the user to specify aspects of the output data.

Under General Output, users should make sure to choose "grams" and "miles" for the output units in order to provide results for air quality modeling. Also, "Distance Travelled" and "Population" should be selected under the "Activity" heading to obtain vehicle volume information for each link in the output.

Output Emissions Detail is used to specify the level of detail desired in the output data. Emissions by hour and link are the default selections and should not be changed. Road type will also be checked if output by Emission Rate was selected. EPA recommends that users check the box labeled "Emission Process." No other boxes should be selected in order to produce fleet aggregate emission factors for each link. Emission rates for each process can be appropriately summed to calculate aggregate PM emission factors for each link (as described in Section 4.4.7).

4.4.11 Advanced Performance Features

(MOVES User Guide Section 2.2.11)

This menu item is used to invoke features of MOVES that improve run time for complex model runs by saving and reusing intermediate results. For specific applications, the user may want to "save data" for deriving the intermediate MOVES calculation of an Op-Mode Distribution from an average speed or link drive schedule. This is discussed further in the MOVES User Guide, as well as demonstrated in the quantitative PM hot-spot analysis example of a transit project in Appendix F.

4.5 ENTERING PROJECT DETAILS USING THE PROJECT DATA MANAGER

After completion of all the necessary panels to create the RunSpec, the user must then create the appropriate input database tables that describe the project in detail. As described in Section 4.3, a typical PM hot-spot analysis will involve 32 MOVES runs (build/no-build), each needing individual sets of input database tables to be created (four sets of database tables for a build scenario of a single quarter). This is done using the Project Data Manager, which can be accessed from the Pre-Processing menu item at the top of the MOVES GUI or by selecting Enter/Edit Data in the Domain Input Database section of the Geographic Bounds panel.

Since modeling a project involves many MOVES runs, good data management practices are essential to prevent confusion and errors. For example, the name of the project input database for each run should reflect the purpose of that run (e.g., "NoBuildSpringAMPeak_in"). A similar naming protocol should be used for the RunSpec for each run. Also, each tab of the Project Data Manager includes a box for entering a "Description of Imported Data." Modelers should make liberal use of these descriptions to (1) indicate whether default or local data were used, and (2) indicate the source and date of any local data, along with the filename of imported spreadsheets. These descriptions are preserved with the input database so reviewers (or future users of the same runs) will have the documentation for the inputs readily at hand.

The Project Data Manager includes multiple tabs that open importers, which are used to enter project-specific data. These tabs and importers are:

- Meteorology
- Age Distribution
- Fuel Supply
- Fuel Formulation
- Inspection and Maintenance
- Link Source Type
- Links
- Link Drive Schedule
- Operating Mode Distribution
- Off-Network

Each of the importers allows the user to create a template file with required data field names and with some key fields populated. The user then edits this template to add project-specific local data with a spreadsheet application or other tool and imports the data files into MOVES. In some importers, there is also the option to export default data from the MOVES database in order to review it. Once the user determines that the default data are accurate and applicable to the particular project, or determines that the default data need to be changed and makes those changes, the user then imports that data into MOVES. Details of the mechanics of using the data importers are provided in the MOVES User Guide. Guidance for the use of these importers in PM hot-spot analyses is described below.

4.5.1 Meteorology
(MOVES User Guide Section 2.3.3.4.1)

The Meteorology Data Importer is used to import temperature and humidity data for the month and hour that are defined in the MOVES run specification. Although temperature and humidity data can be entered for all hours, only the one hour selected in the run specification will be used for PM hot-spot analyses. In order to populate emission factor inputs for air quality models, multiple hours of the day should be run based on the guidance outlined in Section 4.3. Meteorology inputs for MOVES should be the same for build and no-build scenarios.

Users should enter data specific to the project's location and time period modeled, as PM emissions are found to vary significantly depending on temperature. The accuracy of emission estimates at the project level improves when meteorological data gathered specific to the modeled location is included. Default temperature and humidity values are available in MOVES, but are not recommended for use in a PM hot-spot analysis. Temperatures must be consistent with those used for the project's county in the regional emissions analysis (40 CFR 93.123(c)(3)) as well as the air quality modeling inputs used in the hot-spot analysis. Meteorological data may be obtained either from the National Weather Service (NWS) or as part of a site-specific measurement program. Local universities, the Federal Aviation Administration (FAA), military stations, and state and local air agencies may also be sources of such data. The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC; online at www.ncdc.noaa.gov/oa/ncdc.html) is the world's largest active archive of weather data through which years of archived data can be obtained. A data source should be selected that is representative of local meteorological conditions. Meteorological site selection is discussed further in Section 7.5.

As discussed in Section 4.3, MOVES will typically be run for multiple time periods and specific meteorology data that accurately represents these runs is needed to produce emission estimates for comparison with both the 24-hour and annual PM NAAQS. The user should employ a minimum of four hours (corresponding to AM peak traffic/PM peak traffic/MD traffic/ON traffic), one day (weekday), for January, April, July, and October. Within each period of day in each quarter, temperatures should be used that represent the average temperature within that time period. For example, for January AM peak periods corresponding to 6 a.m. to 9 a.m., the average January temperature based on the meteorological record for those hours should be used in estimating the average January AM peak period temperature for MOVES runs. The user may choose to run additional hours and temperatures beyond the number of traffic periods for which data exist. For example, within an 11-hour overnight (ON) modeling period, temperature data could be used to differentiate hours with significantly different temperatures, despite having assumed identical traffic estimates. Humidity estimates should be based on the same hours and data source as the temperature estimates. See Section 4.3 for further information on the number of MOVES runs recommended for different project analyses.

4.5.2 Age Distribution

(MOVES User Guide Section 2.3.3.4.3)

The Age Distribution Importer is used to enter data that provides distribution of vehicle fractions by age for each calendar year (yearID) and vehicle type (sourceTypeID). These data are required for running MOVES at the project level. The distribution of ageID (the variable for age) fractions must sum to one for each vehicle type and year. These inputs should generally be the same for build and no-build scenarios, unless something about the project would change them (e.g., a bus terminal project that includes the purchase of new buses in the build scenario).

To build a MOVES-compatible age distribution table, there are three possible options.

1. If available, users should use the latest state or local available age distribution assumptions from their SIP or transportation conformity regional emissions analysis. For the initial transition from MOBILE6.2 to MOVES, EPA has provided a registration distribution converter.[37] The tool allows users to input a MOBILE6.2 registration distribution table (10, 10, 5 format) and obtain a MOVES age distribution table. Over time, users should develop age distribution data consistent with the requirements of MOVES.

   Some users may have local registration distribution tables for all vehicle classes. However, there may be cases where the user has registration distributions only for one or more vehicle classes (e.g., LDVs) and therefore relies on MOBILE6.2 defaults for the remaining vehicle classes. In these cases, the user may use MOVES default distributions available on the EPA's website.

2. If the project is designed to serve a fleet that operates only locally, such as a drayage yard or bus terminal, the user should provide project-specific fleet age distribution data. For most captive fleets, an exact age distribution should be readily available or obtainable. The data should be in a format compatible with MOVES. This format includes age fractions in 30-year bins rather than the 25 used in MOBILE6.2. Additionally, vehicle categories need to be in terms of the 13 MOVES source types.

3. Default distributions are available on the EPA website at: www.epa.gov/otaq/models/moves/tools.htm. The user can select the analysis year(s) and find the corresponding age distribution. These fractions are national defaults and could be significantly different than the local project age distribution. Age distribution can have a considerable impact on emission estimates, so the default data should be used only if an alternative local dataset cannot be obtained and the regional conformity analysis relies on national defaults.

[37] This convertor can be found online at: www.epa.gov/otaq/models/moves/tools.htm**.**

If the user has relied in the past on the MOBILE6.2 default registration distribution, they should now use the MOVES default age distribution if no other state or local age distribution is available. This can be obtained from the tables available on the EPA website given above.

4.5.3 Fuel Supply and Fuel Formulation

(MOVES User Guide Section 2.3.3.4.8 and 2.3.3.4.9)

The user must define in MOVES what fuel(s) and fuel mix will be used in the project area. The Fuel Supply Importer and Fuel Formulation Importer are used to enter the necessary information describing fuel type and fuel mix for each respective MOVES run. These inputs should generally be the same for build and no-build scenarios, unless something about the project would change them (e.g., a project that includes alternative fuel vehicles and infrastructure in the build scenario).

In general, users should first review the default fuel formulation and fuel supply data in MOVES, and then make changes only where local volumetric fuel property information is available. The lone exception to this convention is in the case of Reid Vapor Pressure (RVP) where a user should potentially change the value to reflect the differences between ethanol and non-ethanol blended gasoline.

For additional guidance on defining fuel supply and formulation information, consult the EPA document, "Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity" located at: www.epa.gov/otaq/stateresources/transconf/policy.htm.

4.5.4 Inspection and Maintenance (I/M)

(MOVES User Guide Section 2.3.3.4.10)

MOVES does not provide a PM emission benefit from an I/M program. If the user includes an I/M program in the run specification, the selection will have no impact on PM emissions.

4.5.5 Link Source Type

(MOVES User Guide Section 2.3.3.4.13)

The Link Source Type Importer allows the user to enter the fraction of the link traffic volume which is represented by each vehicle type (source type). It is not required if the project contains only a transit or other terminal (off-network) link. For each LinkID, the SourceTypeHourFractions must sum to one across all source types.

Additionally, the user must ensure that the source types selected in the MOVES Vehicles/Equipment panel match the source types defined in the Link Source Type Importer.

There are no defaults that can be exported from the Link Source Type Importer. For any analysis at the project level, the user must provide source type fractions for all vehicles being modeled and for each MOVES run (as vehicle mixes may change from hour to hour and month to month). There are two options available to populate the Link Source Type input:

1. For projects that will have an entirely different source type distribution than that of the regional fleet, the preferred option is for the user to collect project-specific data. For projects such as bus or freight terminals or maintenance facilities that contain links that are primarily used by a specific subset of the regional fleet, users must develop the fractions of link traffic volume by vehicle type data specific to the type of project. This could be based on analysis of similar existing projects through the interagency consultation process.

2. If the project traffic data suggests that the source type distribution for the project can be represented by the distribution of the regional fleet for a given road type, the user can provide a source type distribution consistent with the road type used in the latest regional emissions analysis. For example, highways tend to have a higher fraction of truck traffic than arterial roads. Therefore, the highway source type distribution used in the regional emissions analysis may be appropriate to use for a highway project.

4.5.6 Links

(MOVES User Guide Section 2.3.3.4.12)

The Links Importer is used to define the individual roadway links. All links being modeled should have unique IDs. The Links Importer requires information on each link's length (in miles), traffic volume (units of vehicles per hour), average speed, and road grade (percent). Users should follow guidance given above in Section 4.2 when determining the number of links and the length of specific links. Consult Section 7 for information on how these links should be formatted for inputs into an air quality model.

4.5.7 Describing Vehicle Activity

(MOVES User Guide Section 2.3.3.4.14 through Section 2.3.3.4.16)

MOVES determines vehicle emissions based on operating modes, which are different types of vehicle activity such as acceleration (at different rates), deceleration, idle, and cruise that have distinct emission rates. MOVES handles these data in the form of a distribution of the time vehicles spend in different operating modes. This capability is central to the use of MOVES for PM hot-spot analyses because it allows for the analysis of fine distinctions between vehicle behavior and emissions before and after construction of the project. For example, the full emission benefits of a project designed to smooth traffic flow can best be realized by taking into account the changes in acceleration, deceleration, and idle activity that result from the project. This guidance suggests several methods that users may employ to calculate an Op-Mode distribution based on the project design and available traffic information. MOVES currently offers three options that the user can employ to add link activity data, depending on data availability. These are:

1. <u>Provide average speed and road type through the Links input</u>:
   Using this approach, MOVES will generate an operating mode distribution and calculate emissions based on a default drive cycle for a given speed, grade, and road type. Input of link drive schedules or operating mode distributions is not needed. For users modeling a free-flow link with only basic information on average speed and volume on a link, this option may be appropriate. This approach does account for some differences in emissions due to changes in operating modes associated with different average speeds on a specific road type. However, this approach provides the least resolution when analyzing the emission impact of a project because the default drive cycles used by the model may not accurately reflect the specific project. For instance, due to the range of operating modes associated with intersection projects, a single average speed would not spatially capture localized idling and acceleration emissions.

2. <u>Provide a link drive schedule using the Link Drive Schedule Importer</u>:
   The Link Drive Schedule Importer allows the user to define the precise speed and grade as a function of time (seconds) on a particular roadway link. The time domain is entered in units of seconds, the speed variable is miles-per-hour and the grade variable in percent grade (vertical distance/lateral distance, 100% grade equals a 45-degree slope). MOVES builds an Operating Mode Distribution from the Link Drive Schedule and uses it to calculate link running emissions.

   Individual Link Drive Schedules cannot be entered for separate source types. The Link Drive Schedule therefore represents the "tracer" path of an average vehicle on each link. Link drive schedules could be based on observations using methods such as chase (floating) cars on similar types of links, or for some links, on expected vehicle activity based an analysis of link geometry. Link drive schedules will only represent average vehicle activity, not the full range of activity that will occur on the link. As described in Section 4.2, users can overcome this limitation by defining multiple links (links that "overlap") with separate source distributions and drive schedules to model individual vehicles.

3. <u>Provide a detailed operating mode distribution for the link:</u>
   The Operating Mode Distribution Importer allows the user to directly import operating mode fraction data for source types, hour/day combinations, roadway links, and pollutant/process combinations that are included in the run specification. Operating mode distributions may be obtained from:
   - Op-Mode distribution data from other locations with similar geometric and operational (traffic) characteristics;[38] or

[38] For example, chase (or floating) cars, traffic cameras, and radar guns have been used previously to collect some traffic data for use in intelligent transportation systems and other applications. EPA encourages the development of validated methods for collecting verifiable vehicle operating mode distribution data at specific locations representative of different projects covered by this guidance.

- Output from traffic simulation models.[39]

4.5.8 Deciding on an approach for activity

Users should consider the discussion in Section 4.2 when deciding on the appropriate activity input. The MOVES model is capable of using very complex and highly resolved activity datasets to calculate link level emissions. EPA encourages the development of validated methods for collecting verifiable vehicle Op-Mode distribution data at locations and in traffic conditions representative of different projects covered by this guidance. However, the user should determine the most robust activity dataset that can be reasonably collected while still achieving the goal of determining an accurate assessment of the PM air quality impacts from a given project. The decision to populate the Links table, Link Drive Schedule, or Op-Mode Distribution should be based on the data available to the user and should reflect the vehicle activity and behavior on each link.

4.5.9 Off-Network

(MOVES User Guide Section 2.3.3.4.16)

The Off-Network Importer is where the user can provide information about vehicles not driving on the project links, but still contributing to the project's emissions. Currently, only one Off-Network link may be described per run. If more than one off-network link is associated with the project, another set of 16 (or 32) MOVES runs would be required to characterize each additional off-network location. The Off-Network Importer is required if the project includes an area where highway vehicles are parked, starting their engines, or in extended idling mode (such as at a truck stop, parking lot, or passenger or freight intermodal terminal). All such areas within the project area should be modeled, regardless of whether they are part of the project.

The Off-Network table must be populated by the user with information describing vehicle activity in the off-network area being modeled. The required fields are vehicle population, start fraction, and extended idle fraction. The population should reflect the total number of vehicles parked, idling, entering, and exiting the off-network area over the course of the given hour. The start fraction is the fraction of the total vehicle population that starts during the hour.

The extended idle fraction specifies the fraction of time that the vehicle population spends in extended idle operation in the given hour. Extended idle operation applies only to long-haul combination trucks and is defined as any idling that lasts longer than 15 minutes. As discussed in Section 4.2.2, shorter periods of idling for long-haul combination trucks and all idling for other vehicles should be modeled as a project link

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[39] A traffic micro-simulation model to construct link drive schedules or operating mode distributions can be used if prior validation of the model's predictions of speed and acceleration patterns for roadway links similar to those in the project was conducted. If a user has a micro-simulation model that has been previously demonstrated to adequately predict speed/acceleration patterns for relevant vehicle classes (e.g., heavy-duty), and has a procedure for importing data into MOVES, it may be appropriate to use the micro-simulation model, subject to interagency consultation.

with an Op-Mode distribution that consists only of idle operation (Op-Mode 1). This can be specified in the Links table by inputting the vehicle population and specifying an average speed of "0" mph.

There are no default values available for any of the Off-Network inputs, so users will need to input the data as described above. For a transit or other terminal project, the user will need to estimate vehicle population, starts, and idle operation of the facility. For example, in a bus terminal project, the user would need to estimate the bus population, starts, and idling based on expected passenger ridership and proposed operating schedules for the buses using the terminal.

If an Off-Network link is defined, users must also define an Op-Mode distribution that describes the soak-time distribution of vehicles on the link; this will affect the start emissions. Additionally, any extended idle operation on an Off-Network link must be described by the Op-Mode distribution with a fraction of 1.0 for Op-Mode 200 (Extended Idle Mode). Since there is only one possible extended idle mode in MOVES, this fraction should always be 1.0.

4.6 GENERATING EMISSION FACTORS FOR USE IN AIR QUALITY MODELING

The MOVES model outputs emissions as either an emission total (if "Inventory" output is selected) or an emission factor (if "Emission Rates" output is selected). The emission results are output for each pollutant and process and are calculated in terms of grams per link or grams/vehicle-mile per link. Using the equations given in Section 4.4.7, the user will need to sum the appropriate pollutants and processes to derive a link total grams/vehicle-mile or grams/hour emission factor. These totals will be needed as inputs into the appropriate air quality model. Instructions on running AERMOD and CAL3QHCR for quantitative PM hot-spot analyses are given in Section 7.

Note: If MOVES is being run in batch-mode, or if multiple runs are being saved to the same output database, the user should make sure to separate link emissions in the result database by "runID" or "monthID, dayID, hourID." Aggregating separate runs will result in incorrect emission rates.

4.6.1 Highway and intersection links

For links characterized as "highway" or "running" segments of a project, a grams/vehicle-mile emission rate is needed for CAL3QHCR; if AERMOD is being used, a grams/hour emission factor for each roadway link is needed.

- CAL3QHCR uses grams/vehicle-mile emission factors and calculates air quality estimates based on the volume of traffic and length of a given link. All of the information necessary to generate the necessary inputs is available in the MOVES MySQL output database. After running MOVES for a particular hour/day/month scenario, emission results can be located in the user defined MOVES output database in the table "rateperdistance." All links defined in the Project Level Importer will have results in the column "rateperdistance." The units should have been defined as grams and miles in the MOVES RunSpec (see Section 4.4.10). As shown in the equations in Section 4.4.7, all relevant pollutants and processes should be summed together to get a single "rateperdistance" value. This value can then be paired with link volume and link length for use in CAL3QHCR for each link.

- AERMOD requires a grams/hour emission factor for each hour of the day (which should be mapped based on the time periods analyzed with MOVES). If "Inventory" is selected in the Scale panel, MOVES will produce output in terms of grams/hour/link. The user should then calculate aggregate PM grams/hour emission factors by summing the appropriate pollutants and processes as described in Section 4.4.7. Since AERMOD processes emission factors in terms of grams/hour (or second), no further calculation is necessary. Section 7 discusses input formats for different AERMOD source configurations.

4.6.2 Transit and other terminal links

For transit and other terminal projects, or a combination of highway and transit or other terminal components, AERMOD is recommended (see Section 7). AERMOD requires a grams/hour emission factor for each hour of the day (which should be mapped based on the time periods analyzed with MOVES). If "Inventory" is selected in the Scale panel, MOVES will produce output in terms of grams/hour/link. The user should then calculate aggregate PM grams/hour emission factors by summing the appropriate pollutants and processes as described in Section 4.4.7. Since AERMOD processes emission factors in terms of grams/hour (or second), no further calculation is necessary. Section 7 discusses input formats for different AERMOD source configurations.

Note: If a link is defined with an average speed of 0, or all activity in idle mode (Op-ModeID 1), MOVES will output emissions for running processes as well as brake wear and tire wear. In this case, since idling vehicles do not produce any brake wear and tire wear emissions, only running emissions should be considered and the user should disregard the brake wear and tire wear emissions.

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Section 5: Estimating Project-Level PM Emissions Using EMFAC (in California)

5.1 INTRODUCTION

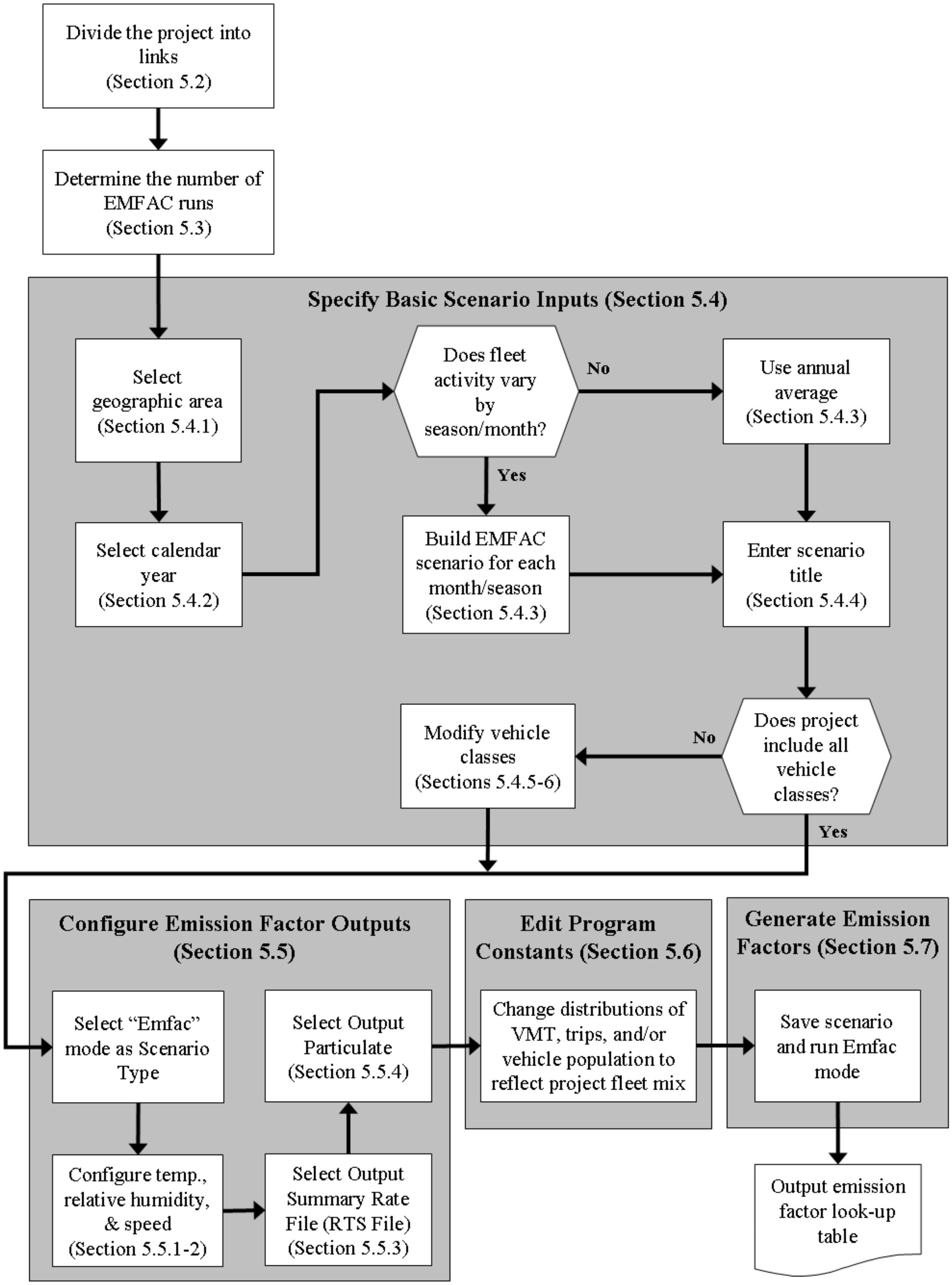
This section of the guidance addresses the necessary steps to run EMFAC to estimate a project's exhaust, brake wear, and tire wear emissions for PM hot-spot analyses in California. The California Air Resources Board (ARB) maintains the EMission FACtors (EMFAC) model which is approved by EPA for developing on-road motor vehicle emission inventories and conformity analyses in California.[40] EMFAC models on-road mobile source emissions under multiple temporal and spatial scales; it produces composite emission factors for an average day of a month (January to December), a season (summer and winter), or an annual average, for specific California geographic areas by air basin, district, and county as well as the statewide level. EMFAC produces $PM_{2.5}$ and PM_{10} emission rates for three exhaust emission processes (running, starting, and idle), tire wear, and brake wear.

To complete an EMFAC-based PM hot-spot analysis, users need to determine the scope and resolution of traffic activity data, specify basic scenario data inputs, choose the desired outputs of the EMFAC model, gather project-specific traffic data and fleet data, and run EMFAC through the "EMFAC Area Fleet Average Emissions Output Mode" (Emfac mode) to produce a look-up table of average emission factors for the planning area and/or county where the project is located. Outside of the model, the relevant emission factors can be combined with project-specific activity data to calculate total link level emission factors. The emission factors can then be used in air quality modeling as discussed in Section 7 of the guidance. The steps to using EMFAC are illustrated in Exhibit 5-1 (following page).

As discussed in Section 2.4, project sponsors should conduct emissions and air quality modeling for the project build scenario first. If this scenario does not exceed the NAAQS, then it is unnecessary to model the no-build scenario. Following this approach will allow users to avoid additional emissions and air quality modeling. Finally, Section 5 describes how to use EMFAC to estimate emissions from a highway and transit project that requires a PM hot-spot analysis ("the project"); this section could also be used to estimate emissions for any other highway and transit facilities in the project area, when necessary.

[40] The current version of the EMFAC model (EMFAC2007), future model versions, and supporting documentation can be downloaded from the ARB website at: www.arb.ca.gov/msei/onroad/latest_version.htm.

Exhibit 5-1. Steps for Using EMFAC in a Quantitative PM Hot-spot Analysis



Note: The steps in this exhibit and in the accompanying text describe how to use EMFAC to complete a scenario run using the model's "Emfac" mode for a PM hot-spot analysis.

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This section presumes users already have a basic understanding of how to run EMFAC. Please note that there are some aspects of Section 5 that differ from the MOVES guidance discussed in Section 4, due to the inherent differences between MOVES and EMFAC. For example, unlike MOVES, EMFAC emission rates do not vary by temperature. EMFAC users do not need to account for variations in temperature over the course of the day or year, and therefore will complete fewer model runs. Additionally, EMFAC generates an emission factor look-up table for a range of average speeds. MOVES calculates emission factors based on a distribution of operating modes, which allows the option of more advanced methods of defining link-level activity.[41]

5.2 CHARACTERIZING A PROJECT IN TERMS OF LINKS

Prior to using EMFAC, users need to first identify the project type and the associated emission processes (running, start, and idle exhaust) to be modeled. This guidance distinguishes between two types of transportation projects: (1) highway and intersection projects, and (2) transit or other terminal projects:

- For highway and intersection projects, running exhaust, brake wear, and tire wear emissions are the main focus.
- For transit and other terminal projects, modeling start and idle emissions is also typically needed, and in some cases these projects will also need to address cruise, approach and departure running exhaust emissions on affected links.

The goal of defining a project's links is to best capture emissions where they occur. From link-specific activity and other inputs, EMFAC calculates emissions from each link.

5.2.1 Highway and intersection projects

General

A PM hot-spot analysis fundamentally depends on the availability of accurate data on roadway link speed and traffic volumes for build and no-build scenarios.[42] Thus, local traffic data should be used to characterize each link sufficiently. Generally, the links specified for a highway project should include road segments with similar traffic conditions and characteristics. It is recommended that the user divide a project into separate links to allow sufficient resolution at different vehicle traffic and activity

[41] If future versions of EMFAC include PM emission rates that differ by temperature, EPA would work with ARB to develop additional EMFAC guidance as needed so that users could adequately capture hourly and seasonal temperature variability in PM hot-spot analyses.

[42] Project sponsors should document available traffic data sets, their sources, key assumptions, and the methods used to develop build and no-build scenario inputs for EMFAC. Documentation should include differences between how build and no-build traffic projections are obtained. For projects of local air quality concern, there will always be differences in traffic volumes and other activity changes between the build and no-build scenarios, and these differences must be accounted for in the data that is used in the PM hot-spot analysis.

patterns; characterizing this variability in emissions within the project area will assist in air quality modeling (see Section 7).

For analyses with EMFAC, an average speed and traffic volume is required for each link. Unlike MOVES, the current version of EMFAC does not allow a user to account for more detailed data to describe the pattern of changes in vehicle activity (proportion of time in acceleration, deceleration, cruise, and idle activity) over the length of a road. The simplest example is a single, one directional, four-lane highway that could be characterized as one link with one average speed. If the project analysis involves intersections, the intersections need to be treated separately from the free-flow links that connect to those intersections. Although road segments between intersections may experience free-flow traffic operations, the approaches and departures from the intersections will involve acceleration, deceleration, and idling activity not present on the free-flow link. For intersection modeling, the definition of link length will depend on the geometry of the intersection, how that geometry affects vehicle activity, and the level of detail of available activity information.

When using EMFAC, project sponsors can use average speeds for highway and intersection links 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 red signal cycle on travel time includes deceleration delay, move-up time in a queue, stopped delay, and acceleration delay. 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 another link to reflect the higher emissions associated with vehicle acceleration through lower speeds affected by acceleration delay. A variety of methods are available to estimate average speed. Project sponsors should determine congested speeds by using appropriate methods based on best practices used for highway analysis.[43] Some resources are available through FHWA's Travel Model Improvement Program (TMIP).[44] Methodologies for computing intersection control delay are provided in the "Highway Capacity Manual 2000."[45]

5.2.2 Transit and other terminal projects

For transit and other terminal projects such as a bus terminal or intermodal freight terminal, the user should have information on starts per hour and number of vehicles idling during each hour. This activity will likely vary from hour to hour. It is recommended that the user divide such a project into separate links to appropriately characterize variability in emission density within the project area (as discussed in

[43] As discussed in Section 7, the use of the CAL3QHCR queuing algorithm for intersection idle queues is not recommended. Rather, idling vehicles should be represented in combination with decelerating, accelerating, and free-flow traffic on an approach segment of an intersection.

[44] See FHWA's Travel Model Improvement Program website: http://tmip.fhwa.dot.gov/.

[45] 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 2000," which can be obtained from the Transportation Research Board (see http://144.171.11.107/Main/Public/Blurbs/152169.aspx for details).

Section 7). In this case, each "link" describes an area with a certain number of vehicle starts per hour, or a certain number of vehicles idling during each hour.

Generally, users need to account for the number of vehicle starts and the amount (in hours) of idle activity. Grams/trip rates can be calculated for start exhaust emissions. Additionally, grams/idle-hour (grams/hour) emission rates can be calculated for both regular idle and extended idle exhaust emissions, but only for heavy-duty vehicles. Users need to have data on the number of vehicle starts per hour and number of heavy-duty diesel vehicles idling during each hour to get the total project or project area emission factor.

In addition, some transit and other terminal projects may have significant running emissions similar to free-flow highway projects (such as buses and trucks coming to and from an intermodal terminal). These emissions can be calculated by defining one or more unique running links as described in Section 5.2.1 (that is, in addition to any other roadway links associated with the project). These running link emissions can then be aggregated with the emissions from starts and idling from non-running activity on the transit or other terminal link to generate the necessary air quality model inputs.

5.3 DETERMINING THE NUMBER OF EMFAC RUNS

5.3.1 General

Before running EMFAC to calculate emission factors, users should first determine the number of unique scenarios that can sufficiently describe activity variation in a project. In most projects, traffic volume, average speed, idling, fleet mix, and the corresponding emission factors will likely vary from hour to hour, day to day, and month to month. However, it is unlikely that data are readily available to capture such finite changes. Project sponsors may have activity data collected at a range of possible temporal resolutions. The conformity rule requires the latest activity data available at the time of the analysis to be used in a quantitative hot-spot analysis (40 CFR 93.110).[46] Depending on the sophistication of the activity data analysis for a given project, these data may range from a daily average-hour and peak-hour value to hourly estimates for all days of the year. EPA encourages the development of sufficient travel activity data to capture the expected ranges of traffic conditions for the build and no-build scenarios.

5.3.2 For projects with typical travel activity data

Traffic forecasts for highway and intersection projects are often completed for annual average daily traffic volumes, with an allocation factor for a daily peak-hour volume. This data can be used to conduct an analysis with EMFAC that is representative for all hours of the year. The most reasonable methods in accordance with good practice should

[46] See "EPA and DOT Joint Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations," EPA420-B-08-901 (December 2008); available online at: www.epa.gov/otaq/stateresources/transconf/policy/420b08901.pdf.

be used to obtain the allocation factors and diurnal distribution of traffic and the methods must be decided in accordance with interagency consultation procedures (40 CFR 93.105(c)(1)(i)).

One option is to use average-hour and peak-hour traffic volumes to represent traffic over four time periods: morning peak (AM), midday (MD), evening peak (PM), and overnight (ON). The peak-hour volume can be used to represent activity conditions over a three-hour morning (AM) and three-hour evening period (PM). The remaining 18 hours of the day can be represented by the average-hour volume. These 18 hours would be divided into a midday and overnight scenario.

The following is one suggested approach for an analysis employing the average-hour/peak-hour traffic scenario based on an examination of national-scale data:

- Morning peak (AM) emissions based on traffic data occurring between 6 a.m. and 9 a.m.;
- Midday (MD) emissions based on data from 9 a.m. to 4 p.m.;
- Evening peak (PM) emissions based on data from 4 p.m. to 7 p.m.; and
- Overnight (ON) emissions based on data from 7 p.m. to 6 a.m.

If there are local or project-specific data to suggest that the AM or PM peak traffic periods will occur in different hours than the default values suggested here, or over a longer or shorter period of time, that information should be documented and the hours representing each time period adjusted accordingly. Additionally, users should independently determine peak periods for the build and no-build scenarios, and should not assume that each scenario is identical, as determined through the interagency consultation process.

If the fleet mix does not vary between the peak-hour and average-hour, then only one EMFAC run is necessary. If there is a difference in fleet mix, two separate runs are necessary.

5.3.3 For projects with additional travel activity data

Some project sponsors may have developed traffic or other activity data to show variations in volume and speed across hours, days, or months. Additionally, if users are modeling a transit or other terminal project, traffic volumes, starts, and idling estimates are likely to be readily available for each hour of the day. Under either of these circumstances, users have the option of applying the methodology described above (using average-hour and peak-hour as representative for all hours of the year) if it is determined through the interagency consultation process that using the additional data would not significantly impact the emissions modeling results. Alternatively, additional EMFAC scenarios could be generated to produce a unique emission factor for each activity scenario (i.e., each period of time for which specific activity data are available).

5.4 DEVELOPING BASIC SCENARIO INPUTS

To generate emission factors in EMFAC for PM hot-spot analyses, users need to first enter a series of basic inputs to the user interface of the EMFAC model. Exhibit 5-2 presents a summary of all basic inputs needed to complete an EMFAC scenario run ("scenario"). The EMFAC defaults can be used directly for most basic input categories; however, some inputs need to be modified to reflect project-specific information.

5.4.1 Geographic area and calculation method

Users should enter into EMFAC the geographic area where the project is located. EMFAC offers four geographic scales and each corresponds to specific defaults for fleet characteristics. The "Area Type" category includes State, Air Basin, District, and County. For PM hot-spot analyses, users will typically select the County area type. When "County" is selected, a list of all the counties in California will be available. Users should select the county where the project is located.

If the selected county is part of only one air basin, users can continue to the next step to specify calendar years. However, if the selected county is within multiple air basins, EMFAC will show two options, "By Sub-Area" and "Use Average," as calculation methods. Users should select "By Sub-Area" to generate EMFAC emission factors in look-up tables for all sub-areas within the selected county.

Exhibit 5-2. Summary of EMFAC Inputs Needed to Evaluate a Project Scenario

Step	EMFAC Basic Input Category	EMFAC Basic Input Data	Modification Needed?
1	Geographic Area	State	Yes
		Air Basin	
		District	
		County	
	Calculation Method	By Sub-Area	Yes
		Use Average	
2	Calendar Year	Calendar Year	Yes
3	Season or Month	Month	Yes
		Season	
		Annual	
4	Scenario Title	Default	Optional
		Modify	
5	Model Years	All	No
		Modify	
6	Vehicle Classes	All	Optional*
		Modify	
7	I/M Program Schedule and Other State Control Measures	Default	No (for I/M); Varies for Other Measures
		Modify	

* If a project uses a subset of the default fleet, users should delete unwanted vehicle classes through the "Vehicle Classes" user interface.

For instance, Los Angeles County is located in both the Mojave Desert Air Basin and the South Coast Air Basin. If the project is located only in the Port of Los Angeles and "Los Angeles County" with "By Sub-Area" is selected in EMFAC runs, EMFAC will provide emission data for both the Mojave Desert Air Basin and the South Coast Air Basin. Only the look-up tables for the South Coast Air Basin would be used because this is where the port is located; the Mojave Desert Air Basin data would be ignored.

5.4.2 Calendar year

EMFAC is able to analyze calendar years from 1970 to 2040 and allows emission calculations for multiple calendar years in a single run. Users should select one or more calendar years in EMFAC based on the project scenarios to be analyzed. If an analysis year beyond 2040 is needed, select 2040 to represent that year.

5.4.3 Season or month

EMFAC can estimate emission factors for each month, two seasons (winter and summer), or an annual average. Although vehicle miles traveled (VMT) and speed is handled external to the model, the vehicle mix may vary by hour and season and these scenarios should be modeled explicitly. As discussed in Section 5.3, users should run EMFAC for the appropriate number of scenarios based on the availability of travel activity data. Users with typical travel activity data may run one or two scenarios (depending whether vehicle mix varies between the peak-hour and average-hour) and will select "annual average" in the "Season or Month" selection panel. Users with additional data that shows variation in fleet mix across seasons or months should select the appropriate month or season for each run.

5.4.4 Scenario title

EMFAC generates a default scenario title that includes the name of the county, calculation method, season or month, and calendar year. A replacement scenario title can be specified, if desired.

5.4.5 Model years

EMFAC includes vehicle model years from 1965 to 2040 and default assumptions about mileage accumulation that vary by model year. EMFAC will generate emission factors for 45 model years (ages 1 through 45) for the build and no-build scenarios for each analysis year. Users can change the range of model years to be included in an EMFAC run through the model interface. If a project involves a specialized and simple fleet (e.g., buses operating in a bus terminal) for which the range of model years is well known or reliably estimated, users may consider including only those model years and exclude unrelated vehicle types in an EMFAC run.

However, under most circumstances, projects that involve multiple vehicle types and model years will require EMFAC defaults to be used for PM hot-spot analyses. The two reasons for this recommendation are: (1) most projects will not affect the age distribution of the vehicles operating at the project site, and (2) changing EMFAC defaults to reflect specific fleet age distributions is complicated for projects that involve multiple vehicle types and model years. These changes require a level of familiarity with EMFAC that many users may not have or need for most hot-spot analyses. Therefore, if users anticipate that it will be necessary to adjust the age distribution of their vehicle fleet, they should consult with ARB for further guidance.

5.4.6 Vehicle classes

All 13 default vehicle classes should be selected for most projects. The exception would be a project or link that involves a specialized fleet of limited vehicle types (e.g., a bus terminal). The EMFAC model assumes vehicle population and travel activity distributions by vehicle class, depending on the geographic area and analysis year selected. Editing the default distribution of vehicle classes will be discussed in Section 5.5. If only one vehicle type is selected (e.g., HHDTs), all emission information in the EMFAC output will be calculated for that one vehicle type.

5.4.7 I/M program schedule and other state control measures

When a particular county from the Geographic Area panel is selected in EMFAC, the model assumes a default I/M program. Although EMFAC allows edits for each I/M program, users should not alter the default settings and parameters associated with I/M programs and their coverage. If I/M program modifications are considered, users should consult with the local air district or ARB for specific guidance. Currently, no PM emission benefit for I/M programs exists in EMFAC2007.

The PM emission reductions from any additional state PM emission control measure should be applied outside of the EMFAC model and be consistent with current implementation of measures and how reductions are calculated for SIP and other air quality planning purposes. For instance, EMFAC2007 currently does not have the capability of modeling diesel engine retrofits. It is recommended that manufacturer specification data be used for calculating emission factors from engines equipped with such devices, consistent with EPA's and ARB's retrofit guidance and methods used to calculate reductions for the SIP. The interagency consultation process should be used to discuss any issues regarding the inclusion of state control measures in PM hot-spot analyses.[47]

[47] For information about quantifying the benefits of retrofitting diesel vehicles and engines to conformity determinations, see EPA's website for the most recent guidance on this topic: www.epa.gov/otaq/stateresources/transconf/policy.htm. Also, see ARB's website at: www.arb.ca.gov/msprog/onrdiesel/calculators.htm.

5.5 CONFIGURING EMISSION FACTOR OUTPUTS

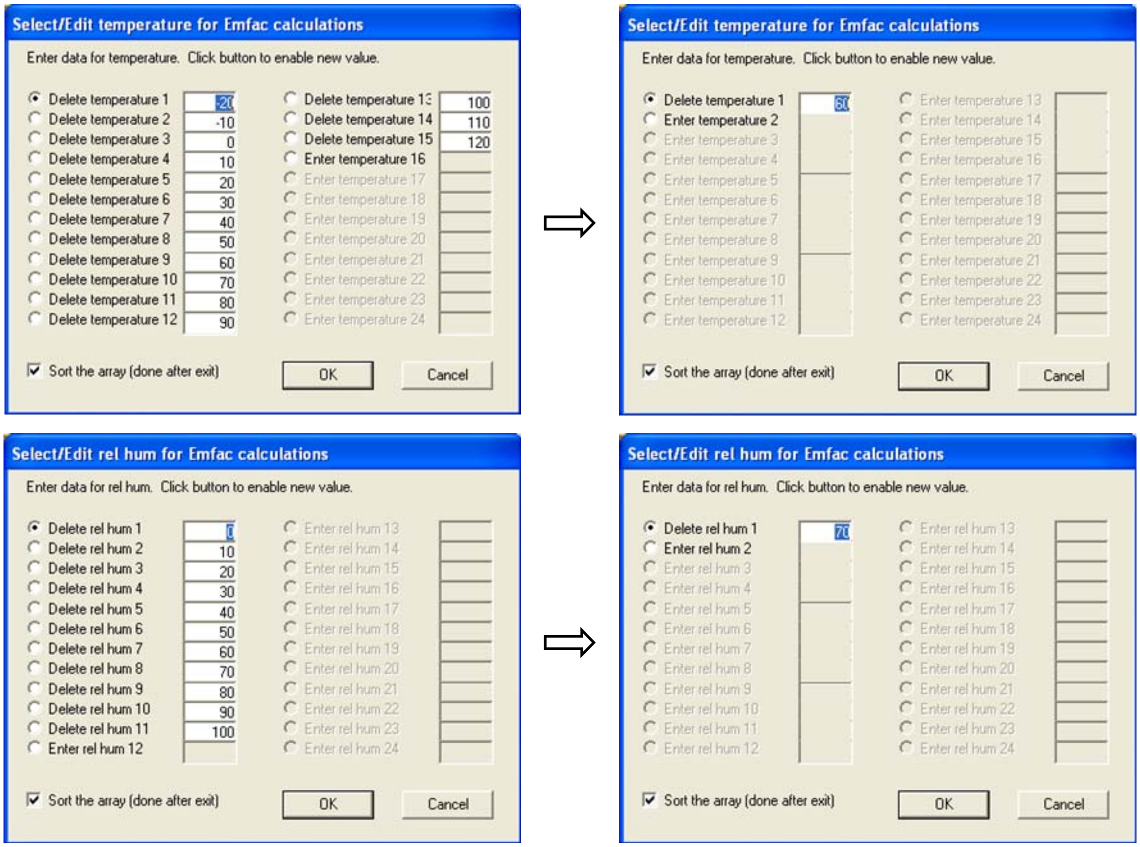
Users must configure how the model will output emission factor information based on the inputs provided in the previous steps. The discussion that follows walks users through these configuration steps in the same order in which users will encounter these options when running EMFAC.

EMFAC includes three scenario types or modeling modes: Burden, Emfac, and Calimfac. For PM hot-spot analyses, users should select the "Emfac" mode, which generates area-specific fleet average emission factors for running exhaust, brake wear, tire wear, starting, and idling emissions.

5.5.1 Temperature and relative humidity

The default settings in the Emfac mode include 15 temperature bins (-20F to 120F) and 11 relative humidity bins (0% to 100% RH) to generate average emission factors. However, because EMFAC PM emission rates are insensitive to changes in temperature and humidity, generating emission factors for all default temperature/relative humidity combinations throughout an analysis year is not necessary. As shown in Exhibit 5-3 (following page), users need to remove the default temperature/relative humidity settings and input only one value (e.g., 60F, 70% RH) for temperature and relative humidity, respectively, to perform an Emfac mode run. Selecting one combination of temperature/relative humidity will reduce computer run time and produce PM emission factor look-up tables that can be easily used. Temperatures must be consistent with those used for the project county's regional emissions analysis (40 CFR 93.123(c)(3)) as well as the air quality modeling inputs used in the hot-spot analysis. See Section 7.5 for more information on selecting representative meteorology data.

Exhibit 5-3. Changing EMFAC Default Settings for Temperature and Relative Humidity



5.5.2 Speed

The Emfac mode allows users to input up to 24 speed values to populate average emission factors. The default setting specifies speed bins for 0 mph through 65 mph in 5 mph increments. Emission factors associated with the 0 mph speed bin can be applied for idle emissions (essentially for heavy-duty trucks only; EMFAC idle emission factors are unavailable for most other vehicle classes).[48] Emission factors for intermediate speeds can also be generated if specific speed values are input into the EMFAC model.

Users have several options to calculate appropriate speed-dependent emission factors for a project. For instance, if a highway link in a build scenario is known to have an average speed of 32 mph, it can be directly input into the speed list of EMFAC to produce the associated PM emission factors. Alternatively, if the EMFAC default settings are used to generate a look-up table for different speed bins, users can either select the emission

[48] Among the 13 vehicle classes in EMFAC, idle emission factors are available only for LHDT1 and LHDT2 (included in the MDT vehicle group in the output .rts file) and MHDT, HHDT, School Buses, and Other Buses (included in the HDT vehicle group in the output .rts file); see Exhibit 5-6 for further information.

factors associated with the closest speed bin (30 mph bin, representing speeds of 27.5 mph to 32.5 mph), or interpolate between the emission factors for speed bins of 30 mph and 35 mph.

Users should include 0 mph in an EMFAC run unless the project to be evaluated does not involve idle emissions. For specific cases for which the average link speed is less than 5 mph, users can either select the emission factors from the 5 mph speed bin, or extrapolate down to the desired speed by using the emission factors from the speed bins for 5 mph and 10 mph to create a trend line to lower speeds.

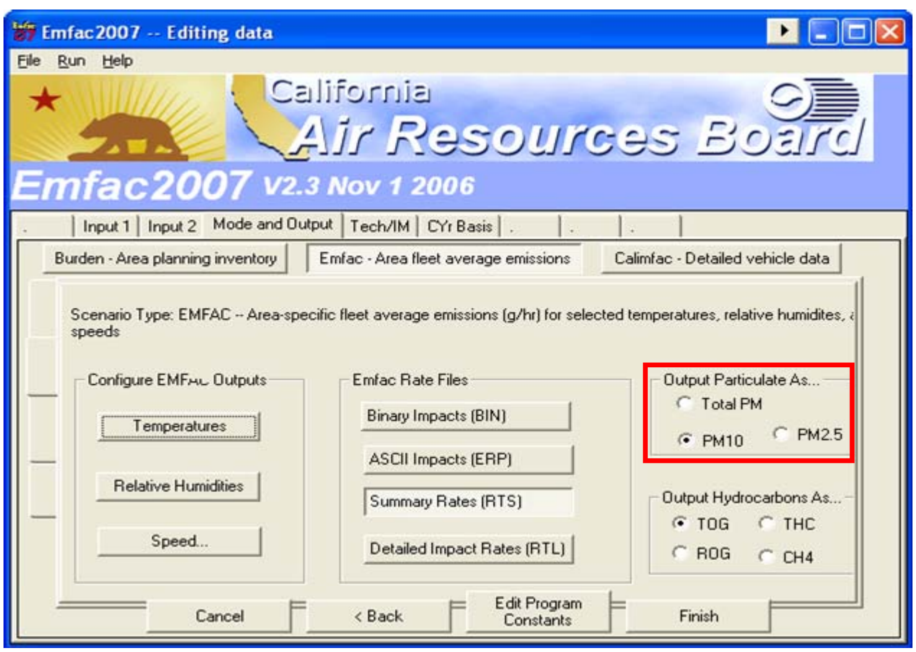
5.5.3 Output rate file

The Emfac mode can provide emission information in four output formats with different levels of detail. Users should select "Summary Rates (RTS)." The Summary Rates format generates average emission factors by speed for six vehicle groups (aggregated from the 13 vehicle classes modeled in EMFAC) and an overall average emission factor for the entire vehicle fleet. The overall average emission factors are appropriate for use in air quality dispersion modeling.

5.5.4 Output particulate

As shown in Exhibit 5-4, users have to select either PM_{10} or $PM_{2.5}$ in an Emfac mode run to obtain particulate emission factors. EMFAC must be run twice to obtain both PM_{10} and $PM_{2.5}$ data for those projects that are located in both PM_{10} and $PM_{2.5}$ nonattainment/maintenance areas.

Exhibit 5-4. Selecting Pollutant Types in EMFAC for PM_{10} and $PM_{2.5}$



5.6 EDITING PROGRAM CONSTANTS

5.6.1 Overview

Typically, users will start the analysis process with only a broad understanding of the project-specific vehicle fleet – specifically, the percentage of vehicles that are considered “trucks,” vs. those that are “non-trucks.” In all cases, projects that require a quantitative PM hot-spot analysis will have a different fleet distribution than the EMFAC regional default mix. Users will therefore need to adjust the project fleet and fleet activity (VMT, trips) to reflect the expected project fleet mix for each EMFAC scenario. Depending on the project, users should modify some combination of VMT (which affects running exhaust emission factors), vehicle trips (which affects starting emission factors), and/or vehicle population (which affects idling emission factors). In the following discussion, overall guidance is provided on how to make these adjustments. Appendices G and H provide more specific illustrations of the step-by-step procedures involved.

5.6.2 Default data in the Emfac mode

The Emfac mode is associated with a range of pre-populated program constants linked to specific time periods and California geographic areas. Exhibit 5-5 lists the default data available in the Emfac mode that can be accessed through the “Edit Program Constants” in the user interface. For a PM hot-spot analysis, many of the defaults do not need to be modified. However, users do need to determine which adjustments are needed for the default distributions of VMT, trips, and vehicle population by vehicle class. The EMFAC interface has “Copy with Headers” and “Paste Data Only” tabs that are helpful for users to easily export the default data and import the adjusted data.

Exhibit 5-5. EMFAC Program Constants and Modification Needs for PM Hot-spot Analyses

EMFAC Program Constants	Description	Modification Needed for PM Analyses?
Exh Tech Fractions	Exhaust control technology fractions	No
Evap Tech Fractions	Evaporative control technology factions	No
Interim I/M	Enhanced interim I/M program	No
Population	Vehicle population by class, fuel type, and age	Yes*
Accrual	Odometer accrual rate by class, fuel type, and age	No
Trips	Vehicle trips/starts per day by class, fuel type, and age	Yes*
VMT	Vehicle miles traveled per day by class, fuel type, and age	Yes*
Speed Fractions	VMT by speed bin distribution for each vehicle class	No
Idle Time	Idle times by vehicle class, fuel, and hour of day	No

* Different distributions in VMT, trips, or vehicle population than those reflected by the EMFAC defaults should be updated through the user interface to incorporate project-specific vehicle activity information.

5.6.3 Comparing project data and EMFAC defaults to determine adjustments

Individual projects will have a mix of vehicle types that varies from the regional average fleet mix. Because PM hot-spot analyses can be especially sensitive to diesel-powered truck activity, it is important to properly characterize the relative fraction of the fleet that is comprised of trucks compared to light-duty vehicles. Users should determine the base (default) case and forecasted vehicle mix (trucks versus non-trucks) applicable to their project's build and no-build scenarios and use that information to adjust EMFAC defaults.

Users should first collapse VMT, vehicle trip and vehicle population data for EMFAC's 13 vehicle classes to two general data categories: "truck" and "non-truck." The common practice in California is to define, for emission purposes, "truck" activity as being comprised of all activity associated with what EMFAC identifies as medium-duty and above heavier vehicles. In addition, travel activity data typically identify "trucks" in a general sense, without regard to their fuel type. Exhibit 5-6, therefore, shows the suggested vehicle class mapping given the likely data available at the project level.

Exhibit 5-6. Mapping EMFAC Vehicle Classes to Project-specific Activity Information

Typical Projects (2 Categories)	EMFAC Default (13 Classes)	Description	EMFAC Output Summary Rates (RTS) File (6 Groups)
Non-truck	LDA	Passenger cars	LDA
	LDT1	Light-duty trucks 1	LDT
	LDT2	Light-duty trucks 2	
	MCY	Motorcycles	MCY
Truck	MDV	Medium-duty trucks	MDT
	LHDT1	Light-heavy-duty trucks 1	
	LHDT2	Light-heavy-duty trucks 2	
	MHDT	Medium-heavy-duty trucks	HDT
	HHDT	Heavy-heavy-duty trucks	
	MH	Motor homes	
	OBUS	Other buses	
	SBUS	School buses	
	UBUS	Urban buses	UBUS

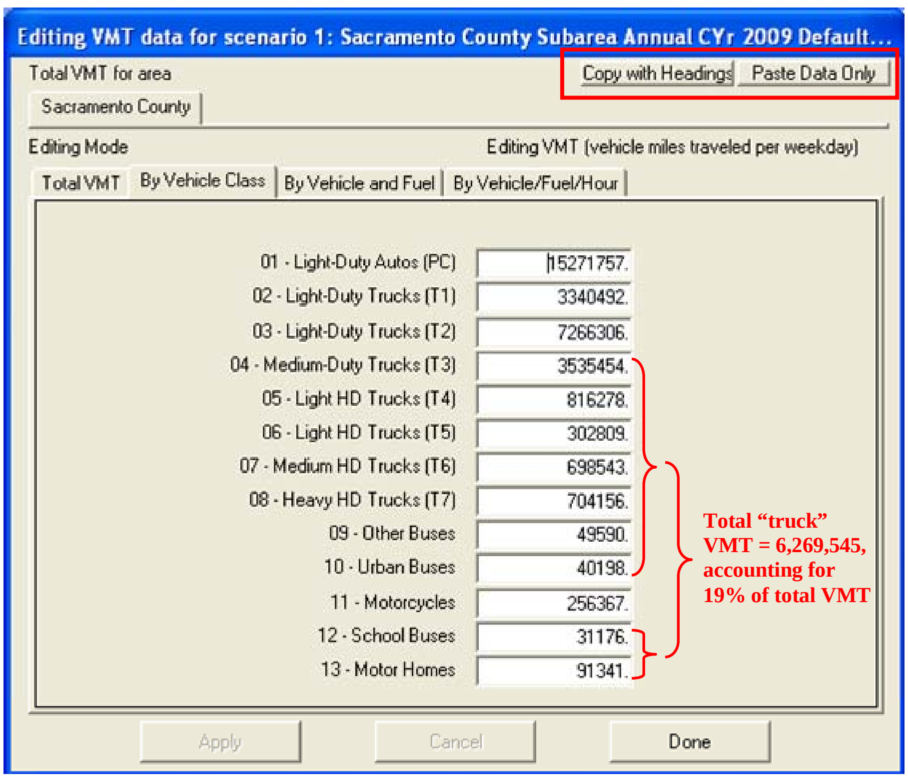
5.6.4 Adjustment of default activity distributions to reflect project data

After the vehicle mapping is complete, users will need to compare the project-specific distributions to the default data included in EMFAC for trucks and non-trucks. For example, assume 2009 is used as the analysis year for a hypothetical highway project in Sacramento County with 25% of total annual average daily VMT apportioned to trucks. After entering all the basic inputs in the EMFAC modeling software, pre-populated (default) county VMT for the truck portion of the fleet is equal to 6,269,545 (when all appropriate vehicle classes are summed up), and the model default activity shows that truck VMT represents 19% of total VMT in Sacramento County (see Exhibit 5-7).

The VMT should then be re-allocated to the correct percentage. EMFAC allows users to adjust the calculated fleet-average emission factors by varying the relative weightings of the 13 vehicle classes. This adjustment is done by replacing the default numbers for each vehicle class in the EMFAC user interface, using the "VMT" option for a highway project, or the "Trips" or "Population" option if analyzing a transit or other terminal project, under the "Edit Program Constants" function available via the Emfac mode screen.

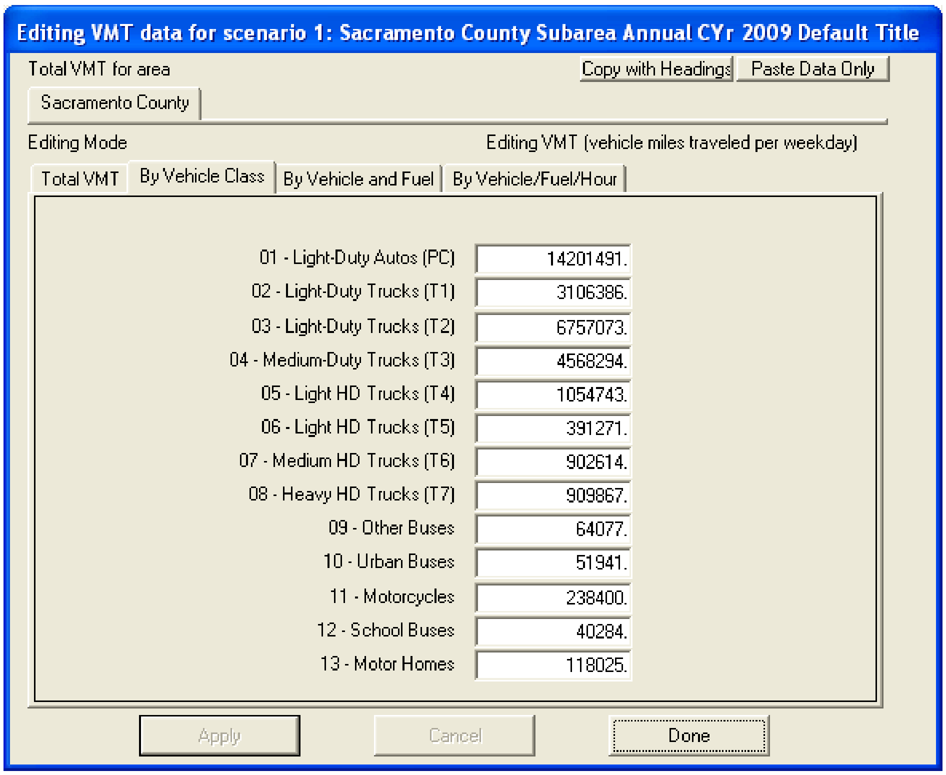
Note: EMFAC also allows users to modify the fuel characteristics (gas/diesel/electric) for each of the 13 vehicle classes. For most PM hot-spot analyses for highway projects with non-captive fleets, users will not need to modify the fuel assumed for the fleet vehicles. For projects involving captive fleets with known fuel use distributions, the default fractions should be modified.

Exhibit 5-7. Example *Default* EMFAC VMT by Vehicle Class Distribution



Continuing with the Sacramento County illustration from the previous step, users would need to scale the EMFAC defaults to reflect the truck/non-truck VMT fractions appropriate to the project (i.e., truck VMT needs to be adjusted from 19% to 25% of the total). The fractional differences for trucks and non-trucks are then applied to the default VMT for each corresponding vehicle class in the EMFAC user interface. As illustrated in Exhibit 5-8, when the VMT values for the truck classes are adjusted, their sum is equal to 8,101,117 (25% of total county VMT). Adjusted non-truck VMT is now 24,303,350 (75% of total VMT). The details of this example are presented in Appendix G. When updating the EMFAC default VMT by vehicle class, the total VMT (for all 13 vehicle classes) must remain unchanged.

Exhibit 5-8. Example *Adjusted* EMFAC VMT by Vehicle Class Distribution



Note that, in special cases, if one or more of the default vehicle classes are not present in the project area, users should set VMT (to address running exhaust emissions), number of trips (to address starting emissions) and population (to address idling emissions) for that class to "1" in the EMFAC interface. In other words, users should functionally zero-out the appropriate vehicle class by inputting a value of "1" because EMFAC does not allow an input of zero in the interface for VMT, trip, and vehicle population distributions. A complete example illustrating how to change EMFAC default distributions to exclude some vehicle classes for a transit project is presented in Appendix H. An alternate way is to delete unwanted vehicle classes in the basic scenario data input to the model. Appendices G and H provide more detailed examples of these steps; these modifications will typically only be necessary for projects involving unique conditions such as truck-only activity.

Note: The average emission factors provided by EMFAC in the "Emfac mode" are VMT-weighted (for running emissions), vehicle trip-weighted (for start emissions), or vehicle population-weighted (for idle emissions) across different vehicle classes. If a user runs *the model for a county, the weighting reflects county-level VMT, trips (starts), or vehicle fleet and their absolute values are not relevant at the project level.*

For most transit and other terminal projects, users may have very detailed information on not only vehicle mix, but also fuel mix (diesel/gas/electric) and age distribution (model year distribution). Users should adjust the fuel mix (changed through the "By Vehicle and Fuel" tabs of the VMT, Population, and Trips panels) to reflect the known or expected fuel use (if, for instance, a bus fleet is expected to use entirely diesel fuel). Similarly, if the age distribution (model year distribution) is known for a particular fleet, this should be entered in place of the EMFAC default values (found in the "By Vehicle/Fuel/Age" tab of the Edit Population panel). Note that EMFAC's ability to model alternate fuel options is not uniform among vehicle classes. If users determine that modification of the fleet in terms of fuel or age distribution is needed, they should contact ARB for further guidance. However, for most highway and intersection projects with a non-captive fleet, the EMFAC default fuel mix and age distribution should be used.

5.7 GENERATING EMISSION FACTORS FOR USE IN AIR QUALITY MODELING

For each EMFAC run, emission factors will be generated in the "Summary Rates (RTS)" file (.rts file) in the form of look-up tables. These tables are organized and numbered by different emission processes and pollutant types. PM emission factors for running exhaust, idle exhaust, tire wear, and brake wear are included in Table 1 of the .rts file; PM start emission factors are included in Table 2 of the .rts file. Exhibit 5-9 (following page) includes example screenshots of EMFAC .rts file output.

5.7.1 Highway and intersection links

For each speed value (greater than 0 mph), EMFAC outputs running exhaust, tire wear, and brake wear emission factors in grams/vehicle-mile, for six vehicle groups plus an aggregate emission factor named as "All" (see Exhibit 5-6). Note that the .rts *output* file includes only six vehicle groups – an aggregation of the 13 vehicle classes manipulated during the *input* process. In general, assuming users have run the model with VMT-weighted distributions appropriate for the project's fleet activity (see Section 5.6), only the emission factors from the "All" column will be needed. The "All" column includes a grams/vehicle-mile value that is a VMT-weighted average based on the user-provided vehicle activity mix. The sum of running exhaust, tire wear, and brake wear grams/mile PM emission factors for a given speed is the total fleet-average grams/vehicle-mile emission factor appropriate for modeling highway project links:

$$\text{Total Link Emission Factor} = (EF_{\text{running}}) + (EF_{\text{tire wear}}) + (EF_{\text{brake wear}})$$

The total link emission factor (grams/vehicle-mile) can be used in combination with the link volume and link length as input into CAL3QHCR. If using AERMOD, an emission rate (in grams/hour) should be calculated for each link. This can be done by multiplying the total link emission factor (calculated above) by the link hourly volume and link length.

Exhibit 5-9. Example EMFAC Running Exhaust, Tire Wear, and Brake Wear Emission Factors in the Summary Rates (rts) Output File

default.rts - WordPad

Pollutant Name: PM10 Temperature: 60F Relative Humidity: 70%

Speed MPH	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
0	0.000	0.000	0.057	1.380	0.000	0.000	0.084
5	0.050	0.095	0.098	1.630	0.888	0.051	0.163
10	0.033	0.062	0.065	1.129	0.643	0.040	0.111
15	0.022	0.043	0.046	0.763	0.483	0.033	0.076
20	0.016	0.032	0.034	0.549	0.376	0.029	0.055
25	0.013	0.024	0.026	0.460	0.303	0.026	0.045
30	0.010	0.020	0.021	0.395	0.252	0.025	0.037
35	0.009	0.017	0.018	0.350	0.218	0.024	0.033
40	0.008	0.015	0.016	0.327	0.195	0.025	0.030
45	0.007	0.014	0.015	0.324	0.181	0.027	0.029
50	0.007	0.014	0.014	0.340	0.173	0.031	0.030
55	0.007	0.014	0.015	0.376	0.172	0.037	0.032
60	0.008	0.015	0.016	0.431	0.177	0.046	0.036
65	0.009	0.018	0.018	0.505	0.189	0.060	0.042

Pollutant Name: PM10 - Tire Wear Temperature: 60F Relative Humidity: 70%

Speed MPH	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.008	0.008	0.009	0.026	0.008	0.004	0.009
10	0.008	0.008	0.009	0.026	0.008	0.004	0.009
15	0.008	0.008	0.009	0.026	0.008	0.004	0.009
20	0.008	0.008	0.009	0.026	0.008	0.004	0.009
25	0.008	0.008	0.009	0.026	0.008	0.004	0.009
30	0.008	0.008	0.009	0.026	0.008	0.004	0.009
35	0.008	0.008	0.009	0.026	0.008	0.004	0.009
40	0.008	0.008	0.009	0.026	0.008	0.004	0.009
45	0.008	0.008	0.009	0.026	0.008	0.004	0.009
50	0.008	0.008	0.009	0.026	0.008	0.004	0.009
55	0.008	0.008	0.009	0.026	0.008	0.004	0.009
60	0.008	0.008	0.009	0.026	0.008	0.004	0.009
65	0.008	0.008	0.009	0.026	0.008	0.004	0.009

Pollutant Name: PM10 - Brake Wear Temperature: 60F Relative Humidity: 70%

Speed MPH	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.013	0.013	0.013	0.022	0.013	0.006	0.013
10	0.013	0.013	0.013	0.022	0.013	0.006	0.013
15	0.013	0.013	0.013	0.022	0.013	0.006	0.013
20	0.013	0.013	0.013	0.022	0.013	0.006	0.013
25	0.013	0.013	0.013	0.022	0.013	0.006	0.013
30	0.013	0.013	0.013	0.022	0.013	0.006	0.013
35	0.013	0.013	0.013	0.022	0.013	0.006	0.013

For Help, press F1 NUM

5.7.2 Transit and other terminal links

For transit and other terminal projects, such as bus terminals or intermodal freight terminals, grams/trip (or grams/start) emission factors can be combined with project-specific estimates of vehicle trips (or starts) per hour to calculate grams/hour emissions. Starting emission factors are dependent on the vehicle soak time (the soak time is the time a vehicle is stationary with the engine turned off, following the last time it was operated). The longer a vehicle is turned off, or soaks, the higher the start emissions embedded in EMFAC. The output look-up table for start emissions includes 18 time bins (5 minutes to 720 minutes); users need to choose an appropriate time bin that is representative for the project activity. Selected examples of some potential associated soak times are shown in Exhibit 5-10 for several possible scenarios.

Exhibit 5-10. Example Soak Times for Several Project Scenarios

Project Type	Example Soak Time (min)*	PM_{10} Start Emission Factors (g/trip)
Bus Transit Facility	10	0.002
Truck Refueling Station	60	0.008
Intermodal Distribution Center	180	0.013
Truck Stop Parking Lot	480	0.016

* Example soak times and emission factors are for illustration purposes and are not to be used as literal values. Users should select soak times and estimate emission factors appropriate to the specific project and implementation dates to be evaluated. Emission factors will vary by analysis year.

Idling emission factors are in grams/idle-hour and are available in Table 1 of the .rts file associated with a speed value of 0 mph (available only for MDT and HDT groups due to EMFAC's data limitations). Note that, for transit and other terminal projects, idling and starting emission factors from EMFAC should not be combined directly because they are generated in different units. The project idling and starting emissions (in grams) need to be calculated separately for a particular time period, based on project-specific idle hour and trips/hour data. The total transit or other terminal project emissions for the time period are the sum of the two values:

$$\text{Total Project Emissions} = (EF_{\text{idling}} * \text{idle hours}) + (EF_{\text{starting}} * \text{trips})$$

The result of this calculation is a grams/hour emission rate that can be used for air quality modeling.

In some cases, users may need to model running exhaust emissions from cruise, approach, and departure link activity, as well as start and idle emissions at the project site. For instance, to assess impacts from a proposed bus terminal, users may need to evaluate start and idle emissions from buses at the terminal itself, and bus running exhaust emissions along the links approaching and departing from the terminal. Given that the link activity will involve a unique vehicle fleet (one with a disproportionate amount of bus activity), users should modify the default travel activity in EMFAC to reflect the bus activity (see the discussion above). EMFAC allows users to generate emission factors for both the approaching/departing links and the bus terminal itself in a single run. To obtain project-specific running exhaust emission factors, users can modify the VMT associated with the buses at the approaching link by adjusting the values for each of the 13 vehicle classes in the user interface with the method described in Section 5.6. In the same EMFAC run, users can enter project-specific vehicle population and trip distributions to produce project-specific start and idle emission factors.

Another special case may involve modeling idling emissions for a specific fleet of heavy heavy-duty diesel trucks (HHDT). Because EMFAC provides only an overall average idle emission factor for heavy-duty trucks regardless of fuel type, ambient conditions, accessory usage, and engine speed, ARB has created supplemental guidance that, off-model, provides season-specific HHDT emission factors for activity that ARB has termed "high idle" and "low idle."[49] Low idle (sometimes also called "curb idle") involves short-term idling with engine speeds of 800 rpm or less and no accessory loading. High idle is idling over an extended period of time with engine speeds over 800 rpm, usually involving the use of heaters, air conditioners, or other vehicle accessories. If the project under evaluation involves HHDT and the user has detailed information about the fleet (vehicle model years and the amount of time spent in low and high idle, in particular), the information from this supplemental guidance may be used to obtain more specific idle emission factors for HHDT than would otherwise be available by simply using EMFAC.

Other special projects may require additional data manipulation. Project sponsors should contact ARB or the local air quality management district for further guidance.

Note: The product of any transit or other terminal project should be a grams/hour emission factor for each defined project area. If approach/departure running emissions are calculated, a grams/hour emission factor should be calculated from the grams/mile EMFAC output as described in Section 5.7.1.

<u>Alternative Method to Estimate Idle and Start Emission Factors for a Specific Vehicle Class</u>

A relatively simple method is available to obtain idle and start emission factors for those cases in which users are interested in only one vehicle class (such as for heavy-duty trucks). Note that this method is not recommended for situations involving multiple vehicle classes (e.g., medium- and heavy-duty trucks). Because this is a methodology to support development of idle and start emission factors, it is applicable only to those vehicle classes for which EMFAC includes idle emissions (LHDT1, LHDT2, MHDT, HHDT, School Buses, and Other Buses).

For example, suppose a project or link involves just HHDT: users could modify EMFAC's basic input of Vehicle Classes in Section 3.6 in the user interface and select "Heavy Heavy Duty Trucks." Editing EMFAC default population and trip distributions is not needed because the output .rts file will reflect emission factors that are associated with the selected single vehicle class only.

[49] See EMFAC Modeling Change Technical Memo, "Revision of Heavy Duty Diesel Truck Emissions Factors and Speed Correction Factors" (original and amendment), October 20, 2006; available through ARB online at: www.arb.ca.gov/msei/supportdocs.htm#onroad.

Section 6: Estimating Emissions from Road Dust, Construction, and Other Emission Sources

6.1 INTRODUCTION

This section provides guidance on how to estimate re-entrained road dust and transportation-related construction dust emissions. MOVES and EMFAC do not estimate emissions of road or construction dust, so this section must be consulted if dust is required to be included in the PM hot-spot analysis. See Section 2.5 for further information regarding when dust emissions are required to be included in a PM hot-spot analysis. This section also includes information on quantifying emissions from construction vehicles and equipment, locomotives, and other sources of emissions in the project area, when applicable.

6.2 OVERVIEW OF DUST METHODS AND REQUIREMENTS

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 www.epa.gov/ttn/chief/ap42/index.html to access the latest versions of AP-42 sections and for more information about AP-42 in general. The sections of AP-42 that address emissions of re-entrained road dust from paved and unpaved roads and emissions of construction dust are found in AP-42, Chapter 13, "Miscellaneous Sources." The key portions of the chapter include:

- Section 13.2: "Introduction to Fugitive Dust Sources,"
- Section 13.2.1: "Paved Roads"
- Section 13.2.2: "Unpaved Roads"
- Section 13.2.3: "Heavy Construction Operations" (includes road construction)

The discussion in this section is based on the November 1, 2006 update to AP-42. Users should consult the above website to ensure they are using the latest final version, as the methodology and procedures may change over time.

Although EPA has approved AP-42 as the official model for calculating re-entrained road dust for regional conformity analyses, there is additional flexibility for what method can be used for calculating road dust for PM hot-spot analyses.[50] In addition to the latest version of AP-42, alternative local methods can be used for estimating road or

[50] See EPA's notice of availability published in the Federal Register on May 19, 2004 (69 FR 28830-28832). Also see EPA's memoranda: "Policy Guidance on the Use of the November 1, 2006, Update to AP-42 for Re-entrained Road Dust for SIP Development and Transportation Conformity," EPA420-B-07-055 (August 2, 2007); and "Policy Guidance on the Use of MOBILE6.2 and the December 2003 AP-42 Method for Re-entrained Road Dust for SIP Development and Transportation Conformity," (February 24, 2004). These documents are available online at: www.epa.gov/otaq/stateresources/transconf/policy.htm#models.

construction dust. The interagency consultation process must be used to discuss what modeling methods and assumptions are appropriate for a given project's PM hot-spot analysis for road dust and construction-related dust (40 CFR 93.105(c)(1)(i)).

This section presumes users already have a basic understanding of how to use AP-42 or other dust methods.

6.3 ESTIMATING RE-ENTRAINED ROAD DUST

6.3.1 $PM_{2.5}$ nonattainment and maintenance areas

The transportation conformity rule requires a hot-spot analysis in a $PM_{2.5}$ nonattainment and maintenance area to include emissions from re-entrained road dust only if emissions from re-entrained road dust are determined to be a significant contributor to the $PM_{2.5}$ nonattainment problem. See Section 2.5 for further information.

6.3.2 PM_{10} nonattainment and maintenance areas

Re-entrained road dust must be included in all PM_{10} hot-spot analyses. EPA has historically required road dust emissions to be included in all conformity analyses of direct PM_{10} emissions – including hot-spot analyses. See Section 2.5 for further information.

6.3.3 Using AP-42 to estimate emissions of re-entrained road dust on paved roads

Section 13.2.1 of AP-42 provides a method for estimating emissions of re-entrained road dust from paved roads for situations for which silt loading, mean vehicle weight, and mean vehicle speeds on paved roads fall within ranges given in AP-42, Section 13.2.1.3 and with reasonably free-flowing traffic (if the project doesn't meet these conditions, see Section 6.3.5, below). Section 13.2.1 of AP-42 contains predictive emission factor equations that can be used to estimate an emission factor for road dust. This section can be downloaded from EPA's website at: www.epa.gov/ttn/chief/ap42/ch13/index.html.

The following bullets describe the type of data needed when using Section 13.2.1 of AP-42 and are based on the November 2006 version of Section 13.2.1 of AP-42.[51]

- Users will need to provide the average weight in tons of vehicles traveling the road (Section 13.2.1 states that the average weight needs to be provided and that the equations are not intended to be used to calculate a separate emission factor for each vehicle weight class).
- Users should obtain and use site-specific silt loading data. The default, site-specific silt loading data contained in Table 13.2.1-3 should not be used.

[51] Please consult the latest version of AP-42, Section 13.2.1 on EPA's website for specific directions for using these equations and to determine whether any updates have been made.

- Users have the choice to include a precipitation correction term. Users could either provide local information or rely on the national map showing mean number of days with measurable precipitation (Figure 13.2.1-2) provided in Section 13.2.1.
- If the project is located in an area where anti-skid abrasives for snow-ice removal are utilized, users should include information about their use, including the number of times such anti-skid abrasives are applied. Section 13.2.1 includes a table of silt loading default values, which can be used when local data are not available (Table 13.2.1-3).

6.3.4 Estimating emissions of re-entrained road dust on unpaved roads

Section 13.2.2 of AP-42 provides a method for estimating emissions of re-entrained road dust from unpaved roads. Different equations are provided for vehicles traveling unpaved surfaces at industrial sites (Equation 1a) and vehicles traveling on publicly accessible roads (Equation 1b). Most PM hot-spot analyses will involve only vehicles traveling on publicly accessible roads. When applying Equation 1b, the following data requirements apply:

- Users will need to provide the mean vehicle speed for traffic using the road.
- The percentage of surface material moisture will also need to be obtained and used in the equation. The default moisture content value should not be used.

As above, this discussion is based on the November 2006 version of Section 13.2.1 of AP-42. Users should consult the latest version of AP-42, Section 13.2.1 on EPA's website to determine whether any updates to the road dust methods have been made.

6.3.5 Using alternative local approaches for estimating re-entrained road dust

$PM_{2.5}$ and PM_{10} nonattainment and maintenance areas can use a locally-developed method for estimating re-entrained road dust for hot-spot analyses. Some areas have historically used alternative methods for estimating re-entrained road dust emissions that may be more appropriate than the AP-42 methods given specific local conditions. Other areas may develop alternatives in the future.

For example, an area may have a locally-developed method that has been approved by EPA for estimating road dust for regional emissions analyses. Also, an alternative method could be used if the equations in AP-42 do not apply to a particular project, as they were developed using a particular range of source conditions. Section 13.2.1 of AP-42 states that the equation provides a range of silt loads, mean vehicle weights, and mean vehicle speeds, but it should not be used outside the specified range. In these cases, users are encouraged to consider alternative methods that can better reflect local conditions.

Therefore, if the project undergoing a PM hot-spot analysis does not fit within the parameters described within AP-42, users should consider whether an alternative method of estimating road dust is appropriate.

As stated above, the interagency consultation process must be used to determine the models and methods used in PM hot-spot analyses.

6.4 ESTIMATING TRANSPORTATION-RELATED CONSTRUCTION DUST

6.4.1 Determining whether construction dust must be considered

Construction-related $PM_{2.5}$ or PM_{10} emissions associated with a particular project are required to be included in hot-spot analyses only if such emissions are not considered temporary as defined in 40 CFR 93.123(c)(5) (i.e., temporary emissions are those that occur only during the construction phase and last five years or less at any individual site). The following discussion includes guidance only for construction-related dust emissions; any other construction emissions (e.g., exhaust emissions from construction equipment) would need to be calculated separately, as discussed in Section 6.6.

6.4.2 Using AP-42 to estimate emissions of construction dust

Section 13.2.3 of AP-42 describes how to estimate emissions of dust from construction of transportation projects. This section can be downloaded from EPA's website at: www.epa.gov/ttn/chief/ap42/ch13/index.html.

The following discussion is based on the latest version of Section 13.2.3 of AP-42, released in 1995. Users should consult EPA's website for the most recent edition of AP-42, Section 13.2.3. Some nonattainment or maintenance areas have historically used alternative methods for estimating construction dust that may be more appropriate than AP-42 given specific local conditions. Other areas may develop alternatives in the future. The interagency consultation process must be used to determine model and methods, as described above.

This section of AP-42 includes one equation for estimating dust where the user would need to provide only the size of the construction site (in acres or hectares) and the number of months of activity. However, Section 13.2.3 indicates there are limitations to this equation's usefulness for specific construction sites and therefore strongly recommends that, when emissions are to be estimated for a particular construction site, the construction process be broken down into component operations (e.g., bulldozing, demolition, or motor grading). Table 13.2.3-1 provides recommended emission factors for the various component operations.

In addition, Section 13.2.3 indicates that another substantial source of emissions could be from material that is tracked out from the site and deposited on adjacent paved streets. Therefore, AP-42 states that persons developing construction site emission estimates must consider the potential for increased adjacent emissions from off-site paved roadways; users should refer to the discussion regarding paved roads in Section 6.3.3.

6.5 ADDING DUST EMISSIONS TO MOVES/EMFAC MODELING RESULTS

Once any emissions from road and construction dust have been determined, these results should be added to the emission factors generated by the motor vehicle emissions model that was used for each link (MOVES, or EMFAC in California). Once this data is available, the user can move on to Section 7 to develop input files for the appropriate air quality model.

6.6 ESTIMATING OTHER SOURCES OF EMISSIONS IN THE PROJECT AREA

6.6.1 Construction-related vehicles and equipment

The interagency consultation process must be used to evaluate and choose the data, models, and methods for quantifying emissions from construction vehicles and equipment, when applicable (40 CFR 93.105(c)(1)(i)). In addition, state and local air agencies may have quantified these types of emissions for the development of SIP non-road mobile source inventories that should be considered for PM hot-spot analyses.

6.6.2 Locomotives

EPA has developed guidance 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. See Appendix I for further general guidance, resources, and examples.

6.6.3 Other emission sources

When applicable, emissions from other sources affecting the project area must be estimated and included in air quality modeling. See Section 8 for further information and use of the interagency consultation process as appropriate.

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Section 7: Selecting an Air Quality Model, Data Inputs, and Receptors

7.1 INTRODUCTION

This section describes the recommended air quality models, data inputs, and receptor considerations for PM hot-spot analyses. This guidance is consistent with the conformity rule and recommendations for air quality modeling in EPA's "Guideline on Air Quality Models" (Appendix W to 40 CFR Part 51).

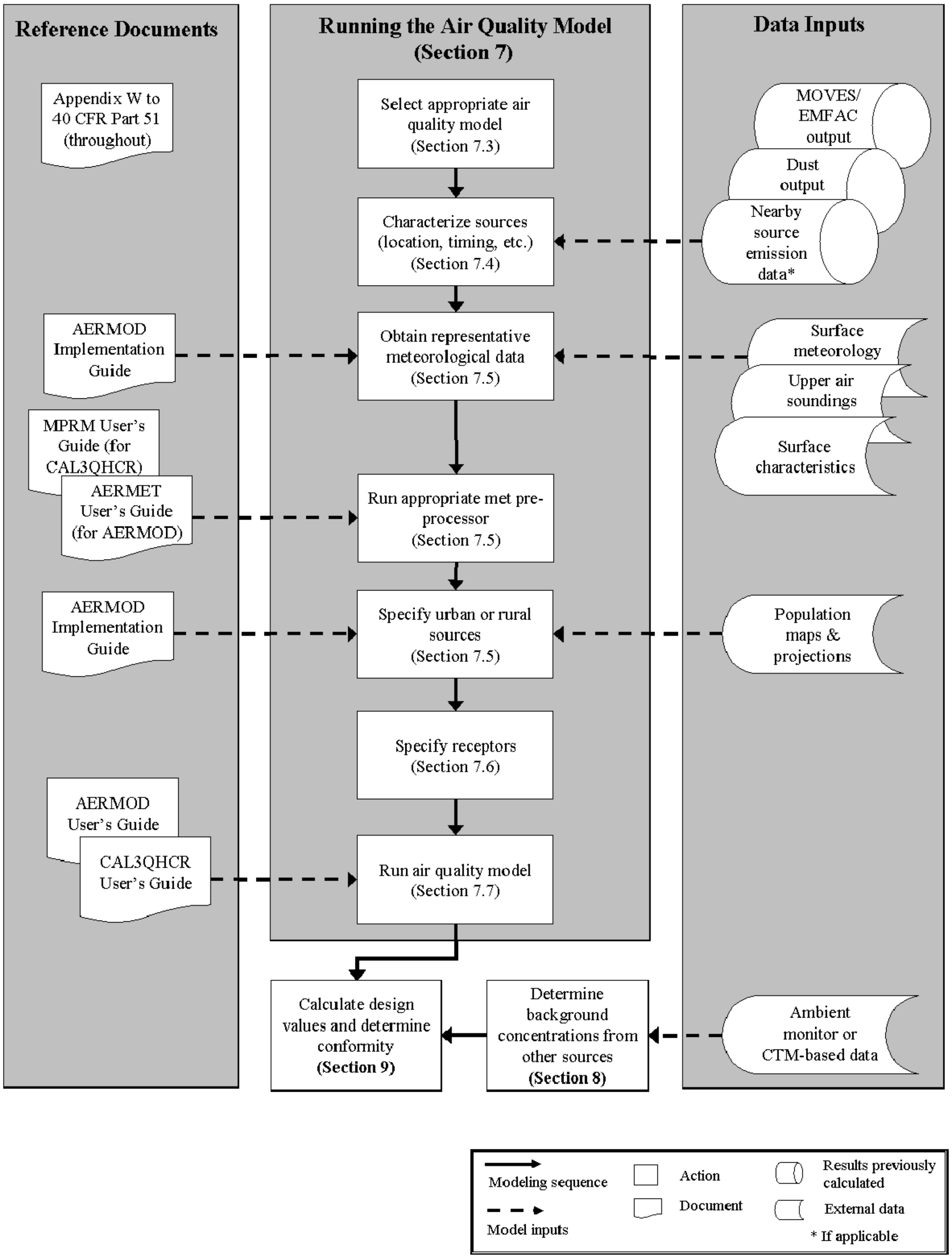
Regardless of the model used, the quality of a model's predictions depends on appropriate input data, proper formatting, model setup, quality assurance, and other assumptions. As noted in Section 2, air quality modeling for PM hot-spot analyses must meet the conformity rule's general requirements for such analyses (40 CFR 93.123(c)) and rely on the latest planning assumptions available when the analysis begins (40 CFR 93.110).

This section presumes that users already have a basic understanding of air quality models and their operation, through previous experience, attending training, and/or reviewing the user guides for the appropriate models. EPA has also included additional details on air quality modeling in Appendix J of this guidance. The models in this section, user guides, and supporting documentation are available through EPA's Support Center for Regulatory Air Models (SCRAM) website at: www.epa.gov/scram001. Project sponsors conducting PM hot-spot analyses will need to refer to the existing user guides and available guidance for complete instructions.

7.2 GENERAL OVERVIEW OF AIR QUALITY MODELING

Air quality models and data inputs need to be determined on a case-by-case basis for each PM hot-spot analysis through the interagency consultation process (40 CFR 93.105(c)(1)(i)). Exhibit 7-1 (following page) outlines the basic process for conducting air quality modeling for a given project. This exhibit depicts the flow of information developed for air quality modeling (as described in this section), the development of background concentration estimates (see Section 8), and the calculation of design values and comparison to the NAAQS (see Section 9).

Exhibit 7-1. Overview and Data Flow for Air Quality Modeling



7.3 SELECTING AN APPROPRIATE AIR QUALITY MODEL

7.3.1 Recommended air quality models

PM hot-spot analyses should be developed consistent with EPA's current recommended models under Appendix W to 40 CFR Part 51. The purpose of recommending a particular model is to ensure that the best-performing methods are used in assessing PM impacts from a particular project and are employed in a consistent fashion.[52] Exhibit 7-2 summarizes the recommended air quality models for PM hot-spot analyses for required projects under 40 CFR 93.123(b)(1).

Exhibit 7-2. Summary of Recommended Air Quality Models

Type of Project	Recommended Model
Highway and intersection projects	AERMOD, CAL3QHCR
Transit, freight, and other terminal projects	AERMOD
Projects that involve both highway/intersections and terminals, and/or nearby sources	AERMOD

As noted above, the selection of an air quality model must be made on a case-by-case basis through the interagency consultation process.

The American Meteorological Society/EPA Regulatory Model (AERMOD) is EPA's recommended near-field dispersion model for many regulatory applications. AERMOD includes options for modeling emissions from volume, area, and point sources and can therefore model the impacts of many different source types.[53]

CAL3QHCR is an extension of the CAL3QHC model, which is the model recommended for use in analyzing CO impacts from intersections.[54] It is appropriate to use CAL3QHCR for PM hot-spot modeling for specified projects.

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[52] The best performing model is one that best predicts regulatory design values for a particular pollutant. EPA's "Protocol for Determining the Best Performing Model" (EPA-454/R-92-025) defines operational and statistical criteria for this evaluation. According to the document: "For a pollutant… for which short-term ambient standards exist, the statistic of interest involves the network-wide highest concentration…the precise time, location, and meteorological condition is of minor concern compared to the magnitude of the highest concentration actually occurring."

[53] EPA recommended AERMOD in a November 9, 2005 final rule that amended EPA's "Guideline on Air Quality Models." The final rule can be found at: www.epa.gov/scram001/guidance/guide/appw_05.pdf. 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.

[54] CAL3QHC is a CALINE3-based model with a traffic model to calculate delays and queues at signalized intersections; CAL3QHCR is a refined model based on CAL3QHC that requires local meteorological data. CAL3QHCR's user guide ("User's Guide to CAL3QHC Version 2.0: A Modeling Methodology for

Both the AERMOD and CAL3QHCR models (and related documentation) can be obtained through EPA's SCRAM website. EPA's Office of Air Quality Planning and Standards (OAQPS) maintains the SCRAM website and maintains, codes, and supports AERMOD on an ongoing basis. Modelers should regularly check this website to ensure use of the latest regulatory version. CAL3QHCR is no longer updated and technical support for the model is not available through OAQPS.

Appendix J includes important additional information about configuring AERMOD and CAL3QHCR when using these models to complete PM hot-spot analyses.

Highway and Intersection Projects

Some projects may consist exclusively of highways and intersections, with little or no emissions coming from long-term idling, non-road engine operations, or explicitly-modeled nearby sources (see more below). Both AERMOD and CAL3QHCR are recommended air quality models for these types of projects.[55] When using CAL3QCHR for highway and intersection projects, its queuing algorithm should not be used. 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.

Note: Users should be aware that to handle quarterly emissions and multiple years of meteorological data, AERMOD and CAL3QHCR require different numbers of input files and runs. AERMOD can handle quarterly variations in emissions and multiple years of meteorological data using a single input file and run. In contrast, CAL3QHCR can handle only one quarter's emissions and one year of meteorological data at a time. See further information in Section 7.5.3.

Transit and Other Terminal Projects

Other projects may include only transit or freight terminals and transfer points where a large share of total emissions arise from engine start and idling emissions or from non-road engine activity. AERMOD is the recommended air quality model for these types of projects.

Projects that Involve Both Highway/Intersection and Terminal Projects, and/or Nearby Sources

There may be some projects that are a combination of the "highway and intersection" and "transit and freight terminal" project types. AERMOD is the recommended model for

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Predicting Pollutant Concentrations Near Roadway Intersections") can be found at: www.epa.gov/scram001.

[55] Appendix W to 40 CFR Part 51 describes both AERMOD and CAL3QHCR as being appropriate for modeling line sources. For further background, see Sections 3.0, 4.0, 5.0, and 8.0 of Appendix W, as well as Appendix A to Appendix W of 40 CFR Part 51.

these projects. As a general recommendation, if AERMOD is used for modeling any source associated with the project, it should be the only air quality model used for the PM hot-spot analysis.[56] There may be other cases where the project area also includes a nearby source that must be explicitly modeled to account for background concentrations around the project (e.g., locomotives at a nearby freight terminal or marine port). In these cases, AERMOD should be used for the project and any such nearby sources. See Section 8 for further information on nearby sources.

7.3.2 How emissions are represented in CAL3QHCR and AERMOD

Both CAL3QHCR and AERMOD simulate how pollutants disperse in the atmosphere. To do so, the models classify emission sources within a project as line, volume, area, and point sources:

- Line sources are generally linear emission sources, which can include highways, intersections, and rail lines. They are directly-specified in the CAL3QHCR input file using road link coordinates. AERMOD can simulate a highway "line source" using a series of adjacent volume or area sources (see the AERMOD user guide and the AERMOD Implementation Guide for suggestions).
- Volume sources (used in AERMOD only) are three-dimensional spaces from which emissions originate. Examples of sources that could be modeled as volume sources include areas designated for truck or bus queuing or idling (e.g., off-network links in MOVES), driveways and pass-throughs in bus terminals, and locomotive activity at commuter rail or freight rail terminals.[57]
- Area sources (used in AERMOD only) are flat, two-dimensional surfaces from which emissions arise (e.g., parking lots).
- Point source emissions (used in AERMOD only) emanate from a discrete location in space, such as a bus garage or transit terminal exhaust stack.

Each of these source types may be appropriate for representing different sources in a PM hot-spot analysis. For example, highways may be modeled as line sources in CAL3QHCR, but they may also be modeled as a series of adjoining volume sources in AERMOD, as described below. Using another example, an exhaust vent from a bus garage might be best represented as a point source, area source, or volume source, depending on its physical characteristics. Project sponsors should consult with the most recent user guides for air quality models to determine the most appropriate way to represent a particular source within a model.

[56] There are several reasons for this recommendation. First, AERMOD is flexible in how different sources are represented, while CAL3QHCR must represent all sources as "line sources" (see Section 7.3.2). Second, AERMOD allows a much wider number of receptors and sources to be modeled simultaneously, which is useful for large projects with different source configurations. Third, AERMOD's treatment of dispersion in the lower atmosphere is based on more current atmospheric science than CAL3QHCR. Furthermore, the use of a single model, rather than multiple models, is recommended to avoid the need to run the same meteorological data through different pre-processors (AERMET, MPRM), avoid different receptor networks for different sources, reduce the number of atmospheric modeling runs required to analyze a project, avoid the use of different modeling algorithms that perform the same task, and reduce double-counting or other errors.

[57] See Section 6 and Appendix I for information on estimating locomotive emissions.

7.3.3 Alternate models

In some limited cases, an alternate model for use in a PM hot-spot analysis may be considered. As stated in Section 3.2 of Appendix W, "Selection of the best techniques for each individual air quality analysis is always encouraged, but the selection should be done in a consistent manner." This section of Appendix W sets out objective criteria by which alternate models may be considered.

Analyses of individual projects are not expected to involve the development of new air quality models. However, should a project sponsor seek to employ a new or alternate model for a particular transit or highway project, that model must address the criteria set forth in Section 3.2 of Appendix W. Determining model acceptability in a particular application is an EPA Regional Office responsibility involving consultation with EPA Headquarters, when appropriate.

7.4 CHARACTERIZING EMISSION SOURCES

Characterizing sources is the way in which the transportation project's features and emissions are represented within an air quality model. In order to determine the concentrations downwind of a particular emission source, an air quality model must have a description of the sources, including:

- Physical characteristics and location;
- Emission rates/emission factors; and
- Timing of emissions.

Within any particular PM hot-spot analysis, there may be several different emission sources within the project area. Sections 4 and 5 describe how a project can be characterized into different links, which will each have separate emission rates to be used in air quality modeling. Sections 6 and 8.2 outline how nearby source emissions, when present, can be characterized to account for emissions throughout the project area. Properly characterizing all of these distinct sources within the PM hot-spot analysis will help ensure that the locations with the greatest impacts on PM air quality concentrations are identified.

This section describes the major elements needed to characterize a source properly for use in an air quality model.

7.4.1 Physical characteristics and location

When modeling an emission source, its physical characteristics and location must be described using the relevant model's input format, as described in the appropriate user guides. For the same emission rate, sources with different physical characteristics may have different impacts on predicted concentrations.

Refer to Appendix J of this guidance and to the user guides for CAL3QCHR and AERMOD for specific information about how physical characteristics and location of sources are included in these models.

7.4.2 Emission rates/emission factors

The magnitude of emissions within a given time period or location is a necessary component of dispersion modeling. For motor vehicles, MOVES-based emission rates are required in all areas other than the state of California, where EMFAC-based emission rates are required, as described in Sections 4 and 5, respectively. For road and construction dust, emission factors from AP-42 or a local method are required, as described in Section 6. For other types of sources, the appropriate emission rates should also be estimated, as described in Section 6.

CAL3QHCR and AERMOD accept emission rates in different formats. For highways and intersections, CAL3QHCR requires emissions to be specified in grams/vehicle-mile traveled (grams/mile).[58] AERMOD needs emission rates in grams/hour (or grams/second).

7.4.3 Timing of emissions

The proper description of emissions across time of year, day of week, and hour of day is critical to the utility of air quality modeling.[59] Sections 4 and 5 describe how to account for different periods of the day in emissions modeling with MOVES and EMFAC. This approach is then applied to air quality modeling to estimate air quality concentrations throughout a day and year. As described in Section 3.3.4, air quality modeling for most PM hot-spot analyses would involve data and modeling for all four quarters of the analysis year, except in limited cases.

Sections 4 and 5 and Appendix J describes how results from MOVES and EMFAC should be prepared for use as inputs in both AERMOD and CAL3QCHR.

7.5 INCORPORATING METEOROLOGICAL DATA

7.5.1 Finding representative meteorological data

One of the key factors in producing credible results in a PM hot-spot analysis is the use of meteorological data that is as representative as possible of the project area. Meteorological data are necessary for running either AERMOD or CAL3QCHR because meteorology affects how pollutants will be dispersed in the lower atmosphere. The

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[58] CAL3QHCR uses the hourly volume of vehicles on each road link and the emission factor (in grams/mile) for the vehicles on each link to calculate time-specific emission rates for use in air quality modeling. As described in Sections 4 and 5, the idle emission factor inputs in CAL3QHCR should not be used in a PM hot-spot analysis.

[59] The timing of emissions in AERMOD is described in Section 3.3.5 of the AERMOD user guide.

following paragraphs provide an overview of the meteorological data needed and sources of this data. More detailed information can be found in Appendix J and in model user and implementation guides.

Meteorological data is used by air quality dispersion models to characterize the extent of wind-driven (mechanical) and temperature-driven (convective) mixing in the lower atmosphere throughout the day.[60] For emissions near the ground, as is common in transportation projects, dispersion is driven more by mechanical mixing, but temperature-driven mixing can still have a significant impact on nearby air quality. As a source's plume moves further downwind, temperature-driven mixing becomes increasingly important in determining concentrations.

Depending on the air quality model to be used, the following types of information are needed to characterize mechanical and convective mixing:

- Surface meteorological data, from surface meteorological monitors that measure the atmosphere near the ground (typically at a height of 10 meters—see Section 7.5.2);
- Upper air data on the vertical temperature profile of the atmosphere (see Section 7.5.2);
- Data describing surface characteristics, including the surface roughness, albedo, and Bowen ratio (see Section 7.5.4); and
- Population data to account for the "urban heat island effect" (see Section 7.5.5).

Project sponsors should first consult with their respective state and local air quality agencies for any representative meteorological data for the project area. In addition, some state and local air agencies may maintain pre-processed meteorological data suitable for use in PM hot-spot analyses. Interagency consultation should be used to determine whether pre-processed meteorological data are available.

To format meteorological data appropriately and prepare them for use in air quality models, EPA maintains meteorological processing software on the SCRAM website.[61] These programs produce input data files that the air quality models read to produce calculations of atmospheric dispersion. AERMOD and CAL3QHCR employ different meteorological pre-processing programs. AERMET is the meteorological pre-processor for AERMOD. The Meteorological Processor for Regulatory Models (MPRM) program is the meteorological pre-processor for CAL3QHCR. User guides for both AERMET and MPRM should be consulted for specific instructions.

The meteorological data used as input to an air quality model should be selected on the basis of geographic and climatologic representativeness and how well measurements at

[60] Mechanical turbulence arises when winds blow across rough surfaces. When wind blows across areas with greater surface roughness (roughness length), more mechanical turbulence and mixing is produced. Temperature-driven mixing is driven by convection (e.g., hot air rising).
[61] These programs and their user guides may be downloaded from the SCRAM website at: www.epa.gov/scram001/metobsdata_procaccprogs.htm.

one site represent the likely transport and dispersion conditions in the area around the project. The representativeness of the data depends on factors such as:

- The proximity of the project area to the meteorological monitoring site;
- The similarity of the project area to the meteorological monitoring site in surface characteristics (particularly surface measurements);
- The time period of data collection;
- Topographic characteristics within and around the project area; and
- Year-to-year variations in weather conditions (hence, a sufficient length of meteorological data should be employed, as discussed in Section 7.5.3 and Appendix J).

The AERMOD Implementation Guide provides up-to-date information and recommendations on how to judge the representativeness of meteorological data.[62] Modelers should consult the most recent version of the AERMOD Implementation Guide for assistance in obtaining and handling meteorological information. Although its recommendations are intended for users of AERMOD, its recommendations for how to assess the representativeness of meteorological data apply to analyses employing CAL3QHCR as well.

7.5.2 Surface and upper air data

Surface Data

Air quality models require representative meteorological data from a near-ground surface weather monitoring station ("surface data"). Models have minimum requirements for what surface observations are needed. For example, when using National Weather Service (NWS) data to produce meteorological input files for AERMOD, the following surface data measurements are required:

- Wind vector (speed and direction);
- Ambient temperature; and
- Opaque sky cover (or, in the absence of opaque sky cover, total sky cover).

Station barometric pressure is recommended, but not required (AERMET includes a default value in the absence of such data).

When processing data using MPRM for use in CAL3QHCR, information on stability category is also required. MPRM estimates stability internally. Alternatively, when using NWS data, the calculation requires:

- Wind speed and direction;
- Ceiling height; and
- Cloud cover (opaque or total).

For details, refer to the AERMET or MPRM user guides on the SCRAM website.[63]

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[62] See www.epa.gov/scram001/dispersion_prefrec.htm#aermod.
[63] See www.epa.gov/scram001/metobsdata_procaccprogs.htm.

Upper Air Data

Upper air soundings measure gradients of vertical temperature in the atmosphere. The vertical temperature gradients of the lower atmosphere are used by air quality models to calculate convective mixing heights. Models require upper air sounding data from a representative measurement site. For AERMOD, consult the AERMOD Implementation Guide for specific recommendations. For CAL3QHCR, consult the MPRM user guide.

Obtaining Surface and Upper Air Meteorological Data

Meteorological data that is most representative of the project area should always be sought. Meteorological data that can be used for air quality modeling are routinely collected by the NWS. Other organizations, such as the FAA, local universities, military bases, industrial facilities, and state and local air agencies may also collect such data. Project sponsors may also choose to collect on-site data for use in PM hot-spot analyses, but it is not necessary to do so. If site-specific data are used, it should be obtained in a manner consistent with EPA guidance on the topic.[64]

There are several locations where such data can be obtained. The National Oceanic and Atmospheric Administration's National Climatic Data Center contains many years of archived surface and upper air data (www.ncdc.noaa.gov) from NWS and other sources. In addition, EPA's SCRAM web site contains archived surface and upper air data from several sources, including NWS, as well as internet links to other data sources. In addition, some states provide processed meteorological data for use in regulatory air quality modeling applications. Other local agencies and institutions may also provide meteorological data, as described above.

7.5.3 Time duration of meteorological data record

As discussed in Section 8.3.1 of Appendix W, when using meteorological data collected off-site, five years of representative meteorological data need to be used when estimating concentrations with an air quality model. Consecutive years are preferred. If meteorological data are collected on the project area prior to analysis, at least one year of site-specific data is required.[64] Consult Section 8.3.1 of Appendix W for additional explanation.

AERMOD and CAL3QHCR have different capabilities for modeling meteorological data, as illustrated in Exhibit 7-3 (following page).

[64] See Section 8.3.3 in Appendix W to 40 CFR Part 51 ("Site Specific Data") and the "Monitoring Guidance for Regulatory Modeling Applications" (www.epa.gov/scram001/metguidance.htm). Other meteorological guidance documents are also available through SCRAM, including procedures for addressing missing data and for quality assuring meteorological measurements.

Exhibit 7-3. Air Quality Model Capabilities for Meteorological Data

Type of Air Quality Model	Number of Runs Required with 5 Years of Off-Site Meteorological Data	Number of Runs Required with 1 Year of On-Site Meteorological Data
AERMOD	1	1
CAL3QHCR	20	4

AERMOD can model either five years of off-site meteorological data or one year of on-site data in a single run, since the model handles different emissions within a year and multiple years of meteorological data with a single input file.

CAL3QHCR requires different input files for each quarter that is modeled using MOVES or EMFAC, since CAL3QHCR does not distinguish between emission changes due to seasonal differences. If off-site data is used, modeling five years of consecutive meteorological data requires five runs of CAL3QHCR for each quarter. If on-site data is collected, CAL3QHCR needs to be run only once for each quarter. As a result, for most PM hot-spot analyses which will model four quarters for the analysis year(s), CAL3QHCR should be run 20 times to represent different emissions by quarter using five years of off-site meteorological data. Using one year of on-site meteorological data, it should be run four times.

7.5.4 Considering surface characteristics

In addition to surface and upper air meteorological data, three surface characteristics for the site of meteorological monitoring are needed for air quality modeling, depending on the model used:

- The surface roughness length (z_o), which indicates how much the surface features at a given site (e.g., buildings, trees, grass) interrupt a smooth-flowing wind;
- Albedo (r), which is the amount of solar radiation absorbed by the ground; and
- Bowen ratio (B_o), which indicates how much heat the ground imparts to the air.

AERMOD and AERMET make use of these parameters directly. CAL3QHCR and MPRM do not require data on surrounding surfaces' albedo or Bowen ratio for modeling ambient PM concentrations, but surface roughness is an input to CAL3QHCR.[65] As described above, surface characteristics are also used to assess a meteorological monitor's representativeness.

The AERMOD Implementation Guide should be consulted for the latest information on processing land surface data, when using either AERMOD or CAL3QHCR. Although its recommendations are intended for AERMOD, they also apply to CAL3QHCR with

[65] As described in Section 4.2 of its user guide, MPRM makes use of surface roughness in calculating stability categories.

meteorological data processed by MPRM.[66] More detailed information about each of these characteristics is found in Appendix J.

Sources of data that can be used to determine appropriate surface characteristics include printed topographic and land use/land cover (LULC) maps available from the U. S. Geological Survey (USGS), aerial photos from web-based services, site visits and/or site photographs, and digitized databases of LULC data available from USGS. For specific transportation projects, detailed nearby LULC data may be developed as part of project design and engineering plans. Furthermore, some MPOs have adopted modeling techniques that estimate the land use impacts resulting from individual highway and transit projects.

LULC data may only be available for particular years in the past. As such, planning for modeling should consider how representative these data are for the year when meteorological data were collected, as well as the PM hot-spot analysis year(s).

The National Land Cover Database (NLCD) is a set of satellite-based land cover measurements that are updated periodically.[67] As of the writing of this guidance, versions of the NLCD have been released representing calendar years 1992 and 2001, with five areas/states (New England, Mississippi, South Dakota, Washington, and Southern California) being updated to reflect 2006. The AERMOD Implementation Guide currently recommends the use of 1992 NLCD data when processing meteorological data. Consult that document for the most current recommendations with regard to the use of NLCD data.[68]

7.5.5 Specifying urban or rural sources

In addition to surface characteristics, night-time dispersion in urban areas can be greater than in surrounding rural areas with similar surface characteristics as a result of the "urban heat island effect."[69] After sunset, urban areas cool at slower rates than surrounding rural areas, because buildings in urban areas slow the release of heat. Furthermore, the urban surface cover has greater capacity for storing thermal energy due to the presence of buildings and other urban structures. As a result, the vertical motion of urban air is enhanced through convection, a phenomenon lacking (or reduced) in rural areas. The magnitude of the urban heat island effect is driven by the urban-rural temperature difference that develops at night.

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[66] The CAL3QHCR user guide does not address pre-processing meteorological data, which is necessary for PM hot-spot analyses. In the absence of such information, project sponsors should rely on the AERMOD Implementation Guide when using either dispersion model.
[67] This database can be accessed at: www.mrlc.gov.
[68] The AERSURFACE model, a non-regulatory component of AERMOD, may also be used to generate information on surface roughness, albedo, and Bowen ratio. As of this writing, AERSURFACE is based on the 1992 NLCD. The latest version of AERSURFACE may be accessed via SCRAM (www.epa.gov/scram001/).
[69] The MPRM user guide refers to the "urban heat island effect" as "anthropogenic heat flux."

The implications for highway and transit projects are that the same emissions in a rural area will undergo less dispersion than the same source in an urban area, all other factors (e.g., surface characteristics, meteorology) being equal. For the purposes of a hot-spot analysis, then:

- In urban areas, sources should generally be treated as urban.
- In isolated rural nonattainment and maintenance areas (as defined by 40 CFR 93.101), sources should be modeled as rural.
- Near the edge of urban areas, additional considerations apply that should be discussed through the interagency consultation process.[70]

Modeling sources as urban or rural can have a large impact on predicted concentrations. Both AERMOD and CAL3QHCR can account for the urban/rural differences in dispersion. When sources are modeled as urban in AERMOD, the urban area's population is a required input.

For projects near or beyond the edge of an urbanized area, there may be situations where the build and no-build scenarios result in different degrees of urbanization. In these situations, sources in the build scenario might be treated as urban, while in the no-build they are treated as rural. Local data on such cases may not be universally available, although some planning agencies have adopted models that may allow the impacts of projects on population growth to be described. Given the potentially large impact of modeling sources as either urban or rural, all available information on population growth in the greater area around the project should be used when modeling projects near or beyond the edge of an urbanized area.

When using AERMOD, consult the latest version of the AERMOD Implementation Guide for additional information, including instructions on what type of population data should be used in making urban/rural determinations. When using CAL3QHCR, consult Section 7.2.3 of Appendix W for guidance on determining urban sources. Refer to Appendix J for additional information on how to handle this data for each model.

7.6 PLACING RECEPTORS

7.6.1 Overview

Receptors for conformity purposes are locations in the project area where an air quality model estimates future PM concentrations. Section 93.123(c)(1) of the conformity rule requires PM hot-spot analyses to estimate air quality concentrations at "appropriate receptor locations in the area substantially affected by the project." An "appropriate receptor location" is a location that is suitable for comparison to the relevant PM NAAQS, consistent with how the PM NAAQS are established and monitored for air

[70] Since the urban heat island is not a localized effect, but regional in character, Section 7.2.3 of Appendix W recommends that all sources within an "urban complex" be modeled as urban.

quality planning purposes.[71] Section 7.2.2 of Appendix W to 40 CFR Part 51 provides guidance on the selection of critical receptor sites for dispersion modeling applications, and recommends that receptor sites be placed with sufficient detail to estimate the highest concentrations. Placing receptors should take into account project emissions as well as other modeled sources. Project sponsors should place receptors in the project area for the relevant NAAQS consistent with applicable requirements. Data, models, and methods used in placing receptors must be discussed through the interagency consultation process (40 CFR 93.105(c)(1)(i)). Project sponsors are encouraged to consult with state and local air quality agencies and EPA, since these agencies have significant expertise in air quality modeling and monitors for the PM NAAQS.

The paragraphs below include general guidance for placing receptors for all PM NAAQS as well as additional guidance for consideration in $PM_{2.5}$ hot-spot analyses. A final summary is also included to assist conformity implementers.

7.6.2 General guidance for receptors for all PM NAAQS

The following general guidance should be followed when placing receptors for air quality modeling of all PM NAAQS. The selection of receptor sites should be determined on a case-by-case basis taking into account factors on a project-specific basis that may influence areas of expected high concentrations, such as prevailing wind directions and topography. In designing a receptor network (e.g., the entire coverage of receptors for the project area), the emphasis should be placed on resolution and location, not the total number of receptors. Design of the receptor network should also consider whether any locations within the project area should be excluded from the modeling based on a location being restricted from public access, or based on a location where a member of the public would normally be present only for a very short period of time. Examples include locations within a fenced property of a business, a median strip of a highway, a right-of-way on a limited access highway, or an approach to a tunnel.

As described in Appendix W, air quality dispersion models are more reliable for estimating the magnitude of highest concentrations somewhere within a specified area and span of time than in predicting concentrations at a specific place and time. Therefore, receptors should be sited at all locations at which high concentrations may occur, rather than simply focusing on the expected “worst case” location.

Receptor spacing in the vicinity of the source should be of sufficient resolution to capture the concentration gradients around the locations of maximum modeled concentrations. The majority of emissions from a highway or transit project will occur within several meters of the ground, and concentrations are likely to be greatest in proximity of near-ground sources. As such, receptors should be placed with finer spacing (e.g., 10-25

[71] Clean Air Act section 176(c)(1)(B) requires that transportation activities do not cause new NAAQS violations, worsen existing NAAQS violations, or delay timely attainment of the NAAQS or interim milestones in the project area. EPA interprets “NAAQS” in this provision to mean the specific NAAQS that has been established through rulemaking and monitored for designation purposes.

meters) closer to a source, and with wider spacing (e.g., 50-100 meters) farther from a source. While prevailing wind directions may influence where maximum impacts are likely to occur, receptors should also be placed in all directions surrounding a project.

Receptors should be sited as near as 3 meters from a source (e.g., the edge of a traffic lane or a source in a terminal),[72] except possibly with projects involving urban street canyons where receptors may be appropriate within 2-10 meters of a project.[73] In addition, if AERMOD is used to create a standardized receptor network (e.g., using AERMOD's Cartesian or polar grid functions), receptors may inadvertently be placed within 3 meters of a project, and subsequently modeled. Such receptors should not be used when calculating design values in most cases.

Receptors should be extended out to a sufficient distance from sources to account for emissions that affect concentrations throughout the project area, depending on the spatial extent of the project and the impacts of other modeled sources.

When completing air quality modeling for build and no-build scenarios, receptors should be placed in the same geographic locations in both scenarios so that direct comparisons can be made between design values calculated at each receptor. Receptors are first determined based on the build scenario, and then placed in the same locations in the no-build scenario (when this scenario is modeled). See Section 9 for further information regarding calculating design values in a build/no-build analysis and appropriate receptors.

7.6.3 Additional guidance for receptors for the $PM_{2.5}$ NAAQS

There are additional considerations when placing receptors for the $PM_{2.5}$ NAAQS, due to how this NAAQS was established. In the March 2006 final rule, EPA stated:

> "Quantitative hot-spot analyses for conformity purposes would consider how projects of air quality concern are predicted to impact air quality at existing and potential $PM_{2.5}$ monitor locations which are appropriate to allow the comparison of predicted $PM_{2.5}$ concentrations to the current $PM_{2.5}$ standards, based on $PM_{2.5}$ monitor siting requirements (40 CFR Part 58)." (71 FR 12471)

EPA included this language in the preamble to the March 2006 final rule so that $PM_{2.5}$ hot-spot analyses would be consistent with how the $PM_{2.5}$ NAAQS were developed, monitored, and implemented. Receptors cannot be used for $PM_{2.5}$ hot-spot analyses if they are at locations that would be inappropriate for ambient air quality monitoring purposes for the NAAQS.

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[72] This recommendation is to ensure that receptors are placed outside the immediate turbulent mixing zone of traffic. This recommendation is consistent with EPA's 1992 "Guideline for Modeling Carbon Monoxide from Roadway Intersections," EPA-454/R-92-005 (November 1992), available online at: www.epa.gov/scram001.

[73] See 40 CFR Part 58, Appendix E, Sections 4.7.1(c)(1) and 6.3(b). The interagency consultation process should be used to discuss when these provisions are relevant for a given analysis.

In general, there are two factors in the $PM_{2.5}$ monitoring regulations that need to be considered in determining the appropriateness of receptors for use in $PM_{2.5}$ hot-spot analyses. First, a receptor must be "population-oriented" in order to be appropriate for comparison to either the 24-hour or annual $PM_{2.5}$ NAAQS. Section 58.1 of the $PM_{2.5}$ monitoring regulations defines population-oriented sites as:

> "…residential areas, commercial areas, recreational areas, industrial areas where workers from more than one company are located, and other areas where a substantial number of people may spend a significant fraction of their day."

Population-orientated receptors can be determined when receptors are placed for air quality modeling. In general, most locations, especially in urban areas, are population-oriented. Receptors placed near transportation projects, therefore, will most likely be population-oriented. Also, consideration should be given to the presence of people at locations around each receptor in determining whether the receptor is population-oriented, because the concentration predicted for the receptor can represent concentrations surrounding the receptor. Changes in the project area in the future analysis year should also be considered when placing receptors. For example, if a receptor is at a location that is currently not population-oriented, but a housing development is planned for that location under the build and/or the no-build scenario, that receptor may be appropriate for comparison to the $PM_{2.5}$ NAAQS.

The second factor from the $PM_{2.5}$ monitoring regulations is only relevant for the annual $PM_{2.5}$ NAAQS. The $PM_{2.5}$ monitoring regulations require that receptors for the annual $PM_{2.5}$ NAAQS also represent "community-wide air quality." Although receptors can be placed for the annual $PM_{2.5}$ NAAQS prior to air quality modeling, further consideration is needed after air quality modeling to determine whether any of the modeled receptors are not appropriate for comparison to the annual $PM_{2.5}$ NAAQS. See Section 9.4 of this guidance for how to determine appropriate receptor locations for the annual $PM_{2.5}$ NAAQS.

7.6.4 Summary

Exhibit 7-4 summarizes the applicable parts of this guidance that can be used for receptors used in PM hot-spot analyses:

Exhibit 7-4. Guidance for Receptors in PM Hot-spot Analyses

NAAQS	**Applicable Receptor Guidance**
24-hour PM_{10} NAAQS	Section 7.6.2
24-hour $PM_{2.5}$ NAAQS	Sections 7.6.2, 7.6.3
Annual $PM_{2.5}$ NAAQS	Sections 7.6.2, 7.6.3, and 9.4
24-hour and Annual $PM_{2.5}$ NAAQS	Sections 7.6.2, 7.6.3, and 9.4

As noted above, appropriate receptor locations for the 24-hour $PM_{2.5}$ and 24-hour PM_{10} NAAQS can be determined prior to air quality modeling. All receptor locations that are consistent with the general guidance are considered appropriate for the current 24-hour PM_{10} NAAQS.[74] For the 24-hour $PM_{2.5}$ NAAQS, receptors need to be placed in locations that are consistent with the general guidance as well as be population-oriented locations. For PM hot-spot analyses involving the annual $PM_{2.5}$ NAAQS, although receptors are placed prior to air quality modeling, the additional guidance in Section 9.4 should be used for determining inappropriate receptor locations after modeling, when needed.

7.7 RUNNING THE MODEL AND OBTAINING RESULTS

After characterizing emissions from the project and nearby sources, pre-processing meteorological data, defining relevant surface characteristics, accounting for urban and rural sources, specifying receptor locations, and any other necessary model inputs, the air quality model should be run to predict concentrations. The model run should be checked for errors and evaluated for data quality and reasonableness of results (e.g., ensuring that concentrations fall with distance from sources).

Note that, before the results of either AERMOD or CAL3QHCR are ready for use in calculating design values and determining conformity (as described in Section 9), the data will have to undergo some post-processing, depending on how the data was run in the models and the NAAQS being evaluated. See Appendix J for more details.

Following completion of air quality modeling, background concentrations must be determined, as described in Section 8. Finally, the resulting concentrations at receptors should be combined with background concentrations from other sources to calculate design values, as described in Section 9.

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[74] The current 24-hour PM_{10} NAAQS was established to account for ambient air quality concentrations at receptor locations that can be accessed by one or more members of the public around homes, hospitals, schools, sidewalks, etc. Therefore, any receptor that follows the general guidance in Section 7.6.2 for placing receptors should be appropriate for comparison to the 24-hour PM_{10} NAAQS. This conformity guidance is consistent with how air quality planning and monitoring are done for this NAAQS.

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Section 8: Determining Background Concentrations from Nearby and Other Emission Sources

8.1 INTRODUCTION

This section describes how to determine background concentrations for PM hot-spot analyses. Section 93.123(c)(1) of the conformity rule states that "estimated pollutant concentrations must be based on the total emissions burden which may result from the implementation of the project, summed together with future background concentrations…." For PM hot-spot analyses, background concentrations can include "nearby sources" and "other sources" of emissions, as described further in this section. By definition, background concentrations do not include the emissions from the project itself.[75]

This section is consistent with EPA's "Guideline on Air Quality Models" (Appendix W to 40 CFR Part 51), which provides the appropriate framework for defining the elements of background concentrations. Section 8.2.1 of Appendix W states that: "Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts."[76] Concentrations are expected to vary throughout a nonattainment or maintenance area, resulting from differences in emission sources, meteorology, terrain, and other factors. The interagency consultation process must be used to determine appropriate background concentrations for each PM hot-spot analysis (40 CFR 93.105(c)(1)(i)), including how nearby sources are characterized in the build and no-build scenarios.

State and local air quality agencies will have the primary expertise on what emission sources are expected to affect background concentrations, including any nearby sources. The state or local air agency is likely to have an understanding of the project area and knowledge about information needed to appropriately characterize background concentrations, due to experience in developing air quality demonstrations, emission inventories, and siting air quality monitors for a given NAAQS. The EPA Regional Office is also a key resource for discussions regarding the air quality monitoring network, SIP modeling, and other issues.

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[75] See Sections 4 through 6 for more information on how to estimate project emissions.

[76] Section 8.2.1 also states, "Background air quality includes pollutant concentrations due to: (1) natural sources; (2) nearby sources other than the one(s) currently under consideration; and (3) unidentified sources." Section 8.2.3 recommends for "multi-source areas" that "two components of background should be determined: contributions from nearby sources and contributions from other sources."

8.2 BACKGROUND CONCENTRATIONS FROM NEARBY SOURCES

Some PM hot-spot analyses may include "nearby sources" that affect PM concentrations in the project area (e.g., a freight terminal, port, stationary source, or adjacent transportation facility).[77] Project sponsors, the relevant state or local air agency, the EPA Regional Office, and other members of the interagency consultation process should discuss:

- Are there any nearby sources in the project area? If no, then the remainder of Section 8.2 can be skipped. If yes, then:
  - Which of those sources are expected to cause significant concentration gradients in vicinity of the project or generally contribute to the air quality concentrations in the project area?
  - How much do any nearby sources emit?
  - Are emissions from any nearby sources expected to differ between the build and no-build scenarios?

- Are any of these nearby sources already captured in the background concentrations from either ambient monitoring data or existing air quality modeling (see Section 8.3)?

When nearby sources are identified, the interagency consultation process must be used for determining how best to reflect these sources in background concentrations, and how nearby source emissions will vary between the build and no-build scenarios for the analysis year(s). In most cases, the emission impacts of nearby sources will need to be explicitly modeled using the air quality models described in Section 7 of this guidance:

- There could be cases where the emissions from nearby sources change as a result of the project. An example of a project that could affect nearby sources would be a freight corridor highway project whose primary purpose is to accommodate future growth in goods movement; such a project could affect emissions from related activity at nearby marine ports, rail yards, or intermodal facilities.

- Other cases could involve nearby sources whose emissions are not expected to change as a result of the project. In most cases, these emissions would be explicitly modeled with the same results for both the build and no-build scenarios. There may be limited cases where such nearby sources may be addressed by finding suitable monitoring data that captures the impact of the source, rather than modeling the source explicitly. However, most projects will probably not be near monitors that capture the impacts of nearby sources; therefore, emissions from

[77] Section 8.2.3 of Appendix W describes "nearby sources" by stating, "All sources expected to cause a significant concentration gradient in the vicinity of the source or sources under consideration for emission limit(s) should be explicitly modeled."

nearby sources should be characterized for the time periods addressed in emissions and air quality modeling for the PM hot-spot analysis.

As discussed in Section 7.3, EPA recommends that the AERMOD model be used for any PM hot-spot analyses that involve nearby sources that need to be explicitly modeled (e.g., a highway expansion and new exit ramps to connect a highway or expressway to a major freight or intermodal terminal). If emissions from nearby sources are expected to change as a result of the project, the air quality modeling must include any reasonably expected changes in operation of the nearby source between the build and no-build scenarios when both are necessary to demonstrate conformity. Refer to Section 7 for more information about using AERMOD, placing receptors, and other information for air quality modeling.

Specific information on emissions from nearby sources should be obtained. The state and local air agency should be consulted on characterizing nearby sources. In addition, emission rates and other parameters of nearby sources should be consistent with any permits approved by the state or local air agency. For unpermitted sources, emission information should be consistent with information used by air agencies for developing emission inventories for regulatory purposes. Sections 8.1 and 8.2 of Appendix W describe the information needed to characterize the emissions of nearby sources for air quality models. For the 24-hour $PM_{2.5}$ and PM_{10} NAAQS, it is also important to consider Section 8.2.3 of Appendix W which states that it is appropriate to "model nearby sources only during those times when they, by their nature, operate at the same time as the primary source(s) being modeled." In nonattainment and maintenance areas, emission inputs for nearby point sources should be consistent with Table 8-1 in Appendix W. Finally, estimation of nearby source impacts may take into account the effectiveness of anticipated control measures in the SIP if they are already enforceable in the SIP.

8.3 OPTIONS FOR BACKGROUND CONCENTRATIONS FROM OTHER SOURCES

In addition to nearby sources, background concentrations from "other sources" must also be estimated, and there are several ways to do so as described below.[78] There are several options provided below that meet the requirements of Section 93.123(c)(1) of the conformity rule that involve using representative air quality monitoring data.

However, EPA has not included the option for calculating background concentrations from section 93.123(c)(2) of the conformity rule. This provision states that "…The future background concentration should be estimated by multiplying current background by the ratio of future to current traffic and the ratio of future to current emission factors." EPA has determined that this method is not a technically viable option for estimating background concentrations in PM hot-spot analyses. This method has been a credible option for CO hot-spot analyses, since on-road mobile sources dominate background

[78] Section 8.2.3 of Appendix W defines "contributions from other sources" as "that portion of the background attributable to all other sources (e.g., natural sources, minor sources and distant major sources)…."

concentrations and adjusting monitored concentrations according to traffic and emission factor changes is appropriate. However, using the same ratios in PM analyses is not supported and would not allow project sponsors to meet 40 CFR 93.123(c)(1) since there are many other types of sources that contribute to PM background concentrations.

8.3.1 Using ambient monitoring data to estimate background concentrations

Ambient monitoring data for PM_{10} and $PM_{2.5}$ provide an important source of information to characterize the contributions from "other sources" that are not captured by explicit modeling of nearby sources. Nonattainment and maintenance areas, and areas that surround them, have numerous sites for monitoring $PM_{2.5}$ and PM_{10} concentrations that may be appropriate for estimating background concentrations.[79] Project sponsors, relevant state or local air agencies, and the EPA Regional Office should identify the appropriate PM_{10} and $PM_{2.5}$ monitoring data, along with information on each monitor's site location, purpose, geographic scale, nearby land uses, and sampling frequency. EPA offers Air Explorer (based on Google Earth software) as a user-friendly way to identify and visualize where monitoring sites are in operation and to obtain concentration data and descriptions of the site (such as the reported scale of spatial representation).[80]

The evaluation and selection of monitoring data for use in a particular analysis should be discussed through the interagency consultation process. These discussions as well as any maps or statistical techniques used to analyze background data should be well-documented and included in the project-level conformity determination.

Project sponsors should not use monitoring data for which EPA has granted data exclusion under the Exceptional Events rule (see 40 CFR 50.14).

Using a Single Monitor

Background concentration data should be as representative as possible for the project area examined by the PM hot-spot analysis.[81] When considering monitors for use of their data as representative background concentrations, several factors should be evaluated:

- First, how does the area around the monitor location compare with the project area? Are there differences in land use or terrain between the two locations that could influence air quality in different ways? Is the monitor probe located at a

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[79] Monitors in adjacent nonattainment, maintenance, and attainment areas should also be evaluated for use in establishing background concentrations, which may be appropriate if the air quality situation at those monitors can be determined to be reasonably similar to the situation in the project area.
[80] Available online at: www.epa.gov/airexplorer/monitor_kml.htm.
[81] In particular, there should be interagency consultation prior to using any ambient monitoring data set for $PM_{2.5}$ that does not meet EPA requirements in Appendix N to 40 CFR Part 50 regarding data completeness, and any data set that reflects a sampling schedule that has been erratic or has resulted in more frequent samples in some seasons of a year than others. The guidance in Section 9 of this document assumes that the normal data completeness requirement (75% of scheduled samples in each calendar quarter of each year) has been met, and that the monitoring data is evenly distributed across the year. Deviation from these conditions may make the steps given in Section 9 inappropriate.

similar height as the project? Is the mix of emission sources around the monitor location similar to those around the project site? Does the monitor capture the influence of nearby sources? What is the purpose of the monitor, and what geographic scale of representation does the monitor have? Monitors should be selected that are more representative of the project area whenever possible.

- Second, how far is the monitor from the project area? Monitors closer to the project are more likely to have concentrations similar to the project area, but consideration of distance alone may mask the influence of differences in the characteristics of the project area and monitored location. In addition, monitors close to a project may reflect the influence of nearby sources that are explicitly modeled along with the project. In those cases, selection of the nearest monitor may result in double-counting of emissions from nearby sources.

- Third, what are the prevailing wind patterns between the monitor(s) and the project area? Monitors that are located in directions that are frequently upwind of a project are more likely to represent a project area's background concentrations than monitors that are infrequently upwind.[82]

The simplest approach to using ambient monitoring data for estimating background concentrations in a project area is the use of data from a representative nearby monitor. However, consideration of a nearby monitor as "representative" should also consider whether it captures the influence of nearby sources. If no nearby sources are included in the air quality model, monitors located in the project area or its immediate vicinity (e.g., less than 1 km) may be considered for selection of a representative site. If one or more nearby sources are included in the air quality model, monitors outside the influence of those sources should be considered to avoid double counting their impacts. The selection of a monitor for representing background concentrations should be considered along with which nearby sources it represents and which nearby sources are explicitly modeled as part of the hot-spot analysis.

Interpolating Between Several Monitors

If, during interagency consultation, agencies conclude that no single ambient monitor is sufficiently representative of the project area, interpolating the data of several monitors surrounding the project area is also an option. The advantage of interpolation is that no single monitor is used exclusively in representing air quality for a project area. There may be projects sited in locations between large emission sources and areas several miles away with relatively low emissions, suggesting a gradient in concentrations across the nonattainment or maintenance area. If there are no nearby monitors, then background concentrations from other sources may be difficult to estimate. Interpolation is an approach that allows estimates of background concentrations for a project to take

[82] Constructing a "wind rose" can be a useful tool in examining the frequency of wind blowing from different directions**.** A wind rose is a graph that depicts the frequency of wind blowing from different directions. EPA's SCRAM website contains two programs for calculating wind statistics and wind roses, WINDROSE and WRPLOT.

advantage of monitoring data from multiple monitoring sites. Any planned interpolation methods must be discussed through the interagency consultation process.

There are several approaches to interpolation that can be used. One simple method is weighted averaging, which places greater weight on nearby monitors and uses the inverse distance between the project site and the monitor to weight each monitor. For example, suppose monitors A, B, and C surround an unmonitored location, at distances 5, 10, and 15 miles from the site, respectively, the weighting of data from monitor A:

$$Weight(A) = \frac{1}{5} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.55$$

The weighting for monitor B:

$$Weight(B) = \frac{1}{10} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.27$$

The weighting for monitor C:

$$Weight(C) = \frac{1}{15} \Big/ \left(\frac{1}{5} + \frac{1}{10} + \frac{1}{15} \right) = 0.18$$

If concentrations at A, B, and C are 10.0, 20.0, and 30.0 $\mu g/m^3$, respectively, the predicted concentration at the unmonitored site is 16.3 $\mu g/m^3$. In most situations, the inverse-distance weighted average will provide a reasonable approximation of background concentrations due to other sources. Another interpolation approach is the inverse-squared distance weighting that weights monitors based on how close they are to the project (1/distance squared).

Other, more advanced statistical methods to interpolate monitoring data may also be used, but these require significant geostatistical expertise.[83]

8.3.2 Adjusting air quality monitoring data to account for future changes in air quality

To account for future emission changes that are documented in a SIP, background concentrations based on monitored PM concentrations may be adjusted with a chemical transport model (CTM). These adjustments must be consistent with other regulatory applications of CTMs for $PM_{2.5}$ and PM_{10}. Specifically, when CTM adjustments are used, agencies should refer to EPA's "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and

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[83] EPA's MATS (www.epa.gov/ttn/scram/modelingapps_mats.htm) and BenMAP (www.epa.gov/air/benmap) models incorporate an interpolation-based approach (Voronoi Neighbor Averaging). Consult those models' documentation for further information.

Regional Haze."[84] CTMs are photochemistry models that are routinely used in regulatory analyses, including attainment demonstrations for PM SIPs.[85]

Project sponsors are not expected to operate CTMs. Rather, the results of CTMs applied by state and local air agencies should be considered to determine if relevant data are available. The state or local air agency should be consulted to determine whether and how the results of CTMs are appropriate for use in a PM hot-spot analysis. A CTM may be used to adjust background concentrations based on monitored concentrations in a current (base) year.

The absolute predictions of a CTM in a future analysis year should not be used to predict future background concentrations directly. Instead, the results of a CTM for a current (base) year and future year should be used to calculate a "relative response factor" (RRF) that reflects the relative changes in concentrations between current and future years. An RRF is calculated as:

$$RRF = \frac{\text{Concentrations in future year, predicted by CTM}}{\text{Concentrations in base year, predicted by CTM}}$$

RRFs should be calculated with the same CTM using the same meteorological data for base and future years, with different emissions for base and future years. RRFs should be calculated in a manner consistent with EPA's "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze," referenced above.

Background concentrations based on monitoring data may be adjusted to reflect conditions in an analysis year based on the following equation:

$$\text{Background Concentrations}_{\text{future year}} = \text{Background Concentrations}_{\text{base year}} \text{ x RRF}$$

To adjust background concentrations to reflect future-year conditions using a CTM, several criteria should be met.

- The CTM should have demonstrated acceptable performance using standard indicators of model performance.[86]
- There should be results of CTM runs that adequately represent both the years from which monitoring data come and the future analysis year(s).
- Any future emission reductions for sources within the CTM modeling demonstration should be based on enforceable commitments in the SIP or should

[84] This document is available online at: www.epa.gov/scram001/guidance/guide/final-03-pm-rh-guidance.pdf.
[85] Examples of commonly employed photochemical models are shown on the SCRAM website at: www.epa.gov/scram001/photochemicalindex.htm.
[86] Examples of model evaluation statistics may be found in Appendix A of the document "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze," referenced above.

be consistent with the latest planning assumptions developed through interagency consultation.

- Any future emission reductions for sources within the CTM modeling demonstration should take effect prior to the year(s) for which the PM hot-spot analysis is conducted.

Because the PM hot-spot analysis is based on a comparison of build and no-build scenarios (see Section 2.4), how the modeled estimates of a project's impacts are combined with CTM predictions for the grid cell should be approached with caution to ensure no double counting of emissions from the project. CTM predictions for a future year may already incorporate emissions that are projected as part of the no-build scenario, including those from the project area and nearby sources. In those cases, the CTM results may be considered representative of the no-build scenario. In those situations, to evaluate predicted concentrations in the build scenario, at each receptor included in the AERMOD or CAL3QHCR input file, the difference between concentrations at each receptor in the build and no-build scenarios should be calculated as:

$$\text{Difference}_{\text{receptor i}} = \text{Concentration}_{\text{receptor i, build scenario}} - \text{Concentration}_{\text{receptor i, no build scenario}}$$

The result – the difference between the build and no-build scenarios at each receptor – should be added to the CTM-adjusted background concentrations when calculating design values. Using this approach, only the changes in receptor concentrations affected by emission changes from the project or nearby sources whose emissions are changed by the project are used in calculating design values.

8.3.3 Other methods of combining ambient monitoring data and modeling results

In addition to the methods described above, there may be other techniques for combining information from monitors and air quality modeling that can be evaluated on a case-by-case basis. Any technique considered for PM hot-spot analyses must be discussed through interagency consultation (40 CFR 93.105(c)(1)(i)).

Section 9: Calculating PM Design Values and Determining Conformity

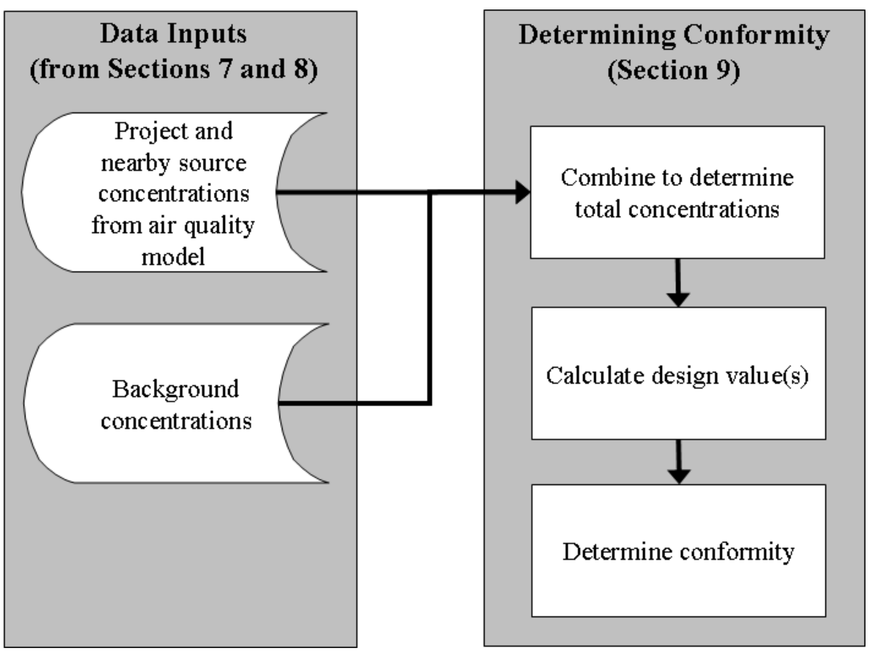
9.1 INTRODUCTION

This section describes how to combine all previous steps of a PM hot-spot analysis into a design value so that a project sponsor can determine if conformity requirements are met. For conformity purposes, a design value is a statistic that describes a future air quality concentration in the project area that can be compared to a particular NAAQS.[87] In general, design values are calculated by combining two pieces of data:

- Modeled PM concentrations from the project and any nearby sources (Sections 7 and 8); and
- Monitored background PM concentrations from other sources (Section 8).[88]

Exhibit 9-1 illustrates the conceptual flow of information described in this section, which is similar for all PM NAAQS.

Exhibit 9-1. General Process for Calculating Design Values for PM Hot-spot Analyses



[87] Design values based on monitoring data are used to determine the air quality status of a given nonattainment or maintenance area (40 CFR Part 50). Design values are also used for SIP modeling and other air quality planning purposes.

[88] Section 9 provides specific guidance on calculating design values with background concentrations from a single air quality monitor. Additional calculations and consultation would be necessary if background concentrations resulted from interpolation between several monitors.

This section describes how to calculate the specific statistical form of design values for each PM NAAQS and how to apply design values in build/no-build analyses for conformity purposes. This section also discusses how to determine which receptors for a particular project may or may not be appropriate for comparison to the annual $PM_{2.5}$ NAAQS.

This guidance is consistent with how design values are calculated for designations and other air quality planning purposes for each PM NAAQS.[89] EPA is considering whether spreadsheet tools can be developed to assist state and local agencies in calculating design values for PM hot-spot analyses.

The interagency consultation process must be used to determine the data, models, and methods used for PM hot-spot analyses, including those used in calculating design values and completing build/no-build analyses (40 CFR 93.105(c)(1)(i)). State and local air quality agencies and EPA have significant expertise in air quality planning that may be useful resources for the topics covered by this section. Project sponsors should document the data and other details used for calculating design values for the build and no-build scenarios for a project-level conformity determination as well as how appropriate receptors were determined.

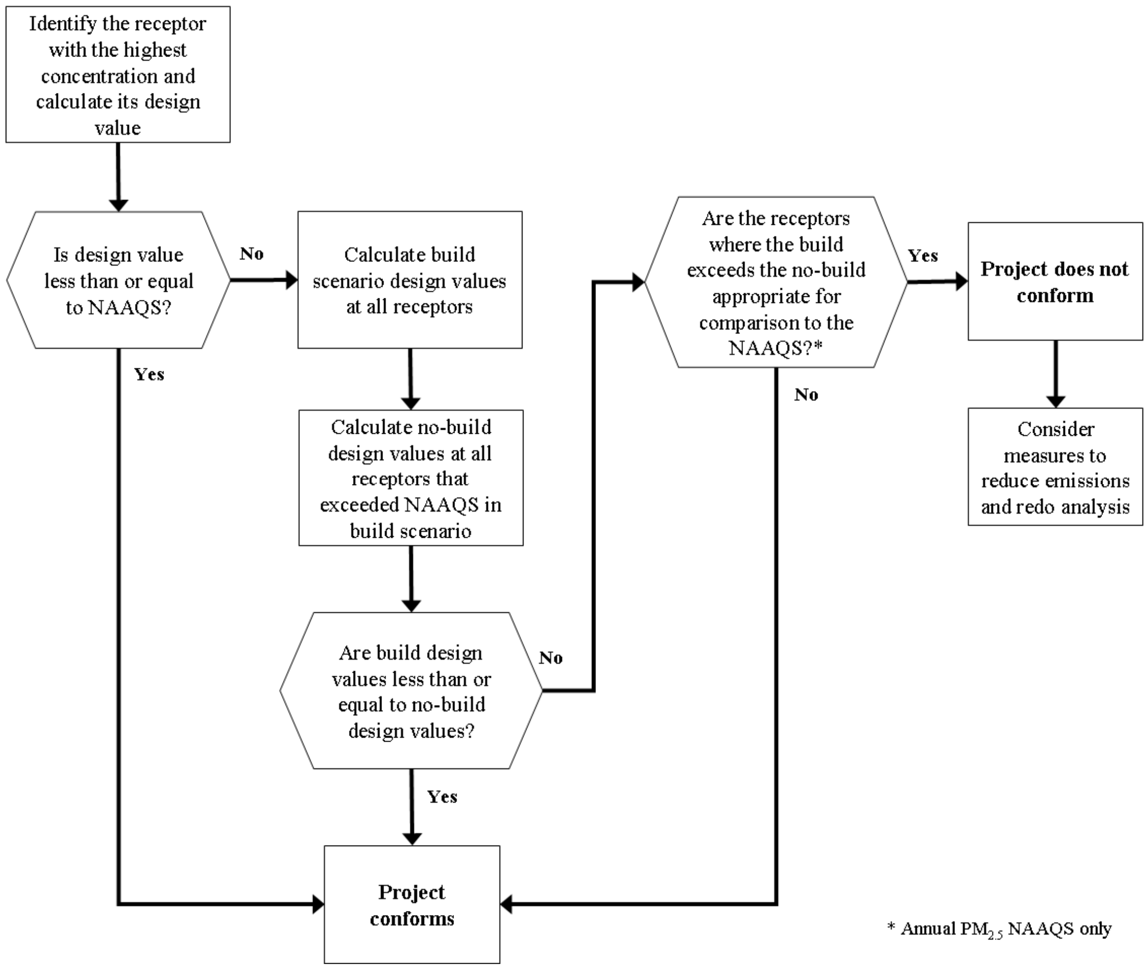
9.2 USING DESIGN VALUES IN BUILD/NO-BUILD ANALYSES

Design values are a fundamental component of PM hot-spot analyses, as they are the values compared to the NAAQS and between build and no-build scenarios. In general, a hot-spot analysis compares air quality concentrations with the proposed project (the build scenario) to air quality concentrations without the project (the no-build scenario). The conformity rule requires that the build scenario not produce any new violations of the NAAQS, increase the frequency or severity of existing violations, or delay timely attainment as compared to the no-build scenario (40 CFR 93.116(a) and 93.123(c)(1)).

Exhibit 9-2 (following page) illustrates the build/no-build analysis approach suggested in Section 2.4.

[89] Note that this section reflects the current $PM_{2.5}$ and PM_{10} NAAQS; EPA will re-evaluate the applicability of this guidance as needed, if different PM NAAQS are promulgated in the future.

Exhibit 9-2. General Process for Using Design Values in Build/No-build Analyses



In general, project sponsors could begin by determining the design value for only one receptor in the build scenario: the receptor with the highest modeled air quality concentration, as described in Section 9.3. If the design value for this receptor is less than or equal to the relevant NAAQS, it can be assumed that conformity requirements are met at all receptors in the project area, without further analysis. If this is not the case, the project sponsor should calculate the design values at all receptors in the build scenario and also model the no-build scenario. Design values should then be calculated for the no-build scenario at all receptors with design values that exceeded the NAAQS in the build scenario. Conformity requirements are met if the design value for every appropriate receptor in the build scenario is less than or equal to the same receptor in the no-build scenario.[90] If not, then the project does not meet conformity requirements without further mitigation or control measures to address air quality concentrations at such receptors, except in certain cases described below.[91]

[90] This would be the receptor at the same geographic location in the build and no-build scenarios.
[91] When mitigation or control measures are considered, additional emissions and air quality modeling would need to be completed and new design values calculated to ensure that conformity requirements are met.

A build/no-build analysis is typically based on design value comparisons done on a receptor-by-receptor basis. However, there may also be cases where a possible "new" violation at one receptor (in the build scenario) is relocated from a different receptor (in the no-build scenario). It would be necessary to calculate the design values for all receptors in the build and no-build scenarios to determine whether a "new" violation is actually a relocated violation. EPA addressed this issue in the preamble to the November 24, 1993 transportation conformity rule (58 FR 62213), where a "new" violation within the same intersection could be considered a relocated violation. Since 1993, EPA has made this interpretation only in limited cases with CO hot-spot analyses where there is a clear relationship between such changes (e.g., a reduced CO NAAQS violation is relocated from one corner of an intersection to another due to traffic-related changes from an expanded intersection). The interagency consultation process should be used to discuss any potential relocated violations in PM hot-spot analyses.

When completing air quality modeling for build and no-build scenarios, receptors should be placed in identical locations so that direct comparisons can be made between design values calculated at receptors under each scenario. Also, design values are compared to the relevant NAAQS and between build and no-build scenarios after rounding has been done, which occurs in the final steps of design value calculations.[92] Further details on rounding conventions for different PM NAAQS are included in Section 9.3 below.

Determining whether receptors are appropriate for the annual $PM_{2.5}$ NAAQS would be done after air quality modeling is completed and design values are calculated, as described further in Section 9.4. Project sponsors should refer to Section 8.3.2 for additional considerations for build/no-build analyses when chemical transportation model (CTM) results are used to adjust background concentrations for other sources. In such cases, it may be advisable to add only the difference between the build and no-build modeled concentrations at each receptor to the CTM-adjusted future background concentrations. This approach may be needed to avoid double-counting emissions.

9.3 CALCULATING DESIGN VALUES AND DETERMINING CONFORMITY FOR PM HOT-SPOT ANALYSES

9.3.1 General

As noted above, this conformity guidance is generally consistent with how design values are calculated for air quality monitoring and other EPA regulatory programs.[93]

[92] For example, conformity requirements would be met at a receptor if the final build design value is no greater than the final no-build design value, even if the pre-rounding build design value is greater than the pre-rounding no-build design value.

[93] EPA notes that design value calculations for PM hot-spot analyses involve using air quality modeling results based on either one year of on-site measured meteorological data or five years of off-site measured meteorological data, rather than three years.

Further details are included below about how design values should be calculated at receptors for build/no-build analyses, and examples of each design value calculation can be found in Appendix K of this guidance. These details and examples are primarily narrative in nature. EPA has also provided mathematical formulas of design values in Appendix K, which may be helpful for certain users.

9.3.2 Annual $PM_{2.5}$ NAAQS

Design Value

The annual $PM_{2.5}$ design value is defined as the average of three consecutive years' annual averages, each estimated using equally-weighted quarterly averages.[94] This NAAQS is met when the three-year average concentration is less than or equal to the annual $PM_{2.5}$ NAAQS (currently 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

The annual $PM_{2.5}$ NAAQS is rounded to the nearest tenth of a $\mu g/m^3$. For example, 15.049 rounds to 15.0, and 15.050 rounds to 15.1.[95] These rounding conventions should be followed when calculating design values for this NAAQS.

Necessary Data

This design value calculation assumes the project sponsor already has the following data in hand:

- Air quality modeling results: Average annual concentrations from the project and any nearby sources should be calculated from the air quality model output files.[96] The methodology for post-processing the air quality model output files will vary depending on what air quality model is used. Refer to Appendix J for details on preparing air quality model outputs for use in design value calculations.

[94] The design value for the annual $PM_{2.5}$ NAAQS is defined for air quality monitoring purposes in 40 CFR Part 50.13.
[95] 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.
[96] See Section 7.5.3 for further information on the number of years of meteorological data used in air quality modeling. For most PM hot-spot analyses, five years of meteorological data will be used.

- Air quality monitoring data: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background concentrations that meet all applicable monitoring requirements (such as data completeness).[97]

Calculating Design Values and Determining Conformity

Exhibit 9-3 (following page) illustrates how a design value is to be calculated and conformity determined for the annual $PM_{2.5}$ NAAQS. This exhibit assumes that the project sponsor would first compare the receptor with the highest average annual concentration in the build scenario to the NAAQS to determine conformity. If conformity is not met at this receptor, design values would be calculated at all receptors in the build scenario. For any receptors with design values above the NAAQS in the build scenario, the project sponsor would then model the no-build scenario and calculate design values to determine if conformity requirements are met.

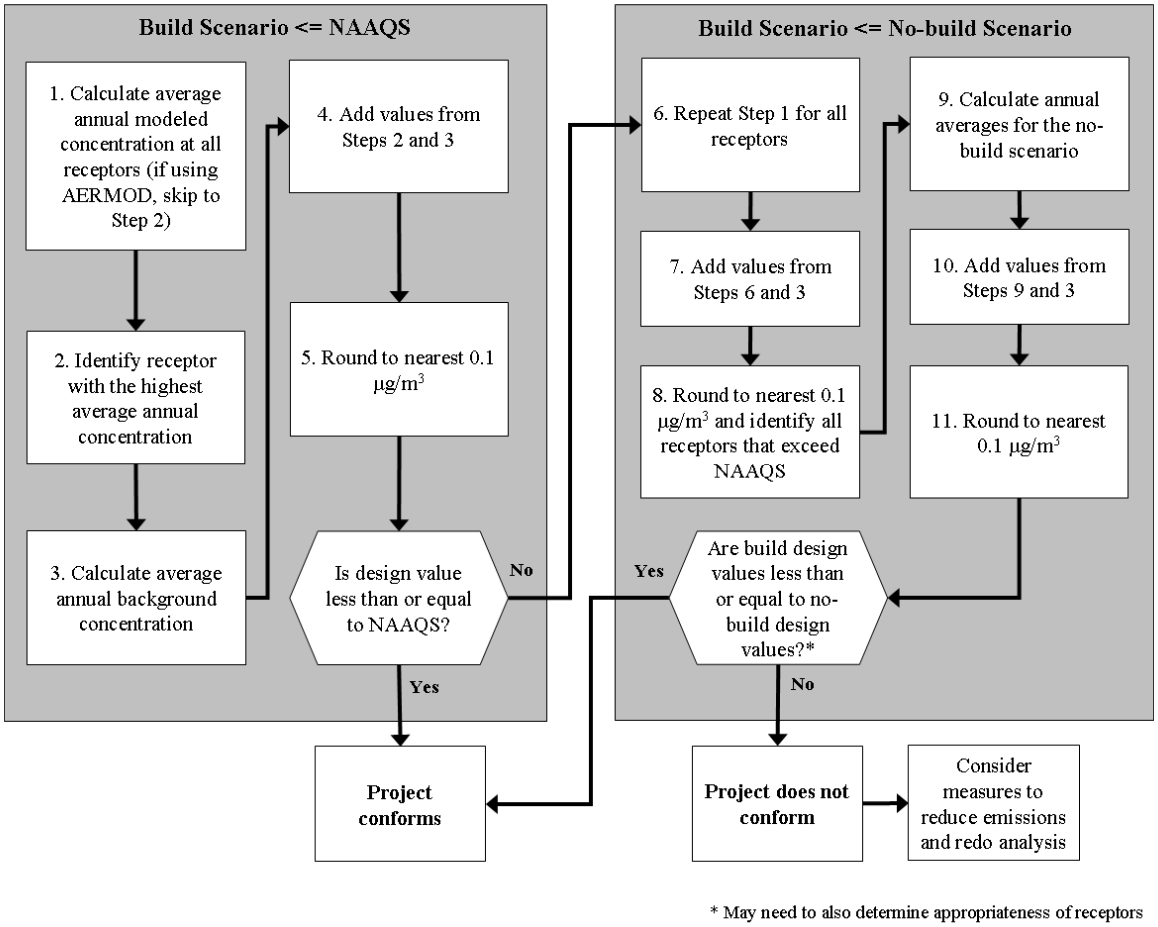
An example of how to calculate design values for the annual $PM_{2.5}$ NAAQS using this procedure is included in Appendix K. The steps below can also be described mathematically using the formulas found in Equation Set 1 in Appendix K.

The steps shown in Exhibit 9-3 are described below. The initial step is to compare the build scenario to the NAAQS to see if the project conforms:

- Step 1. For each receptor, calculate the average annual concentrations with the air quality modeling results for each quarter and year of meteorological data used. If using AERMOD, the model does this step for you and provides the average annual concentrations as output; proceed to Step 2. If using CAL3QHCR, for each year of meteorological data, first determine the average concentration in each quarter. Then, within each year of meteorological data, add the average concentrations of all four quarters and divide by four to calculate the average annual modeled concentration for each year of meteorological data. Sum the modeled average annual concentrations from each year of meteorological data, and divide by the number of years of meteorological data used.
- Step 2. Identify the receptor with the highest modeled average annual concentration.
- Step 3. For each year of background data, first determine the average monitored concentration in each quarter. Then, within each year of background data, add the average concentrations of all four quarters and divide by four to calculate the average annual background concentration for each year of monitoring data. Next, add the average annual concentrations from each of the consecutive years of monitoring data and divide by three. This value is the average annual background concentration based on monitoring data.

[97] This section does not address calculating design values with CTM-adjusted background concentrations. The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.

Exhibit 9-3. Determining Conformity to the Annual $PM_{2.5}$ NAAQS



- Step 4. Add the average annual background concentration (from Step 3) to the average annual modeled concentration at the highest receptor (from Step 2) to determine the total average annual background concentration at this receptor.
- Step 5. Round to the nearest 0.1 µg/m^3. This result is the annual $PM_{2.5}$ design value at the highest receptor in the build scenario.

The project sponsor should then compare the design value from Step 5 to the annual $PM_{2.5}$ NAAQS (currently 15.0 µg/m^3). If the value is less than or equal to the NAAQS, the project conforms. If the design value is greater than the NAAQS, the project sponsor should then continue to Step 6:

- Step 6. Repeat the calculations described in Step 1 to determine average annual concentrations for all receptors in the build scenario.
- Step 7. Add the average annual modeled concentrations (from Step 6) to the average annual background concentrations (from Step 3).[98] The result will be the total average annual concentration at each receptor in the build scenario.

[98] As discussed in Section 8, the same air quality monitoring concentrations would not be expected to change between the build and no-build scenarios. As a result, the same background concentrations would be used for every receptor in the build and no-build scenario.

- Step 8. Round to the nearest 0.1 μg/m^3. At each receptor, this value is the annual $PM_{2.5}$ design value for the build scenario. Identify all receptors that exceed the annual $PM_{2.5}$ NAAQS.
- Step 9. From the no-build air quality modeling results, calculate the average annual concentrations at each receptor identified in Step 8.
- Step 10. For the no-build scenario, add the average annual modeled concentrations for the no-build scenario (from Step 9) to the average annual background concentrations (from Step 3). The result will be the total average annual concentration for each receptor identified in Step 8 under the no-build scenario.
- Step 11. Round to the nearest 0.1 μg/m^3. This result is the annual $PM_{2.5}$ design value for each receptor identified in Step 8 under the no-build scenario.

For each receptor with a design value that exceeded the NAAQS in the build scenario, compare the build design value (Step 8) to the no-build design value (Step 11). For the project to conform, the build design value must be less than or equal to the no-build design value at each receptor in the build scenario that exceeded the NAAQS (Step 8). If this is not the case, the interagency consultation process would be used to determine if any receptors are not appropriate for conformity purposes (see Section 9.4).[99] If a build scenario design value is greater than the no-build design value at any appropriate receptor, the sponsor should then consider additional mitigation and control measures, and revise the PM hot-spot analysis accordingly. Refer to Section 10 for a discussion of potential measures.

9.3.3 24-hour $PM_{2.5}$ NAAQS

Design Value

The 24-hour $PM_{2.5}$ design value is defined as the average of three consecutive years' 98th percentile concentrations of 24-hour values for each of those years.[100] 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 μg/m^3 for nonattainment areas for the 2006 $PM_{2.5}$ NAAQS and 65 μg/m^3 for nonattainment areas for the 1997 $PM_{2.5}$ NAAQS).[101]

The design value for comparison to any 24-hour $PM_{2.5}$ NAAQS is rounded to the nearest 1 μg/m^3 (decimals 0.5 and greater are rounded up to the nearest whole number; decimals lower than 0.5 are rounded down to the nearest whole number). For example, 35.499

[99] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

[100] The design value for the 24-hour $PM_{2.5}$ NAAQS is defined for air quality monitoring purposes in 40 CFR Part 50.13.

[101] There are only two areas where conformity currently applies for both the 1997 and 2006 24-hour $PM_{2.5}$ 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.

rounds to 35 μg/m^3, while 35.500 rounds to 36.[102] These rounding conventions should be followed when calculating design values for this NAAQS.

There are two analysis options, or tiers, that are available to project sponsors to estimate a 24-hour $PM_{2.5}$ design value. Project sponsors can start with either the first or second tier analysis, since either tier is a viable approach for meeting conformity requirements. There may be cases where a project sponsor may decide to start with a first tier analysis, which is a conservative but less data intensive approach.[103] In other cases, project sponsors may decide to go directly to a second tier analysis. For example, depending on how the air quality model was run and its data post-processed, the actions required to identify the highest modeled 24-hour concentration by quarter for a second tier analysis may not involve much additional time or effort, in which case the second tier approach may be preferred from that start. Under either tier, the contributions from the project, any nearby sources, and background concentrations from other sources are combined for a given analysis year, as described further below.

Examples of how to calculate design values for the 24-hour $PM_{2.5}$ NAAQS using each tier are included in Appendix K.

<u>Necessary Data</u>

This design value calculation assumes the project sponsor already has the following data in hand:

- <u>Air quality modeling results</u>: The highest 24-hour average concentration from the project and any nearby sources should be calculated based on the air quality model output files, depending on what tier of analysis is used:
  - In a first tier analysis, the highest 24-hour values from each year of meteorological data should be averaged together.
  - In a second tier analysis, the highest 24-hour values from each quarter and year of meteorological data should be averaged together per quarter.

  Post-processing the air quality model output files will vary depending on what air quality model is used in the hot-spot analysis. Refer to Appendix J for a discussion of air quality model output file formats.
- <u>Air quality monitoring data</u>: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background

[102] 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.

[103] While less data intensive and therefore possibly quicker to execute, the first tier approach is considered more conservative as compared to the second tier analysis. The first tier approach assumes that the estimated highest predicted concentration attributable to the project and nearby sources will occur in the future on each of the days from which the three-year average 98th percentile background concentration is derived (which may not occur).

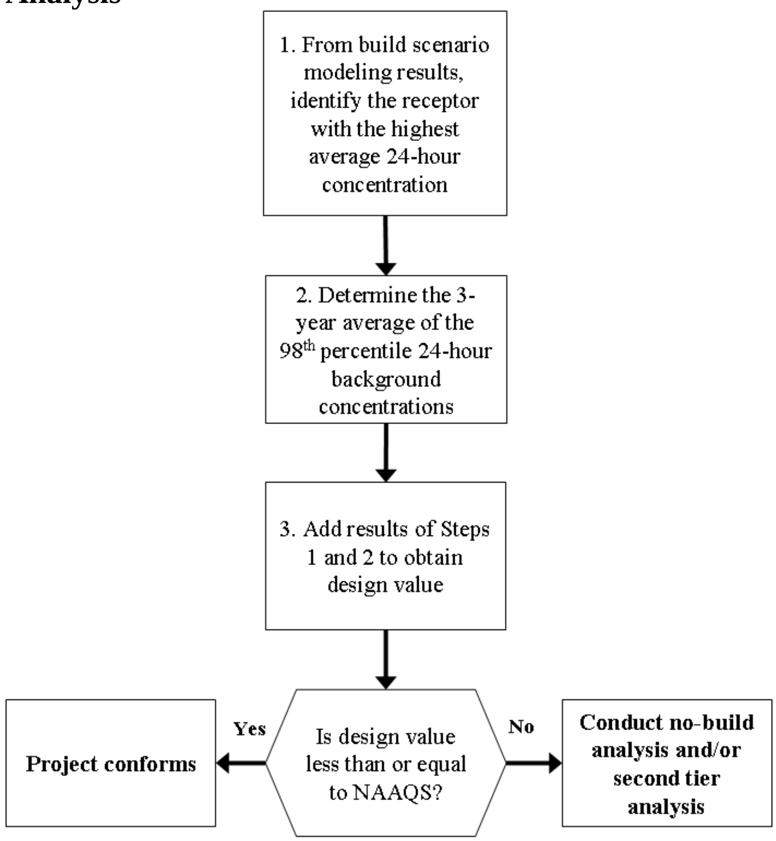
concentrations that meet all applicable monitoring requirements (such as data completeness).[104]

Calculating Design Values and Determining Conformity Using a First Tier Analysis

The first tier consists of directly adding the highest average modeled 24-hour concentrations to the average 98th percentile 24-hour background concentrations.

Exhibit 9-4 illustrates how a design value would be calculated under a first tier analysis for a given receptor. The steps shown in Exhibit 9-4 are described in detail below, and are also described mathematically using the formulas found in Equation Set 2 in Appendix K.

Exhibit 9-4. Determining Conformity to the 24-hour $PM_{2.5}$ NAAQS Using First Tier Analysis



[104] This section does not address calculating design values with CTM-adjusted background concentrations. The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.

The initial step in a first tier analysis is to compare the build scenario to the NAAQS to see if the project conforms:

- Step 1. From the air quality modeling results from the build scenario, identify the receptor with the highest average 24-hour concentration. This is done by first separating the air quality model output into each year of meteorological data. Second, for each receptor and year of meteorological data, identify the 24-hour period (midnight-to-midnight) with the highest average concentration throughout the entire year. Finally, at each receptor, calculate the average of the highest 24-hour concentrations from each year of meteorological data, and average these across all the years. The receptor with the highest value is used to calculate the 24-hour $PM_{2.5}$ design value.
- Step 2. Calculate the average 98th percentile 24-hour background concentration using the 98th percentile 24-hour concentrations of the three most recent years of air quality monitoring data. To calculate the 98th percentile background concentrations for each year of monitoring data, first count the number of 24-hour background measurements in each year. Next, order the highest eight monitoring values in each year from highest to lowest and rank each value from 1 (highest) to 8 (eighth highest). Consult Exhibit 9-5 to determine which of these eight values is the 98th percentile value. Using the results from the three years of monitoring data, calculate the three-year average of the 98th percentile concentrations.[105]

Exhibit 9-5. Ranking of 98th Percentile Background Concentration Values[106]

Number of Background Concentration Values	Rank of Value Corresponding to 98th Percentile Concentration
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

[105] Assuming a regular monitoring schedule and a resulting data set that meets the completeness requirements of 40 CFR Part 50 Appendix N, the result of Step 2 will simply be the design value for the monitoring site used to estimate the background concentrations. EPA calculates the design value for every $PM_{2.5}$ monitor each year, based on the most recent three-year period of data reported to EPA's Air Quality System. Project sponsors may use the EPA-calculated design values directly instead of executing Step 2, or may compare their result from Step 2 to the EPA-calculated design value. These design values appear in the worksheet "Site Listing" of the latest $PM_{2.5}$ design value spreadsheet posted at: www.epa.gov/airtrends/values.html.

[106] This exhibit is based on a table in Appendix N to 40 CFR Part 50, and ranks the 98th percentile of background concentrations pursuant to the total number of air quality monitoring measurements.

- <u>Step 3.</u> Add the highest average 24-hour modeled concentration (Step 1) to the average 98th percentile 24-hour background concentration (Step 2) and round to the nearest 1 μg/m^3. The result is the 24-hour $PM_{2.5}$ design value at the highest receptor in the build scenario.

If the design value calculated in Step 3 is less than or equal to the relevant 24-hour $PM_{2.5}$ NAAQS, then the project conforms. If it is greater than the 24-hour $PM_{2.5}$ NAAQS, conformity is not met, and the project sponsor has two options:

- 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;[107] or
- Conduct a second tier analysis as described below.

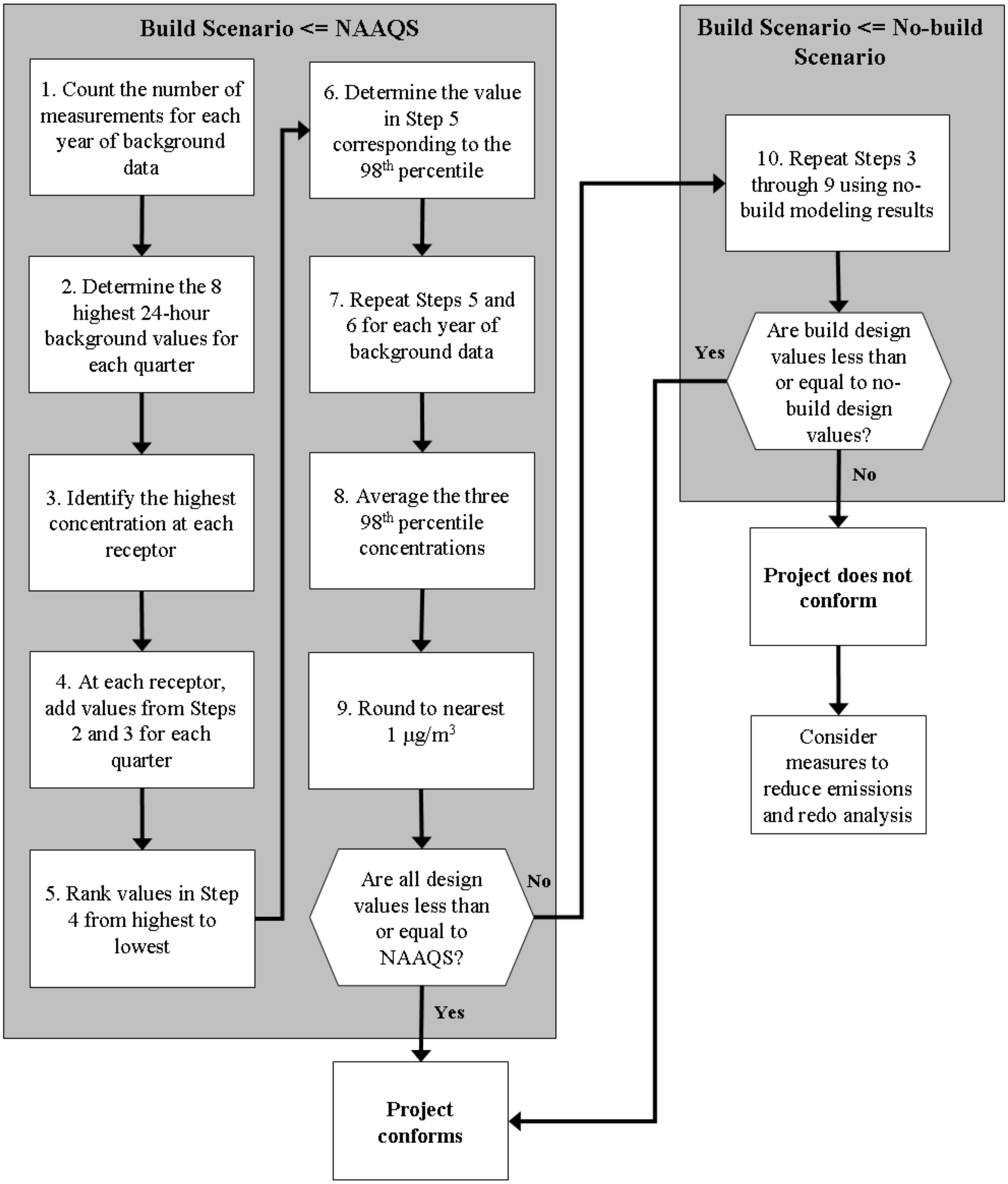
<u>Calculating Design Values and Determining Conformity Using a Second Tier Analysis</u>

The second tier involves a greater degree of analysis, in that the highest modeled concentrations and the 98th percentile background concentrations are not added together for each receptor directly, as in a first tier analysis. Unlike a first tier analysis, which uses the average of the highest modeled 24-hour concentration from <u>each year</u> of meteorological data, a second tier analysis uses the average of the highest modeled 24-hour concentration within <u>each quarter</u> of each year of meteorological data. In other words, impacts from the project, nearby sources, and other background concentrations are calculated on a quarterly basis before determining the 98th percentile concentration resulting from these inputs.

Exhibit 9-6 (following page) and the following steps provide details for calculating a design value for the 24-hour $PM_{2.5}$ NAAQS under a second tier analysis. These steps can also be described mathematically using the formulas found in Equation Set 3 in Appendix K.

[107] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

Exhibit 9-6. Determining Conformity to the 24-hour $PM_{2.5}$ NAAQS Using Second Tier Analysis



A project sponsor would initially complete these steps for the build scenario; then, if necessary, repeat the steps for the no-build scenario. Steps 1 and 2 of a second tier analysis are completed only once for all receptors, since the same background concentrations would be used for every receptor in either the build or no-build scenario.

- Step 1. Count the number of measurements for each year of monitoring data used for background concentrations for other sources.
- Step 2. For each year of monitoring data used, determine the eight highest 24-hour background concentrations for each quarter modeled. For most hot-spot analyses for the 24-hour $PM_{2.5}$ NAAQS, modeling would be completed for all four quarters of each analysis year. This would therefore result in 32 values (eight concentrations for four quarters) for each year of monitoring data.[108]

The remaining steps are completed for calculating the 24-hour $PM_{2.5}$ design value at each receptor:

- Step 3. At each receptor, identify the highest modeled 24-hour concentration in each quarter, averaged across each year of meteorological data used for air quality modeling.
- Step 4. At each receptor, add the highest modeled concentration in each quarter (from Step 3) to each of the eight highest 24-hour background concentrations for the same quarter for each year of monitoring data (from Step 2). At each receptor, this step will result in eight 24-hour concentrations in each of four quarters for a total of 32 values for each year of monitoring data.
- Step 5. For each receptor and year of monitoring data, order the 32 values from Step 4 from highest to lowest and rank each value from 1 (highest concentration) to 32 (lowest concentration).
- Step 6. Based on the number of background concentration values you have (from Step 1), use Exhibit 9-7 (following page) to determine which value in the column (from Step 5) represents the 98th percentile concentration for each receptor. For example, if you have 180 background concentration values in a year, Exhibit 9-7 shows that the 4th highest value would represent the 98th percentile. Take the value at each receptor that has this rank.
- Step 7. Repeat Step 6 for each of the three years of background monitoring data. The result will be three 24-hour 98th percentile concentrations at each receptor, one for each year of monitoring data.
- Step 8. At each receptor, calculate the average of the three 24-hour 98th percentile concentrations determined in Step 7.
- Step 9. Round the average concentrations from Step 8 to the nearest 1 $\mu g/m^3$. At each receptor, this value is the 24-hour $PM_{2.5}$ design value for the build scenario.

[108] Section 3.3.4 describes how the number of quarters modeled should be determined. In most PM hot-spot analyses for the 24-hour $PM_{2.5}$ NAAQS, all four quarters of the analysis year will be modeled. There are limited cases where modeling only one quarter would be appropriate.

Exhibit 9-7. Ranking of 98th Percentile Background Concentration Values[109]

Number of Background Concentration Values	Rank of Value Corresponding to 98th Percentile Concentration
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

Compare the design values to the relevant 24-hour $PM_{2.5}$ NAAQS. If the design values at all receptors are less than or equal to the NAAQS, then the project conforms. If this is not the case, proceed to Step 10:

- Step 10. Using modeling results for the no-build scenario, repeat Steps 3 through 9 for all receptors with a design value that exceeded the $PM_{2.5}$ NAAQS in the build scenario. The result will be a 24-hour $PM_{2.5}$ design value at such receptors for the no-build scenario.

Compare the build design values (from Step 9) to the no-build design values (from Step 10), identifying which value is higher at each receptor. For the project to conform, the build design values must be less than or equal to the no-build design value for all of the receptors that exceeded the NAAQS in the build scenario.[110] If the build scenario design value is greater than the no-build design value at any appropriate receptor, the project sponsor should then consider additional mitigation and control measures, and revise the PM hot-spot analysis accordingly. Refer to Section 10 for a discussion of potential measures.

9.3.4 24-hour PM_{10} NAAQS

Design Value

Compliance with the 24-hour PM_{10} NAAQS is based on the expected number of 24-hour exceedances of 150 $\mu g/m^3$, averaged over three consecutive years.[111] The NAAQS is met when the expected number of exceedances is less than or equal to 1.0.[112]

[109] This exhibit is based on a table in Appendix N to 40 CFR Part 50, and ranks the 98th percentile of background concentrations pursuant to the number of air quality monitoring measurements.
[110] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).
[111] The 24-hour PM_{10} NAAQS and supporting technical documentation can be found in 40 CFR Part 50.6.

The 24-hour PM_{10} NAAQS design value is rounded to the nearest 10 μg/m^3. For example, 155.511 rounds to 160, and 154.999 rounds to 150.[113] These rounding conventions should be followed when calculating design values for this NAAQS.

The contributions from the project, any nearby sources, and background concentrations from other sources are combined for a given analysis year, as described further below. Examples of how to calculate design values for the 24-hour PM_{10} NAAQS are included in Appendix K.

Necessary Data

This design value calculation assumes the project sponsor already has the following data in hand:

- Air quality modeling results: In most PM hot-spot analyses, five years of meteorological data will be used to complete air quality modeling for the project and any nearby sources.[114] In this case, the sixth-highest 24-hour modeled concentration should be calculated for each receptor.[115] Note that AERMOD can be configured to give you these values directly. CAL3QHCR output must be post-processed to obtain the sixth-highest value from five years of meteorological data. See more details below and refer to Appendix J for a discussion of air quality model output file formats.
- Air quality monitoring data: 12 quarters of background concentration measurements (four quarters for each of three consecutive years). See Section 8 for more details on determining representative monitored background concentrations that meet all applicable monitoring requirements (such as data completeness).[116]

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[112] The term "expected" means that the actual number of observed exceedances is adjusted upwards when observations are missing for some days, to reflect the air quality statistically expected for those days. The design value for the 24-hour PM_{10} NAAQS is the next highest observed (monitored or modeled) concentration after the concentrations that could be above 150 μg/m^3 without causing the expected number of exceedances to be greater than 1.0.

[113] 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.

[114] Section 7.5.3 of this guidance provides further information on the number of years of meteorological data used in air quality modeling.

[115] See description in Section 7.2.1.1 of Appendix W. Users with one year of on-site meteorological data should select the 2nd highest 24-hour PM_{10} concentration. If using less than one year of meteorological data (such as one quarter), users should select the highest 24-hour concentration.

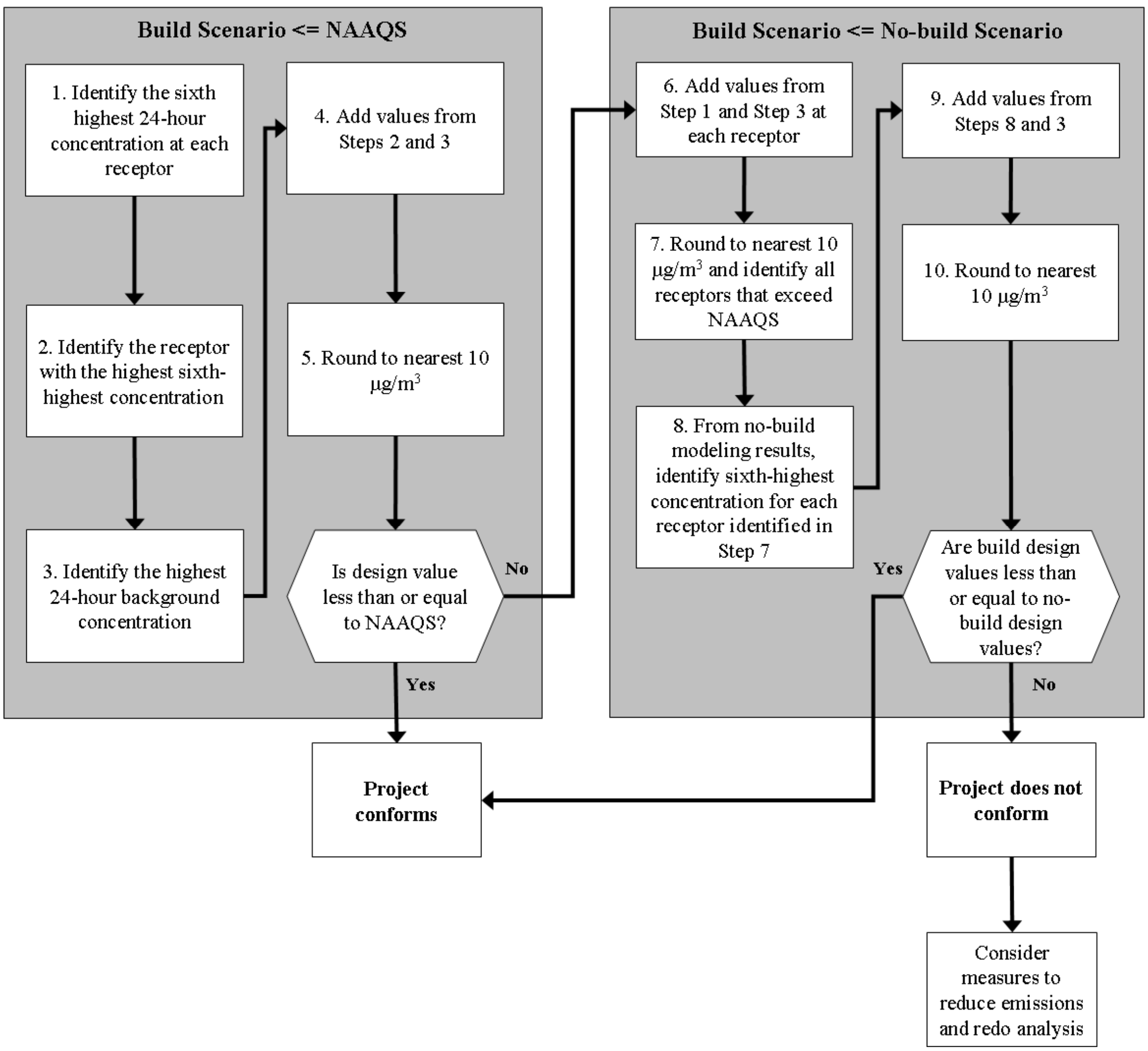
[116] This section does not address calculating design values with CTM-adjusted background concentrations. The interagency consultation process should be used when situations require incorporation of any CTM results into design value calculations.

Calculating Design Values and Determining Conformity

The 24-hour PM_{10} design value is calculated at each receptor by directly adding the sixth-highest modeled 24-hour concentrations (if using five years of meteorological data) to the highest 24-hour background concentration (from three years of monitoring data).

Exhibit 9-8 illustrates how a design value would be calculated. The steps shown in Exhibit 9-8 are described in detail below and are also described mathematically using the formulas found in Equation Set 4 in Appendix K.

Exhibit 9-8. Determining Conformity to the 24-hour PM_{10} NAAQS



The initial step is to compare the build scenario to the NAAQS to see if the project conforms:

- <u>Step 1.</u> From the air quality modeling results for the build scenario, identify the sixth-highest 24-hour concentration for each receptor (across five years of meteorological data, in most cases). When using AERMOD, the model can be configured to produce these values.[117] When using CAL3QHCR, output must be post-processed to obtain the sixth-highest values from five years of meteorological data.
- <u>Step 2.</u> Identify the receptor with the highest sixth-highest 24-hour concentration. That is, compare the sixth-highest modeled concentrations (i.e., the concentrations at Rank 6) across receptors and identify the receptor with the highest value at Rank 6.
- <u>Step 3.</u> Identify the highest 24-hour background concentration from the three most recent years of air quality monitoring data.
- <u>Step 4.</u> For the receptor identified in Step 2, add the sixth-highest 24-hour modeled concentration to the highest 24-hour background concentration (from Step 3).
- <u>Step 5.</u> Round to the nearest 10 $\mu g/m^3$. The result is the highest 24-hour PM_{10} design value in the build scenario.

The project sponsor should then compare the design value from Step 5 to the 24-hour PM_{10} NAAQS (150 $\mu g/m^3$). If the design value calculated in Step 5 is less than or equal to the NAAQS, the project conforms. If the design value is greater than the NAAQS, the project sponsor should then continue to Step 6:

- <u>Step 6.</u> For each receptor in the build scenario, add the sixth-highest 24-hour modeled concentration (from Step 1) to the highest 24-hour background concentration from the three most recent years of air quality monitoring data (from Step 3).
- <u>Step 7.</u> Round to the nearest 10 $\mu g/m^3$. At each receptor, this value is the 24-hour PM_{10} design value for the build scenario. Identify all receptors that exceed the 24-hour PM_{10} NAAQS.
- <u>Step 8.</u> From the no-build air quality modeling results, identify the sixth-highest 24-hour concentration for each receptor identified in Step 7.
- <u>Step 9.</u> Add the sixth-highest 24-hour modeled concentration in the no-build scenario (from Step 8) to the highest 24-hour background concentration from the three most recent years of air quality monitoring data (from Step 3).
- <u>Step 10.</u> Round to the nearest 10 $\mu g/m^3$. The result is the 24-hour PM_{10} design value under the no-build scenario for each receptor identified in Step 7.

For each receptor with a design value that exceeded the NAAQS in the build scenario, compare the build design value (from Step 7) to the no-build design value (from Step 10). For the project to conform, the build design value must be less than or equal to the no-build design value at each receptor in the build scenario that exceeded the NAAQS (Step

[117] For example, users could employ the RECTABLE keyword in the AERMOD output pathway. See Appendix J to this guidance for further information.

7).[118] If the build scenario design value is greater than the no-build design value at any appropriate receptor, the project sponsor should then consider additional mitigation and control measures, and revise the PM hot-spot analysis accordingly. Refer to Section 10 for a discussion of potential measures.

More advanced methods of calculating a PM_{10} design value, such as combining modeled and monitored concentrations on a quarterly basis, may be considered on a case-by-case basis. The decision to pursue an alternative method should be decided through interagency consultation.

9.4 DETERMINING APPROPRIATE RECEPTORS FOR COMPARISON TO THE ANNUAL $PM_{2.5}$ NAAQS

9.4.1 General

When hot-spot analyses are done for the annual $PM_{2.5}$ NAAQS, there is an additional step that may be necessary to determine whether a receptor is appropriate to compare to this NAAQS. In the March 2006 final rule, EPA stated:

> "Quantitative hot-spot analyses for conformity purposes would consider how projects of air quality concern are predicted to impact air quality at existing and potential $PM_{2.5}$ monitor locations which are appropriate to allow the comparison of predicted $PM_{2.5}$ concentrations to the current $PM_{2.5}$ standards, based on $PM_{2.5}$ monitor siting requirements (40 CFR Part 58)." (71 FR 12471)

EPA included this language in the preamble to the March 2006 final rule so that $PM_{2.5}$ hot-spot analyses would be consistent with how the $PM_{2.5}$ NAAQS are developed, monitored, and implemented. Receptors cannot be used for $PM_{2.5}$ hot-spot analyses if they are at locations that would not be appropriate for air quality monitoring purposes for the NAAQS. If conformity requirements are met at all receptors, it is unnecessary to determine whether receptors are appropriate for comparison to the annual $PM_{2.5}$ NAAQS; in such a case, project sponsors can conclude that conformity requirements are met at all appropriate receptors.

An "appropriate receptor location" under Section 93.123(c)(1) of the conformity rule is a location that is suitable for comparison to the relevant NAAQS, consistent with how the PM NAAQS are established and monitored for air quality planning purposes.[119]

[118] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

[119] See Clean Air Act section 176(c)(1)(B). EPA interprets "NAAQS" in this provision to mean the specific NAAQS that has been established through rulemaking and monitored for designations purposes.

9.4.2 Factors for appropriate receptors for comparison to the annual $PM_{2.5}$ NAAQS

As discussed in Section 7.6, receptors can be placed prior to air quality modeling for all PM NAAQS. Furthermore, the appropriateness of receptor locations for the 24-hour $PM_{2.5}$ NAAQS (and the 24-hour PM_{10} NAAQS) can be determined prior to air quality modeling. However, for the annual $PM_{2.5}$ NAAQS, appropriate receptors should be determined after air quality modeling is completed. The paragraphs below provide additional guidance when calculating design values and determining conformity for the annual $PM_{2.5}$ NAAQS, through the steps described in Section 9.3.2.

There are generally two factors in the $PM_{2.5}$ monitoring regulations that need to be considered in determining the appropriateness of receptors for use in $PM_{2.5}$ hot-spot analyses:

- Population-orientation: A receptor must be "population-oriented" in order to be appropriate for comparison to either the 24-hour or annual $PM_{2.5}$ NAAQS.[120] This factor can be addressed when placing receptors prior to air quality modeling (see Section 7.6).
- Community-wide air quality: A receptor for the annual $PM_{2.5}$ NAAQS must also represent "community-wide air quality;" this factor does not have to be satisfied for the 24-hour $PM_{2.5}$ NAAQS.

Section 9.3.2 includes an approach for conducting build/no-build analyses for the annual $PM_{2.5}$ NAAQS, in which the appropriateness of receptors is determined only in cases where a design value in the build scenario is higher than the NAAQS and the design value in the no-build scenario. As noted above, if conformity requirements are met at all receptors, it is unnecessary to determine whether receptors are not appropriate for comparison to the annual $PM_{2.5}$ NAAQS; in such a case, project sponsors can conclude that conformity requirements are met at all appropriate receptors.

The interagency consultation process must be used to discuss the data and methods in PM hot-spot analyses (40 CFR 93.105(c)(1)(i)), including appropriate receptor locations for the annual $PM_{2.5}$ NAAQS. State and local air quality agencies and EPA have significant expertise in air quality planning and monitoring purposes that may be useful resources in determining appropriate receptor locations for the annual $PM_{2.5}$ NAAQS. For example, under the $PM_{2.5}$ monitoring regulations, the EPA Regional Offices determine whether micro or middle scale $PM_{2.5}$ air quality monitors are eligible for comparison to the annual $PM_{2.5}$ NAAQS, as discussed further below.

9.4.3 Overview of $PM_{2.5}$ monitoring regulations

The annual $PM_{2.5}$ NAAQS was established to capture air quality concentrations over larger areas that represent "community-wide air quality."[121] Therefore, an appropriate

[120] See 40 CFR 58.1.

[121] The 1997 annual $PM_{2.5}$ NAAQS was primarily based on health studies using neighborhood and larger scale air quality monitoring data (62 FR 38651-38760).

receptor for hot-spot analyses for this NAAQS must also represent community-wide air quality. There are several parts of the $PM_{2.5}$ monitoring regulations that describe how an existing or potential monitor location can represent community-wide air quality, and EPA will rely on this same information for determining appropriate receptor locations for conformity purposes. Like ambient $PM_{2.5}$ monitoring sites, not every receptor may be appropriate for comparing a predicted design value with the annual $PM_{2.5}$ NAAQS.

Air quality monitors that represent community-wide air quality and are compared to the annual $PM_{2.5}$ NAAQS typically are of neighborhood and larger scales, as defined by the $PM_{2.5}$ monitoring regulations. Section 4.7.1(b) of Appendix D to 40 CFR Part 58 states:

> "The required monitoring stations or sites must be sited to represent community-wide air quality….These monitoring stations will typically be at neighborhood or urban scale."

Therefore, conformity requirements must be met at any receptor that is at a location that would also be appropriate for an existing or potential neighborhood or larger scale air quality monitor for the annual $PM_{2.5}$ NAAQS. In general, population-oriented receptors that are farther away from the project would be similar to potential neighborhood or larger scale monitoring sites, and would be representative of community-wide air quality in all PM hot-spot analyses.

The $PM_{2.5}$ monitoring regulations also address when smaller scale locations are considered to represent community-wide air quality and can be compared to the annual $PM_{2.5}$ NAAQS. Section 58.30(a) of the regulations states:

> "(1) $PM_{2.5}$ data that are representative, not of areawide but rather, of relatively unique population-oriented microscale, or localized hot-spot, or unique population-oriented middle-scale impact sites are only eligible for comparison to the 24-hour $PM_{2.5}$ NAAQS; and
> (2) There are cases where certain population-oriented micro scale or middle scale $PM_{2.5}$ monitoring sites are determined by the Regional Administrator to collectively identify a larger region of localized high ambient $PM_{2.5}$ concentrations. In those cases, data from these population-oriented sites would be eligible for comparison to the annual $PM_{2.5}$ NAAQS."

Other parts of the $PM_{2.5}$ monitoring regulations also address middle and micro scale locations. Section 4.7.1(b) of Appendix D to 40 CFR Part 58 states:

> "… in certain instances where population-oriented micro- or middle-scale $PM_{2.5}$ monitoring are determined by the Regional Administrator to represent many such locations throughout a metropolitan area, these smaller scales can be considered to represent community-wide air quality."

Section 4.7.1(c)(1) and (2) note that sites very close to individual sources, such as traffic corridors in urban areas, may be appropriate sites for locating $PM_{2.5}$ monitors that represent community-wide air quality:

> "In some circumstances, the microscale is appropriate for particulate sites; community-oriented…sites measured at the microscale level should, however, be limited to urban sites that are representative of long-term human exposure and of many such microenvironments in the area."
>
> "In many situations, monitoring sites that are representative of microscale or middle-scale impacts are not unique and are representative of many similar situations. This can occur along traffic corridors or other locations in a residential district. In this case, one location is representative of a number of small scale sites and is appropriate for evaluation of long-term or chronic effects."

In general, receptors that are closer to a project would be similar to potential micro and middle scale air quality monitoring sites, and would be appropriate for comparison to the annual $PM_{2.5}$ NAAQS if they represent community-wide air quality.

9.4.4 Conformity guidance for all projects in annual $PM_{2.5}$ NAAQS areas

<u>Receptors at Neighborhood or Larger Scale Locations</u>

As described above, all population-oriented receptors at locations where a neighborhood or larger scale monitor could be located are appropriate for comparison to the annual $PM_{2.5}$ NAAQS in a $PM_{2.5}$ hot-spot analysis. In general, receptors farther away from any transportation project (e.g., 100 meters or more away from a larger highway project) would represent neighborhood scale locations under the $PM_{2.5}$ monitoring regulations. The $PM_{2.5}$ monitoring regulations do not provide further specific information for determining neighborhood or larger scale locations for PM hot-spot analyses. However, Figure E-1 in Appendix E of 40 CFR Part 58 specifies distances from a roadside where monitors of different scales may be located relative to a highway or intersection. See Section 9.4.5 for further information on when a receptor represents neighborhood and larger scale locations for these types of projects.

<u>Receptors at Micro or Middle Scale Locations</u>

As described above, population-oriented receptors that are at locations where a micro or middle scale monitor could be located are appropriate for comparison to the annual $PM_{2.5}$ NAAQS, if they represent community-wide air quality. In general, a receptor or collection of receptors closer to any project (e.g., 100 meters or less from a larger highway project) would represent community-wide air quality and be appropriate for the annual $PM_{2.5}$ NAAQS if such receptor(s) collectively identify a larger region of localized high $PM_{2.5}$ concentrations and are not within a unique location(s).

The $PM_{2.5}$ monitoring regulations do not provide further information for determining when micro or middle scale locations are appropriate for PM hot-spot analyses. However, the air quality modeling results for the PM hot-spot analysis will provide critical information for determining whether there is a large region of high $PM_{2.5}$ concentrations, especially if high concentrations are predicted in a large number of adjacent receptors. In addition, a unique location may involve a portion of a project area that involves concentrations, land uses, development, or a transportation project not like other locations in the nonattainment or maintenance area. In addition, Figure E-1 in Appendix E of 40 CFR Part 58 specifies distances from a roadside where monitors of different scales may be located relative to a highway or intersection. See Section 9.4.5 for further information on when a receptor represents a micro or middle scale location for these types of projects.

The following are examples of micro and middle scale locations where receptors may represent community-wide air quality and be compared to the annual $PM_{2.5}$ NAAQS:

- Locations with characteristics (e.g., land use and development patterns, emission sources, and/or populations) that are similar to locations where existing air quality monitors are sited that are eligible for use in annual $PM_{2.5}$ designations;
- Locations where similar high annual $PM_{2.5}$ concentrations are modeled in the PM hot-spot analysis at adjacent receptors that cover a sufficiently large populated area; and
- Locations along urban highway corridors in residential areas that are not considered unique and involve areas with large neighborhoods, schools, etc.

The following are examples of micro and middle scale locations where receptors may not be appropriate to compare to the annual $PM_{2.5}$ NAAQS:

- Locations with characteristics (e.g., land use and development patterns, emission sources, and/or populations) that are similar to locations where existing air quality monitors are sited that are not eligible for use in annual $PM_{2.5}$ designations;
- Locations where uniquely high annual $PM_{2.5}$ concentrations at one or a few adjacent receptors are modeled in the PM hot-spot analysis in small isolated portions of the greater project area; and
- Locations closer to the project than neighborhood or larger scale that would be considered unique under the $PM_{2.5}$ monitoring regulations, such as locations within 100 meters of a new or expanded transit terminal where no other such terminals exist in the nonattainment or maintenance area.

The interagency consultation process would be used to determine when a receptor at a micro or middle scale location is not appropriate for comparison to the annual $PM_{2.5}$ NAAQS. The above examples are illustrative in nature, and may not reflect of a specific PM hot-spot analysis. A case-by-case review of each situation is necessary to ensure that PM hot-spot analyses for the annual $PM_{2.5}$ NAAQS meet applicable requirements.

Additional Considerations and Techniques

Decisions about whether receptors are appropriate for the annual $PM_{2.5}$ NAAQS for conformity purposes cannot be determined based on existing conditions in the project area. Receptors will be at the same locations in the build and no-build scenarios, but the decision on whether a receptor represents community-wide air quality should be based on information for the build scenario. Any differences between the build and no-build scenarios should be documented. For example, anticipated changes in the number of populated areas within the project area such as zoned or platted housing or commercial developments should be described.

To assist project sponsors, it is recommended that the locations of populations, businesses, other institutions, any air quality monitors, and predicted receptor concentrations and other relevant concentration data be displayed on a map along with the project area, whenever possible. Such a map may help visualize locations where receptors are population-oriented, and determine whether particular receptor concentrations represent small, unique areas (and therefore are not appropriate for the annual $PM_{2.5}$ NAAQS), or represent "a larger region of localized high $PM_{2.5}$ concentrations" (and therefore are appropriate for the annual $PM_{2.5}$ NAAQS).

EPA notes that every air quality model produces estimates of concentrations at each receptor. There are several common visualization techniques in the air quality modeling and geography professions that are likely to be useful ways of displaying receptor concentrations, such as contour plots, surface plots, and maps generated using geographic information systems (GIS). Many computer programs can generate these types of graphics.

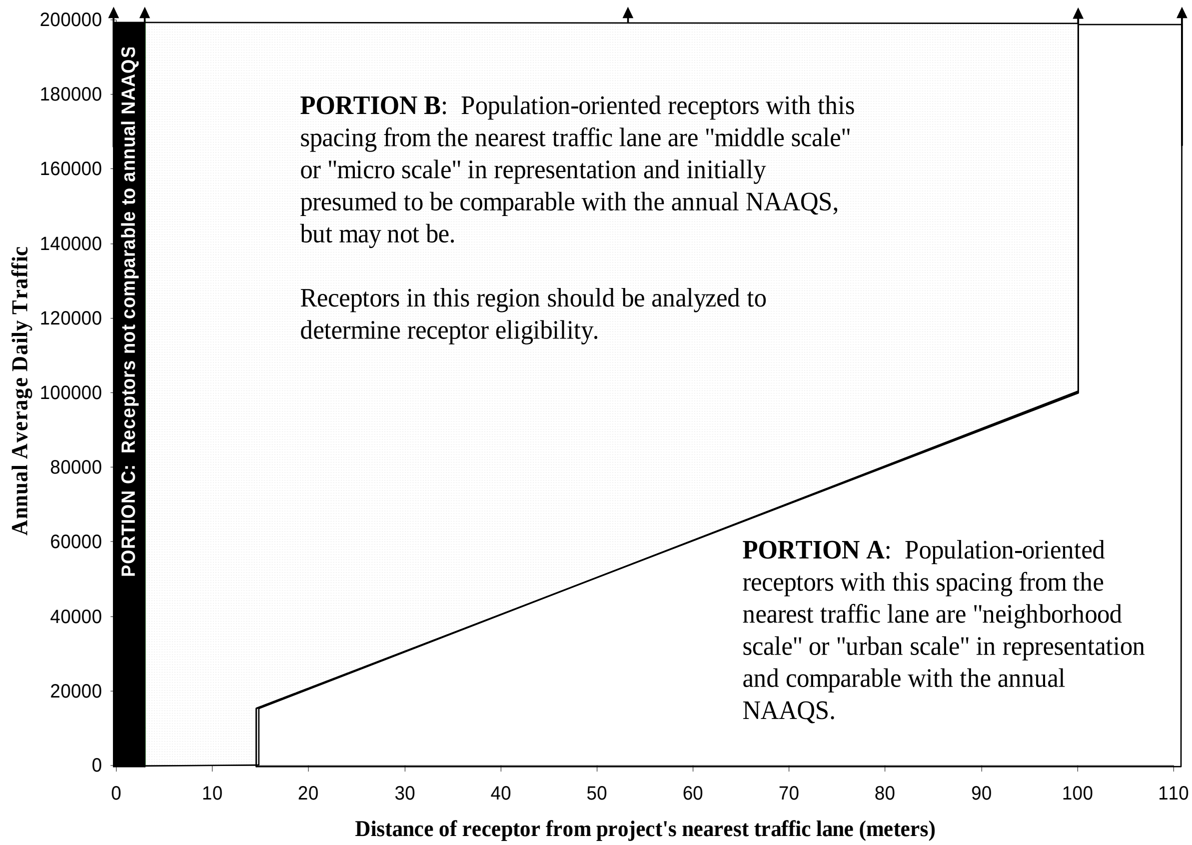
9.4.5 Additional conformity guidance for the annual $PM_{2.5}$ NAAQS and highway and intersection projects

As noted above, Appendix E of the $PM_{2.5}$ monitoring regulation provides further information to determine whether a receptor represents a micro, middle, neighborhood, or larger scale location for highway and intersection projects. Exhibit 9-9 (following page) is a helpful guide in determining what receptor locations could be considered neighborhood scale, and thus always appropriate for comparison to the annual $PM_{2.5}$ NAAQS in PM hot-spot analyses.[122] This exhibit could also help implementers identify what receptor locations could be considered micro and middle scale.

Exhibit 9-9 categorizes population-oriented receptors into Portion A, Portion B, and Portion C, expressed as annual average daily traffic (AADT) and the distance of receptors from a proposed highway or intersection location.

[122] Exhibit 9-9 is adapted from Figure E-1 in Appendix E of 40 CFR Part 51.

Exhibit 9-9. Determining Scale of Receptor Locations for the Annual $PM_{2.5}$ NAAQS



Note: Exhibit 9-9 does not apply to receptors near projects that consist of terminals, garages, or other non-road emission sources, such as transit terminals, bus garages, and intermodal freight terminals. In addition, Exhibit 9-9 does not apply when evaluating receptors that capture the impacts of nearby sources that do not involve highways and intersections, since such projects do not involve AADT data. The interagency consultation process should be used to discuss appropriate receptors for projects not covered by the above exhibit.

<u>Portion A</u>

Receptors at these locations are considered appropriate for comparison to the annual $PM_{2.5}$ NAAQS because they represent locations that would be considered neighborhood scale locations under the $PM_{2.5}$ monitoring regulations. In addition, any receptor farther than 100 meters from the nearest lane of traffic is comparable to the annual $PM_{2.5}$ NAAQS, regardless of AADT. Neighborhood or urban scale monitoring sites are always compared to the annual $PM_{2.5}$ NAAQS.

Receptors in Portion A are at least 10 meters away from the project's nearest lane of traffic for every 10,000 AADT for a project. For example, if a highway has 80,000 AADT, any receptor presumed to be comparable to the annual $PM_{2.5}$ NAAQS at neighborhood and larger scales must be located at least 80 meters from the project's nearest lane of traffic. Again, any receptor farther than 100 meters from the nearest lane of traffic is comparable to the annual NAAQS, regardless of AADT.

Portion B

Receptors at these locations need further evaluation to determine if they are not appropriate for comparison to the annual $PM_{2.5}$ NAAQS because they represent micro and middle scale locations under the $PM_{2.5}$ monitoring regulations. Micro and middle scale monitoring sites are compared to the annual $PM_{2.5}$ NAAQS if they represent community-wide air quality, as described above.

Receptors in Portion B of Exhibit 9-9 would initially be modeled with respect to the annual $PM_{2.5}$ NAAQS; subsequent analysis could then be used to determine whether certain receptors or groups of receptors are appropriate for comparison to the annual $PM_{2.5}$ NAAQS (i.e., to determine whether such locations do or do not represent community-wide air quality).

Portion C

Receptors within 3 meters of a highway or transit project are not considered appropriate for comparison to any NAAQS, including the annual $PM_{2.5}$ NAAQS, except possibly with projects involving urban canyons where receptors may be appropriate for comparison to both $PM_{2.5}$ NAAQS within 2-10 meters of a project.[123]

9.5 DOCUMENTING CONFORMITY DETERMINATION RESULTS

Once a PM hot-spot analysis is completed, details need to be documented in the conformity determination. See Section 3.10 for more information on properly documenting a PM hot-spot analysis, including modeling data, assumptions, and results. Any questions about what information needs to be documented should be handled through interagency consultation.

[123] See 40 CFR Part 58, Appendix E, Section 6.3(b).

Section 10: Mitigation and Control Measures

10.1 INTRODUCTION

This section describes mitigation and control measures that could be considered by project sponsors to reduce emissions and any predicted new or worsened PM NAAQS violations. These measures can be applied to the transportation project itself, or other PM sources in the project area. Written commitments for mitigation or control measures must be obtained from the project sponsor and/or operator, or other emission source's owner and/or operator, as appropriate, prior to making a project-level conformity determination (40 CFR 93.123(c)(4) and 93.125(a)). If measures are selected, additional emissions and air quality modeling will need to be completed and new design values calculated to ensure that conformity requirements are met.

The following information provides more details on potential measures for PM hot-spot analyses; others may be possible. The interagency consultation process should be used to discuss any measures that are relied upon in the PM hot-spot analysis. The models, methods, and assumptions used to quantify reductions should be documented in the final project-level conformity determination.

General categories of mitigation and control measures that could be considered include:

- Retrofitting, replacing vehicles/engines, and using cleaner fuels;
- Reducing idling;
- Redesigning the transportation project itself;
- Controlling fugitive dust; and
- Controlling other sources of emissions.

More information is provided for each of these categories below.

10.2 MITIGATION AND CONTROL MEASURES BY CATEGORY

10.2.1 Retrofitting, replacing vehicles/engines, and using cleaner fuels

- The installation of retrofit devices on older, higher emitting vehicles is one way to reduce emissions. Retrofit devices such as Diesel Particulate Filters (DPFs) or Diesel Oxidation Catalysts (DOCs) can be installed on diesel truck or bus fleets, and off-road construction equipment when applicable to lower emissions cost-effectively.[124]

- Replacing older engines with newer, cleaner engines, including engines powered by compressed natural gas (CNG), liquefied natural gas (LNG), biodiesel, or

[124] It would be appropriate to replace or retrofit construction equipment in those cases where construction emissions are included in the analysis (i.e., when construction emissions are not considered temporary).

electricity is another way to reduce emissions from existing diesel truck or bus fleets. Many engines can also benefit from being rebuilt, repaired, upgraded to a more recent standard, and properly maintained. The emission reduction calculations should take into account whether retired vehicles or engines are permanently scrapped.

- The accelerated retirement or replacement of older heavy-duty diesel vehicles with cleaner vehicles is another way to reduce emissions. A replacement program could apply to buses, trucks, or construction equipment.[125] In some areas, local regulations to ban older trucks at specific port facilities have encouraged early replacement of vehicles. Such an option would need to be discussed through the interagency consultation process and with the local government with implementing authority.
    - 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.
    - Also see EPA's National Clean Diesel Campaign website, which includes information about retrofitting vehicles, including lists of EPA-verified retrofit technologies and certified technologies; clean fuels; grants; case studies; toolkits; and partnership programs: www.epa.gov/otaq/diesel/.

10.2.2 Reduced idling programs

- Anti-idling programs for diesel trucks or buses may be relevant for projects where significant numbers of diesel vehicles are congregating for extended periods of time (e.g., restrictions on long duration truck idling, truck stop electrification, or time limits on bus idling at a terminal).
    - For additional information about quantifying the benefits of anti-idling programs for conformity determinations, see EPA's website for the most recent guidance on this topic: www.epa.gov/otaq/stateresources/transconf/policy.htm.
    - A list of EPA-verified anti-idle technologies for trucks can be found at: www.epa.gov/otaq/smartway/transport/what-smartway/verified-technologies.htm.

[125] The Federal Transit Administration (FTA) has minimum service life requirements for transit vehicles purchased with FTA funds. If a transit agency disposes of a vehicle earlier than its full useful service life, it will incur a payback penalty. Please refer to Chapter IV of FTA Circular 5010.1D for the establishment and calculation of a vehicle's useful service life. In addition, Appendix D of the circular address the useful life calculation and disposition of vehicles acquired with FTA funds: www.fta.dot.gov/documents/C_5010_1D_Finalpub.pdf.

10.2.3 Transportation project design revisions

- For transit and other terminals, project sponsors could consider redesigning the project to reduce the number of diesel vehicles congregating at any one location. Terminal operators can also take steps to improve gate operations to reduce vehicle idling inside and outside the facility. Fewer diesel vehicles congregating could reduce localized $PM_{2.5}$ or PM_{10} emissions for transit and other terminal projects.

    - A list of strategies to reduce emissions from trucks operating at marine and rail terminals is available at: www.epa.gov/otaq/smartway/transport/partner-resources/resources-publications.htm.

- It may be possible in some cases to route existing or projected traffic away from populated areas to an industrial setting (e.g., truck only lanes). Project sponsors should take into account any changes in travel activity, including additional VMT, that would result from rerouting this traffic. Note that this option may also change the air quality modeling receptors that are examined in the PM hot-spot analysis.

- Finally, project sponsors could consider additional modes for travel and goods movement. An example of such a mode would be transporting freight by cleaner rail instead of by highway (e.g., putting port freight on electric trains instead of transporting it by truck).

10.2.4 Fugitive dust control programs

Fugitive dust control programs will primarily be applicable in PM_{10} hot-spot analyses, since all PM_{10} nonattainment and maintenance areas must include these emissions in such analyses. However, there may be $PM_{2.5}$ nonattainment and maintenance areas that also could take advantage of these measures if re-entrained road dust or construction dust is required for a $PM_{2.5}$ hot-spot analysis. See Section 2.5 for further background.

- A project sponsor could commit to cover any open trucks used in construction of the project if construction emissions are included in an analysis year. Some states have laws requiring that open truck containers be covered to reduce dispersion of material. Laws may differ in terms of requirements, e.g., some require covering at all times, some require covering in limited circumstances, and some restrict spillage.

- A project sponsor could employ or obtain a commitment from another local agency to implement a street cleaning program. There is a variety of equipment available for this purpose and such programs could include vacuuming or flushing techniques. There have been circumstances where municipalities have implemented street sweeping programs for air quality purposes.

- Another option to reduce dust could be a site watering program, which may be relevant during the construction phase of a project, if construction emissions are included in the PM hot-spot analysis.

- Project sponsors may consider street and shoulder paving and runoff and erosion control in the project area, which can reduce significant quantities of dust.

- It may also be possible to reduce the use of sand in snow and ice control programs, apply additional chemical treatments, or use harder material (that is less likely to grind into finer particles).

10.2.5 Addressing other source emissions

Note: Controlling emissions from other sources may sufficiently reduce background concentrations in the PM hot-spot analysis.

- Reducing emissions from school buses may be relevant where such emissions are part of background concentrations. Information about retrofitting, replacing, and reducing idling of school buses can be found on EPA's website at: www.epa.gov/otaq/schoolbus/index.htm.

- Reducing emissions from ships, cargo handling equipment and other vehicles at ports may change the result of the PM hot-spot analysis. Options such as retrofitting, repowering, or replacing engines or vehicles, use of cleaner fuels, or "cold ironing" (that allows ships to plug in to shore-side power units) could be relevant where these sources significantly influence background concentrations in the project area. More information about reducing emissions at ports can be found on EPA's website at: www.epa.gov/otaq/diesel/ports/index.htm and www.epa.gov/otaq/smartway/transport/partner-resources/resources-publications.htm.

- Adopting locomotive anti-idling policies or other measures. For additional information, see the following EPA resources:
  - "Guidance for Quantifying and Using Long Duration Switch Yard Locomotive Idling Emission Reductions in State Implementation Plans," EPA420-B-04-09-037 (October 2009) available at: www.epa.gov/otaq/diesel/documents/420b09037.pdf.
  - EPA-verified anti-idle technologies for locomotives can be found at: www.epa.gov/otaq/smartway/transport/what-smartway/verified-technologies.htm.

- Remanufacturing existing locomotives to meet more stringent standards at a rate faster than the historical average, or using only Tier 3 and/or Tier 4 locomotives at a proposed terminal (once such locomotives become available).

- Reducing emissions from a stationary source might also change the result of the PM hot-spot analysis. Reductions could come from adding a control technology to a stationary source or adopting policies to reduce peak emissions at such a source. EPA and the state and/or local air quality agency could provide input on the feasibility and implementation of such a measure, as well as any necessary commitments to such measures from operators.

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

Public Draft

Appendices

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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.

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). The following specific guidance documents, in particular, may be useful references when implementing PM hot-spot analyses:

- "Policy Guidance on the Use of MOVES2010 for SIP Development and Transportation Conformity, and Other Purposes," EPA-420-B-09-046 (December 2009). This document describes how and when to use the MOVES2010 emissions model for SIP development, transportation conformity determinations, and other purposes.

- "Technical Guidance on the Use of MOVES2010 for Emission Inventory Preparation in State Implementation Plans and Transportation Conformity." This document provides guidance on appropriate input assumptions and sources of data for the use of MOVES2010 in SIP submissions and regional emissions analyses for transportation conformity purposes.

- EPA and FHWA, "Transportation Conformity Guidance for Qualitative Hot-spot Analyses in $PM_{2.5}$ and PM_{10} Nonattainment and Maintenance Areas," EPA420-B-06-902 (March 2006).

- EPA and FHWA, "Guidance for the Use of Latest Planning Assumptions in Transportation Conformity Determinations," EPA420-B-08-901 (December 2008).

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

- The most recent guidance for quantifying and using long duration truck idling emission reductions in transportation conformity can be found at: www.epa.gov/otaq/stateresources/transconf/policy.htm.

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

- 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.

- For additional information about quantifying the benefits of anti-idling programs 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 qualitative PM hot-spot analyses. Available at: www.fhwa.dot.gov/environment/conformity/practices/index.cfm.

A.3 MOVES MODEL TECHNICAL INFORMATION AND USER GUIDES

Technical information on the MOVES model can be found at www.epa.gov/otaq/models/moves/index.htm, including the following:

- "MOVES2010 User Guide." This guide provides detailed instructions for setting up and running MOVES2010. Available at www.epa.gov/otaq/models/moves/index.htm.

Guidance on using the MOVES model at the project level, as well as examples of using MOVES for quantitative PM hot-spot analyses, can be found in Section 4 of the guidance and in Appendices D, E and F.

A.4 EMFAC2007 MODEL TECHNICAL INFORMATION, USER GUIDES, AND OTHER GUIDANCE

EMFAC2007, 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/onroad/latest_version.htm.

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 and in Appendices G and H.

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.

Current and future policy documents related to AP-42 and/or road dust emissions can be found on the EPA's website at: www.epa.gov/otaq/stateresources/transconf/policy.htm#models, including the following current guidance:

- "Policy Guidance on the Use of the November 1, 2006, Update to AP-42 for Re-entrained Road Dust for SIP Development and Transportation Conformity," (August 2, 2007).
- "Policy Guidance on the Use of MOBILE6.2 and the December 2003 AP-42 Method for Re-entrained Road Dust for SIP Development and Transportation Conformity," (February 24, 2004).

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: www.epa.gov/OMS/invntory/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/420f08014.htm.

- "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/otaq/smartway/documents/420b04002.pdf.

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

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 particularly useful when running these models:

- AERMOD Implementation Guide

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

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

- MPRM User's Guide

- AERMET User's Guide

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. Examples of using an air quality model for a PM hot-spot analysis can be found in Appendices E and F.

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: http://tmip.fhwa.dot.gov/.

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

"NCHRP 255: Highway Traffic Data for Urbanized Area Project Planning and Design." Available online at: http://tmip.fhwa.dot.gov/sites/tmip.fhwa.dot.gov/files/NCHRP_255.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 2000. Transportation Research Board, Washington, D.C., 2000. Not available online; purchase information available at: http://144.171.11.107/Main/Public/Blurbs/Highway_Capacity_Manual_2000_152169.aspx. As of this writing, the 2000 edition is most current; the most recent version of the manual, and the associated guidebook, should be consulted when completing PM hot-spot analyses.

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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).

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[1]; and,

[1] 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 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 outdated 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 should 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 Sections 1.4 and 2.2 of this guidance and the preamble of the March 10, 2006 final rule for further information (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 qualitative 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 outdated provisions and take advantage of the streamlining flexibilities provided by the current Clean Air Act. EPA's January 2008 final conformity rule[4] significantly streamlined the requirements for conformity SIPs in 40 CFR 51.390. 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 outdated 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.

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-

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[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.

09-001 (January 2009); available online at:
www.epa.gov/otaq/stateresources/transconf/policy/420b09001.pdf.

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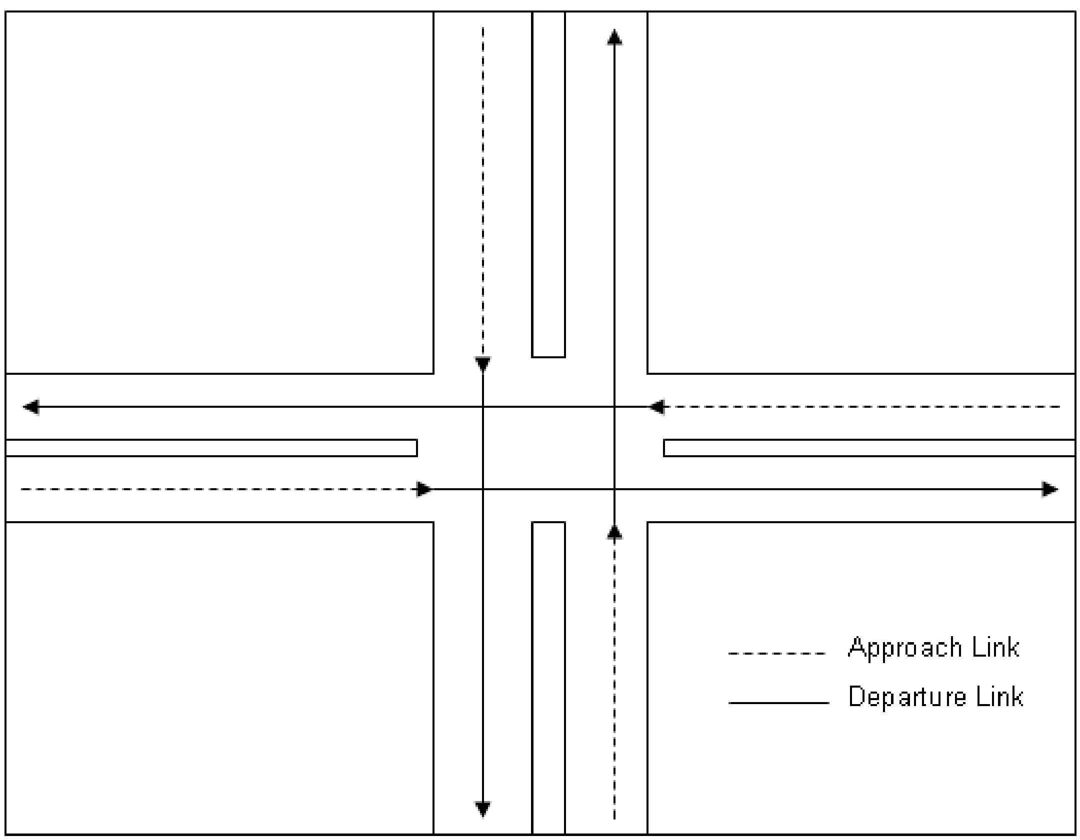
Appendix D:
Characterizing Intersection Projects for MOVES

D.1 INTRODUCTION

This appendix expands upon the discussion in Section 4.2 on how to best characterize links when modeling an intersection project using MOVES. The MOVES emission 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 emission model for PM hot-spot analyses in areas outside if 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. In addition, there may be other options for characterizing vehicle activity for an intersection; these should be discussed through the interagency consultation process prior to being used for a particular project.

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. The same method of characterizing vehicle activity should be used for all links in both the build and no-build scenarios.

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. A variety of methods are available to estimate average speed. Project sponsors 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 2000*.[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/.

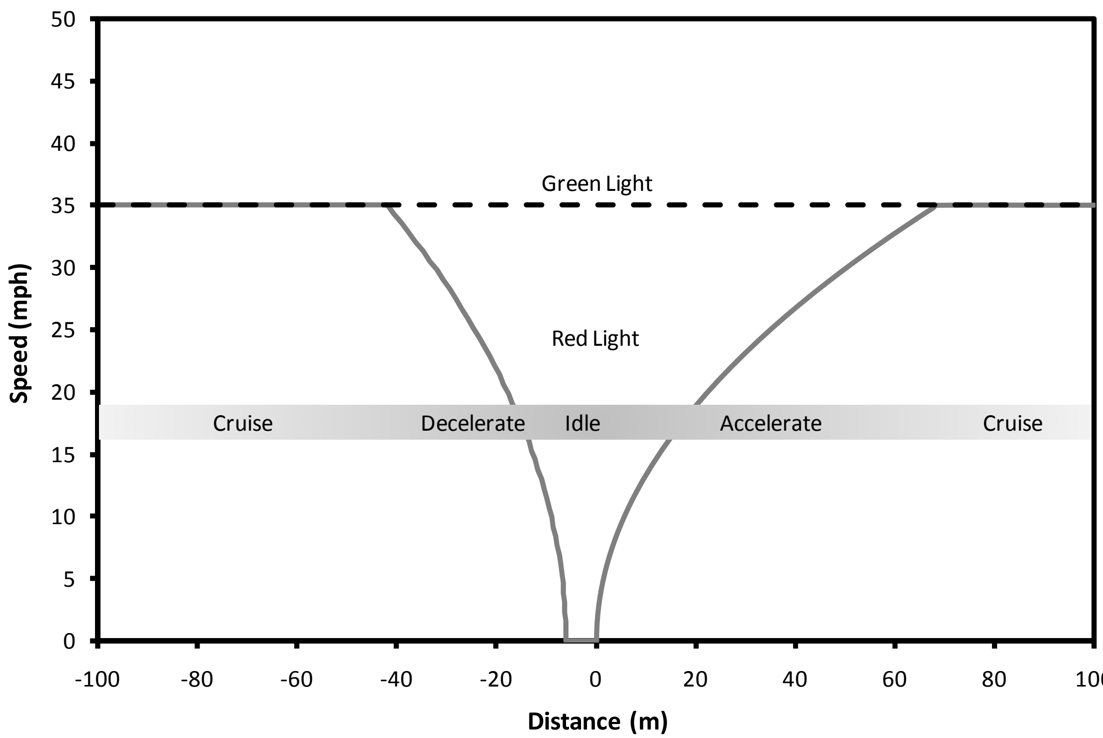
[2] Users should consult the most recent version of the Highway Capacity Manual. As of the release of this guidance, the latest version is the *Highway Capacity Manual 2000*, which can be obtained from the Transportation Research Board (see http://144.171.11.107/Main/Public/Blurbs/152169.aspx for details).

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.

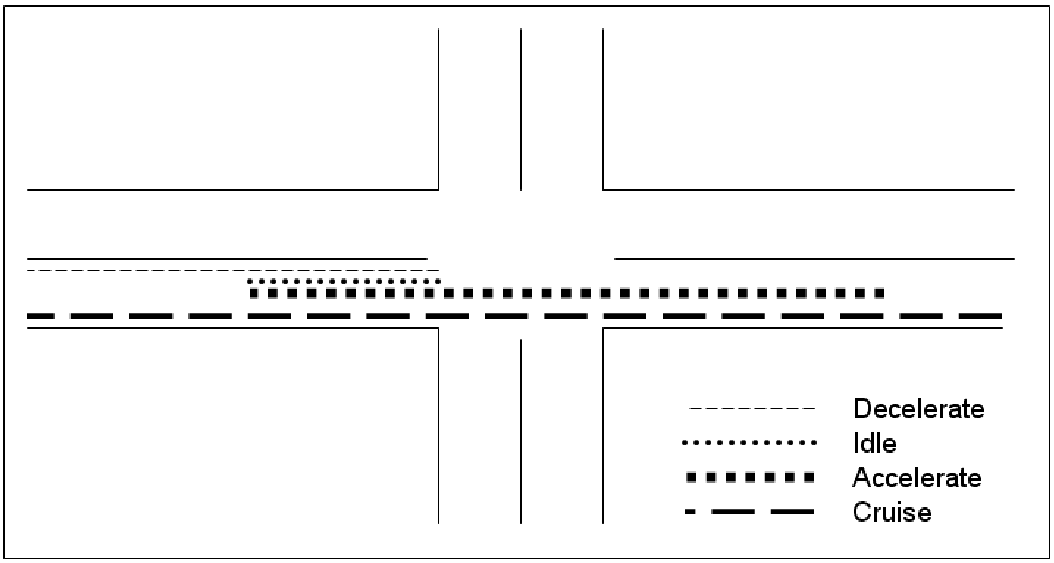
Exhibit D-2 illustrates why using this more refined approach can result in a more detailed emissions analysis. This exhibit shows the simple trajectory of a single vehicle approaching an intersection during the red signal phase of a traffic light cycle. This trajectory is characterized by several distinct 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. And 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 emission factors obtained from MOVES 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.

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 ID 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 (Op-Modes 11-16, 22-30, 33, 35-40);
- Low and moderate speed coasting (Op-Modes 11, 21);
- Braking (Op-Mode 0);
- Idling (Op-Mode 1); and
- Tire wear (Op-Modes 401-416).

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 ID corresponding to each particular type of activity (see Section 4.5.7 for more information). The operating modes typifying departure links include:

- Cruise/acceleration (Op-Modes 11-16, 22-30, 33, 35-40); and
- Tire wear (Op-Mode 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.

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

E.1 INTRODUCTION

The purpose of this appendix is to demonstrate the procedures for completing a hot-spot analysis using MOVES and CAL3QHCR following the basic steps described in Section 3. Readers should reference the appropriate sections in the guidance as needed for more detail on how to complete each step of the analysis. This example is limited to showing the build scenario; in practice, project sponsors may have to also analyze the no-build scenario. While this example calculates emission rates using MOVES, EMFAC users may find the air quality modeling described in this appendix helpful.

Note: The following example of a quantitative PM hot-spot analysis is highly simplified and intended only to demonstrate the basic procedures described in the guidance. This example uses default data in places where the use of project–specific data in a real-world situation would be expected. In addition, actual PM hot-spot analyses could be significantly more complex, and are likely to require more documentation of data and decisions.

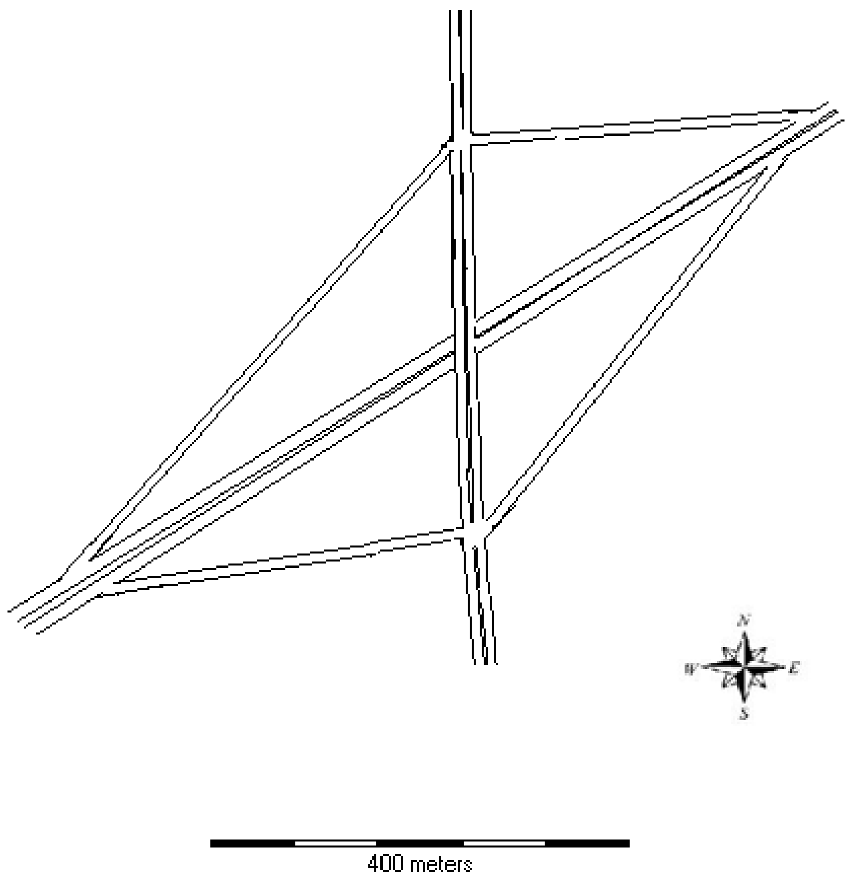
E.2 PROJECT DESCRIPTION AND CONTEXT

The proposed project is the construction of a highway interchange connecting a four-lane principle arterial with a six-lane freeway through on-and-off ramps (see Exhibit E-1, following page). The project is being built to allow truck access to local businesses. The project is located in an area that was designated nonattainment for the 2006 $PM_{2.5}$ 24-hour NAAQS and 1997 $PM_{2.5}$ annual NAAQS.

The following is some additional pertinent data about the project:

- The project is located in a medium-sized city (within one county) in a state other than California.
- The project is expected to take less than a year to complete and has an estimated completion date of 2013. The year of peak emissions is expected to be 2015, when considering the project's emissions and background concentrations.
- In 2015, the average annual daily traffic (AADT) at this location is expected to exceed 125,000 vehicles and greater than eight percent of the traffic will be heavy-duty diesel trucks.
- The area surrounding the proposed project is primarily residential, with no nearby sources that need to be explicitly modeled.
- The state does not have an adequate or approved SIP budget for either $PM_{2.5}$ NAAQS, and neither the EPA nor the state air agency have made a finding that road dust is a significant contributor to the $PM_{2.5}$ nonattainment problem.

Exhibit E-1. Simple Diagram of the Proposed Highway Project



E.3 DETERMINE NEED FOR ANALYSIS (STEP 1)

Through interagency consultation, the proposed project is determined to be of local air quality concern under the conformity rule because it is a new freeway project with a significant number of diesel vehicles (see 40 CFR 93.123(b)(1)(i) and Sections 1.4 and 3.2 and Appendix B of the guidance). Therefore, a quantitative PM hot-spot analysis is required.

E.4 DETERMINE APPROACH, MODELS, AND DATA (STEP 2)

E.4.1 Determining geographic area and emission sources to be covered by the analysis

First, the interagency consultation process is used to ensure that the project area is defined so that the analysis includes the entire project, as required by 40 CFR 93.123(c)(2). As previously noted, it is also determined that, in this case, there are no nearby emission sources to be explicitly modeled (see Section 3.3.2).

E.4.2 Deciding on general analysis approach and analysis year(s)

Second, the project sponsor determines that the preferred approach in this case is to model the build scenario first, completing a no-build scenario only if necessary.

In addition, it is determined that the year of peak emissions (within the timeframe of the current transportation plan) is mostly likely to be 2015. Therefore, 2015 is selected as the year of the analysis, and the analysis considers traffic data from 2015 (see Section 3.3.3).

E.4.3 Determining which PM NAAQS to be evaluated

Because the area has been designated nonattainment for both the 2006 $PM_{2.5}$ 24-hour NAAQS and 1997 $PM_{2.5}$ annual NAAQS, the results of the analysis will have to be compared to both NAAQS (see Section 3.3.4). All four quarters are included in the analysis in order to estimate a year's worth of emissions for both NAAQS.

E.4.4 Deciding on the type of PM emissions to be modeled

Next, through interagency consultation, the following directly-emitted $PM_{2.5}$ emissions are determined to be relevant for estimating the emissions in the analysis (see Section 3.3.5):

- Vehicle exhaust[1]
- Brake wear
- Tire wear

E.4.5 Determining the models and methods to be used

Since this project is located outside of California, MOVES2010 is used for emissions modeling. In addition, it is determined that, since this is a highway project with no nearby sources that need to be explicitly modeled, either AERMOD or CAL3QHCR could be used for air quality modeling (see Section 3.3.6). In this case, CAL3QHCR is selected. Making the decision on what air quality model to use at this stage is important so that the appropriate data are collected, among other reasons (see next step).

E.4.6 Obtaining project-specific modeling data

Finally, the project sponsor compiles the data required to use MOVES, including project traffic data, vehicle types and age, and temperature and humidity data for the months and hours to be modeled (specifics on the data collected are described in the following steps). In addition, information necessary to use CAL3QHCR to model air quality is gathered, including meteorological data and information on representative air quality monitors. The sponsor also ensures the latest planning assumptions are used and that data used for the analysis are consistent with that used in the latest regional emissions analysis, as

[1] Represented in MOVES as $PM_{total\ running}$ and $PM_{total\ crankcase\ running}$.

required by the conformity rule (see Section 3.3.7). The interagency consultation process is used to discuss the data for the PM hot-spot analysis.

E.5 ESTIMATE ON-ROAD MOTOR VEHICLE EMISSIONS (STEP 3)

Having completed the analysis preparations described above, the project sponsor then follows the instructions provided in Section 4 of the guidance to use MOVES to estimate the project's on-road emissions:

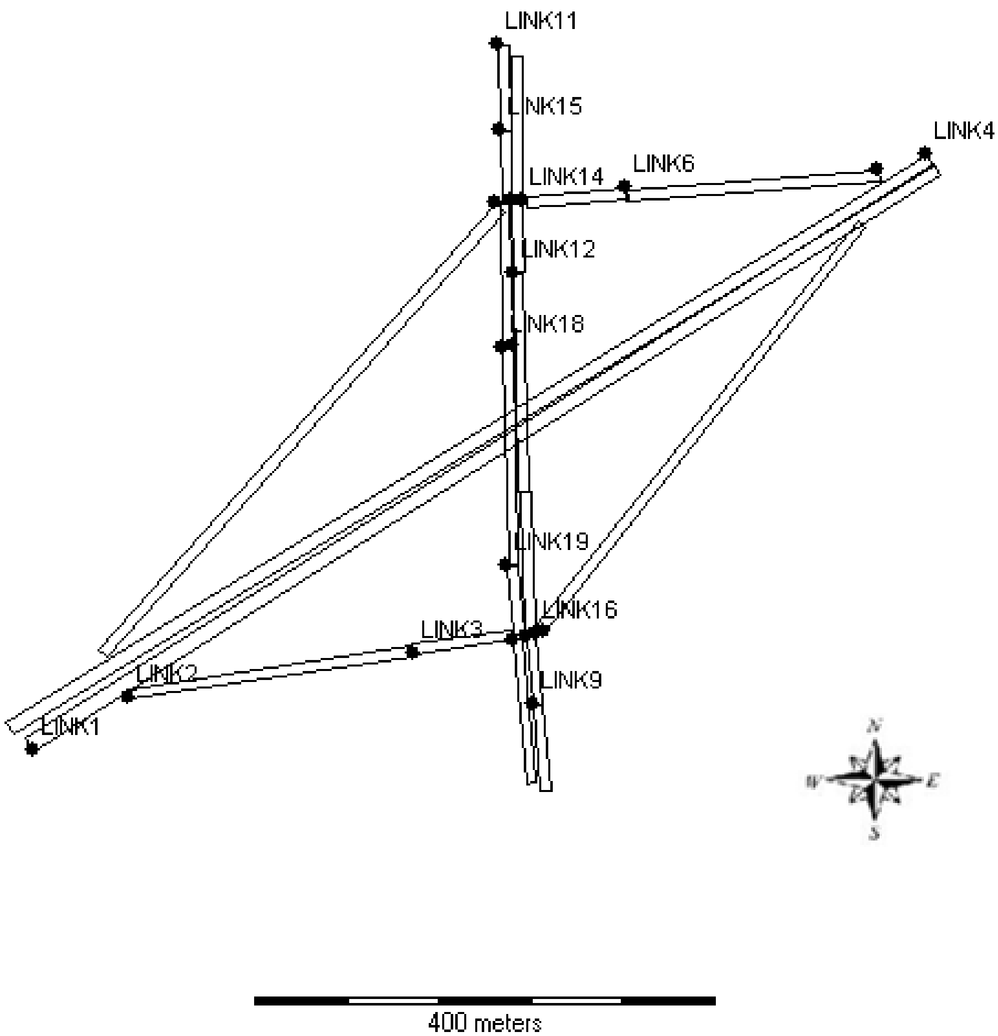
E.5.1 Characterizing the project in terms of links

As described in Section 4.2 of the guidance, links are defined based on the expected emission rate variability across the project. Generally, a highway project like the one proposed in this example can be broken into four unique activity modes:

- Freeway driving at 55 mph;
- Arterial cruise at 45 mph;
- Acceleration away from intersections to a cruising speed of 45/55 mph; and
- Cruise, deceleration, and idle/cruise (depending on light timing) at intersections.

Following the guidance given in Section 4.2, 20 links are defined for MOVES and CAL3QHCR modeling, each representing unique geographic and activity parameters (see Exhibits E-2 and E-3, following pages). Each LinkID is defined with the necessary information for air quality modeling: link length, link width, link volume, as well as link start and end points (x1, y1, x2, y2 coordinates).

Exhibit E-2. Diagram of Proposed Highway Project Showing Links



Decisions on how to best define links are based on an analysis of vehicle activity and patterns within the project area. AADT is calculated from a travel demand model for passenger cars, passenger trucks, intercity buses, short haul trucks, and long haul trucks. From these values, both an average-hour and peak-hour volume is calculated. The average and peak-hour vehicle counts for each part of the project are shown in Exhibit E-3.

Based on the conditions in the project area, for this analysis peak traffic is assumed to be representative of morning rush hour (AM: 6 a.m. to 9 a.m.) and evening rush hour (PM: 4 p.m. to 7 p.m.), while average hour traffic represents all other hours: midday (MD: 9 a.m. to 4 p.m.), and overnight (ON: 7 p.m. to 6 a.m.) Identical traffic volume and speed profiles are assumed for all quarters of the year. Quarters are defined as described in Section 3.3.4 of the guidance: Q1 (January-March), Q2 (April-June), Q3 (July-September), and Q4 (October-December).

Exhibit E-3. Peak-Hour and Average-Hour Traffic Counts for Each Project Link

Freeway	Peak Hour Count	Average Hour Count	Fraction of Total
Passenger Cars	2260	452	0.45
Passenger Trucks	1760	352	0.35
Intercity Buses	36	7	0.01
Short Haul Trucks (gas)	60	12	0.01
Long Haul Trucks (diesel)	944	189	0.19
Total	5060	1012	1.00
Exit Ramps	Peak Hour Count	Average Hour Count	Fraction of Total
Passenger Cars	124	25	0.22
Passenger Trucks	124	25	0.22
Intercity Buses	8	2	0.01
Short Haul Trucks (gas)	12	2	0.02
Long Haul Trucks (diesel)	300	60	0.53
Total	568	114	1.00
Entrance Ramps	Peak Hour Count	Average Hour Count	Fraction of Total
Passenger Cars	176	35	0.29
Passenger Trucks	148	30	0.24
Intercity Buses	0	0	0.00
Short Haul Trucks (gas)	16	3	0.03
Long Haul Trucks (diesel)	276	55	0.45
Total	616	123	1.00
Arterial Road	Peak Hour Count	Average Hour Count	Fraction of Total
Passenger Cars	124	25	0.22
Passenger Trucks	116	23	0.20
Intercity Buses	12	2	0.02
Short Haul Trucks (gas)	0	0	0.00
Long Haul Trucks (diesel)	316	63	0.56
Total	568	114	1.00

A significant amount of traffic using the project is expected to be diesel trucks. While the freeway contains approximately 19% diesel truck traffic, traffic modeling for the on- and off-ramps connecting the freeway to the arterial road suggests approximately half of vehicles are long-haul diesel trucks.

The average speeds on the freeway, arterial, and on/off-ramps are anticipated to be identical in the analysis year for both peak and average hours and assumed to approximately reflect the speed limit (55 mph, 45 mph, and 45 mph, respectively). Traffic flow through the two intersections is controlled by a signalized light with a 60%

wait time (that is, 60% idle) for vehicles exiting the freeway and 40% wait time for traffic entering the freeway from the arterial road or traveling north and south on the arterial road passing over the freeway. The total project emissions, therefore, are determined to be a function of:

- Vehicles traveling east and west on the freeway at a relatively constant 55 mph;
- Exiting vehicles decelerating to a stop at either the north or south signalized intersection (or continuing through if the light is green);
- Vehicles accelerating away from the signalized intersections north and south, as well as accelerating to a 55 mph cruise speed on the on-ramps;
- Idling activity at both intersections during the red phase of the traffic light; and
- Vehicles traveling between the north and south intersections at a constant 45 mph.

As there is no new parking associated with the project (e.g., parking lots), there are no start emissions to be considered. Additionally, there are no trucks parked or “hoteling” in extended idle mode anywhere in the project area, so extended idle emissions do not need to be calculated.

E.5.2 Deciding how to handle link activity

As discussed in Section 4.2 of the guidance, MOVES offers several options for users to apply activity information to each LinkID. For illustrative purposes, based on the available information for the project (in this case, average speed, link average and peak volume, and red-light idle time) several methods of deriving Op-Mode distributions are employed in this example, as described below.

The links parameter table in Exhibit E-4 (following page) shows the various methods that activity is entered into MOVES for each link. The column “MOVES activity input” describes how the Op-Mode distribution is calculated for each particular link (again, in a real-world situation, only one method would be used for all links):

- Freeway links (links 1 and 4) are defined through a 55 mph average speed input, from which MOVES calculated an Op-Mode distribution (as described in Appendix D.2).
- Arterial cruise links (links 12 and 18) and links approaching an intersection queue (links 2, 5, 9 and 15) are defined through a link-drive schedule with a constant speed of 45 mph; indicating vehicles are cruising at 45 mph, with no acceleration or deceleration (as described in Appendix D.3).
- Links representing vehicles accelerating away from intersections (links 7, 8, 11, 14, 17, 20) are given “adjusted average speeds” calculated from guidance in the 2000 Highway Capacity Manual, based on the link cruise speed (45 mph or 55 mph), red-light timing, and expected volume to capacity ratios. The adjusted average speeds (16.6 mph or 30.3 mph) are entered into MOVES, which calculates an Op-Mode distribution to reflect the lower average speed and subsequent higher emissions (as described in Appendix D.2).
- Queue links are given an Op-Mode distribution that represents vehicles decelerating and idling (red light) as well as cruising through (green light) (as described in Appendix D.4).

1. First, an Op-Mode is calculated for the link average speed (45 mph).
2. Because this does not adequately account for idling at the intersection, the Op-Mode fractions are re-allocated to add in idling. For instance, after consulting the 2000 Highway Capacity Manual, for this project scenario, the red light timing corresponds to approximately 40% idle time. A fraction of 0.4 for Op-Mode "1" is added to Op-Mode distribution calculated from the 45 mph average speed in Step 1.

The resulting Op-Mode distribution represents all activity on a queuing intersection link.

The length of the queue links are estimated as a function of the length of three trucks, one car, and one passenger truck with two meters in between each car and five meters in between each truck.

Departure links on the arterial road are assumed to have a link length of 125 meters (estimated to be the approximate distance that vehicles accelerate to a 45 mph cruising speed). The departure links from the intersection to the on-ramp are assumed to have a link length of 200 meters (estimated to be the approximate distance that vehicles accelerate to a 55 mph cruising speed).

Exhibit E-4. Link Parameters (Peak Traffic)

link parameters.xls

linkID	linkLengtl	linkwidth	linkVolume	linkAvgSpeed	adj. average speed	linkDescription	MOVES activity input	x1	y1	x2	y2
1	935	12	5060	55	n/a	EB highway	average speed	-422	-469	367	32
2	250	9	568	45	n/a	EB off-ramp cruise	**linkdrive schedule**	-337	-424	-89	-386
3	87	9	568	45	n/a	EB off-ramp queue	avg spd/opMode	-89	-386	-3	-372
4	940	12	5060	55	n/a	WB highway	average speed	358	44	-440	-453
5	220	9	568	45	n/a	WB off-ramp cruise	**linkdrive schedule**	315	29	96	13
6	87	9	568	45	n/a	WB off-ramp queue	avg spd/opMode	96	13	10	7
7	450	9	616	45	16.6	EB on-ramp	adj. average speed	19	-367	300	-13
8	520	9	616	45	16.6	WB on-ramp	adj. average speed	-14	2	-360	-386
9	75	9	568	45	n/a	sNB cruise	**linkdrive schedule**	26	-507	18	-433
10	61	9	568	45	n/a	sNB queue	avg spd/opMode	18	-433	12	-371
11	125	9	568	45	30.3	sNB depart	adj. average speed	12	-371	9	-246
12	190	9	568	45	n/a	NB connect	**linkdrive schedule**	9	-246	2	-56
13	61	9	568	45	n/a	nNB queue	avg spd/opMode	2	-56	1	5
14	125	9	568	45	30.3	nNB depart	adj. average speed	1	5	1	130
15	75	9	568	45	n/a	nSB cruise	**linkdrive schedule**	-10	142	-8	68
16	61	9	568	45	n/a	nSB queue	avg spd/opMode	-8	68	-9	6
17	125	9	568	45	30.3	nSB depart	adj. average speed	-9	6	-7	-122
18	189	9	568	45	n/a	SB connect	**linkdrive schedule**	-7	-122	-3	-311
19	61	9	568	45	n/a	sSB queue	avg spd/opMode	-3	-311	2	-371
20	125	9	568	45	30.3	sSB depart	adj. average speed	2	-371	12	-501

E.5.3 Determining the number of MOVES runs

Following the guidance given in Section 4.3, it is determined that 16 MOVES runs should be completed to produce emission factors that show variation across four hourly periods (12 a.m., 6 a.m., 12 p.m., and 6 p.m., corresponding to overnight, morning, midday, and evening traffic scenarios, respectively) and four quarterly periods (represented by the months of January, April, July, and October; see Section 3.3). MOVES will calculate values for all project links for the time period specified in each run. The 16 emission factors produced for each link are calculated as grams/vehicle-mile, which will then be paired with corresponding traffic volumes (peak or average hour, depending on the hour) and used in CAL3QHCR.

E.5.4 Developing basic run specification inputs

When configuring MOVES for the analysis, the project sponsor follows Section 4.4 of the guidance, including, but not limited to, the following:

- From the Scale menu, selecting the "Project" domain; in addition, choosing output in "Emission Rates," so that emission factors will be in grams/vehicle-mile as needed for CAL3QHCR (see Section 4.4.2).
- From the Time Spans Panel, the appropriate year, month, day, and hour for each run is selected (see Section 4.4.3).
- From the Geographic Bounds Panel, the custom domain is selected (see Section 4.4.4).
- From the Vehicles/Equipment Panel, appropriate Source Types are selected (see Section 4.4.5).
- From the Road Types Panel, Urban Restricted and Unrestricted road types are selected (see Section 4.4.6).
- From the Pollutants and Processes Panel, appropriate pollutant/processes are selected according to Section 4.4.7 of the guidance for "highway links."
- In the Output Panel, an output database is specified with grams and miles selected as units (see Section 4.4.10).

E.5.5 Entering project details using the Project Data Manager

<u>Meteorology</u>

As described previously, it is determined that MOVES should be run 16 times to reflect the following scenarios: 12 a.m., 6 a.m., 12 p.m., and 6 p.m. (corresponding to overnight, morning, midday, and evening traffic scenarios, respectfully) for the months of January, April, July, and October. Through the interagency consultation process, temperature and humidity data from a representative meteorological monitoring station are obtained and confirmed to be consistent with data used in the regional emissions analysis from the currently conforming transportation plan and TIP (see Section 4.5.1). Average values for each hour and month combination are used for each of the 16 MOVES runs. As an example, temperature and humidity values for 12 a.m. January are shown in Exhibit E-5 (following page).

Exhibit E-5. Temperature and Humidity Input (January 12 a.m.)

metjan12am.xls

monthID	zoneID	hourID	temperatur	relHumidity
1	990010	1	26.2	75.4

ZoneMonthHour / HourOfAl

<u>Age Distribution</u>

Section 4.5.2 of the guidance specifies that default data should be used only if an alternative local dataset cannot be obtained and the regional conformity analysis relies on national defaults. However, for the sake of simplicity only, in this example the national default age distribution for 2015 is used for all vehicles and all runs (see Exhibit E-6).

Exhibit E-6. Age Distribution Table

agedist.xls

sourceTyp	yearID	ageID	ageFraction
21	2015	0	0.0599
21	2015	1	0.0609
21	2015	2	0.0616
21	2015	3	0.0622
21	2015	4	0.0620
21	2015	5	0.0579
21	2015	6	0.0559
21	2015	7	0.0556
21	2015	8	0.0578
21	2015	9	0.0584
21	2015	10	0.0591
21	2015	11	0.0558
21	2015	12	0.0497
21	2015	13	0.0461
21	2015	14	0.0404
21	2015	15	0.0339
21	2015	16	0.0286
21	2015	17	0.0215
21	2015	18	0.0163
21	2015	19	0.0125
21	2015	20	0.0109
21	2015	21	0.0089

sourceTypeAgeDistribution

Fuel Supply and Fuel Formulation

In this example, it is determined appropriate to use the default fuel supply and formulation (see Exhibits E-7 and E-8). The default fuel supply and formulation are input for each respective quarter (January, April, July, and October) and used for the corresponding MOVES runs.

Exhibit E-7. Fuel Supply Table

fuelsupplyJan.xls

countyID	fuelYearID	monthGrou	fuelFormul	marketSha	marketShareCV
99001	2015	1	1054	1	0.5
99001	2015	1	3043	1	0.5

FuelSupply / County / FuelFormulati

Exhibit E-8. Fuel Formulation Table

fuelformjan.xls

fuelFormul	fuelSubtyp	RVP	sulfurLevel	ETOHVolu	MTBEVolu	ETBEVolu	TAMEVolu	arc
3011	20	0	11	0	0	0	0	
3043	20	0	43	0	0	0	0	
3100	20	0	100	0	0	0	0	
3113	20	0	113	0	0	0	0	
3281	20	0	281	0	0	0	0	
3300	20	0	300	0	0	0	0	
3337	20	0	337	0	0	0	0	
3450	20	0	450	0	0	0	0	
3468	20	0	468	0	0	0	0	
20	20	0	0	0	0	0	0	

FuelFormulation / FuelSubtype

<u>Inspection and Maintenance (I/M)</u>

As there is no PM emissions benefit in MOVES for I/M programs, this menu item is skipped (see Section 4.5.4).

<u>Link Source Type</u>

The distribution of vehicle types on each link is defined in the Link Source Type table (Exhibit E-9) following the guidance in Section 4.5.5. The fractions are derived from the vehicle count estimates in Exhibit E-3.

Exhibit E-9. Link Source Type Table

linkID	sourceTyp	sourceTypeHourFraction
1	21	0.45
1	31	0.35
1	41	0.01
1	61	0.01
1	62	0.19
2	21	0.22
2	31	0.22
2	41	0.01
2	61	0.02
2	62	0.53
3	21	0.22
3	31	0.22
3	41	0.01
3	61	0.02
3	62	0.53
4	21	0.45
4	31	0.35

<u>Links</u>

The Links input table shown in Exhibit E-10 (following page) is used to define each individual project link in MOVES. Road Types 4 and 5 indicate Urban Restricted (freeway) and Urban Unrestricted (arterial) road types, respectively; these correspond to the two road types represented in this example. The average speed is entered for all links, but only used to calculate Op-Mode distributions for links 1, 4, 7, 8, 11, 14, 17, and 20 (others links are explicitly defined with a link-drive schedule or Op-Mode distribution). Link length and link volume is entered for each link; however, since the "Emission Rates" option is selected in the Scale Panel, MOVES will produce grams/vehicle-mile. The volume and link length will become relevant when running the air quality model later in this analysis.

Exhibit E-10. Links Input (AM Period)

links.xls

linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription
1	99001	990010	4	0.58	5060	55	EB highway
2	99001	990010	5	0.16	568	45	EB off-ramp cruise
3	99001	990010	5	0.05	568	45	EB off-ramp queue
4	99001	990010	4	0.58	5060	55	WB highway
5	99001	990010	5	0.14	568	45	WB off-ramp cruise
6	99001	990010	5	0.05	568	45	WB off-ramp queue
7	99001	990010	5	0.28	616	16.6	EB on-ramp
8	99001	990010	5	0.32	616	16.6	WB on-ramp
9	99001	990010	5	0.05	568	45	sNB cruise
10	99001	990010	5	0.04	568	45	sNB queue
11	99001	990010	5	0.08	568	30.3	sNB depart
12	99001	990010	5	0.12	568	45	NB connect
13	99001	990010	5	0.04	568	45	nNB queue
14	99001	990010	5	0.08	568	30.3	nNB depart
15	99001	990010	5	0.05	568	45	nSB cruise
16	99001	990010	5	0.04	568	45	nSB queue
17	99001	990010	5	0.08	568	30.3	nSB depart
18	99001	990010	5	0.12	568	45	SB connect
19	99001	990010	5	0.04	568	45	sSB queue
20	99001	990010	5	0.08	568	30.3	sSB depart

link / County / RoadType / Zone

The remaining links are defined with an Op-Mode distribution (Exhibit E-11) calculated separately, as discussed earlier. Operating modes used in this analysis vary by both link and source type, but not by hour or day.

Exhibit E-11. Operating Mode Distribution Table

opmode.xls

sourceTyp	hourDayID	linkID	polProces	opModeID	opModeFraction
21	15	1	9101	35	0.2
21	15	1	9101	40	0.28
21	15	1	9101	38	0.08
21	15	1	9101	39	0.08
21	15	1	9101	0	0.2
21	15	1	9101	33	0.16
21	15	1	9190	35	0.2
21	15	1	9190	40	0.28
21	15	1	9190	38	0.08
21	15	1	9190	39	0.08
21	15	1	9190	0	0.2
21	15	1	9190	33	0.16
21	15	1	11001	35	0.2
21	15	1	11001	40	0.28
21	15	1	11001	38	0.08
21	15	1	11001	39	0.08
21	15	1	11001	0	0.2
21	15	1	11001	33	0.16
21	15	1	11015	35	0.2
21	15	1	11015	40	0.28
21	15	1	11015	38	0.08
21	15	1	11015	39	0.08
21	15	1	11015	0	0.2
21	15	1	11015	33	0.16

Op_mode / Sheet2 / Sheet3

<u>Off-Network</u>

As it was determined that there are no off-network links (such as parking lots or truck stops) that would have to be considered using the Off-Network Importer, there is no need to use this option in this example.

E.5.6 Generating emission factors for use in air quality modeling

After generating the run specification and entering the required information into the Project Data Manager as described above, MOVES is run 16 times, once for each unique hour/month combination. Upon completion of each run, the MOVES output is located in the MySQL output database table "rateperdistance" and sorted by Month, Hour, LinkID, ProcessID, and PollutantID. An aggregate $PM_{2.5}$ emission factor is then calculated by the project sponsor for each Month, Hour, and LinkID combination using the following equation and the guidance given in Section 4.4.7 of the guidance:

$$PM_{\text{aggregate total}} = (PM_{\text{total running}}) + (PM_{\text{total crankcase running}}) + (\text{brake wear}) + (\text{tire wear})$$

The 16 resulting grams/vehicle-mile emission factors (Exhibit E-12, following page) for each link are then ready to be used as input into the CAL3QHCR dispersion model to predict future $PM_{2.5}$ concentrations.

Exhibit E-12. Grams/Vehicle-Mile Emission Factors Calculated from MOVES Output by Link, Quarter, and Hour

output_summary.xls

	A	B	C	D	E	F	G	H	I	J
1	linkID	linkLength (miles)	Jan12am	Jan6am	Jan12pm	Jan6pm	Apr12am	Apr6am	Apr12pm	Apr6pm
2	1	0.58	0.121	0.128	0.113	0.111	0.098	0.103	0.090	0.089
3	2	0.16	0.374	0.374	0.373	0.373	0.371	0.372	0.371	0.370
4	3	0.05	0.260	0.265	0.255	0.254	0.246	0.249	0.242	0.241
5	4	0.58	0.121	0.128	0.113	0.111	0.098	0.103	0.090	0.089
6	5	0.14	0.374	0.374	0.373	0.373	0.371	0.372	0.371	0.370
7	6	0.05	0.260	0.265	0.255	0.254	0.246	0.249	0.242	0.241
8	7	0.28	0.539	0.552	0.524	0.522	0.498	0.507	0.484	0.482
9	8	0.32	0.539	0.552	0.524	0.522	0.498	0.507	0.484	0.482
10	9	0.05	0.399	0.399	0.398	0.398	0.396	0.397	0.396	0.395
11	10	0.04	0.336	0.342	0.328	0.327	0.316	0.320	0.309	0.308
12	11	0.08	0.364	0.370	0.357	0.356	0.346	0.350	0.340	0.339
13	12	0.12	0.399	0.399	0.398	0.398	0.396	0.397	0.396	0.395
14	13	0.04	0.336	0.342	0.328	0.327	0.316	0.320	0.309	0.308
15	14	0.08	0.364	0.370	0.357	0.356	0.346	0.350	0.340	0.339
16	15	0.05	0.399	0.399	0.398	0.398	0.396	0.397	0.396	0.395
17	16	0.04	0.336	0.342	0.328	0.327	0.316	0.320	0.309	0.308
18	17	0.08	0.364	0.370	0.357	0.356	0.346	0.350	0.340	0.339
19	18	0.12	0.399	0.399	0.398	0.398	0.396	0.397	0.396	0.395
20	19	0.04	0.336	0.342	0.328	0.327	0.316	0.320	0.309	0.308
21	20	0.08	0.364	0.370	0.357	0.356	0.346	0.350	0.340	0.339
22	linkID	linkLength (miles)	Jul12am	Jul6am	Jul12pm	Jul6pm	Oct12am	Oct6am	Oct12pm	Oct6pm
23	1	0.58	0.085	0.086	0.084	0.084	0.096	0.099	0.088	0.088
24	2	0.16	0.369	0.369	0.369	0.369	0.370	0.371	0.370	0.370
25	3	0.05	0.238	0.239	0.237	0.237	0.244	0.247	0.240	0.240
26	4	0.58	0.085	0.086	0.084	0.084	0.096	0.099	0.088	0.088
27	5	0.14	0.369	0.369	0.369	0.369	0.370	0.371	0.370	0.370
28	6	0.05	0.238	0.239	0.237	0.237	0.244	0.247	0.240	0.240
29	7	0.28	0.469	0.472	0.468	0.468	0.489	0.495	0.475	0.476
30	8	0.32	0.469	0.472	0.468	0.468	0.489	0.495	0.475	0.476
31	9	0.05	0.394	0.394	0.394	0.394	0.395	0.396	0.394	0.395
32	10	0.04	0.304	0.305	0.303	0.303	0.313	0.316	0.306	0.307
33	11	0.08	0.332	0.333	0.331	0.331	0.340	0.343	0.334	0.334
34	12	0.12	0.394	0.394	0.394	0.394	0.395	0.396	0.394	0.395
35	13	0.04	0.304	0.305	0.303	0.303	0.313	0.316	0.306	0.307
36	14	0.08	0.332	0.333	0.331	0.331	0.340	0.343	0.334	0.334
37	15	0.05	0.394	0.394	0.394	0.394	0.395	0.396	0.394	0.395
38	16	0.04	0.304	0.305	0.303	0.303	0.313	0.316	0.306	0.307
39	17	0.08	0.332	0.333	0.331	0.331	0.340	0.343	0.334	0.334
40	18	0.12	0.394	0.394	0.394	0.394	0.395	0.396	0.394	0.395
41	19	0.04	0.304	0.305	0.303	0.303	0.313	0.316	0.306	0.307
42	20	0.08	0.332	0.333	0.331	0.331	0.340	0.343	0.334	0.334

Output | **gramspervehiclemile** | CAL3QHCR Inputs

E.6 ESTIMATE DUST AND OTHER EMISSIONS (STEP 4)

E.6.1 Estimating re-entrained road dust

In this case, this area does not have any adequate or approved SIP budgets for either $PM_{2.5}$ NAAQS, and neither the EPA nor the state air agency have made a finding that road dust emissions are a significant contributor to the air quality problem for either $PM_{2.5}$ NAAQS. Therefore, $PM_{2.5}$ emissions from road dust do not need to be considered in this analysis (see Sections 2.5.3 and 6.2).

E.6.2 Estimating transportation-related construction dust

The construction of this project will not occur during the analysis year. Therefore, emissions from construction dust are not included in this analysis (see Sections 2.5.5 and 6.4).

E.6.3 Estimating other sources of emissions in the project area

Through interagency consultation, it is determined that the project area in the analysis year does not include locomotives or other nearby emission sources that have to be considered in the analysis (see Section 6.6).

E.7 SELECT AN AIR QUALITY MODEL, DATA INPUTS, AND RECEPTORS (STEP 5)

E.7.1 Characterizing emission sources

As discussed previously, the CAL3QHCR model is selected to estimate $PM_{2.5}$ concentrations for this analysis (see Section 7.3). Each link is defined in CAL3QHCR with coordinates and dimensions matching the project parameters (shown in Exhibit E-4). The necessary inputs for link length, traffic volume, and corresponding link emission factor are also added using the CAL3QHCR Tier II approach. Each MOVES emission factor (12 a.m., 6 a.m., 12 p.m., and 6 p.m.) and traffic volume (average or peak) for each link is applied to multiple hours of the day, as follows:

- Morning peak (AM) emissions based on traffic data and meteorology occurring between 6 a.m. and 9 a.m.;
- Midday (MD) emissions based on data from 9 a.m. to 4 p.m.;
- Evening peak (PM) emissions based on data from 4 p.m. to 7 p.m.;
- Overnight (ON) emissions based on data from 7 p.m. to 6 a.m.

In addition, these factors are applied to each of the four quarters being modeled.

CAL3QHCR scenarios are built to model traffic conditions for all 24 hours of a weekday in each quarter (partial elements of the CAL3QHCR input file can be found in Exhibits E-13a and 13b): in all, four separate scenarios.

Exhibit E-13a. CAL3QHCR Quarter 1, 6 a.m. Input File (Partial)

highway_jan.INP - Notepad

File Edit Format View Help

```
'Hot-Spot Highway Example'  60. 175.  0. 0.  41  1 0
 1 1 98 12 31 98
 94823  98  94823 98
 1 1 'U'
'1'      -42.9   -20     1.8
'2'      -28.8   -3.1    1.8
'3'      -16.5   29      1.8
'4'      -16.5   48.8    1.8
'5'      29.6    31.8    1.8
'6'      12.7    -101    1.8
'7'      -14.6   -100.1  1.8
'8'      15.5    -152.9  1.8
'9'      -14.6   -154.7  1.8
'10'     -12.7   -220.7  1.8
'11'     17.4    -205.6  1.8
'12'     -11.8   -265.9  1.8
'13'     21.2    -257.4  1.8
'14'     19.3    -334.7  1.8
'15'     35.3    -333.7  1.8
'16'     34.4    -317.7  1.8
'17'     -21.2   -395.9  1.8
'18'     -23.1   -349.7  1.8
'19'     24      -18.1   1.8
'20'     -31.6   15.8    1.8
'21'     -3.3    -435.5  1.8
'22'     12.7    -7.8    1.8
'23'     24      -379    1.8
'24'     28.7    -411    1.8
'25'     45.7    -353.5  1.8
'26'     -9.9    -360.1  1.8
'27'     -12.7   -320.5  1.8
'28'     -42.9   -365.8  1.8
'29'     -19.3   -21     1.8
'30'     -22.2   -57.7   1.8
'31'     10.8    19.6    1.8
'32'     46.6    20.5    1.8
'33'     10.8    52.5    1.8
'34'     13.6    -32.3   1.8
'35'     48.5    -6.8    1.8
'36'     -7.1    -386.5  1.8
'37'     -43.8   -394    1.8
'38'     -6.2    -410    1.8
'39'     43.8    -387.4  1.8
'40'     -33.5   -38.9   1.8
'41'     33.4    -432.7  1.8
```

Exhibit E-13b. CAL3QHCR Quarter 1, 6 a.m. Input File (Partial)

highway_jan.INP - Notepad

File Edit Format View Help

```
2 'p'
1 1 1 1 1 1 1
'Example Highway Project'       20
   1  1
'EB highway'      'ag'   -422    367    -469    32     0      12
   2  1
'EB off-ramp cruise'      'ag'   -337    -89    -424       -386      0      9
   3  1
'EB off-ramp queue'       'ag'   -89     -3     -386     -372      0      9
   4  1
'WB highway'      'ag'   358     -440   44     -453     0      12
   5  1
'WB off-ramp cruise'      'ag'   315     96     29     13       0      9
   6  1
'WB off-ramp queue'       'ag'   96      10     13      7       0      9
   7  1
'EB on-ramp'      'ag'   19      300    -367    -13    0      9
   8  1
'WB on-ramp'      'ag'   -14     -360   2      -386    0      9
   9  1
'sNB cruise'      'ag'   26      18     -507    -433    0      9
   10  1
'sNB queue'       'ag'   18      12     -433    -371    0      9
   11  1
'sNB depart'      'ag'   12      9      -371    -246    0      9
   12  1
'NB connect'      'br'   9       2      -246    -56     0      9
   13  1
'nNB queue'       'ag'   2       1      -56     5       0      9
   14  1
'nNB depart'      'ag'   1       1      5       130     0      9
   15  1
'nSB cruise'      'ag'   -10     -8     142     68      0      9
   16  1
'nSB queue'       'ag'   -8      -9     68      6       0      9
   17  1
'nSB depart'      'ag'   -9      -7     6       -122    0      9
   18  1
'SB connect'      'br'   -7      -3     -122    -311    0      9
   19  1
'sSB queue'       'ag'   -3      2      -311    -371    0      9
   20  1
'sSB depart'      'ag'   2       12     -371    -501    0      9
01        0.0
          1       5060    0.1214
          2       568     0.3737
          3       568     0.2605
          4       5060    0.1214
          5       568     0.3737
          6       568     0.2605
          7       616     0.5392
          8       616     0.5392
          9       568     0.3985
          10      568     0.3356
          11      568     0.3642
```

Section 7.5 of the guidance recommends that users run the air quality model for five years of meteorological data when on-site meteorology data is not available. Since CAL3QHCR can only process one year of meteorological data for each run, each quarterly scenario is run for five years of meteorological data for a total of 20 runs.[2]

E.7.2 Incorporating meteorological data

Through the interagency consultation process, a representative set of meteorology data, as well as an appropriate surface roughness are selected (see Section 7.5). The recommended five years of meteorological data are obtained from a local airport for calendar years 1998-2002. A surface roughness of 175 cm is selected for the site; this is consistent with the recommendations made in the Section 7 of the guidance.

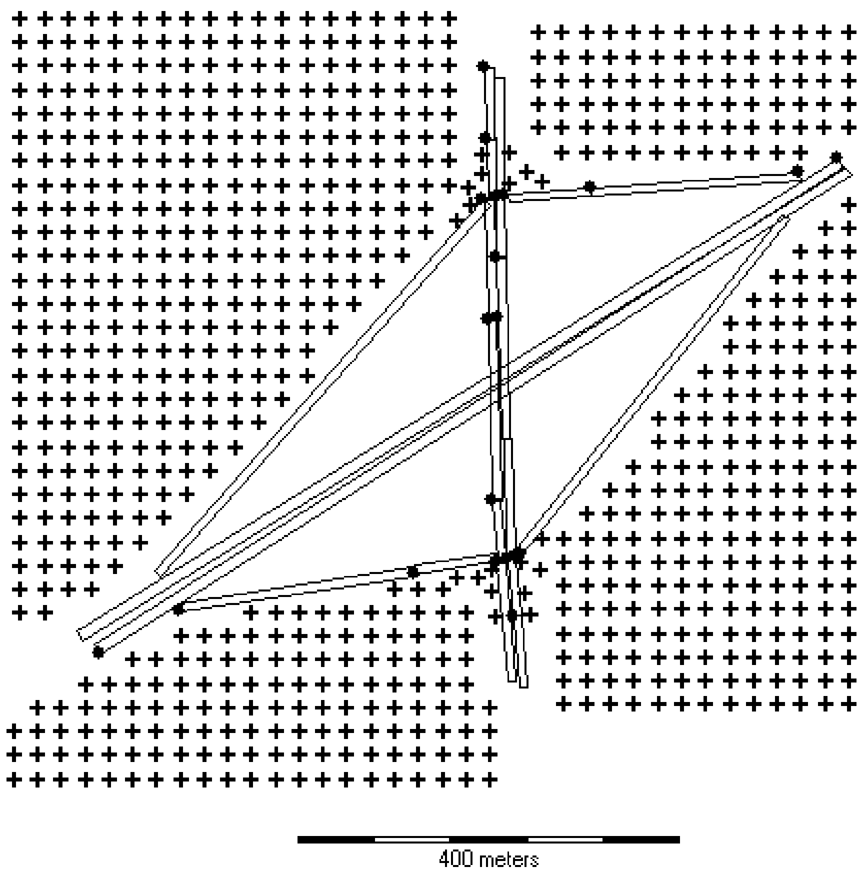
E.7.3 Specifying receptors

Using the interagency consultation process and the guidance given in Section 7.6, receptors are placed in appropriate areas within the area substantially affected by the project (Exhibit E-14, following page). Receptor heights are set at 1.8 meters (the approximate height at which a person breathes). Additionally, a background concentration of "0" is input into the model. Representative background concentrations are added later (see Step 7).

CAL3QHCR is then run with five years of meteorological data (1998 through 2002) and output is produced for all receptors for each of the five years of meteorological data.

[2] As explained in Section 7, AERMOD allows five years of meteorological data to be modeled in a single run (see Section 7.5.3)

Exhibit E-14. Receptor Locations for Air Quality Modeling



E.8 DETERMINE BACKGROUND CONCENTRATIONS (STEP 6)

Through the interagency consultation process, a nearby upwind $PM_{2.5}$ monitor that has been collecting ambient data for both the annual and 24-hour $PM_{2.5}$ NAAQS is determined to be representative of the background air quality at the project location. The most recent data set is used (in this case, calendar year 2008 through 2010) and average 24-hour $PM_{2.5}$ values are taken in a four-day/three-day measurement interval. As previously noted, no nearby sources requiring explicit modeling are identified.

Note: This is a highly simplified situation for illustrative purposes; refer to Section 8 of the guidance for additional considerations for how to most accurately reflect background concentrations in a real-world scenario.

E.9 CALCULATE DESIGN VALUES AND COMPARE BUILD AND NO-BUILD SCENARIO RESULTS (STEP 7)

With both CAL3QHCR outputs and background concentrations now available, the project sponsor can calculate the design values. For illustrative purposes, calculations for a single receptor for the build scenario are shown in this example, but any analysis should be done at all receptors for comparison with the relevant NAAQS. In this step, the guidance from Section 9.3.2 and 9.3.3 is used to calculate design values from the modeled results and the background concentrations for comparison with the 24-hour and annual $PM_{2.5}$ NAAQS.

E.9.1 Determining conformity to the annual $PM_{2.5}$ NAAQS

First, average background concentrations are determined for each year of monitored data (shown in Exhibit E-15).

Exhibit E-15. Annual Average Background Concentration for Each Year

Monitoring Year	Annual Average Background Concentration
2008	13.348
2009	12.785
2010	13.927

The three-year average background concentration is then calculated (see Exhibit E-16).

Exhibit E-16. Calculation of Annual Design Value (At Highest Receptor)

Annual Average Background Concentration (Three-year Average)	Annual Average Modeled Concentration (Five-year Average)	Sum of Background + Project	Annual Design Value
13.353	1.580	14.933	14.9

To determine the annual $PM_{2.5}$ design value, the annual average background concentration is added to the five-year annual average modeled concentration (at the receptor with the highest annual average concentration from the CAL3QHCR output). This calculation is shown in Exhibit E-16. The sum (background + project) results in a design value of 14.9 $\mu g/m^3$. This value at the highest receptor is less than the 1997 NAAQS of 15.0 $\mu g/m^3$. It can be assumed that all other receptors with lower modeled concentrations will also have design values less than the 1997 NAAQS. In this example it is unnecessary to determine appropriate receptors in the build scenario or develop a no-build scenario for the annual $PM_{2.5}$ NAAQS, since the build scenario demonstrates that the hot-spot analysis requirements in the transportation conformity rule are met at all receptors.

E.9.2 Determining conformity to the 24-Hour $PM_{2.5}$ NAAQS

The next step is to calculate a design value to compare with the 2006 24-hour $PM_{2.5}$ NAAQS through a "Second Tier" analysis as described in Section 9.3.3. For ease of explanation, this process has been divided into individual steps, consistent with the guidance.

<u>Step 7.1</u>
The number of background measurements is counted for each year of monitored data (2008 to 2010). Based on a 4-day/3-day measurement interval, the dataset has 104 values per year.

<u>Step 7.2</u>
For each year of monitored concentrations, the eight highest daily background concentrations for each quarter are determined, resulting in 32 values (4 quarters; 8 concentrations/quarter) for each year of data (shown in Exhibit E-17, following page).

<u>Step 7.3</u>
Identify the highest-predicted modeled concentration resulting from the project in each quarter, averaged across each year of meteorological data used for air quality modeling. For illustrative purposes, the highest average concentration across five years of meteorological data for a single receptor in each quarter is shown in Exhibit E-18 (following page). Note that, in a real-world situation, this process would be repeated for all receptors in the build scenario.

Exhibit E-17. Highest Daily Background Concentrations for Each Quarter and Each Year

2008				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	20.574	21.262	22.354	20.434
2	20.152	20.823	22.042	20.016
3	19.743	20.398	21.735	19.611
4	19.346	19.985	21.434	19.218
5	18.961	19.584	21.140	18.837
6	18.588	19.196	20.851	18.467
7	18.226	18.819	20.568	18.109
8	17.874	18.454	20.291	17.761
2009				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	20.195	20.867	21.932	20.058
2	19.784	20.440	21.628	19.651
3	19.386	20.026	21.329	19.257
4	19.000	19.624	21.037	18.875
5	18.625	19.235	20.750	18.504
6	18.262	18.857	20.469	18.145
7	17.910	18.490	20.194	17.796
8	17.568	18.135	19.924	17.457
2010				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	21.137	21.847	22.980	20.990
2	20.698	21.390	22.655	20.556
3	20.272	20.948	22.336	20.135
4	19.860	20.519	22.023	19.726
5	19.459	20.102	21.717	19.330
6	19.071	19.698	21.417	18.945
7	18.694	19.307	21.123	18.572
8	18.329	18.927	20.834	18.211

Exhibit E-18. Five-year Average 24-hour Modeled Concentrations for Each Quarter (At Example Receptor)

	Q1	**Q2**	**Q3**	**Q4**
Five Year Average Maximum Concentration (At Example Receptor)	10.42	10.62	10.74	10.61

Step 7.4

The highest modeled concentration in each quarter (from Step 7.3) is added to each of the eight highest monitored concentrations for the same quarter for each year of monitoring data (from Step 7.2). As shown in Exhibit E-19, this step results in eight concentrations in each of four quarters for a total of 32 values for each year of monitoring data. As mentioned, this example analysis shows only a single receptor's values, but project sponsors should calculate design values at all receptors in the build scenario.

Exhibit E-19. Sum of Background and Modeled Concentrations at Example Receptor for Each Quarter

2008				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	31.084	31.902	32.994	31.074
2	30.662	31.463	32.682	30.656
3	30.253	31.038	32.375	30.251
4	29.856	30.625	32.074	29.858
5	29.471	30.224	31.780	29.477
6	29.098	29.836	31.491	29.107
7	28.736	29.459	31.208	28.749
8	28.384	29.094	30.931	28.401
2009				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	30.705	31.507	32.572	30.698
2	30.294	31.080	32.268	30.291
3	29.896	30.666	31.969	29.897
4	29.510	30.264	31.677	29.515
5	29.135	29.875	31.390	29.144
6	28.772	29.497	31.109	28.785
7	28.420	29.130	30.834	28.436
8	28.078	28.775	30.564	28.097
2010				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	31.647	32.487	33.620	31.630
2	31.208	32.030	33.295	31.196
3	30.782	31.588	32.976	30.775
4	30.370	31.159	32.663	30.366
5	29.969	30.742	32.357	29.970
6	29.581	30.338	32.057	29.585
7	29.204	29.947	31.763	29.212
8	28.839	29.567	31.474	28.851

Step 7.5

As shown in Exhibit E-20, for each year of monitoring data, the 32 values from Step 7.4 are ordered together in a column and assigned a yearly rank for each value, from 1 (highest concentration) to 32 (lowest concentration).

Exhibit E-20. Ranking Sum of Background and Modeled Concentrations at Example Receptor for Each Year of Background Data

Rank	2008	2009	2010
1	32.994	32.572	33.620
2	32.682	32.268	33.295
3	**32.375**	**31.969**	**32.976**
4	32.074	31.677	32.663
5	31.902	31.507	32.487
6	31.780	31.390	32.357
7	31.491	31.109	32.057
8	31.463	31.080	32.030
9	31.208	30.834	31.763
10	31.084	30.705	31.647
11	31.074	30.698	31.630
12	31.038	30.666	31.588
13	30.931	30.564	31.474
14	30.662	30.294	31.208
15	30.656	30.291	31.196
16	30.625	30.264	31.159
17	30.253	29.897	30.782
18	30.251	29.896	30.775
19	30.224	29.875	30.742
20	29.858	29.515	30.370
21	29.856	29.510	30.366
22	29.836	29.497	30.338
23	29.477	29.144	29.970
24	29.471	29.135	29.969
25	29.459	29.130	29.947
26	29.107	28.785	29.585
27	29.098	28.775	29.581
28	29.094	28.772	29.567
29	28.749	28.436	29.212
30	28.736	28.420	29.204
31	28.401	28.097	28.851
32	28.384	28.078	28.839

Step 7.6

For each year of monitoring data, the value with a rank that corresponds to the projected 98^{th} percentile concentration is determined. As discussed in Section 9, an analysis employing 101-150 background values for each year (as noted in Step 7.1, this analysis uses 104 values per year) uses the 3^{rd} highest rank to represent a 98^{th} percentile. The 3^{rd} highest concentration (highlighted in Exhibit E-20) is referred to as the "projected 98^{th} percentile concentration."

Step 7.7

Steps 7.1 through 7.6 are repeated to calculate a projected 98^{th} percentile concentration at each receptor based on each year of monitoring data and modeled concentrations.

Step 7.8

For the example receptor, the average of the three projected 98^{th} percentile concentrations (see Step 7.6) is calculated.

Step 7.9

The resulting value of 32.440 $\mu g/m^3$ is then rounded to the nearest whole $\mu g/m^3$, resulting in a design value at the example receptor of 32 $\mu g/m^3$. At each receptor this process should be repeated. In the case of this analysis, the example receptor is the receptor with the highest design value in the build scenario.

Step 7.10

The design values calculated at each receptor are compared to the NAAQS. In the case of this example, the highest 24-hour design value (32 $\mu g/m^3$) is less than the 2006 $PM_{2.5}$ 24-hour NAAQS of 35 $\mu g/m^3$. Since this is the design value at the highest receptor, it can be assumed that the conformity requirements are met at all receptors in the build scenario. Therefore, it is unnecessary for the project sponsor to calculate design values for the no-build scenario for the 24-hour NAAQS.

E.10 CONSIDER MITIGATION AND CONTROL MEASURES (STEP 8)

In this case, the project is determined to conform. In situations when this is not the case, it may be necessary to consider additional mitigation or control measures. If measures are considered, additional air quality modeling would need to be completed and new design values calculated to ensure that conformity requirements are met. See Section 10 for more information, including some specific measures that might be considered.

E.11 DOCUMENT THE PM HOT-SPOT ANALYSIS (STEP 9)

The final step is to properly document the PM hot-spot analysis in the conformity determination (see Section 3.10).

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

F.1 INTRODUCTION

This purpose of this appendix is to demonstrate the procedures for completing a hot-spot analysis using MOVES and AERMOD following the basic steps described in Section 3. Readers should reference the appropriate sections in the guidance as needed for more detail on how to complete each step of the analysis. This example is limited to showing the build scenario; in practice, project sponsors may have to also analyze the no-build scenario. While this example calculates emission rates using MOVES, EMFAC users may find the air quality modeling described in this appendix helpful.

Note: The following example of a quantitative PM hot-spot analysis is highly simplified and intended only to demonstrate the basic procedures described in the guidance. This example uses default data in places where the use of project–specific data in a real-world situation would be expected. In addition, actual PM hot-spot analyses could be significantly more complex, and are likely to require more documentation of data and decisions.

F.2 PROJECT DESCRIPTION AND CONTEXT

The proposed project is a new regionally significant bus terminal that would be created by taking a downtown street segment one block in length and reserving it for bus use only. It would be an open-air facility containing six "sawtooth" lanes where buses enter to load and unload passengers. The terminal is designed to handle about 575 diesel buses per day with up to 48 buses in the peak hour. The project is located in an area designated nonattainment for the 2006 $PM_{2.5}$ 24-hour NAAQS and 1997 $PM_{2.5}$ annual NAAQS.

The following is some additional pertinent data about the project:

- The proposed project is located in a medium-size city (within one county) in a state other than California.
- The project is expected to take less than a year to complete and has an estimated completion date of 2013. The year of peak emissions is expected to be 2015, when considering the project's emissions and background concentrations.
- The area surrounding the proposed project is primarily commercial, with no nearby sources of $PM_{2.5}$ that need to be explicitly modeled. This assumption is made to simplify the example. In most cases, transit projects include parking lots with emissions that would be considered in a PM hot-spot analysis.
- The state does not have an adequate or approved SIP budget for either $PM_{2.5}$ NAAQS, and neither the EPA nor the state air quality agency has made a finding that road dust is a significant contributor to the $PM_{2.5}$ nonattainment problem.

F.3 DETERMINE NEED FOR ANALYSIS (STEP 1)

Through interagency consultation, the proposed project is determined to be of local air quality concern under the conformity rule because it is a new bus terminal that has a significant number of diesel vehicles congregating at a single location (see 40 CFR 93.123(b)(1)(iii) and Sections 1.4 and 3.2 of the guidance). Therefore, a quantitative PM hot-spot analysis is required.

F.4 DETERMINE APPROACH, MODELS, AND DATA (STEP 2)

F.4.1 Determining geographic area and emission sources to be covered by the analysis

First, the interagency consultation process is used to ensure that the project area is defined so that the analysis includes the entire project, as required by 40 CFR 93.123(c)(2). As previously noted, it is also determined that, in this case, there are no nearby emission sources to be explicitly modeled (see Section 3.3.2).

F.4.2 Deciding on general analysis approach and analysis year(s)

The project sponsor then determines that the preferred approach in this case is to model the build scenario first, completing a no-build scenario only if necessary.

The year of peak emissions (within the timeframe of the current transportation plan) is determined to be 2015. Therefore, 2015 is selected as the year of the analysis, and the analysis will consider traffic data from 2015 (see Section 3.3.3).

F.4.3 Determining which PM NAAQS to be evaluated

Because the area has been designated nonattainment for both the 2006 NAAQS and 1997 NAAQS, the results of the analysis will have to be compared to both NAAQS (see Section 3.3.4). All four quarters are included in the analysis in order to estimate a year's worth of emissions for both NAAQS.

F.4.4 Deciding on the type of PM emissions to be modeled

Next, through interagency consultation the following directly-emitted PM emissions are determined to be relevant for estimating the emissions in the analysis (see Section 3.3.5):

- Vehicle exhaust[1]
- Brake wear
- Tire wear

F.4.5 Determining the models and methods to be used

Since this project will be located outside of California, MOVES2010 is used for emissions modeling. In addition, it is determined that, since this is a terminal project, the appropriate air quality model to use would be AERMOD (see Section 3.3.6). Making the decision on what air quality model to use at this stage is important so that the appropriate data are collected, among other reasons (see next step).

F.4.6 Obtaining project-specific modeling data

Finally, having selected a model and a general modeling approach, the project sponsor compiles the data required to use MOVES, including project traffic data, vehicle types and age, and temperature and humidity data for the months and hours to be modeled (specifics on the data collected are described in the following steps). In addition, information required to use AERMOD to model air quality is gathered, including meteorological data and information on representative air quality monitors. The sponsor ensures the latest planning assumptions are used and that data used for the analysis are consistent with that used in the latest regional emissions analysis, as required by the conformity rule (see Section 3.3.7). The interagency consultation process is used to discuss the data for the analysis.

F.5 ESTIMATE ON-ROAD MOTOR VEHICLE EMISSIONS (STEP 3)

Having completed the analysis preparations described above, the project sponsor then follows the instructions provided in Section 4 of the guidance to use MOVES to estimate the on-road emissions from this terminal project:

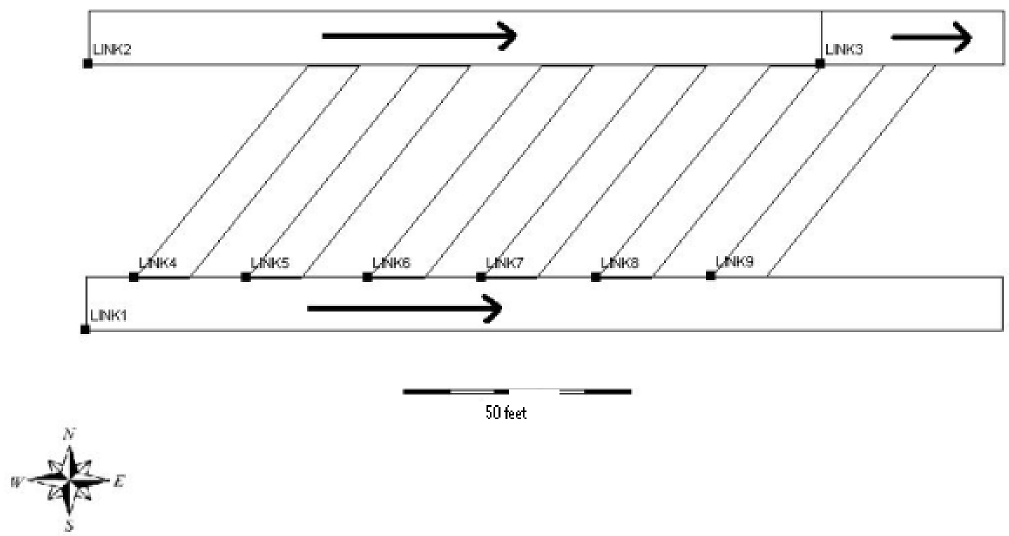
F.5.1 Characterizing the project in terms of links

Using the guidance described in Section 4.2, a series of links are defined in order to accurately capture the activity at the proposed terminal. As shown in Exhibit F-1 (following page), two one-way running links north and south of the facility ("Link 1" and "Link 2") are defined to describe buses entering and exiting the terminal. A third running/idle link (shown as "Link 3" to the north of the facility), is used to describe vehicles idling at the signalized light before exiting the facility. Links 4 through 9

[1] Represented in MOVES as $PM_{total\ running}$, $PM_{total\ crankcase\ running}$, $PM_{total\ ext.\ idle}$, and $PM_{total\ crankcase\ ext.\ idle}$.

represented bus bays where buses drop-off and pick-up passengers; these are referred to as the terminal links.

Exhibit F-1. Diagram of Proposed Bus Terminal Showing Links



The running links have the following dimensions:

Link 1: 200 feet long by 24 feet wide
Link 2: 160 feet long by 24 feet wide
Link 3: 40 feet long by 24 feet wide

Additionally, the dimensions of the six terminal links (Links 4 through 9) are 60 feet long by 12 feet wide. These links are oriented diagonally from southwest to northeast. The queue link (Link 3) is defined with a length of 40 feet, based on the average length of a transit bus.

After identifying and defining the links, traffic conditions are estimated for the project in the analysis year of 2015. The terminal was presumed to be in operation all hours of the year. Based on expected terminal operations, the anticipated future traffic volumes are available for each hour of an average weekday (see Exhibit F-2, following page). To simplify the analysis, the sponsor conservatively assumes weekday traffic for all days of the year, even though the operating plan calls for reduced service on weekends.[2] Identical traffic volume and activity profiles are assumed for all quarters of the year. Quarters are defined for this analysis as described in Section 3.3.4 of the guidance: Q1 (January-March), Q2 (April-June), Q3 (July-September), and Q4 (October-December).

[2] This decision, which would be discussed through interagency consultation, is made to save time and effort, as it would result in the need for fewer modeling runs. More accurate results would be obtained by treating weekends differently and modeling them using the actual estimated Saturday and Sunday traffic.

Exhibit F-2. Average Weekday Bus Trips through Transit Terminal for Each Hour

Hour	Bus Trips
12am - 1am	7
1am - 2am	6
2am - 3am	6
3am - 4am	6
4am - 5am	7
5am - 6am	9
6am - 7am	27
7am - 8am	48
8am - 9am	39
9am - 10am	29
10am - 11am	26
11am - 12pm	28
12pm - 1pm	30
1pm - 2pm	31
2pm - 3pm	31
3pm - 4pm	39
4pm - 5pm	44
5pm - 6pm	42
6pm - 7pm	26
7pm - 8pm	21
8pm - 9pm	22
9pm - 10pm	17
10pm - 11pm	13
11pm - 12am	10

F.5.2 Deciding on how to handle link activity

As discussed in Section 4.2 of the guidance, MOVES offers several options for users to apply activity information to each LinkID. For illustrative purposes, based on the available information for the project (average speed, hourly bus volume, idle time, and fraction of vehicles encountering a red-light) several methods of deriving Op-Mode distributions are employed in this example, as described below.

- Links 1 and 2 represent buses driving at an average of 5 mph through the terminal, entering and exiting the bus bays. An average speed of 5 mph is entered into the MOVES "links" input, which calculates an Op-Mode distribution to reflect the MOVES default 5 mph driving pattern.
- The queue link (Link 3) is given an Op-Mode distribution that represents buses decelerating, idling, and accelerating (red light) as well as cruising through (green light). First, an Op-Mode distribution is calculated for the link average speed (5 mph). Because this does not adequately account for idling at the intersection, the Op-Mode fractions are re-allocated to add in 50% idling (determined after consulting the 2000 Highway Capacity Manual to approximate idle time in an under-capacity scenario) reflecting 50% of buses encountering a red light. A

fraction of 0.5 for Op-Mode "1" is added to the re-allocated 5 mph average speed Op-Mode distribution. The resulting Op-Mode distribution represents all activity on a queuing intersection link.

- The bus bays (Links 4 through 9) are represented by a single link (modeled in MOVES as "LinkID 4") and activity is defined in the Links table by an average speed of "0", representing exclusively idle activity.

F.5.3 Determining the number of MOVES runs

Following the guidance given in Section 4.3, it is determined that 16 MOVES runs should be completed to produce emission factors that show variation across four hourly periods (12 a.m., 6 a.m., 12 p.m., and 6 p.m., corresponding to overnight, morning, midday, and evening traffic scenarios, respectfully) and four quarterly periods (represented by the months of January, April, July, and October; see Section 3.3). MOVES would calculate values for all project links for the time period specified in each run. Although traffic data is available for 24 hours, the emission factors produced from the 16 scenarios would be post-processed into grams/vehicle-hour and further converted to grams/hour emission factors that vary based on the hour-specific vehicle count. This methodology avoids running 24 hourly scenarios for four quarters (96 runs). A grams/hour emissions rate is required to use AERMOD.

F.5.4 Developing basic run specification inputs

When configuring MOVES for the analysis, the project sponsor follows Section 4.4 of the guidance, including, but not limited to, the following:

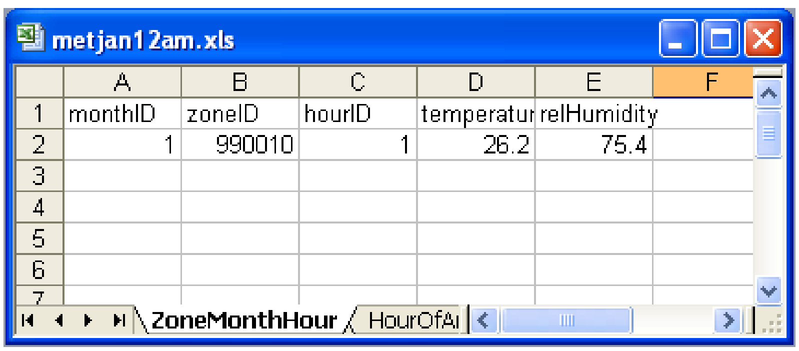
- From the Scale menu, selecting the "Project" domain; in addition, choosing output in "Inventory" so that total emission results are produced for each link, which is equivalent to a grams/hour/link emission factor needed by AERMOD (see Section 4.4.2).
- From the Time Spans Panel, the appropriate year, month, day, and hour for each run is selected (see Section 4.4.3).
- From the Geographic Bounds Panel, the custom domain is selected (see Section 4.4.4).
- From the Vehicles/Equipment Panel, Diesel Transit Buses are selected (see Section 4.4.5).
- From the Road Types Panel, the Urban Restricted road type is selected (see Section 4.4.6).
- From the Pollutants and Processes Panel, appropriate pollutant/processes are selected according to Section 4.4.7 of the guidance for "highway links".
- In the Output Panel, an output database is specified with grams and miles selected as units (see Section 4.4.10).

F.5.5 Entering project details using the Project Data Manager

Meteorology

As described previously, it is determined that MOVES should be run 16 times to reflect the following scenarios: 12 a.m., 6 a.m., 12 p.m., and 6 p.m. (corresponding to overnight, morning, midday, and evening traffic scenarios, respectfully) for the months of January, April, July, and October. Through the interagency consultation process, temperature and humidity data from a representative meteorological monitoring station are obtained and confirmed to be consistent with data used in the regional emissions analysis from the currently conforming transportation plan and TIP (see Section 4.5.1). Average values for each hour and month combination are used for each of the 16 MOVES runs. As an example, temperature and humidity values for 12 a.m. January are shown in Exhibit F-3.

Exhibit F-3. Temperature and Humidity Input (January 12 a.m.)



metjan12am.xls

	A	B	C	D	E	F
1	monthID	zoneID	hourID	temperatur	relHumidity	
2	1	990010	1	26.2	75.4	
3						
4						
5						
6						

ZoneMonthHour / HourOfAı

<u>Age Distribution</u>

Section 4.5.2 of the guidance specifies that default data should be used only if an alternative local dataset cannot be obtained and the regional conformity analysis relies on national defaults. However, for the sake of simplicity only, in this example the national default age distribution for 2015 is used for all vehicles and all runs (see Exhibit F-4). As discussed in the guidance, transit agencies should be able to provide a fleet-specific age distribution, and the use of fleet-specific data is always recommended (and would be expected in a real-world scenario) because emission factors vary significantly depending on the age of the fleet.

Exhibit F-4. Age Distribution Table

agedist.xls

	A	B	C	D	E	F
1	sourceTyp	yearID	ageID	ageFraction		
2	42	2015	0	0.052013		
3	42	2015	1	0.052432		
4	42	2015	2	0.051104		
5	42	2015	3	0.050951		
6	42	2015	4	0.0509		
7	42	2015	5	0.050341		
8	42	2015	6	0.045595		
9	42	2015	7	0.038191		
10	42	2015	8	0.034719		
11	42	2015	9	0.038183		
12	42	2015	10	0.043573		
13	42	2015	11	0.043438		
14	42	2015	12	0.051516		
15	42	2015	13	0.047071		
16	42	2015	14	0.043819		
17	42	2015	15	0.035929		
18	42	2015	16	0.031348		

sourceTypeAgeDistribution

<u>Fuel Supply and Fuel Formulation</u>

An appropriate fuel supply and formulation is selected to match the project area's diesel use. In MOVES, diesel fuel formulation is constant across all quarters, so one fuel supply/fuel formulation combination is used for all MOVES runs. Also, it is known that 100% of the transit buses would use diesel fuel, so a fraction of 1 is entered for fuel 3043 (ultra-low-sulfur diesel fuel) in the Fuel Supply Table. In the case of this example, the default fuel supply/formulation matches the actual fuel supply/formulation, so it is therefore appropriate to use the default in the analysis (see Exhibits F-5 and F-6).

Exhibit F-5. Fuel Supply Table

fuelsupplyJan.xls

countyID	fuelYearID	monthGrou	fuelFormul	marketSha	marketShareCV
99001	2015	1	1054	1	0.5
99001	2015	1	3043	1	0.5

FuelSupply / County / FuelFormulati

Exhibit F-6. Fuel Formulation Table

fuelformjan.xls

fuelFormul	fuelSubtyp	RVP	sulfurLevel	ETOHVolu	MTBEVolu	ETBEVolu	TAMEVolu	arc
3011	20	0	11	0	0	0	0	
3043	20	0	43	0	0	0	0	
3100	20	0	100	0	0	0	0	
3113	20	0	113	0	0	0	0	
3281	20	0	281	0	0	0	0	
3300	20	0	300	0	0	0	0	
3337	20	0	337	0	0	0	0	
3450	20	0	450	0	0	0	0	
3468	20	0	468	0	0	0	0	
20	20	0	0	0	0	0	0	

FuelFormulation / FuelSubtype /

<u>Inspection and Maintenance (I/M)</u>

As there is no PM emissions benefit in MOVES for I/M programs, this menu item is skipped (see Section 4.5.4).

<u>Link Source Type</u>

The distribution of vehicle types on each link is defined in the Link Source Type table following the guidance in Section 4.5.5. Given that the project will be a dedicated transit bus terminal this analysis assumes only transit buses are operating on all links. Therefore, a fraction of 1 is entered for Source Type 42 (Transit Buses) for each LinkID indicating 100% of vehicles using the project are transit buses (see Exhibit F-7).

Exhibit F-7. Link Source Type Table

linksource.xls

linkID	sourceTypeID	sourceTypeHourFraction
1	42	1
2	42	1
3	42	1
4	42	1

linkSourceTypeHour / SourceU

Links

The links table (see Exhibit F-8) is populated with parameters for the four defined links of the bus terminal: three running links (Links 1-3) and one idle link (representing the terminal links). The link length is entered in terms of miles for each link. The road type for the four links is classified as “5” (Urban Unrestricted). The entrance and exit links (Links 1 and 2) are given an average speed of 5 mph. The queue link (Link 3) is given an average speed of 2.5 mph, representing 50% of the vehicle operating hours in idling mode and 50% operating hours traveling at 5 mph. Although MOVES is capable of calculating emissions from an average speed (as is done for Links 1 and 2), the specific activity on Link 3 is directly entered with an Op-Mode distribution. LinkID 4 is given a link average speed of “0” mph, which indicates entirely idle operation. Link volume (which represents the number of buses per hour) is entered for each link; however, since the goal of the analysis is to produce an estimate in grams/vehicle-hour, the volume (i.e., the number of vehicles) will be divided out during post-processing.

Exhibit F-8. Links Table

links.xls

linkID	countyID	zoneID	roadTypeID	linkLength	linkVolume	linkAvgSpeed	linkDescription
1	99001	990010	5	0.038	48	5	Entrance Link
2	99001	990010	5	0.030	24	5	Exit Approach Link
3	99001	990010	5	0.008	24	2.5	Left Turn Exit Link
4	99001	990010	1	0.011	8	0	Terminals

link / County / RoadType / Zone

Describing Vehicle Activity

MOVES can capture details about vehicle activity in a number of ways. In this case, it is decided to provide a detailed Op-Mode distribution for each link (see Section 4.5.7).

Op-Mode distributions for Links 1 and 2 are calculated based on a 5 mph average speed. The MOVES model calculates a default Op-Mode distribution based on average speed and road type (for these links, 5 mph on Road Type 5). Link 3 is given a unique Op-Mode distribution to better simulate the queuing and idling that occurs prior to buses exiting the facility at a traffic signal. The sponsor estimates that 50% of buses would idle at a red light before exiting the facility, so the idling operation (OpMode ID 1) is assumed to be 0.5 for Link 3. The remaining 50% is re-allocated based on the default 5 mph Op-Mode distribution calculated for Links 1 and 2 (which includes acceleration, deceleration, and cruise operating modes). This process requires an additional MOVES run to extract the default 5 mph Op-Mode distribution from the MOVES execution database. By selecting "save data" for the "Operating Mode Distribution Generator (Running OMDG)" under the MOVES "Advanced Performance Features" panel, the Op-Mode distributions generated for 5 mph on an urban unrestricted road type are saved in the MOVES execution database in the MySQL table "opmodedistribution." The Op-Mode distribution used in the analysis for Link 3 is partially shown in Exhibit F-9.

Exhibit F-9. Link 3 (Queue Link) Op-Mode Distribution Input Table (Partial)

opmode.xls

	A	B	C	D	E	F	G	H	I
1	sourceTyp	hourDayID	linkID	polProces	opModeID	opModeFraction			
2	42	75	3	9101	1	0.5			
3	42	75	3	9190	1	0.5			
4	42	75	3	11001	1	0.5			
5	42	75	3	11015	1	0.5			
6	42	75	3	11017	1	0.5			
7	42	75	3	11090	1	0.5			
8	42	75	3	11101	1	0.5			
9	42	75	3	11115	1	0.5			
10	42	75	3	11117	1	0.5			
11	42	75	3	11190	1	0.5			
12	42	75	3	11201	1	0.5			
13	42	75	3	11215	1	0.5			
14	42	75	3	11217	1	0.5			
15	42	75	3	11290	1	0.5			
16	42	75	3	11501	1	0.5			
17	42	75	3	11515	1	0.5			
18	42	75	3	11517	1	0.5			
19	42	75	3	11590	1	0.5			
20	42	75	3	11609	1	0.5			
21	42	75	3	11710	1	0.5			
22	42	75	3	9101	11	0.25			
23	42	75	3	9190	11	0.25			
24	42	75	3	11001	11	0.25			
25	42	75	3	11015	11	0.25			
26	42	75	3	11017	11	0.25			
27	42	75	3	11090	11	0.25			
28	42	75	3	11101	11	0.25			
29	42	75	3	11115	11	0.25			
30	42	75	3	11117	11	0.25			
31	42	75	3	11190	11	0.25			
32	42	75	3	11201	11	0.25			

opModeDistribution / HourDay / OperatingMode

Off-Network

As it is assumed that there are no off-network links (such as parking lots or truck stops) that would have to be considered using the Off-Network Importer (bus idling at the terminal is captured by the terminal links), there is no need to use this option in this example. As noted earlier, this assumption is made to simplify the example. Most transit projects would include rider parking lots and should include these emissions in a PM hot-spot analysis.

F.5.6 Generating emission factors for use in air quality modeling

After generating the run specification and entering the required information into the Project Data Manager as described above, MOVES is run 17 times: 16 runs (four hours of the day for four quarters of the year) plus an initial run to generate the Op-Mode distribution for 5 mph as discussed earlier. Upon completion of each run, the MOVES output is located in the MySQL output database table "movesoutput" and sorted by Month, Hour, LinkID, ProcessID, and PollutantID. An aggregate $PM_{2.5}$ emission factor is then calculated by the project sponsor for each Month, Hour, and LinkID combination using the following equation and the guidance given in Section 4.4.7 of the guidance:

$$PM_{\text{aggregate total}} = (PM_{\text{total running}}) + (PM_{\text{total crankcase running}}) + (\text{brake wear}) + (\text{tire wear})$$

For each link, the total emissions are divided by the number of vehicles on each link (as reported in the "movesactivityoutput" table ActivitytypeID = 6) to produce a grams/vehicle-hour value. This value is then multiplied by the number of buses on each link, for each of the 24 hours where data are available (see Exhibit F-2).

The emission factor (grams/vehicle-hour) for LinkID 4 (links 4 through 9) is converted into grams per vehicle-minute, and then multiplied by the total idle time for each unique hour. For instance, the hour from 5 pm to 6 pm has a volume of 42 buses per hour (7 buses per bus bay). If each bus is expected to idle for 60 seconds each hour, the total idle time for each bus bay for that hour would be 7 minutes per hour. If MOVES calculated a PM emission factor of 2.0 grams per vehicle-minute, the emission factor for each bus bay link under this scenario would be 14.0 grams/hour.

To account for temperature changes throughout the day, emission factors are evenly paired with corresponding traffic volumes (six hours per period):

- 6am results – traffic data from 3am to 9am
- 12pm results – traffic data from 9am to 3 pm
- 6pm results – traffic data from 3pm to 9 pm
- 12pm results - traffic data from 9pm to 3am

The emission factor results for each quarter are similarly paired with traffic volumes.

The 96 resulting grams/hour emission factors (24 hours each for four quarters) for each link are then ready to be used as an input to the AERMOD dispersion model to predict future $PM_{2.5}$ concentrations.

F.6 ESTIMATE DUST AND OTHER EMISSIONS (STEP 4)

F.6.1 Estimating re-entrained road dust

In this case, this area does not have any adequate or approved SIP budgets for either $PM_{2.5}$ NAAQS, and neither the EPA nor the state air agency have made a finding that road dust emissions are a significant contributor to the air quality problem for either $PM_{2.5}$ NAAQS. Therefore, $PM_{2.5}$ emissions from road dust do not need to be considered in this analysis (see Sections 2.5.3 and 6.2).

F.6.2 Estimating transportation-related construction dust

The construction of this project will not occur during the analysis year. Therefore, emissions from construction dust are not included in this analysis (see Sections 2.5.5 and 6.4).

F.6.3 Estimating other sources of emissions in the project area

Through interagency consultation, it is determined that the project area in the analysis year does not include locomotives or other nearby emissions sources that would have to be considered in the analysis (see Section 6.6).

F.7 SELECT AN AIR QUALITY MODEL, DATA INPUTS, AND RECEPTORS (STEP 5)

F.7.1 Characterizing emission sources

Because this is a transit terminal project, EPA's AERMOD model is determined to be the appropriate dispersion model to use for this analysis (see Section 7.3). AERMOD is run to estimate $PM_{2.5}$ concentrations in and around the bus terminal project. Each link is represented in AERMOD as an "Area Source" with dimensions matching the project description (see Exhibit F-1). The emission release height is set to three meters, the approximate exhaust height of most transit buses.

F.7.2 Incorporating meteorological data

Through the interagency consultation process, a representative set of meteorology data, as well as an appropriate surface roughness are selected (see Section 7.5). The recommended five years of meteorological data is obtained from a local airport for calendar years 1998-2002. Additionally, surface roughness is set at 1 meter, consistent with the recommendations made in the "AERMOD Implementation Guide."

Emission factors generated from the MOVES runs are added to the AERMOD input file (see Exhibit F-10). For this analysis, emissions vary significantly from hour to hour due to fluctuating bus volumes as well as from daily and quarterly temperature effects. Adjustment factors are used to model these hourly and quarterly variations in emission factors.

Exhibit F-10. AERMOD Input File (Partial) with Seasonal (Quarterly) and Hourly Adjustments (Circled)

AERMOD Input.txt - Notepad

File Edit Format View Help

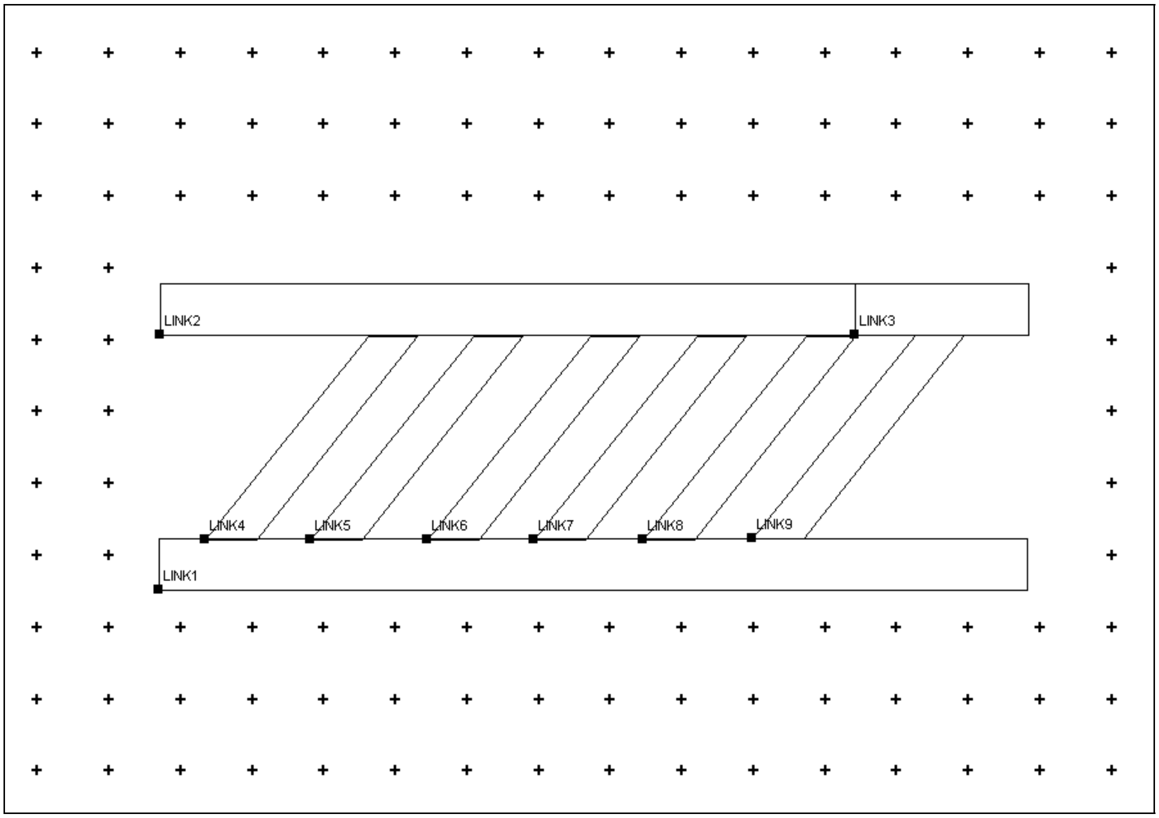
```
CO STARTING
CO TITLEONE  Transit Example
CO MODELOPT  DFAULT   CONC
CO RUNORNOT  RUN
CO AVERTIME  24   ANNUAL
CO POLLUTID  OTHER
CO FINISHED

SO STARTING
SO ELEVUNIT  METERS
SO LOCATION  LINK1      AREA       -166.7   -50.9   0
SO LOCATION  LINK2      AREA       -166.6   -33.2   0
SO LOCATION  LINK3      AREA       -118.1   -33.2   0
SO LOCATION  LINK5      AREAPOLY   -156.1   -47.4   0
SO LOCATION  LINK4      AREAPOLY   -163.5   -47.4   0
SO LOCATION  LINK7      AREAPOLY   -140.5   -47.4   0
SO LOCATION  LINK8      AREAPOLY   -132.9   -47.4   0
SO LOCATION  LINK9      AREAPOLY   -125.3   -47.3   0
SO LOCATION  LINK6      AREAPOLY   -148   -47.4   0
SO SRCPARAM  LINK1      7E-06  3   60.6   3.6   0.0   0
SO SRCPARAM  LINK2      4E-06  3   48.5   3.6   0.0   0
SO SRCPARAM  LINK3      4E-06  3   12.1   3.6   0.0   0
SO SRCPARAM  LINK5      2E-06  3   4   0
SO SRCPARAM  LINK4      2E-06  3   4   0
SO SRCPARAM  LINK7      2E-06  3   4   0
SO SRCPARAM  LINK8      2E-06  3   4   0
SO SRCPARAM  LINK9      2E-06  3   4   0
SO SRCPARAM  LINK6      2E-06  3   4   0
SO AREAVERT  LINK5      -156.1 -47.4   -152.5 -47.4   -141.3 -33.3   -144.7 -33.3
SO AREAVERT  LINK4      -163.5 -47.4   -159.9 -47.4   -148.7 -33.3   -152.1 -33.3
SO AREAVERT  LINK7      -140.5 -47.4   -136.9 -47.4   -125.7 -33.3   -129.1 -33.3
SO AREAVERT  LINK8      -132.9 -47.4   -129.3 -47.4   -118.1 -33.3   -121.5 -33.3
SO AREAVERT  LINK9      -125.3 -47.3   -121.7 -47.3   -110.5 -33.2   -113.9 -33.2
SO AREAVERT  LINK6      -148.0 -47.4   -144.4 -47.4   -133.2 -33.3   -136.6 -33.3
SO EMISFACT  LINK1      SEASHR  0.37  0.44  0.51  0.58  0.65  0.72  0.79  0.86
SO EMISFACT  LINK1      SEASHR  0.93  1  0.93  0.86  0.79  0.72  0.65  0.72  0.79
SO EMISFACT  LINK1      SEASHR  0.86  1  0.93  0.86  0.79  0.72  0.65  0.37  0.44
SO EMISFACT  LINK1      SEASHR  0.51  0.58  0.65  0.72  0.79  0.86  0.93  1  0.93
SO EMISFACT  LINK1      SEASHR  0.86  0.79  0.72  0.65  0.72  0.79  0.86  1  0.93
SO EMISFACT  LINK1      SEASHR  0.86  0.79  0.72  0.65  0.37  0.44  0.51  0.58
SO EMISFACT  LINK1      SEASHR  0.65  0.72  0.79  0.86  0.93  1  0.93  0.86  0.79
SO EMISFACT  LINK1      SEASHR  0.72  0.65  0.72  0.79  0.86  1  0.93  0.86  0.79
SO EMISFACT  LINK1      SEASHR  0.72  0.65  0.37  0.44  0.51  0.58  0.65  0.72
SO EMISFACT  LINK1      SEASHR  0.79  0.86  0.93  1  0.93  0.86  0.79  0.72  0.65
SO EMISFACT  LINK1      SEASHR  0.72  0.79  0.86  1  0.93  0.86  0.79  0.72  0.65
SO EMISFACT  LINK2      SEASHR  0.37  0.44  0.51  0.58  0.65  0.72  0.79  0.86
SO EMISFACT  LINK2      SEASHR  0.93  1  0.93  0.86  0.79  0.72  0.65  0.72  0.79
SO EMISFACT  LINK2      SEASHR  0.86  1  0.93  0.86  0.79  0.72  0.65  0.37  0.44
SO EMISFACT  LINK2      SEASHR  0.51  0.58  0.65  0.72  0.79  0.86  0.93  1  0.93
SO EMISFACT  LINK2      SEASHR  0.86  0.79  0.72  0.65  0.72  0.79  0.86  1  0.93
SO EMISFACT  LINK2      SEASHR  0.86  0.79  0.72  0.65  0.37  0.44  0.51  0.58
SO EMISFACT  LINK2      SEASHR  0.65  0.72  0.79  0.86  0.93  1  0.93  0.86  0.79
SO EMISFACT  LINK2      SEASHR  0.72  0.65  0.72  0.79  0.86  1  0.93  0.86  0.79
SO EMISFACT  LINK2      SEASHR  0.72  0.65  0.37  0.44  0.51  0.58  0.65  0.72
SO EMISFACT  LINK2      SEASHR  0.79  0.86  0.93  1  0.93  0.86  0.79  0.72  0.65
```

F.7.3 Specifying receptors

Using the interagency consultation process and the guidance given in Section 7.6, receptors are placed in appropriate areas within the area substantially affected by the project (see Exhibit F-11).[3] It is determined in this instance to locate receptors around the perimeter of the project in increments of five meters as well as within the passenger loading areas adjacent to the bus bays. Receptor heights are set at 1.8 meters (the approximate height at which a person breathes). A background concentration of "0" is input into the model. Representative background concentrations are added at a later step (see Step 7).

AERMOD is run using five years of meteorological data and output produced for all receptors for each of the five years of meteorological data.

Exhibit F-11. Area Source and Receptor Locations for Air Quality Modeling



[3] The number and arrangement of receptors used in this example are simplified for ease of explanation; real-world projects could expect to see a significantly larger number of receptors.

F.8 DETERMINE BACKGROUND CONCENTRATIONS (STEP 6)

Through the interagency consultation process, a nearby upwind $PM_{2.5}$ monitor that has been collecting ambient data for both the annual and 24-hour $PM_{2.5}$ NAAQS is determined to be representative of the background air quality at the project location (see Exhibit F-12). The most recent data set is used (in this case, calendar year 2008 through 2010) and average 24-hour $PM_{2.5}$ values are provided in a four-day/three-day measurement interval. As previously noted, no nearby sources requiring explicit modeling are identified.

Note: This is a highly simplified situation for illustrative purposes; refer to Section 8 of the guidance for additional considerations for how to most accurately reflect background concentrations in a real-world scenario.

Exhibit F-12. $PM_{2.5}$ Monitor Data from a Representative Nearby Site (Partial)

backgroundcalcs.xls

	A	B	C	D	E	F	G
1	Month	Day	Year	Date	PM2.5 Concentration		
2	1	1	2008	1/1/2008	23.08		
3	1	5	2008	1/5/2008	5.69		
4	1	8	2008	1/8/2008	12.19		
5	1	12	2008	1/12/2008	6.71		
6	1	15	2008	1/15/2008	7.26		
7	1	19	2008	1/19/2008	17.92		
8	1	22	2008	1/22/2008	11.90		
9	1	26	2008	1/26/2008	14.37		
10	1	29	2008	1/29/2008	16.54		
11	2	2	2008	2/2/2008	7.40		
12	2	5	2008	2/5/2008	13.63		
13	2	9	2008	2/9/2008	19.15		
14	2	12	2008	2/12/2008	12.65		
15	2	16	2008	2/16/2008	14.77		
16	2	19	2008	2/19/2008	11.08		
17	2	23	2008	2/23/2008	18.00		
18	2	26	2008	2/26/2008	21.62		
19	3	1	2008	3/1/2008	14.65		
20	3	4	2008	3/4/2008	6.93		
21	3	8	2008	3/8/2008	19.03		
22	3	11	2008	3/11/2008	20.66		
23	3	15	2008	3/15/2008	11.99		
24	3	18	2008	3/18/2008	4.71		
25	3	22	2008	3/22/2008	11.05		
26	3	25	2008	3/25/2008	15.64		
27	3	29	2008	3/29/2008	6.64		
28	4	1	2008	4/1/2008	11.68		
29	4	5	2008	4/5/2008	5.04		
30	4	8	2008	4/8/2008	10.11		
31	4	12	2008	4/12/2008	11.96		

Monitoring Data | AERMOD 24-hour Output

F.9 CALCULATE DESIGN VALUES AND COMPARE BUILD AND NO-BUILD SCENARIO RESULTS (STEP 7)

With both MOVES outputs and background concentrations now available, the project sponsor can calculate the design values. For illustrative purposes, calculations for a single receptor for the build scenario are shown in this example, but any analysis should be done at all receptors for comparison with the relevant NAAQS. In Step 7, the guidance from Section 9.3.2 is used to calculate design values from the modeled results and the background concentrations for comparison with the 24-hour and annual $PM_{2.5}$ NAAQS.

F.9.1 Determining conformity to the annual $PM_{2.5}$ NAAQS

First, average background concentrations are determined for each year of monitored data (shown in Exhibit F-13). The three-year average background concentration is then calculated (see Exhibit F-14).

Exhibit F-13. Annual Average Background Concentration for Each Year

Monitoring Year	Annual Average Background Concentration
2008	13.348
2009	12.785
2010	13.927
Annual Average	13.353

Exhibit F-14. Calculation of Annual Design Value (At Highest Receptor)

Annual Average Background Concentration (Three-year Average)	Annual Average Modeled Concentration (Five-year Average)	Sum of Background + Project	Annual Design Value
13.353	1.423	14.776	14.8

To determine the annual $PM_{2.5}$ design value, the annual average background concentration is added to the five-year annual average modeled concentration (at the receptor with the highest annual average concentration from the AERMOD output). This calculation is shown in Exhibit F-14. The sum (background + project) results in a design value of 14.8 $\mu g/m^3$. This value at the highest receptor is less than the 1997 $PM_{2.5}$ annual NAAQS of 15.0 ug/m^3. It can be assumed that all other receptors with lower modeled concentrations will also have design values less than the 1997 $PM_{2.5}$ annual NAAQS. In this example it is unnecessary to determine appropriate receptors in the build scenario or develop a no-build scenario for the annual $PM_{2.5}$ NAAQS, since the build scenario demonstrates that the hot-spot analysis requirements in the transportation conformity rule are met at all receptors.

F.9.2 Determining conformity to the 24-Hour $PM_{2.5}$ NAAQS

The next step is to calculate a design value to compare with the 2006 24-hour $PM_{2.5}$ NAAQS through a "Second Tier" analysis as described in Section 9.3.3. For ease of explanation, this process has been divided into individual steps, consistent with the guidance.

Step 7.1
The number of background measurements is counted for each year of monitored data (2008 to 2010). Based on a 4-day/3-day measurement interval, the dataset has 104 values per year.

Step 7.2
For each year of monitored concentrations, the eight highest daily background concentrations for each quarter are determined, resulting in 32 values (4 quarters; 8 concentrations/quarter) for each year of data (shown in Exhibit F-15, following page).

Step 7.3
Identify the highest-predicted modeled concentration resulting from the project in each quarter, averaged across each year of meteorological data used for air quality modeling is identified. For illustrative purposes, the highest average concentration across five years of meteorological data for a single receptor in each quarter is shown in Exhibit F-16 (following page). Note that, in a real-world situation, this process would be repeated for all receptors in the build scenario.

Exhibit F-15. Highest Daily Background Concentrations for Each Quarter and Each Year

2008				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	20.574	21.262	22.354	20.434
2	20.152	20.823	22.042	20.016
3	19.743	20.398	21.735	19.611
4	19.346	19.985	21.434	19.218
5	18.961	19.584	21.140	18.837
6	18.588	19.196	20.851	18.467
7	18.226	18.819	20.568	18.109
8	17.874	18.454	20.291	17.761
2009				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	20.195	20.867	21.932	20.058
2	19.784	20.440	21.628	19.651
3	19.386	20.026	21.329	19.257
4	19.000	19.624	21.037	18.875
5	18.625	19.235	20.750	18.504
6	18.262	18.857	20.469	18.145
7	17.910	18.490	20.194	17.796
8	17.568	18.135	19.924	17.457
2010				
Rank	**Q1**	**Q2**	**Q3**	**Q4**
1	21.137	21.847	22.980	20.990
2	20.698	21.390	22.655	20.556
3	20.272	20.948	22.336	20.135
4	19.860	20.519	22.023	19.726
5	19.459	20.102	21.717	19.330
6	19.071	19.698	21.417	18.945
7	18.694	19.307	21.123	18.572
8	18.329	18.927	20.834	18.211

Exhibit F-16. Five-year Average of Highest Modeled Concentrations for Each Quarter (At Example Receptor)

	Q1	**Q2**	**Q3**	**Q4**
Five Year Average Maximum Concentration (At Example Receptor)	**6.51**	**6.64**	**6.71**	**6.63**

Step 7.4

The highest modeled concentration in each quarter (from Step 7.3) is added to each of the eight highest monitored concentrations for the same quarter for each year of monitoring data (from Step 7.2). As shown in Exhibit F-17, this step results in eight concentrations in each of four quarters for a total of 32 values for each year of monitoring data. As mentioned, this example analysis shows only a single receptor's values, but project sponsors should calculate design values at all receptors in the build scenario.

Exhibit F-17. Sum of Background and Modeled Concentrations at Example Receptor for Each Quarter

2008				
	Q1	**Q2**	**Q3**	**Q4**
1	27.088	27.901	29.063	26.948
2	26.667	27.462	28.750	26.530
3	26.258	27.037	28.443	26.125
4	25.861	26.624	28.143	25.732
5	25.476	26.224	27.848	25.351
6	25.102	25.835	27.560	24.982
7	24.740	25.459	27.277	24.623
8	24.389	25.093	27.000	24.275
2009				
	Q1	**Q2**	**Q3**	**Q4**
1	26.709	27.506	28.641	26.572
2	26.298	27.079	28.336	26.166
3	25.900	26.665	28.038	25.772
4	25.514	26.264	27.745	25.389
5	25.140	25.874	27.459	25.019
6	24.776	25.496	27.178	24.659
7	24.424	25.130	26.903	24.310
8	24.082	24.774	26.633	23.971
2010				
	Q1	**Q2**	**Q3**	**Q4**
1	27.651	28.486	29.689	27.505
2	27.212	28.030	29.363	27.070
3	26.787	27.587	29.044	26.649
4	26.374	27.158	28.732	26.240
5	25.974	26.742	28.426	25.844
6	25.585	26.338	28.125	25.460
7	25.209	25.946	27.831	25.087
8	24.843	25.566	27.543	24.725

Step 7.5
As shown in Exhibit F-18, for each year of monitoring data, the 32 values from Step 7.4 are ordered together in a column and assigned a yearly rank for each value, from 1 (highest concentration) to 32 (lowest concentration).

Exhibit F-18. Ranking Sum of Background and Modeled Concentrations at Example Receptor for Each Year of Background Data

Rank	2008	2009	2010
1	29.063	28.641	29.689
2	28.750	28.336	29.363
3	**28.443**	**28.038**	**29.044**
4	28.143	27.745	28.732
5	27.901	27.506	28.486
6	27.848	27.459	28.426
7	27.560	27.178	28.125
8	27.462	27.079	28.030
9	27.277	26.903	27.831
10	27.088	26.709	27.651
11	27.037	26.665	27.587
12	27.000	26.633	27.543
13	26.948	26.572	27.505
14	26.667	26.298	27.212
15	26.624	26.264	27.158
16	26.530	26.166	27.070
17	26.258	25.900	26.787
18	26.224	25.874	26.742
19	26.125	25.772	26.649
20	25.861	25.514	26.374
21	25.835	25.496	26.338
22	25.732	25.389	26.240
23	25.476	25.140	25.974
24	25.459	25.130	25.946
25	25.351	25.019	25.844
26	25.102	24.776	25.585
27	25.093	24.774	25.566
28	24.982	24.659	25.460
29	24.740	24.424	25.209
30	24.623	24.310	25.087
31	24.389	24.082	24.843
32	24.275	23.971	24.725

Step 7.6
For each year of monitoring data, the value with a rank that corresponds to the projected 98^{th} percentile concentration is determined. As discussed in Section 9, an analysis employing 101-150 background values for each year (as noted in Step 7.1, this analysis uses 104 values per year) uses the 3^{rd} highest rank to represent a 98^{th} percentile. The 3^{rd} highest concentration (highlighted in Exhibit F-18) is referred to as the "projected 98^{th} percentile concentration."

Step 7.7
Steps 7.1 through 7.6 are repeated to calculate a projected 98^{th} percentile concentration at each receptor based on each year of monitoring data and modeled concentrations.

Step 7.8
For the example receptor, the average of the three projected 98^{th} percentile concentrations (highlighted in Exhibit F-18) is calculated.

Step 7.9
The resulting value of 28.508 $\mu g/m^3$ is then rounded to the nearest whole $\mu g/m^3$ resulting in a design value at the example receptor of 29 $\mu g/m^3$. At each receptor this process should be repeated. However, in the case of this analysis, the example receptor is the receptor with the highest design value in the build scenario.

Step 7.10
The design values calculated at each receptor are compared to the NAAQS. In the case of this example, the highest 24-hour design value (29 $\mu g/m^3$) is less than the 2006 NAAQS of 35 $\mu g/m^3$. Since this is the design value at the highest receptor, it can be assumed that the conformity requirements are met at all receptors in the build scenario. Therefore, it is unnecessary for the project sponsor to calculate design values for the no-build scenario for the 24-hour $PM_{2.5}$ NAAQS.

F.10 CONSIDER MITIGATION AND CONTROL MEASURES (STEP 8)

In this case, the project is determined to conform. In situations when this is not the case, it may be necessary to consider additional mitigation or control measures. If measures are considered, additional air quality modeling would need to be completed and new design values calculated to ensure that conformity requirements are met. See Section 10 for more information, including some specific measures that might be considered.

F.11 DOCUMENT THE PM HOT-SPOT ANALYSIS (STEP 9)

The final step is to properly document the PM hot-spot analysis in the conformity determination (see Section 3.10).

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Appendix G:
Example of Using EMFAC 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 EMFAC2007 to generate emission factors for air quality modeling. The following example, based on a hypothetical highway project, illustrates the modeling steps required for users to change EMFAC's default VMT distribution and to develop project-specific PM running exhaust emission factors. This example uses the "Emfac" mode in EMFAC2007 (v2.3) to generate gram per mile (g/mi) emission factors stored in the "Summary Rate" output file (.rts file) suitable for use in an air quality model. Users will be able to generate running emission factors in a single EMFAC 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 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] 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 emission 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.

[1] These are simplified data to illustrate EMFAC's use; 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 PREPARING EMFAC BASIC INPUTS

Based on the project characteristics, it is first necessary to specify the basic inputs and default settings in EMFAC (see Exhibit G-1).

Exhibit G-1. Basic Inputs in EMFAC 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 shown in the EMFAC 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 EMFAC 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 all speed bins from 5 mph to 65 mph
11	Emfac Rate Files	Summary Rates (RTS)	Select from EMFAC user interface
12	Output Particulate	PM_{10}	Select from EMFAC user interface

G.4 EDITING EMFAC DEFAULT VMT DISTRIBUTIONS

The next step is to calculate the EMFAC defaults for trucks and non-trucks. As shown in Exhibit G-2, EMFAC's 13 vehicle classes are grouped into trucks and non-trucks to match the project-specific traffic data. Specifically, Light-Duty Autos, Light-Duty Trucks (T1 and T2), and Motorcycles are grouped together to represent the "non-truck" class. All other vehicle classes (Medium-Duty Trucks, Light HD Trucks (T4 and T5), Medium HD Trucks, Heavy HD Trucks, Other Buses, Urban Buses, School Buses, and Motor Homes) are classified as "trucks." The total pre-populated VMT for truck and non-truck for this highway project are 6,269,545 miles and 26,134,922 miles, respectively.

Exhibit G-2. Example Highway Project Pre-Populated VMT for 13 Default Vehicle Classes

EMFAC Vehicle Class	EMFAC default VMT
01 - Light-Duty Autos (PC)	15,271,757
02 - Light-Duty Trucks (T1)	3,340,492
03 - Light-Duty Trucks (T2)	7,266,306
04 – Medium-Duty Trucks (T3)*	3,535,454
05 - Light HD Trucks (T4)*	816,278
06 - Light HD Trucks (T5)*	302,809
07 – Medium HD Trucks (T6)*	698,543
08 - Heavy HD Trucks (T7)*	704,156
09 - Other Buses*	49,590
10 - Urban Buses*	40,198
11 – Motorcycles	256,367
12 - School Buses*	31,176
13 - Motor Homes*	91,341
Truck VMT	6,269,545
Non-truck VMT	26,134,922
TOTAL	32,404,467

* Classified as trucks to match project-specific data

The next step is to calculate percentage VMT for trucks and non-trucks and their respective adjustment factors to match project-specific VMT distributions as shown in Exhibit G-3 (following page). The default VMT percentages for trucks (19%) and non-trucks (81%) are much different from what the project traffic data suggest (25% and 75% in the build scenario). Therefore the EMFAC default VMT for each vehicle class is scaled down for non-trucks and scaled up for trucks, respectively, based on the calculated adjustment factors (0.93 and 1.29).

Exhibit G-3. Calculation of Adjustment Factors for Truck and Non-Truck VMT

	VMT	Column A % of total VMT (EMFAC default)	Column B % of total VMT (Project-specific)	Adjustment Factor (AF)*
Trucks	6,269,545	19%	25%	1.29
Non-trucks	26,134,922	81%	75%	0.93
Sum	32,404,467	100%	100%	

* Adjustment factor is equal to the ratio between project-specific % VMT (Column B) and EMFAC default % VMT (Column A), for trucks and non-trucks, respectively.

Multiplying the EMFAC default VMT by the calculated adjustment factors (AF) for each vehicle class will produce updated VMT numbers that reflect project-specific information in terms of truck and non-truck VMT percentage. As shown in Exhibit G-4, when the adjusted VMT values for the truck group are added up, the sum is equal to 8,101,117 (which is 25% of the total VMT). The non-truck VMT is 24,303,350 (which accounts for 75% of the total VMT). Note that the overall VMT before and after the adjustment stays constant. Next, the adjusted VMT values are entered into the EMFAC interface; pressing the "Apply" button accepts the changes.

Exhibit G-4. Example Adjusted VMT for 13 Default Vehicle Classes

Vehicle Class	Default VMT	% VMT by vehicle class	Adjusted VMT (default VMT*AF)	Adjusted % VMT by vehicle class
01 - Light-Duty Autos (PC)	15,271,757	47.1%	14,201,491	43.8%
02 - Light-Duty Trucks (T1)	3,340,492	10.3%	3,106,386	9.6%
03 - Light-Duty Trucks (T2)	7,266,306	22.4%	6,757,073	20.9%
04 - Medium-Duty Trucks (T3)*	3,535,454	10.9%	4,568,294	14.1%
05 - Light HD Trucks (T4)*	816,278	2.5%	1,054,743	3.3%
06 - Light HD Trucks (T5)*	302,809	0.9%	391,271	1.2%
07 - Medium HD Trucks (T6)*	698,543	2.2%	902,614	2.8%
08 - Heavy HD Trucks (T7)*	704,156	2.2%	909,867	2.8%
09 - Other Buses*	49,590	0.2%	64,077	0.2%
10 - Urban Buses*	40,198	0.1%	51,941	0.2%
11 – Motorcycles	256,367	0.8%	238,400	0.7%
12 - School Buses*	31,176	0.1%	40,284	0.1%
13 - Motor Homes*	91,341	0.3%	118,025	0.4%
Truck	6,269,545	19.4%	8,101,117	25.0%
Non-truck	26,134,922	80.7%	24,303,350	75.0%
TOTAL	32,404,467	100.0%	32,404,467	100.0%

* Classified as trucks to match project-specific data

G.5 GENERATING LINK-SPECIFIC EMISSION FACTORS

After the EMFAC run is completed, the project-specific running exhaust emission factors are presented in Table 1 of the output Summary Rates file (.rts file). As highlighted in Exhibit G-5, the PM_{10} running exhaust emission factor is 0.040 g/mi under the associated speed bin of 65 mph. Tire wear and brake wear PM_{10} emission factors are 0.009 g/mi and 0.013 g/mi, respectively, and do not vary by speed. For the one link in this example, the total running link emission factor is 0.062 g/mi, which is the sum of these three emission factors. For comparison, the total running link emission factor (based on EMFAC default VMT distribution) is equal to 0.056 g/mi. It is lower than the project-specific emission factor because the EMFAC default includes a smaller proportion of truck VMT than this hypothetical highway project.

Exhibit G-5. Generating Running Exhaust Emission Factors in EMFAC

```
Title     : Sacramento County Subarea Annual CYr 2015 Default Title
Version   : Emfac2007 V2.3 Nov 1 2006
Run Date  : 2010/02/04 14:54:50
Scen Year: 2015 -- All model years in the range 1971 to 2015 selected
Season    : Annual
Area      : Sacramento
*****************************************************************************************
     Year: 2015 -- Model Years 1971 to 2015 Inclusive -- Annual
     Emfac2007 Emission Factors: V2.3 Nov 1 2006

     County Average                          Sacramento                 County Average

                         Table   1:  Running Exhaust Emissions (grams/mile; grams/idle-hour)

     Pollutant Name: PM10                      Temperature:  60F  Relative Humidity:  70%

     Speed
      MPH       LDA       LDT       MDT       HDT       UBUS      MCY       ALL

       0       0.000     0.000     0.064     1.297     0.000     0.000     0.093
       5       0.051     0.092     0.096     1.442     0.457     0.056     0.160
      10       0.033     0.061     0.064     1.011     0.328     0.044     0.109
      15       0.023     0.042     0.045     0.697     0.245     0.036     0.076
      20       0.017     0.031     0.034     0.510     0.189     0.031     0.056
      25       0.013     0.024     0.026     0.427     0.152     0.028     0.045
      30       0.010     0.019     0.021     0.365     0.126     0.027     0.038
      35       0.009     0.016     0.018     0.323     0.109     0.027     0.033
      40       0.008     0.015     0.016     0.298     0.097     0.028     0.030
      45       0.007     0.014     0.015     0.290     0.090     0.030     0.029
      50       0.007     0.013     0.015     0.299     0.086     0.034     0.029
      55       0.007     0.014     0.015     0.324     0.085     0.040     0.031
      60       0.008     0.015     0.016     0.364     0.087     0.050     0.035
      65       0.009     0.017     0.018     0.420     0.093     0.065     0.040
```

This completes the use of EMFAC for determining emissions factors for this project. The total running link emission factor of 0.062 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.

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Appendix H:
Example of Using EMFAC 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 change EMFAC's defaults and to develop project-specific PM idling and start exhaust emission factors for a hypothetical bus terminal project. It also shows how to generate emission factors from EMFAC for a project that involves a limited selection of vehicle classes (e.g., urban buses).[1] This example uses the "Emfac" mode in EMFAC2007 (v2.3) to generate grams per hour (g/hr) and grams per trip start (g/trip) 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 start and idle emissions at the project site, and (2) the running exhaust emissions on the links approaching and departing the project site. This example is intended to help project sponsors understand how to create representative idle and start emission factors based on the best available information supplied by EMFAC, thus providing an example of how users may have to adapt the information in EMFAC to their individual project circumstances.

As a preliminary note, the reader should understand that to estimate idle emissions, the main task will involve modifying the default vehicle populations, by vehicle class, embedded in EMFAC. When estimating start emissions, users will be modifying the default vehicle trips, also by vehicle class. This appendix walks through the steps to model its idle and start emissions for this hypothetical project. Users will be able to generate idle and start emission factors in a single EMFAC 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.

[1] This is a highly simplified example showing how to employ EMFAC to calculate idle and start 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 emission and background concentrations). The PM analysis focuses on idle and start emissions from buses operated in the terminal. It is assumed that these buses correspond to the "Urban Buses" vehicle class specified in EMFAC and their average soak time is 540 minutes (all buses are parked overnight before trip starts).

H.3 PREPARING EMFAC BASIC INPUTS (APPLICABLE TO BOTH IDLE AND START EMISSIONS ESTIMATION)

Based on the project characteristics, basic inputs and default settings in EMFAC are first specified (see Exhibit H-1). These basic inputs are similar to those specified for highway projects. To generate idle emission factors from EMFAC, a speed bin of 0 mph must be selected in the EMFAC interface.

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

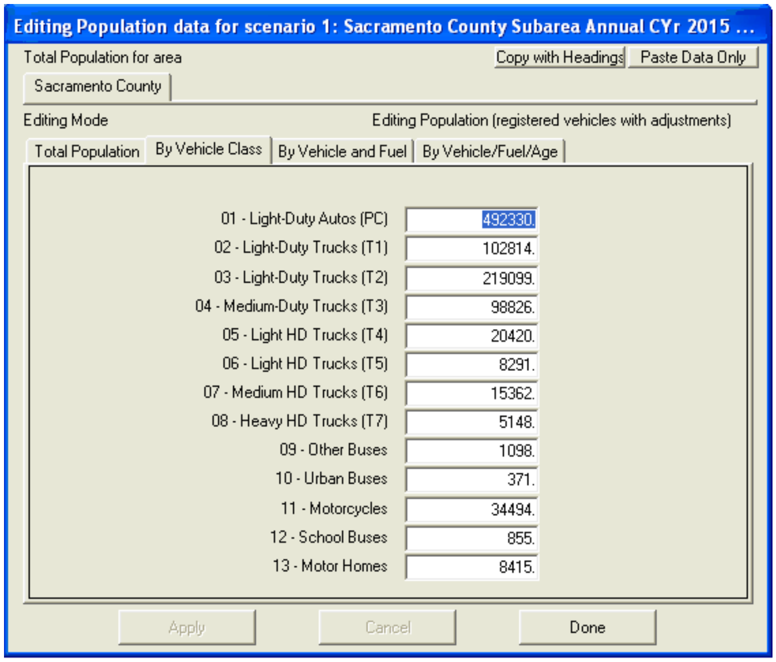
Step	Input Category	Input Data	Note
1	Geographic Area	County → Sacramento	Select from drop-down list
	Calculation Method	Use Average	Default (not visible in the EMFAC user interface)
2	Calendar Years	2015	Select from drop-down list
3	Season or Month	Annual	Select from drop-down list
4	Scenario Title	Use default	Define default title in the EMFAC 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 0 mph
11	Emfac Rate Files	Summary Rates (RTS)	Select from EMFAC user interface
12	Output Particulate	PM_{10}	Select from EMFAC user interface

H.4 EDITING EMFAC DEFAULT POPULATION DISTRIBUTIONS TO OBTAIN IDLE EMISSION FACTORS

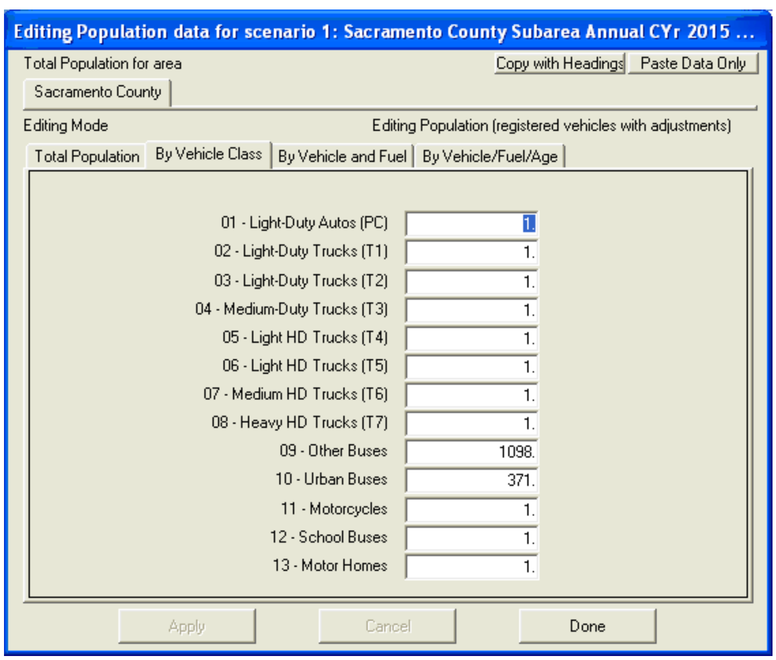
To generate idle emission factors that reflect the bus terminal project data, vehicle population by vehicle class must be modified in the EMFAC user interface. EMFAC has data limitations regarding idle emissions: among the 13 vehicle classes in EMFAC, idle emission factors are available only for LHDT1, LHDT2, MHDT, HHDT, School Buses, and Other Buses. Although EMFAC does not provide idle emission factors for the "Urban Buses" class (the class most typically associated with transit buses), the idle emission factors for "Other Buses" may be used to represent transit buses.

Note that only the "Other Buses" vehicle population will affect idle emissions in this example; however, the "Urban Buses" class also needs to be included at this point to address idling and starting emission factors in one single run. Thus, except for "Other Buses" and "Urban Buses," all other vehicle classes are eliminated in EMFAC by inputting very low values (such as "1"; entering "0" is not allowed in EMFAC). Exhibit H-2 (following page) shows the EMFAC interface before and after vehicle population by vehicle class is changed.

Exhibit H-2. Changing EMFAC Vehicle Population Distributions to Estimate Idle Emission Factors



Default EMFAC data before modification



Modified EMFAC data

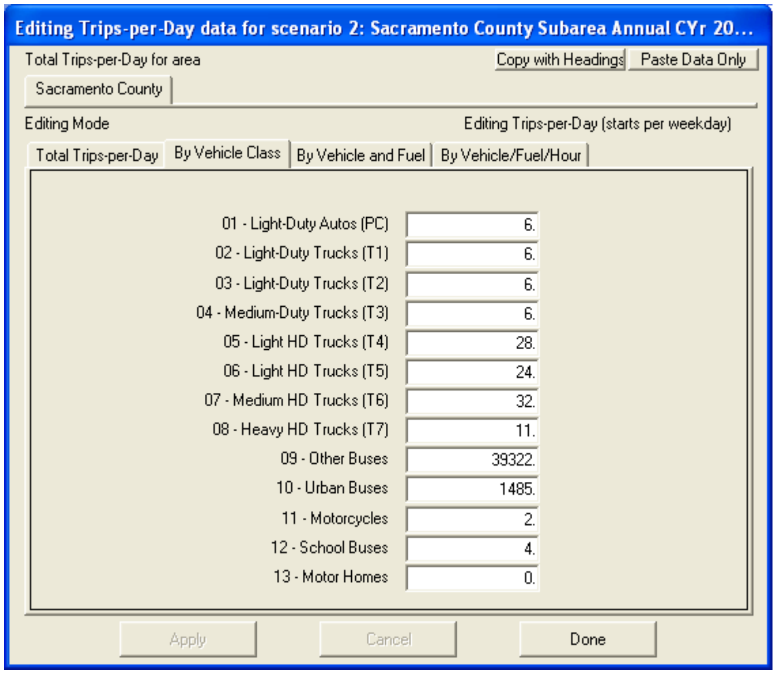
Note: In this bus terminal example, start emissions are available for "urban buses"; however, idle emission factors are only available for "other buses." Therefore, users will access emission factor information for both "other" and "urban" buses, and the population data for these fleets are left intact (see modified version of Exhibit H-2).

H.5 EDITING EMFAC DEFAULT TRIP DISTRIBUTIONS TO OBTAIN START EMISSION FACTORS

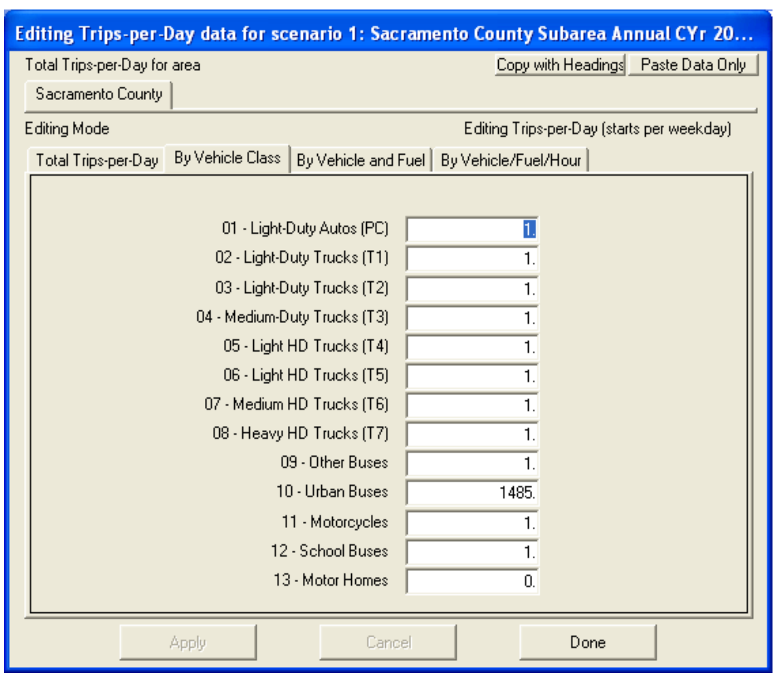
After users modify the population distribution in EMFAC, the new population distribution will be used by EMFAC to create vehicle trip distributions. The new distribution will affect the EMFAC data displayed during the trip distribution modification steps described below. Users need to manually update the trip distributions through the EMFAC user interface to obtain project-specific start emission factors.

Average start emission factors in EMFAC depend on the number of trips made by a particular vehicle class and the corresponding soak time. To generate project-specific start emission factors, the number of trips by vehicle class must be modified in the EMFAC user interface. For this example bus terminal project, a very low value (“1”) is entered into the interface for all vehicle classes except for “Urban Buses” to represent the project-specific data. Exhibit H-3 (following page) shows the EMFAC interface before and after vehicle trip distributions by vehicle class are changed.

Exhibit H-3. Changing EMFAC Trip Distributions to Estimate Start Emission Factors



Default EMFAC data before modification



Modified EMFAC data

H.6 GENERATING IDLE AND START EMISSION FACTORS

"Urban Buses" is the vehicle class best representing transit buses in this hypothetical bus terminal project. After the EMFAC 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-4, the PM_{10} idle exhaust emission factor for the example bus terminal project (0.734 grams/idle-hour) can be found under the 0 mph speed bin for the HDT vehicle class (associated with "Other Buses" because EMFAC does not provide "Urban Buses" idle emission factors). The start emission factor for vehicle class "Urban Buses" (0.011 g/trip) is presented in Table 2 under the 540-min time bin in the column "All" or "UBUS" (see Exhibit H-5, following page).

In order to produce a grams/hour emission factor for use in AERMOD, several post-processing calculations are necessary. First, the idle emission factor (0.734 grams/idle-hour) is multiplied by the number of vehicle idle-hours. Next, the start emissions can be calculated by multiplying the start emission factor (0.011 grams/trip) by the number of starts expected in a given hour. If the area being modeled has both idling and starts, these values can be summed to produce an aggregate grams/hour value.

Exhibit H-4. Generating Idling Emission Factors in EMFAC

```
Title     : Sacramento County Subarea Annual CYr 2015 Default Title
Version   : Emfac2007 V2.3 Nov 1 2006
Run Date  : 2010/02/04 14:54:50
Scen Year: 2015 -- All model years in the range 1971 to 2015 selected
Season    : Annual
Area      : Sacramento
*****************************************************************************************
     Year: 2015 -- Model Years 1971 to 2015 Inclusive -- Annual
     Emfac2007 Emission Factors: V2.3 Nov 1 2006

     County Average                          Sacramento                County Average

                         Table  1:  Running Exhaust Emissions (grams/mile; grams/idle-hour)


     Pollutant Name: PM10                     Temperature:  60F  Relative Humidity:  70%
```

Speed MPH	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
0	0.000	0.000	0.220	0.734	0.000	0.000	0.406
5	0.051	0.083	0.082	0.479	0.457	0.056	0.468
10	0.033	0.055	0.058	0.373	0.328	0.044	0.352
15	0.023	0.038	0.042	0.297	0.245	0.036	0.273
20	0.017	0.028	0.033	0.242	0.189	0.031	0.218
25	0.013	0.022	0.026	0.203	0.152	0.028	0.180
30	0.010	0.018	0.022	0.173	0.126	0.027	0.152
35	0.009	0.015	0.018	0.152	0.109	0.027	0.132
40	0.008	0.013	0.016	0.136	0.097	0.028	0.118
45	0.007	0.013	0.015	0.124	0.090	0.030	0.109
50	0.007	0.012	0.014	0.117	0.086	0.034	0.103
55	0.007	0.013	0.014	0.112	0.085	0.040	0.100
60	0.008	0.014	0.014	0.110	0.087	0.050	0.100
65	0.009	0.016	0.015	0.110	0.093	0.065	0.102

Exhibit H-5. Generating Start Emission Factors in EMFAC[2]

```
Title     : Sacramento County Subarea Annual CYr 2015 Default Title
Version   : Emfac2007 V2.3 Nov 1 2006
Run Date  : 2010/02/04 14:54:50
Scen Year: 2015 -- All model years in the range 1971 to 2015 selected
Season    : Annual
Area      : Sacramento
*************************************************************************************
     Year: 2015 -- Model Years 1971 to 2015 Inclusive -- Annual
     Emfac2007 Emission Factors: V2.3 Nov 1 2006

     County Average                          Sacramento                County Average

                            Table   2:  Starting Emissions (grams/trip)

     Pollutant Name: PM10                     Temperature:  60F  Relative Humidity: ALL
```

Time min	LDA	LDT	MDT	HDT	UBUS	MCY	ALL
5	0.001	0.001	0.001	0.001	0.001	0.014	0.001
10	0.001	0.002	0.002	0.002	0.002	0.013	0.002
20	0.002	0.004	0.003	0.002	0.003	0.010	0.003
30	0.004	0.005	0.005	0.003	0.004	0.008	0.004
40	0.004	0.007	0.006	0.003	0.005	0.006	0.005
50	0.005	0.008	0.008	0.004	0.006	0.005	0.006
60	0.006	0.010	0.009	0.004	0.007	0.004	0.007
120	0.009	0.014	0.012	0.006	0.009	0.010	0.009
180	0.010	0.015	0.013	0.007	0.009	0.015	0.009
240	0.010	0.016	0.014	0.007	0.010	0.020	0.010
300	0.011	0.017	0.014	0.008	0.010	0.024	0.010
360	0.011	0.018	0.015	0.008	0.010	0.027	0.010
420	0.012	0.019	0.015	0.008	0.011	0.030	0.011
480	0.012	0.019	0.016	0.009	0.011	0.033	0.011
540	0.013	0.020	0.016	0.009	0.011	0.035	0.011
600	0.013	0.020	0.017	0.009	0.012	0.036	0.012
660	0.013	0.021	0.017	0.010	0.012	0.037	0.012
720	0.013	0.021	0.017	0.010	0.012	0.037	0.012

This completes the use of EMFAC for determining start and idle emission factors for this project. The aggregate grams/hour value for starts and idle can now be input into AERMOD, as discussed in Section 7 of the guidance.

[2] Note that the start emission factors for UBUS and ALL are identical in this exhibit because the user modified the number of trips by vehicle class to include activity from only "Urban Buses". EMFAC collapsed the 13 vehicle classes to six vehicle groups in the output file. The collapsed output provides start emission factors for the "Urban Buses" in the UBUS category and because fleet activity was composed entirely from this vehicle class, the start emission factors for UBUS and ALL are essentially the same.

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 the state 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 (its "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 when calculating locomotive emissions (40 CFR 93.105(c)(1)(i)), including determining which method may be most appropriate for a given project.

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.2.3).

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 it is agreed through interagency consultation that 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.

The interagency consultation process must be used to evaluate and choose the method and data used for quantifying locomotive emissions for PM hot-spot analyses (40 CFR

[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.

93.105(c)(1)(i)). Unless otherwise determined through consultation, only one method should be used for a given project.

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).

Calculating Engine Load Factors

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

[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.

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 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:

Step 1. 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.

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

Step 3. 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's not at idle; that is, when moving, the 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.

Step 4. 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

[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.

(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 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 its 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

[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.

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).

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.

Calculating Average Fuel Consumption

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/OMS/invntory/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/420f08014.htm.
- 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.

It's decided to calculate the locomotive $PM_{2.5}$ emissions rates 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 (following page).

<ins>Step 1</ins>: 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).

<ins>Step 2</ins>: 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.

<ins>Step 3</ins>: 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.

<ins>Step 4</ins>: 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.

<ins>Step 5</ins>: 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")

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[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.

<u>Calculating 24-hour Moving Emissions</u>

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 have to 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).

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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 main guidance document.

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

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[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 CAL3QCHR 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.

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[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 CAL3QHCR and AERMOD, 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 CAL3QHCR and AERMOD user guides.

J.3.1 Physical characteristics and locations of sources in CAL3QCHR

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:[4]

- The coordinates (X, Y) of the endpoints of each link;[5]
- 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);[6] 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 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.3.2 Timing of emissions in CAL3QCHR

The CAL3QHCR user's guide describes two methods for accepting time-varying emissions and traffic data; these are labeled the "Tier I" and "Tier II" approaches.[7] Project-level PM hotspot modeling should use the Tier II method, which can

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[4] 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.

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

[6] 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 that circumstance, the relevant EPA Regional Office should be consulted for determination of the most appropriate model.

[7] This nomenclature is unrelated to EPA's motor vehicle emission standards.

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 explicitly 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.3.3 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 volume, area, and point sources.

<u>Modeling Volume Sources</u>

Many different sources in a project undergoing a PM hot-spot analysis might be modeled as volume sources. Examples 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.[8] AERMOD can also approximate a highway “line source” using a series of adjacent volume sources (see the AERMOD user guide for suggestions). Certain nearby sources that have been selected to be explicitly 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).

Volume source parameters are entered using the source parameter (SRCPARAM) keyword in the AERMOD input file. This requires the user to provide the following information:

- The emission rate (mass per unit time, such as g/s);
- The initial lateral dimension (width) of the volume, and the initial lateral dispersion coefficient;
- The initial vertical dimension (height) of the volume and initial vertical dispersion coefficient; and

[8] See Section 6 and Appendix I for information regarding calculating locomotive emissions.

- The source release height of the volume source center, (i.e., meters above the ground).

Within AERMOD, the volume source algorithms are most applicable to line sources with some initial plume depth (e.g., highways, rail lines).[9] There are three methods available to characterize the initial size of a roadway plume:

1. Initial lateral dimension and dispersion coefficient (σ_{yo}). To estimate the initial lateral dimension (or width) of the volume source, you could use one of the following approaches:
   - Use the average vehicle width plus 6 meters, when modeling a single lane of traffic;
   - Use road width multiplied by 2; or
   - Use a set width, such as 10 meters per lane of traffic.

   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.

2. Initial vertical dimension and dispersion coefficient (σ_{zo}). A typical approach to estimating the initial vertical dimension (height) of the plume for volume sources is to assume it 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;
   - For mixed fleets, 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.

   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 of the source by 2.15. For typical light-duty vehicles, this corresponds to an *Szinit* (σ_{zo}) of 1.2 meters. For typical heavy-duty vehicles, the initial value of *Szinit* (σ_{zo}) is 3.2 meters[10].

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[9] 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).

[10] At this time, AERMOD (version dated 09292) allows the initial dimensions and release heights of volume sources to change by hour of the day, which may be considered if the fraction of heavy-duty vehicles is expected to significantly change throughout a day. Users should consult the latest information on AERMOD when starting a PM hot-spot analysis.

3. Source release height. The source release height (*Relhgt* in AERMOD), which is the height at which wind effectively begins to affect the plume, may be estimated from the midpoint of the initial vertical dimension:

- For moving light-duty vehicles, this is about 1.3 meters.
- For moving heavy-duty vehicles, it is 3.4 meters.

Similar to the initial vertical dimension of a volume source, the release height of mixed fleets may be estimated using an emissions-weighted average. For a 40%/60% light-duty/heavy-duty emissions share, the source release height would be 0.4 * 1.3 + 0.6 * 3.4 = 2.6 meters.

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

Finally, 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.

Consult the AERMOD User Guide and AERMOD Implementation Guide for details in applying AERMOD to roadway sources.

Modeling Area Sources

AERMOD can represent rectangular, polygon-shaped, and circular area sources using the AREA, AREAPOLY, or AREACIRC keywords. Sources that may be modeled as area sources may include areas within which emissions occur relatively evenly.[11] Evenly-distributed ground-level sources might also be modeled as area sources.

AERMOD requires the following information when modeling an area source:

- The emission rate per unit area (mass per unit area per unit time);
- The release height above the ground;
- The length of the north-south side of the area;
- The length of the east-west side of the area (if the area is not a square);
- The orientation of the rectangular area in degrees relative to north; and
- The initial height (vertical dimension) of the area source plume.

Modeling Point Sources

[11]At present, the AERMOD Implementation Guide recommends that, where possible, a volume source approximation be used to model area sources, because area sources in AERMOD do not include AERMOD's "plume meander approach." Consult the latest version of the AERMOD Implementation Guide for the most current information on when volume sources or area sources are most appropriate.

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.

J.3.4 Placement and sizing of sources within AERMOD

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

First, volume, area, and point sources should be placed in the locations where emissions are most likely to occur. For example: if, within, a bus terminal, buses enter and exit from a single driveway within the terminal yard, 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 explicitly modeled (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.3.5 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 3 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.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 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.[12] 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 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, described in Section 9.3 of the guidance. This guidance is applicable regardless of how many quarters are being modeled.

J.5.1 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).

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 PERIOD averaging time could be specified using the CO AVERTIME keyword.

For the 24-hour $PM_{2.5}$ design value calculations described in Section 9.3.3, the DAYTABLE option provides output files with 24-hour concentrations at each receptor for each day processed. Users should flag the quarter and year for each day listed in the DAYTABLE that AERMOD generates. Note users should also specify a 24-hour averaging time with the CO AVERTIME command as well.

Another option for calculating 24-hour $PM_{2.5}$ design values is with a POSTFILE, a file of results at each receptor for each day processed. By specifying a POSTFILE with a 24-hour averaging time, a user can generate a file of daily concentrations for each day of meteorological data. When using this option, users should specify a POSTFILE with a 24-hour averaging time to generate the outputs needed to calculate design values, and

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

flag the quarter and year for each day listed in the POSTFILE that AERMOD generates. Note that POSTFILE output files can be very large.

For the 24-hour PM_{10} calculations described in Section 9.3.4, the RECTABLE keyword may be used to obtain the six highest 24-hour concentrations over the entire modeling period. A RECTABLE is a file summarizing the highest concentrations at each receptor over an averaging period (e.g., 24 hours) across a modeling period (e.g., 5 years).

EPA is actively working towards a post-processing tool for AERMOD that will provide the appropriate modeling metrics that may then be combined with background concentrations for comparisons to the PM NAAQS. EPA will announce these new options as they become available on EPA's SCRAM website at: www.epa.gov/scram001/.

J.5.2 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. CAL3QHCR accepts only a single quarter's emission factors per input file.

Calculating 24-hour $PM_{2.5}$ design values under a first or second tier analysis is described in Section 9.3.3. To get annual average modeled concentrations for a first tier analysis (Step 1), the highest 24-hour concentrations in each quarter and year of meteorological data should be identified. Within each year of meteorological data, the highest 24-hour concentration at each receptor should be identified. For a first-tier analysis, at each receptor, the highest concentrations from each year of meteorological data should be averaged together. Under a second tier analysis, at each receptor, the highest modeled concentration in each quarter, from each year of meteorological data, should be averaged together. These average highest 24-hour concentrations in each quarter, across multiple years of meteorological data, are used in second tier $PM_{2.5}$ design value calculations.

In 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 five highest 24-hour concentrations. To estimate the sixth-highest concentration at a receptor, the five 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. This concentration, at each receptor, is used in calculations of the PM_{10} design value described in Section 9.3.4.

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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. Specifically, this appendix provides examples of how to calculate design values for the annual $PM_{2.5}$ NAAQS, the 24-hour $PM_{2.5}$ NAAQS, and the 24-hour PM_{10} NAAQS 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; it is a nearby source.

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), there are 122 monitored values in that year and 121 values for both 2009 and 2010 (365 days each).

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).[1] There are five years of representative off-site meteorological data being used in this PM hot-spot analysis.

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.[2]

Each year's annual average concentrations include contributions from the project, any explicitly modeled nearby sources, 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[3]
[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

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.

[1] 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.
[2] 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.
[3] The number of air quality monitoring measurements may vary by year.

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 $\mu g/m^3$.

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

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.

[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.

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 $\mu g/m^3$.

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 $\mu g/m^3$ from Step 3:

$$11.582 + 3.521 = 15.103$$

Step 11. Rounding to the nearest 0.1 $\mu g/m^3$ produces a design value of 15.1 $\mu g/m^3$.

In this example, the design value at the receptor in the build scenario (15.2 $\mu g/m^3$) is greater than the design value at the same receptor in the no-build scenario (15.1 $\mu g/m^3$).[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 Section 9.2 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 in Appendix K.3.3 above would not need to be recalculated since the no-build scenario would not change.

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

K.4.1 General

This example illustrates the two-tiered approach to calculating design values for comparison with the 24-hour $PM_{2.5}$ NAAQS, as described in Section 9.3.3. The 24-hour design value is the average of three consecutive years' 98th percentile $PM_{2.5}$ concentration

[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.

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 first tier and second 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. It also shows second tier no-build scenario results for this same receptor. In an actual PM hot-spot analysis, design values would be calculated at additional receptors, as described further in Section 9.3.3.

As explained in Section 9.3.3, project sponsors can start with either a first or second tier analysis. This example begins with a first tier analysis. However, it would also be acceptable to begin with the second tier analysis and skip the first tier altogether.

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 (i.e., the freight terminal) was included in air quality modeling.

<u>First Tier Analysis</u>

Under a first tier analysis, the average highest 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 highest modeled 24-hour concentrations are produced by AERMOD, using five years of meteorological data in one run.

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[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.

Step 1. The receptor with the highest average 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 highest 24-hour concentration for each year of meteorological data used, regardless of the quarter in which they were modeled. The average concentration of these outcomes, 6.710 μg/m^3 (highlighted in Exhibit K-2), is the highest, compared to the averages at all of the other receptors.

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

Year	Highest $PM_{2.5}$ Concentration
Met Year 1	6.413
Met Year 2	5.846
Met Year 3	6.671
Met Year 4	7.951
Met Year 5	6.667
Average	6.710

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 2008 - 2010. 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/m^3) of the monitor throughout the years employed for estimating background concentrations. The values at Rank 3, highlighted, are the 98th percentile concentrations:

Exhibit K-3. Top Eight Monitored Concentrations in Years 2008 – 2010

Rank	2008	2009	2010
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

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

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 highest 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):

$6.710 + 31.247 = 37.957\ \mu g/m^3$.

Rounding to the nearest whole number results in a 24-hour $PM_{2.5}$ design value of 38 $\mu g/m^3$.

Because this concentration is greater than the 2006 24-hour $PM_{2.5}$ NAAQS (35 $\mu g/m^3$), this first tier analysis does not demonstrate that conformity is met. As described in Section 9.3.3, the project sponsor has two options:

- 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
- Conduct a second tier analysis.

In this example, the next step chosen is a second tier analysis.

Second Tier Analysis

In a second tier analysis, the highest modeled concentrations are not added to the 98th percentile background concentrations on a yearly basis. Instead, a second tier analysis uses the average of the highest modeled 24-hour concentration within each quarter of each year of meteorological data. Impacts from the project, nearby sources, and other background concentrations are calculated on a quarterly basis before determining the 98th percentile concentration resulting from these inputs. The steps presented below follow the steps described in Section 9.3.3.

Step 1. The first step is to count the number of measurements for each year of monitoring data used for background concentrations. As described in Appendix K.2 and in Step 2 of the first tier analysis above, there are 122 monitored values during 2008, 121 values during 2009, and 121 values during 2010.

Step 2. For each year of monitoring data, the eight highest 24-hour background concentrations in each quarter are determined. The eight highest concentrations in each quarter of 2008, 2009, and 2010 are shown in Exhibit K-4.

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[9] In certain cases, project sponsors can also decide to calculate the design values for all receptors in the build and no-build scenarios and use the interagency consultation process to determine whether a "new" violation has been relocated (see Section 9.2).

Exhibit K-4. Eight Highest 24-hour Background Concentrations By Quarter for Each Year

Year	Rank of Background Concentration	Q1	Q2	Q3	Q4
2008	1	27.611	31.749	34.123	30.099
	2	25.974	30.219	31.443	28.096
	3	25.760	30.134	30.809	26.990
	4	25.493	28.368	28.481	25.649
	5	25.099	27.319	27.372	25.526
	6	24.902	25.788	25.748	25.509
	7	24.780	25.564	25.288	25.207
	8	23.287	24.794	24.631	24.525
2009	1	26.962	32.405	33.537	31.126
	2	24.820	30.487	30.819	28.553
	3	24.330	28.937	29.998	25.920
	4	23.768	27.035	29.872	25.856
	5	23.685	25.880	25.596	25.565
	6	23.287	25.867	25.148	24.746
	7	23.226	25.254	24.744	24.147
	8	22.698	24.268	24.267	23.142
2010	1	27.493	31.579	35.417	30.425
	2	24.637	31.173	31.095	26.927
	3	24.637	30.193	30.329	26.263
	4	24.392	27.994	28.751	25.684
	5	24.050	25.439	26.084	25.170
	6	23.413	24.253	24.890	24.254
	7	22.453	23.006	24.749	23.425
	8	22.061	21.790	22.538	22.891

Step 3. The highest modeled 24-hour concentrations in each quarter are identified at each receptor. Exhibit K-5 presents the highest 24-hour concentrations within each quarter at one receptor (for each of the five years of meteorological data used in air quality modeling) as well as the average of these quarterly concentrations. This step would be repeated for each receptor in an actual PM hot-spot analysis.

Exhibit K-5. Highest Modeled 24-hour Concentrations Within Each Quarter (Build Scenario)

	Q1	Q2	Q3	Q4
Met Year 1	6.413	3.332	6.201	6.193
Met Year 2	3.229	3.481	5.846	4.521
Met Year 3	6.671	3.330	5.696	6.554
Met Year 4	7.095	3.584	7.722	7.951
Met Year 5	6.664	4.193	4.916	6.667
Average	6.014	3.584	6.076	6.377

The average highest concentrations on a quarterly basis (i.e., the values highlighted in Exhibit K-5) constitute the contributions of the project and nearby source to the projected 24-hour $PM_{2.5}$ design value, and are used in subsequent calculations.

Step 4. For each receptor, the highest modeled 24-hour concentration in each quarter (from Step 3) is added to each of the eight highest monitored concentrations for the same quarter for each year of monitoring data (from Step 2). To obtain this result, the average highest modeled concentration for each quarter, found in the last row of Exhibit K-5, is added to each of the eight highest background concentrations in each quarter in Exhibit K-4. The results are shown in Exhibit K-6.

Exhibit K-6. Sum of Modeled and Monitored Concentrations (Build Scenario)

Year	Rank of Background Concentration	Q1	Q2	Q3	Q4
2008	1	33.625	35.333	40.200	36.476
	2	31.989	33.803	37.520	34.474
	3	31.774	33.718	36.886	33.368
	4	31.507	31.952	34.557	32.026
	5	31.113	30.903	33.448	31.903
	6	30.916	29.372	31.824	31.886
	7	30.794	29.148	31.365	31.584
	8	29.301	28.378	30.707	30.902
2009	1	32.976	35.989	39.613	37.503
	2	30.835	34.071	36.895	34.931
	3	30.344	32.521	36.074	32.297
	4	29.782	30.619	35.948	32.233
	5	29.700	29.464	31.672	31.942
	6	29.301	29.451	31.225	31.124
	7	29.240	28.838	30.820	30.524
	8	28.712	27.852	30.343	29.520
2010	1	33.507	35.163	41.493	36.802
	2	30.651	34.757	37.172	33.304
	3	30.651	33.777	36.405	32.640
	4	30.406	31.578	34.827	32.062
	5	30.064	29.022	32.160	31.547
	6	29.428	27.837	30.966	30.631
	7	28.468	26.590	30.825	29.803
	8	28.075	25.374	28.614	29.269

Step 5. The 32 values from each year in Exhibit K-6 are then ranked from highest to lowest, regardless of the quarter from which each value comes. This step is shown in Exhibit K-7. Note that only the top eight values are shown for each year instead of the entire set of 32. Exhibit K-7 also displays the quarter from which each concentration comes and the value's rank within its quarter.

Exhibit K-7. Eight Highest Concentrations in Each Year, Ranked from Highest to Lowest (Build Scenario)

Year	µg/m^3	Yearly Rank	Quarter	Quarterly Rank
2008	40.200	1	Q3	1
	37.520	2	Q3	2
	36.886	3	Q3	3
	36.476	4	Q4	1
	35.333	5	Q2	1
	34.557	6	Q3	4
	34.474	7	Q4	2
	33.803	8	Q2	2
2009	39.613	1	Q3	1
	37.503	2	Q4	1
	36.895	3	Q3	2
	36.074	4	Q3	3
	35.989	5	Q2	1
	35.948	6	Q3	4
	34.931	7	Q4	2
	34.071	8	Q2	2
2010	41.493	1	Q3	1
	37.172	2	Q3	2
	36.802	3	Q4	1
	36.405	4	Q3	3
	35.163	5	Q2	1
	34.827	6	Q3	4
	34.757	7	Q2	2
	33.777	8	Q2	3

Steps 6-7. The value that represents the 98th percentile 24-hour concentration is determined, based on the number of background concentration values there are. As described in Step 1, there are 122 monitored values for the year 2008 and 121 values for both 2009 and 2010. According to Exhibit 9-7 in Section 9.3.3, for a year with 101-150 samples per year, the 98th percentile is the 3rd highest concentration for that year. Therefore, for this example, the 3rd highest 24-hour concentration of each year, highlighted in Exhibit K-7, represents the 98th percentile value for that year.

Step 8. At each receptor, the average of the three 24-hour 98th percentile concentrations is calculated. For the receptor in this example, the average is:

$$(36.886 + 36.895 + 36.802) \div 3 = 36.861$$

Step 9. The average for the receptor in this example from Step 8 (36.861 µg/m^3) is then rounded to the nearest whole number (37 µg/m^3) and compared to the 2006 24-hour

$PM_{2.5}$ NAAQS (35 μg/m^3). In an actual $PM_{2.5}$ hot-spot analysis, the design value calculations need to be repeated for all receptors, and compared to the NAAQS.

The design value at the receptor in this example is higher than the relevant 24-hour $PM_{2.5}$ NAAQS. Since one (and possibly more) receptors have design values greater than the 24-hour $PM_{2.5}$ NAAQS, the project will only conform if the design value in the no-build scenario are less than the design value in the build scenario at each receptor. Therefore, the no-build scenario needs to be modeled for comparison, as described further below.

K.4.3 No-build scenario

The no-build scenario is described in Section 9.3.3 as Step 10:

- Step 10. Using modeling results for the no-build scenario, repeat steps 3 through 9 for all receptors with a design value that exceeded the $PM_{2.5}$ NAAQS in the build scenario. The result will be a 24-hour $PM_{2.5}$ design value at such receptors for the no-build scenario.

For this part of the example, air quality modeling is completed for the no-build scenario for the same receptor as the build scenario. Steps 1 and 2 for the build scenario do not need to be repeated, since the background concentrations in the no-build scenario are identical to those in the build scenario. Exhibit K-4, which shows the eight highest monitored concentrations in each quarter over three years, therefore can also be used for the no-build scenario.

Step 3. For the same receptor examined above in the build scenario, the highest modeled 24-hour concentrations for the no-build scenario are calculated for each quarter, using each year of meteorological data used for air quality modeling. Exhibit K-8 provides these concentrations, as well as the quarterly averages (highlighted).

Exhibit K-8. Highest Modeled 24-hour Concentrations Within Each Quarter (No-Build Scenario)

	Q1	Q2	Q3	Q4
Met Year 1	6.757	3.383	6.725	6.269
Met Year 2	3.402	3.535	6.340	4.577
Met Year 3	7.029	3.381	6.177	6.635
Met Year 4	7.476	3.639	8.374	8.048
Met Year 5	7.022	4.258	5.331	6.748
Average	6.337	3.639	6.589	6.455

Step 4. The highest modeled 24-hour concentration in each quarter (i.e., the values in the last row of Exhibit K-8) are added to each of the eight highest concentrations for the same quarter for each year of monitoring data (found in Exhibit K-4), and the resulting values are shown in Exhibit K-9.

Exhibit K-9. Sum of Modeled and Monitored Concentrations (No-Build Scenario)

Year	Rank of Background Concentration	Q1	Q2	Q3	Q4
2008	1	33.948	35.389	40.713	36.555
	2	32.312	33.858	38.033	34.552
	3	32.097	33.774	37.399	33.446
	4	31.830	32.007	35.070	32.104
	5	31.436	30.959	33.961	31.981
	6	31.239	29.428	32.337	31.964
	7	31.117	29.204	31.878	31.662
	8	29.624	28.433	31.220	30.980
2009	1	33.299	36.044	40.127	37.581
	2	31.158	34.126	37.408	35.009
	3	30.667	32.576	36.587	32.375
	4	30.105	30.674	36.461	32.311
	5	30.023	29.520	32.185	32.020
	6	29.624	29.506	31.738	31.202
	7	29.563	28.894	31.333	30.602
	8	29.035	27.907	30.856	29.598
2010	1	33.830	35.218	42.007	36.880
	2	30.974	34.812	37.685	33.382
	3	30.974	33.832	36.918	32.719
	4	30.729	31.633	35.340	32.140
	5	30.387	29.078	32.674	31.625
	6	29.751	27.893	31.479	30.709
	7	28.791	26.645	31.338	29.881
	8	28.398	25.429	29.127	29.347

Step 5. The 32 values from each year in Exhibit K-9 are ranked from highest to lowest, regardless of the quarter from which each value comes. This step is shown in Exhibit K-10. Note that only the top eight values are shown for each year instead of the entire set of 32.

Exhibit K-10. Eight Highest Concentrations in Each Year, Ranked from Highest to Lowest (No-Build Scenario)

Year	μg/m^3	Yearly Rank	Quarter	Quarterly Rank
2008	40.713	1	Q3	1
	38.033	2	Q3	2
	37.399	3	Q3	3
	36.555	4	Q4	1
	35.389	5	Q2	1
	35.070	6	Q3	4
	34.552	7	Q4	2
	33.961	8	Q3	5
2009	40.127	1	Q3	1
	37.581	2	Q4	1
	37.408	3	Q3	2
	36.587	4	Q3	3
	36.461	5	Q3	4
	36.044	6	Q2	1
	35.009	7	Q4	2
	34.126	8	Q2	2
2010	42.007	1	Q3	7
	37.685	2	Q1	3
	36.918	3	Q1	2
	36.880	4	Q4	8
	35.340	5	Q4	6
	35.218	6	Q1	1
	34.812	7	Q4	2
	33.832	8	Q4	3

Steps 6-7. Based on the number of background measurements available per year in this example (122 for 2008 and 121 for both 2009 and 2010, as discussed in the analysis of the build scenario), Exhibit 9-7 in Section 9.3.3 indicates that the 3rd highest 24-hour concentration in each year represents the 98th percentile concentration for that year. The third highest concentrations are highlighted in Exhibit K-10.

Step 8. For this receptor, the average of the Rank 3 concentrations in 2008, 2009, and 2010 is calculated:

$$(37.399 + 37.408 + 36.918) \div 3 = 37.242$$

Step 9. The average for the receptor in this example from Step 8 (37.242 μg/m^3) is rounded to the nearest whole μg/m^3 (37 μg/m^3).

In this example, the design value at this receptor for both the build and no-build scenarios is 37 μg/m^3, which is greater than the 2006 24-hour NAAQS (35 mg/m^3). However, the build scenario's design value is equal to the design value in the no-build scenario.[10] For the project to conform, the build design values must be less than or equal to the no-build value for all the receptors that exceeded the NAAQS in the build scenario. Assuming that this is the case at all other receptors, the proposed project in this example would therefore demonstrate conformity.

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, 155.511 rounds to 160, and 154.999 rounds to 150.[11]

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 highest 24-hour background concentration (from three years of monitored data).

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. In an actual PM hot-spot analysis, design values would be calculated at additional receptors, as described in Section 9.3.4.

[10] 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.

[11] 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.

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.[12] 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-11 shows the six highest 24-hour concentrations at this receptor.

Exhibit K-11. 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. The highest 24-hour background concentration from the three most recent years of monitoring data (2008, 2009, and 2010) is identified. In this example, the highest 24-hour background concentration from these three years is 86.251 μg/m^3.

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

15.218 + 86.251 = 101.469

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

[12] 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.

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: build scenario design values for each receptor would be calculated (Steps 6-7 in Section 9.3.4); for all those that exceed the NAAQS, the no-build design values would also be calculated (Steps 8-10 in Section 9.3.4) and build and no-build design values compared.[13]

K.6 MATHEMATICAL FORMULAS FOR DESIGN VALUE CALCULATIONS

K.6.1 Introduction

This part of the appendix includes mathematical formulas to represent the calculations described narratively in Section 9.3. This information is intended to supplement Section 9, which may be helpful for certain users.

Appendix K.6 relies on conventions of mathematical and logical notation that are described after the formulas are presented. Several symbols are used that may be useful to review prior to reading the individual formulas.

<u>Notation symbols</u>

- $\bar{x}$ - a single bar over variable *x* represents a single arithmetic mean of that variable
- $\bar{\bar{x}}$ - double bars over variable *x* represents an "average of averages"
- $\hat{x}$ - a "hat" over variable *x* represents the arithmetic of multiple high concentration values from different years, either from monitoring data or from modeling results

<u>Logical symbols</u>

- $\forall x$ - an upside down A before variable *x* means "for all" values of x
- $\in x$ - an "$\in$" before variable *x* means "in x"
- $\forall x \in y$ - means "for all x in y"

The following information present equations for calculating design values for the $PM_{2.5}$ annual NAAQS, 24-hour $PM_{2.5}$ NAAQS, and 24-hour PM_{10} NAAQS. The equations are organized into the sets that are referenced in Section 9.3.

[13] 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.6.2 Equation Set 1: Annual $PM_{2.5}$ design value

Formulas

$$\overline{\overline{c}}_i = \overline{\overline{b}}_i + \overline{\overline{p}}_i$$

$$\overline{\overline{b}}_i = \sum_{m=1}^{3} \frac{\overline{b}_{im}}{3}$$

$$\overline{b}_{im} = \sum_{j=1}^{4} \frac{\overline{b}_{ijm}}{4}$$

$$\overline{\overline{p}}_i = \sum_{k=1}^{l} \frac{\overline{p}_{ik}}{l}$$

When using CAL3QHCR, $\overline{p}_{ik} = \sum_{j=1}^{4} \frac{\overline{p}_{ijk}}{4}$

Definitions

$\overline{\overline{b}}_i$ = average of three consecutive years' average annual background concentrations at receptor *i*

$\overline{\overline{b}}_{im}$ = quarterly-weighted average annual background concentrations at receptor *i* during monitoring year *m*

$\overline{b}_{ijm}$ = quarterly average background concentration at receptor *i*, during quarter *j* in monitoring year *m*

$\overline{\overline{c}}_i$ = annual $PM_{2.5}$ design value at receptor *i*

i = receptor

j = quarter

k = year of meteorological data

l = length in years of meteorological data record

m = year of background monitoring data

$\overline{p}_{ik}$ = average modeled quarterly average concentrations at receptor *i* for meteorological year *k*. When using AERMOD, it is presumed that AERMOD's input file is used to specify this averaging time. When using CAL3QHCR with a single quarter of meteorological data, $\overline{p}_{ik}$ must be calculated using each $\overline{p}_{ijk}$ for each quarter of meteorological year *k*.

$\overline{p}_{ijk}$ = quarterly average concentration at receptor *i* for quarter *j*, in meteorological data year *k*. This variable is the product of CAL3QHCR when run with a single quarter of meteorological data. $\overline{p}_{ik}$ can be calculated directly using AERMOD without explicitly calculating $\overline{p}_{ijk}$.

K.6.3 Equation Set 2: 24-Hour $PM_{2.5}$ design value (First Tier Analysis)

Formulas

$\hat{c}_i = \hat{b}_i + \hat{p}_i$

$b_{im} = \forall b_{ijm} \in m$

$\hat{b}_i = \sum_{m=1}^{3} \frac{b_{im \bullet r_m}}{3}$

$\hat{p}_i = \sum_{k=1}^{l} \frac{\max_k [\max_{jk}(p_{ijk})]}{l}$ (when using CAL3QHCR), which compresses to:

$\hat{p}_i = \sum_{k=1}^{l} \frac{\max_k (p_{ik})}{l}$ (when using AERMOD with maximum concentration by year)

Definitions

$\hat{b}_i$ = the average of 98^{th} percentile 24-hour concentrations from three consecutive years of monitoring data

b_{ijm} = daily 24-hour background concentration at receptor *i*, during quarter *j* in monitoring year *m*

$b_{im} = \forall b_{ijm} \in m$ = All 24-hour background concentration measurements in year *m*

$b_{im \bullet r_m}$ = The 24-hour period within year *m* whose concentration rank among all 24-hour measurements in year *m* is r_m (this represents the 98^{th} percentile of 24-hour background concentrations within one year.)

$\hat{c}_i$ = 24-hour $PM_{2.5}$ design value at receptor *i*

i = receptor

j = quarter

k = year of meteorological data

l = length in years of meteorological data record

m = year of background monitoring data

$\max_k$ = maximum predicted 24-hour concentration within meteorological year *k*

$\max_{jk}$ = maximum predicted 24-hour concentration within quarter *j* within meteorological year *k*

$\hat{p}_i$ = average of highest predicted concentrations from each year modeled with the *l* years from which meteorological data are used (≥5 years for off-site data, ≥1 year for on-site data)

p_{ijk} = modeled daily 24-hour concentration at receptor *i*, in quarter *j* and meteorological year *k*

p_{ik} = modeled daily 24-hour concentration at receptor *i*, in meteorological year *k*

r_m = concentration rank of b_{im} corresponding to 98th percentile of all b_{im} in year *m*, based on number of background concentration measurements per year (n_m). r_m is given by the following table:

n_m	r_m
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

K.6.4 Equation Set 3: 24-Hour $PM_{2.5}$ design value (Second Tier Analysis)

Formulas

$$\hat{c}_i = \sum_{m=1}^{3} \frac{c_{im\bullet r_m}}{3}$$

$$c_{im} = \forall c_{ijm} \in m$$

$c_{ijm} = b_{ijm} + \hat{p}_{ij}$, for the eight (8) highest b_{ijm} in quarter *j* in monitoring year *m*

$$\hat{p}_{ij} = \sum_{k=1}^{l} \frac{\max_{jk}(p_{ijk})}{l}$$

Definitions

b_{ijm} = daily 24-hour background concentration at receptor *i*, during quarter *j* in monitoring year *m*

$\hat{c}_i$ = 24-hour $PM_{2.5}$ design value at receptor *i*

c_{ijm} = The set of all sums of modeled concentrations ($\hat{p}_{ij}$) with background concentrations from quarter *j* and monitoring year *m*, using the eight highest background concentrations (b_{ijm}) for the corresponding receptor, quarter, and monitoring year.

$c_{im} = \forall c_{ijm} \in m$ = the set of all c_{imj} corresponding to monitoring year *m*

$c_{im\bullet r_m}$ = predicted 98th percentile total concentration from the project, nearby sources, and background measurements from year *m*. Given by the value of c_{im} whose concentration rank in year *m* is r_m, using background measurements from year *m*.

i = receptor

j = quarter

k = year of meteorological data
l = length in years of meteorological data record
m = year of background monitoring data
$\max_{jk}$ = maximum predicted 24-hour concentration within quarter j within meteorological year k
p_{ijk} = Predicted daily 24-hour concentration at receptor i, during quarter j, based on data from meteorological year k
$\hat{p}_{ij}$ = Average highest 24-hour modeled concentration (p_{ijk}) using l years of meteorological data
r_m = concentration rank of c_{im} corresponding to 98th percentile of all c_{im} in year m, based on number of background concentration measurements per year (n_m). r_m is given by the following table:

n_m	r_m
1-50	1
51-100	2
101-150	3
151-200	4
201-250	5
251-300	6
301-350	7
351-366	8

K.6.5 Equation Set 5: 24-Hour PM_{10} design value

<u>Formulas</u>

$$\tilde{c}_i = \tilde{b}_i + \tilde{p}_i$$
$$\tilde{b}_i = \max_{in}(b_{in})$$
$$b_{in} = \bigcup_{m=1}^{3} b_{im}$$
$$\tilde{p}_i = p_{il \bullet r_l}$$
$$p_{il} = \bigcup_{k=1}^{l} p_{ik}$$

<u>Definitions</u>

$\tilde{c}_i$ = 24-hour PM_{10} design value
$\tilde{b}_i$ = maximum monitored 24-hour PM_{10} background concentration at within b_{in}
b_{im} = the set of all monitored 24-hour PM_{10} background concentrations at receptor i within monitoring year m

b_{in} = the set of all b_{im} within monitoring years n
i = receptor
k = year of meteorological data
l = length in years of meteorological data record.
$\max_{in}$ = the maximum monitored 24-hour background concentration at receptor i within monitoring years n
n = the set of all years of monitoring data, $m = \{1,2,3\}$
$\tilde{p}_i = p_{il \bullet r_l}$ = modeled 24-hour PM_{10} concentration with concentration rank of r_l among all concentrations modeled using l years of meteorological data
p_{il} = set of all modeled 24-hour concentrations at receptor i across l years of meteorological data
$r_l = l + 1$ (for example, $r_l = 6$ when using 5 years of meteorological data)
$\bigcup_{a=1}^{z} c_a$ = the set (finite union) of all c_a with integer values of $a = \{1,\ldots,z\}$