State of California **Business, Transportation and Housing Agency**

Memorandum

To: Users of CO Protocol

Date: October 13, 2010

File No.

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF TRANSPORTATION PLANNING
Office of Regional and Interagency Planning
Air Quality/Conformity Coordination Branch

Subject: Searchable PDF version of CO Protocol

This PDF (Adobe Acrobat) copy of the CO Protocol duplicates the original (1997) version of the protocol. It has been re-created from the Microsoft Word original to be searchable and accessible. However, due to differences between the version of Microsoft Word used at the time the document was originally published (6.0) and the version used to prepare this PDF file (2003), page numbering has unavoidably changed. No changes were made to the content of the document, but header formatting, footers, table of contents, and lists of figures and tables, are updated to reflect Word 2003 formatting.

NOTICE: AS OF JANUARY 1, 2003, DO NOT USE THE QUANTITATIVE SCREENING PROCEDURE IN APPENDIX A. It is based on an obsolete version of the EMFAC model. If referred to this procedure by the general screening process in the CO Protocol, perform detailed modeling using Appendix B instead. Appendix A is retained in the published document for historical purposes only; it was part of the package approved by U.S. EPA in 1997.

NOTICE: THE CURRENT VERSION OF THE EMFAC MODEL MUST ALWAYS BE USED WHEN PERFORMING CO OR OTHER MODELING. References in this document to EMFAC 7F, which was current at the time of writing, should be considered to refer to the current version "EMFAC" generally. The current version of EMFAC can be obtained from the California ARB web site at (correct as of December 2009): http://www.arb.ca.gov/msei/onroad/latest_version.htm

Copies of approval letters (Appendix D) are not included in this document. If approval letters need to be viewed, consult the scanned-image version of the original Protocol document with letters that is also available at the Caltrans web site.

Finally, readers should note that the list of California Air Pollution Control Districts and Metropolitan Planning Organizations (Appendix C), while correct in 1997, is now out of date. Agencies move, and new MPOs have been formed in California since 1997. Contact information on the Internet (correct as of December 2009) can be found at:

Air Districts
California Air Resources Board (ARB): http://www.arb.ca.gov/capcoa/roster.htm
California Air Pollution Control Officers Association (CAPCOA): http://www.capcoa.org/

Metropolitan Planning Organizations
Caltrans: http://www.dot.ca.gov/hq/tpp/offices/orip/index.html
CALCOG: http://www.calcog.org/

Transportation Project-Level
Carbon Monoxide Protocol
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1 PURPOSE

Procedures and guidelines are provided in this project-level protocol (herein referred to as the Protocol) for use by agencies that sponsor transportation projects, to evaluate the potential local level carbon monoxide (CO) impacts of a project. The procedures and guidelines comply with the following regulations without imposing additional requirements: Section 176(c) of the 1990 Clean Air Act Amendments, federal conformity rules, state and local adoptions of the federal conformity rules, the National Environmental Policy Act (NEPA), and the California Environmental Quality Act (CEQA) requirements [Cal. Code Regs., tit. 21, § 1509.3(25)].

Upon approval the procedures and guidelines described herein constitute a Protocol that is intended to replace the procedures for determining localized CO concentrations (hot-spot analysis) that are given in 40 CFR § 93.131[1]. Future versions of the Protocol will be issued to incorporate changes in the laws and regulations pertaining to CO project-level requirements and analysis. The Protocol may also be supplemented via the local consultation process to incorporate region-specific processes.

The Protocol has three sections. The first section constitutes the main body and provides a framework and roadmap for conducting a federal conformity determination at the project level as well as for NEPA and CEQA. The treatment of projects is very general and is not limited to a specific type of project. The second section, Appendix A, is intended to provide a procedure for conducting a "screening analysis" of local impacts of intersections. The procedure is intended to be simple, capable of being performed without familiarity with programs such as CT-EMFAC or CALINE4 from which it was developed. An example calculation is included to assist a novice as well as more experienced air quality analysts in conducting the analysis. A brief description of the assumptions used in the procedure is given. The third section, Appendix B, provides guidance to an experienced analyst conducting a more "detailed analysis", required when a project does not pass the screening analysis or in situations for which the screening analysis is not applicable. In that case, the analyst is assumed to have familiarity with programs such as CT-EMFAC and CALINE4, and availability of references and sources of data, e.g., the CALINE4 user's manual by Benson [1989] and other useful references. The purpose of Appendix B, similar to the Protocol itself, is to assist the analyst in making decisions regarding required modeling parameters. Unlike Appendix A, Appendix B is not intended to be a "cookbook" method. Additional screening procedure supplements similar to Appendix A and applicable to scenarios other than intersections are planned to be issued in the future.

[1]The references to the conformity regulations are to 40 CFR Part 93; references to the duplicate sections contained in 40 CFR Part 51 are omitted to avoid excess.

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2 GENERAL PROVISIONS

2.1 Affected Projects

The transportation projects that are affected by this Protocol are those proposed for areas designated as attainment, nonattainment, or maintenance.

The Protocol applies to all projects subject to NEPA and projects that may not require a conformity determination under federal conformity rules but that still require approval under CEQA.

The Protocol specifically applies to Federal Highway Administration (FHWA)/Federal Transit Administration (FTA) transportation projects; defined as projects that are proposed to receive funding assistance and approval through the Federal-Aid Highway program or the Federal Mass Transit program, or require FHWA or FTA approval for some aspect of the project, such as connection to an interstate highway or deviation from applicable design standards on the interstate system (refer to Section 2.10 for further guidance on affected projects).

2.2 Project Alternatives

The protocol is applicable for the assessment of potential impacts of "project alternatives" as identified within the scope of an environmental impact study (EIS)/environmental impact report (EIR) required by NEPA/CEQA. The results of that screening evaluation and further detailed studies should be incorporated, as needed, into the environmental documentation or used as part of a major investment study (MIS). The project sponsor may use the Protocol as a screening tool to guide the evaluation and decision making process for project development.

2.3 Project Sponsor(s)

For the purposes of this Protocol, a project sponsor is any federal, state, or local agency responsible for the approval and/or funding of affected transportation projects, as delineated under Section 2.1. These agencies include the FHWA, the FTA, the California Department of Transportation (Caltrans), and other regional/local transportation agencies. Projects that cross Metropolitan Planning Organization (MPO) and/or regional boundaries are also subject to the provisions contained herein. These projects have multiple project sponsors as mandated by the consultation procedures adopted to meet the requirements of 40 CFR § 93.105(c)(3).

2.4 Responsibility of Project Sponsor(s)

The project sponsor(s) is responsible for ensuring that a transportation project action conforms to an approved or promulgated air quality implementation plan and to all applicable state and national air quality standards. The project sponsor(s) is required to make a positive conformity finding in accordance with this Protocol (not merely the absence of a negative conformity finding) before a project may proceed.

2.5 Inter-agency Consultation

The project sponsor(s) is responsible for consulting with other agencies at all stages of the process of determining project-level conformity.

The consultation should be in accordance with:

- specific consultation procedures outlined in state and local rules and regulations consistent with state and local agency adoption of the federal conformity regulations [40 CFR § 93.112];
- the consultation requirements under NEPA and/or CEQA [40 CFR §§ 1501.1, 1501.5, and 1501.6; 23 CFR §§ 771.109(3), 771.111(a); Cal. Code Regs., tit. 21, § 1509.9]; and
- specific requirements for inter-agency consultation, prescribed by this Protocol, for several key action items. These requirements are set forth in Sections 3 and 4 of the Protocol.

2.6 Conformity Tests

An affirmative regional conformity determination must be made before a project may proceed. This is satisfied if the project is included in the Regional Transportation Plan (RTP) and Transportation Improvement Program (TIP) and if the project has not been altered in design concept or scope from that described in the RTP and TIP (see Section 2.9). See Sections 3.1.5, 3.1.6, 3.1.7, and 3.1.11 for more guidance. A discussion of regional planning and conformity can also be found in the FHWA report titled "A Guide to Metropolitan Planning under ISTEA - How the Pieces Fit Together" [FHWA, 1995]. Exceptions to these criteria are projects in areas designated as attainment for <u>all</u> transportation-related criteria pollutants; projects specifically exempt from regional conformity determinations (such as those described in Sections 2.11, 2.14, and 2.15); or projects for which a specific regional conformity determination is made.

In addition, all projects (except those exempt under Section 2.14) are subject to local CO impact review. The provisions in the Protocol for local CO impact review apply to all regions in the state regardless of State Implementation Plan (SIP) status or EPA CO area designation (attainment, nonattainment, or maintenance).

2.7 Timing of Project-level Conformity Determination

The project sponsor(s) must make the required conformity determination, outlined in this protocol, as part of the project environmental review process. Regional re-evaluations due to changes in the assumptions used in the regional conformity modeling (Section 2.6) may trigger a new project-level CO review for the project.

2.8 Segmented/Staged Projects

The project-level conformity determination is made for an entire project as it is defined for purposes of NEPA/CEQA review, not for stages of the project. Projects that will be implemented along with the subject project should also be considered (i.e., the conformity determination should be based on the combined impact of the grouped projects).

The entire project is defined as those stages included in the RTP. Stages not included in the RTP are not subject to project-level CO reviews at this time, as construction of such subsequent stages are not able to be considered for approval. Further, project-level CO reviews "may be performed only after the major design features which will significantly impact concentrations have been identified" [40 CFR § 93.123(c)].

In some instances, however, only some of a project's stages are included in the conforming TIP. In this case, the project may still be found to be in conformity if:

1. the NEPA/CEQA process is completed for the entire project as described in the RTP;
2. the entire project is included in the regional emissions analysis performed in conjunction with the RTP and TIP; and
3. the local impacts are addressed separately for different project stages when there is more than three year's delay between major steps to advance subsequent stages of the project.

The third criterion above prevents violations from being caused by interim stages of a segmented/staged project that await the final programming and construction of later stages that would eventually correct local violations. If there is less than three years between major steps to advance subsequent stages of a project, there is no need to analyze the project phases separately.

"After a finding of conformity is made on the project, no further conformity analysis of individual segments will be required unless the project design concept or scope changes, or if major steps to advance the action do not occur for three years or more." [SCAG 1993, p. 6]. Changes in project design concept and scope are discussed in Section 2.9.

Note that for purposes of this protocol, there is a cap on the number of intersections that need to be analyzed for any one project. For a single project with multiple intersections, only the three intersections representing the worst LOS ratings of the project, and, to the extent they are different intersections, the three intersections representing the highest traffic volumes need be analyzed. For each intersection failing a screening test as described in this protocol, an additional intersection should be analyzed.

2.9 Changes in Project Design Concept and Scope

A project's *design concept* refers to the "type of facility identified by the project, e.g., freeway, expressway, arterial highway, grade-separated highway, reserved right-of-way rail transit, mixed-traffic rail transit, exclusive busway, etc." A project's *design scope* refers to "the design aspects…that affect the proposed facility's impact on emissions, usually as they relate to carrying capacity and control, e.g., the number of lanes or tracks to be constructed or added, length of project, signalization, access control including approximate number and location of interchanges, preferential treatment for high-occupancy vehicles, etc." [FR v. 58, n. 225, p. 62235].

Projects that have a significant change in design concept and/or scope from that which is described in the adopted RTP and TIP may require a new regional conformity determination and/or a re-examination of local CO impacts (see Section 2.6).

2.10 Changes in Funding Sources

Federal money introduced into a project that had not been previously funded by federal dollars may necessitate a regional conformity determination and/or a project-level CO review.

2.11 Regionally Significant Projects

For the purposes of this protocol, a *regionally significant* transportation project is one that is defined as regionally significant in accordance with 40 CFR § 93.101 and with any locally adopted extensions to this definition, as set forth in the state and/or local implementation of the federal conformity regulations and pursuant to 40 CFR § 93.105(c)(1)(ii). A project that is exempt from regional emission analysis is not subject to a regional conformity determination. However, the project is still subject to a local CO impact review.

2.12 Transportation Control Measures

Projects carry with them the obligation to incorporate all applicable Transportation Control Measures (TCMs), and applicable mitigation measures (Section 2.13) identified during the CEQA review of the RTP.

Most TCMs are regional in nature, and are appropriately addressed within the regional transportation planning/programming process. Occasionally there may be TCMs that should be addressed at the project level. Such TCMs may stipulate certain project specific requirements related to design concept and/or scope.

Attainment plans that have not been recently updated may contain some TCMs which are no longer applicable and/or feasible. If such is the case for TCMs applicable at the project level, the project sponsor(s) should address this in the project's environmental documentation.

TCMs shall be accounted for in the project-level CO review only where there are written commitments from the project sponsor(s) and/or operator to the implementation of such measures. "Written commitments must also be obtained for project-level…control measures which are conditions for making conformity determinations for a transportation plan or TIP and are included in the project design concept and scope which is used in the regional emissions analysis…or used in the project-level hot-spot analysis" [40 CFR §§ 93.125(a) and 123(c)(4)]. For projects not contained within a conforming RTP and TIP, this criterion is satisfied if the project does not interfere with the implementation of any TCM in the applicable implementation plan [40 CFR § 93.113(d)]. Other issues concerning the enforceability of project-level TCMs are contained in 40 CFR § 93.125(b)-(d). The project sponsor(s) should consult these sections prior to making the final conformity determination.

2.13 Mitigation Measures

For the purposes of the Protocol a mitigation measure is anything added to the project design concept or scope that is intended to reduce local CO emissions. Such measures are often added to projects as a result of the environmental review process of the RTP. Applicable mitigation measures shall be accounted for in the project-level CO reviews only where there are written commitments from the project sponsor(s) and/or operator to the implementation of such measures. "Written commitments must also be obtained for project-level mitigation…measures which are conditions for making conformity determinations for a transportation plan or TIP and are included in the project design concept and scope which is used in the regional emissions analysis…or used in the project-level hot-spot analysis" [40 CFR §§ 93.125(a) and 123(c)(4)]. Other issues concerning the enforceability of project-level mitigation measures are contained in 40 CFR § 93.125(b)-(d). The project sponsor(s) should consult these sections prior to making the final conformity determination.

2.14 Projects Exempt from All Emissions Analyses

Certain projects are ordinarily exempt from all emissions analyses according to Table 2 of 40 CFR § 93.126, reproduced in Table 1 of the Protocol. However, the exempt status may be revoked if the MPO, in consultation with the local air district, the California Air Resources Board (CARB), Caltrans, EPA, and the FHWA (in the case of a highway project) or the FTA (in the case of a transit project) concur that a project has potential adverse local and/or regional emissions impacts for any reason [40 CFR § 93.126].

Table 1. Projects Exempt from All Emissions Analyses

Safety
Railroad/highway crossing
Hazard elimination program
Safer non-Federal-aid system roads
Shoulder improvements
Increasing sight distance
Safety improvement program
Traffic control devices and operating assistance other than signalization projects
Railroad/highway crossing warning devices
Guardrails, median barriers, crash cushions
Pavement resurfacing and/or rehabilitation
Pavement marking demonstration
Emergency relief (23 U.S.C. 125)
Fencing
Skid treatments
Safety roadside rest areas
Adding medians
Truck climbing lanes outside the urbanized area
Lighting improvements
Widening narrow pavements or reconstructing bridges (no additional travel lanes)
Emergency truck pullovers

Mass Transit
Operating assistance to transit agencies
Purchase of support vehicles
Rehabilitation of transit vehicles[2]
Purchase of office, shop, and operating equipment for existing facilities
Purchase of operating equipment for vehicles (e.g. radios, fareboxes, lifts, etc.)
Construction of renovation of power, signal, and communications systems
Construction of small passenger shelters and information kiosks
Reconstruction or renovation of transit buildings and structures (e.g., rail or bus buildings, storage and maintenance facilities, stations, terminals, and ancillary structures).
Rehabilitation or reconstruction of track structures, track and track bed in existing right-of-way
Purchase of new buses and rail cars to replace exiting vehicles or for minor expansions of the fleet[2]
Construction of new bus or rail storage/maintenance facilities categorically excluded in 23 CFR Part 771

Air Quality
Continuation of ride-sharing and van-pooling promotion activities at current level
Bicycle and pedestrian facilities

Table 1 (continued). Projects Exempt from all Emissions Analyses

Other

[2] PM_{10} nonattainment or maintenance areas, such projects are exempt only if they are in compliance with control measures in the applicable implementation plan.

Specific activities which do not involve or lead directly to construction, such as:
Planning and technical studies
Grants for training and research programs
Planning activities conducted pursuant to titles 23 and 49 U.S.C.
Federal-aid systems revisions
Engineering to assess social, economic, and environmental effects of the proposed action or alternatives to that action
Noise attenuation
Emergency or hardship advance land acquisitions [23 CFR 712.204(d)]
Acquisition of scenic easements
Plantings, landscaping, etc.
Sign removal
Directional and informational signs
Transportation enhancement activities (except rehabilitation and operation of historic transportation buildings, structures, or facilities)
Repair of damage caused by natural disasters, civil unrest, or terrorist acts, except projects involving substantial functional, locational or capacity changes

Source: 40 CFR Part 93, Table 2

2.15 Projects Exempt from Regional Emissions Analyses

Certain projects are ordinarily exempt from all regional emissions analyses according to Table 3 of 40 CFR § 93.127, reproduced in Table 2 of the Protocol. However, the exempt status may be revoked if the MPO, in consultation with the local air district, the California Air Resources Board (CARB), Caltrans, EPA, and the FHWA (in the case of a highway project) or the FTA (in the case of a transit project) concur that a project has potential regional emissions impacts for any reason [40 CFR § 93.127].

Table 2. Projects Exempt from Regional Emissions Analysis

Intersection channelization projects
Intersection signalization projects at individual intersections
Interchange reconfiguration projects
Changes in vertical and horizontal alignment
Truck size and weight inspection stations
Bus terminals and transfer points

Source: 40 CFR Part 93, Table 3

2.16 Traffic signal synchronization projects

Traffic signal synchronization projects may be approved, funded, and implemented without satisfying the requirements of the conformity rule. However, all subsequent regional emissions analyses required by 40 CFR 93.118 and 93.119 for transportation plans, TIPs, or projects not from a conforming plan and TIP must include such regionally significant traffic signal synchronization projects. [FR Doc. 97–20968 Filed 8–14–97; 8:45 am]

3 DETERMINATION OF PROJECT REQUIREMENTS

Two conformity requirement decision flow charts are provided in the Protocol. They are designed to assist the project sponsor(s) in evaluating the requirements that apply to specific projects. The first chart, Figure 1, should be applied to the evaluation of *new projects*. Figure 2 applies to the *re-examination of projects* previously approved under NEPA and/or CEQA. Background information and procedures for new projects, and similar detail for project re-examinations, are contained in Sections 3.1 and 3.2, respectively.

3.1 Requirements for New Projects

Figure 1 should be used to determine the conformity requirements that apply to new projects. Each step of the flow chart is covered in detail in the following subsections.

3.1.1 Project exempt from all emissions analyses?

The project sponsor(s) should use Table 1 to determine if the project being evaluated qualifies for an exemption from all emissions analyses (see Section 2.14).

3.1.2 Project exempt from regional emissions analyses?

The project sponsor(s) should use Table 2 to determine if the project being evaluated qualifies for an exemption from regional emissions analyses (see Section 2.15).

3.1.3 Project locally defined as regionally significant?

If a project is locally defined as regionally significant (see Section 2.11 for definition) then the project may be subject to a regional conformity determination. A project that is not locally defined as regionally significant is subject to an examination of local impacts.

3.1.4 Project in a federal attainment area?

A project that is in an area classified as attainment of all transportation-related criteria pollutants is not subject to a regional conformity determination. However, it may require a CEQA finding for regional air quality impacts. This is determined in the following steps:

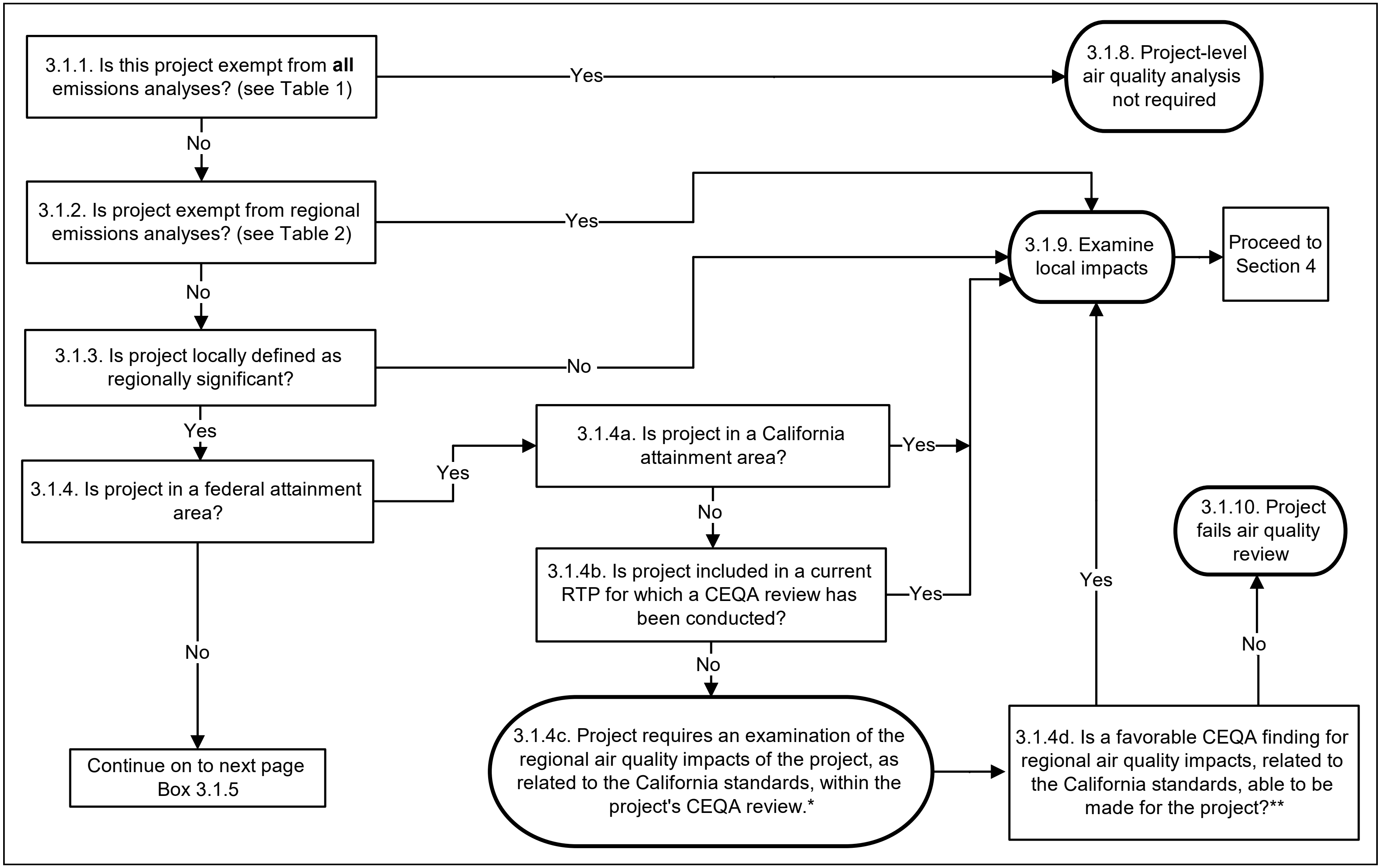

Figure 1. Requirements for New Projects

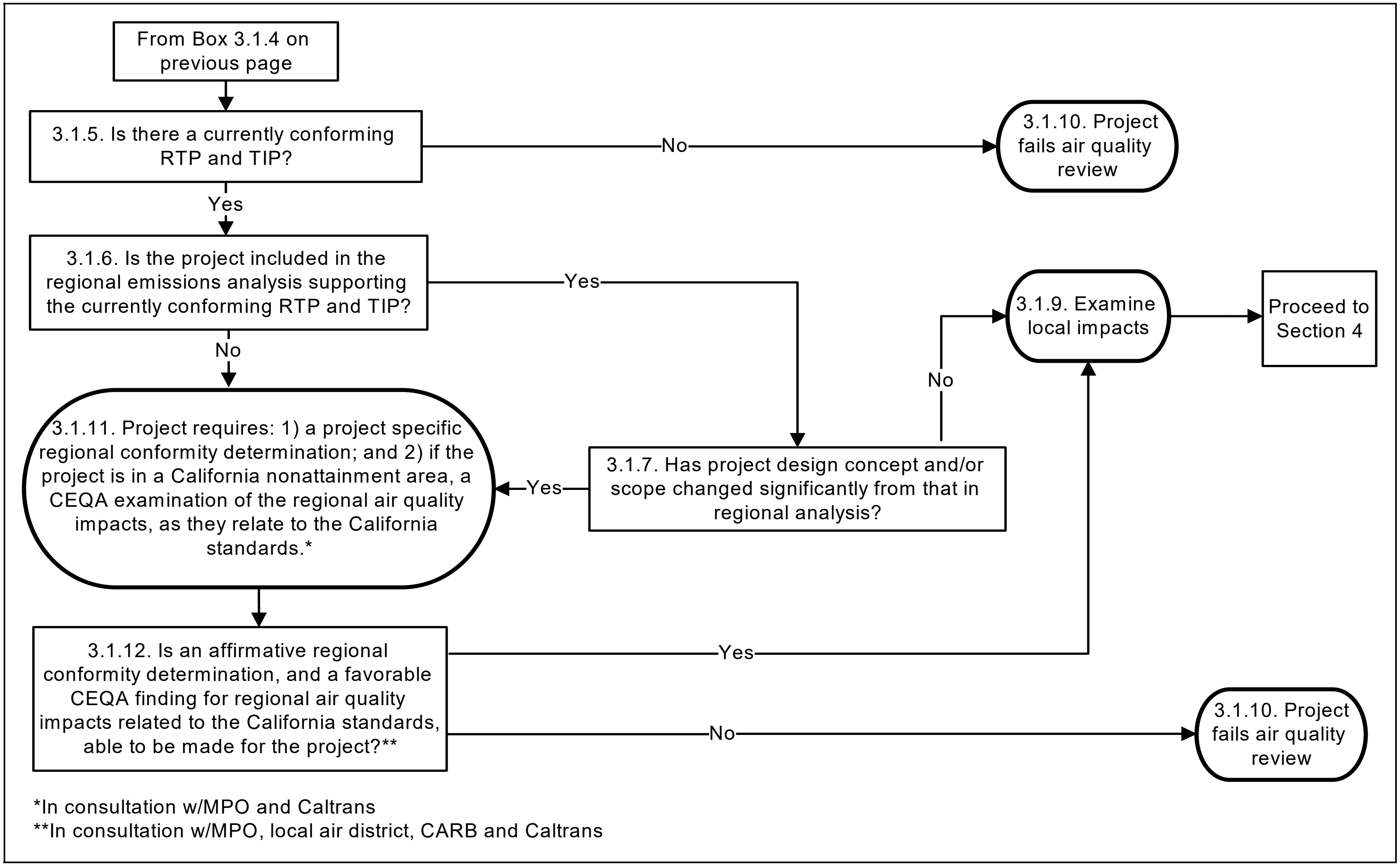

Figure 1 (cont.). Requirements for New Projects

a) Is project in a California attainment area?

   A project in a California attainment area does not require a regional CEQA finding. The next step in the air quality review process is to examine local impacts.

b) Is project included in a current RTP for which a CEQA review has been conducted?

   A project included in a current RTP for which a CEQA review has been conducted does not require a regional CEQA finding. The project may proceed to the examination of local impacts. All other projects require a regional CEQA finding described in the next step.

c) Project requires an examination of the regional air quality impacts of the project, as related to the California standards, within the project's CEQA review.

   At this point the project sponsor(s) is required to consult with the MPO and Caltrans for guidance regarding how to proceed.

d) Is a favorable CEQA finding for regional air quality impacts, related to the California standards, able to be made for the project?

   The project sponsor(s) in consultation with the MPO, local Air District, CARB, and Caltrans must make a favorable CEQA finding for regional air quality impacts related to the California standards. If a favorable CEQA finding is able to be made then proceed to examine local impacts. If a favorable CEQA finding is not able to be made, then the project fails the air quality review.

3.1.5 Conforming RTP and TIP?

At this point in the flow chart the project has failed to qualify for an exemption from a regional conformity finding. The project may not proceed past this step in the conformity review process unless the region has a currently conforming RTP and TIP. [40 CFR § 93.114]

3.1.6 Project included in the regional emissions analysis?

Regionally significant projects (federal and non-federal) must be included in the regional emissions analysis supporting the currently conforming RTP and TIP. If the project is not included in the regional emissions analysis supporting the currently conforming RTP and TIP, the project is subject to a regional conformity determination (see Section 3.1.11). The regional emissions analysis must account for the emissions impacts of all regionally significant projects, even if a project is not required to be officially listed as part of the region's RTP and TIP. As part of the documentation of project-level conformity, the project sponsor(s) must provide specific evidence that the project was indeed modeled in the regional emissions analysis [40 CFR § 93.115; 40 CFR § 93.118].

3.1.7 Design concept and/or scope changed significantly?

If the project design concept and/or scope has changed significantly (see Section 2.9) from that used in the regional emissions analysis then a new regional conformity determination is required.

3.1.8 Project-level (or local) air quality analysis not required

No analysis is required for exempt projects and the project sponsor(s) may proceed with the project.

3.1.9 Examine local impacts

The project sponsor(s) is required to examine local CO impacts as outlined in Section 4, make an affirmative finding as outlined in Section 5, and complete documentation as outlined in Section 6.

3.1.10 Project fails air quality review

If the project reaches this action item on the flow chart then the project has failed a significant conformity test and/or a significant CEQA-related air quality review requirement. The project cannot receive approval.

3.1.11 Project requires a project specific regional conformity determination

Before the project may proceed the project requires: 1) a project-specific regional conformity determination; and 2) if the project is in a California nonattainment area, a CEQA examination of the regional air quality impacts, as they relate to the California standards. For conformity, the project must be consistent with the motor vehicle emissions budgets(s) in the applicable implementation plan (or implementation plan submission). At this point the project sponsor(s) is required to consult with the MPO and Caltrans for guidance regarding how to proceed.

There are two possible outcomes to this consultation process:

a) the MPO or other party may perform a project specific regional air quality study; or
b) the project may not proceed until incorporated/reflected in a conforming RTP and TIP.

3.1.12 An affirmative regional conformity determination for the project?

The project sponsor(s) in consultation with the MPO, local Air District, CARB, and Caltrans must certify that the project passes all regional conformity requirements and must make a favorable CEQA finding for regional air quality impacts related to the California standards.

3.2 Project Re-examinations

Projects that have already demonstrated compliance with all federal and state air quality requirements may not require a new air quality analysis when the project is advanced. However, consideration of alternatives in the NEPA/CEQA process or other project development studies may result in a project with design concept and scope significantly different from that in the RTP or TIP. Figure 2 should be used to determine if the air quality impacts of the project must be re-examined. The following four sub-sections describe the elements of the procedure shown in Figure 2.

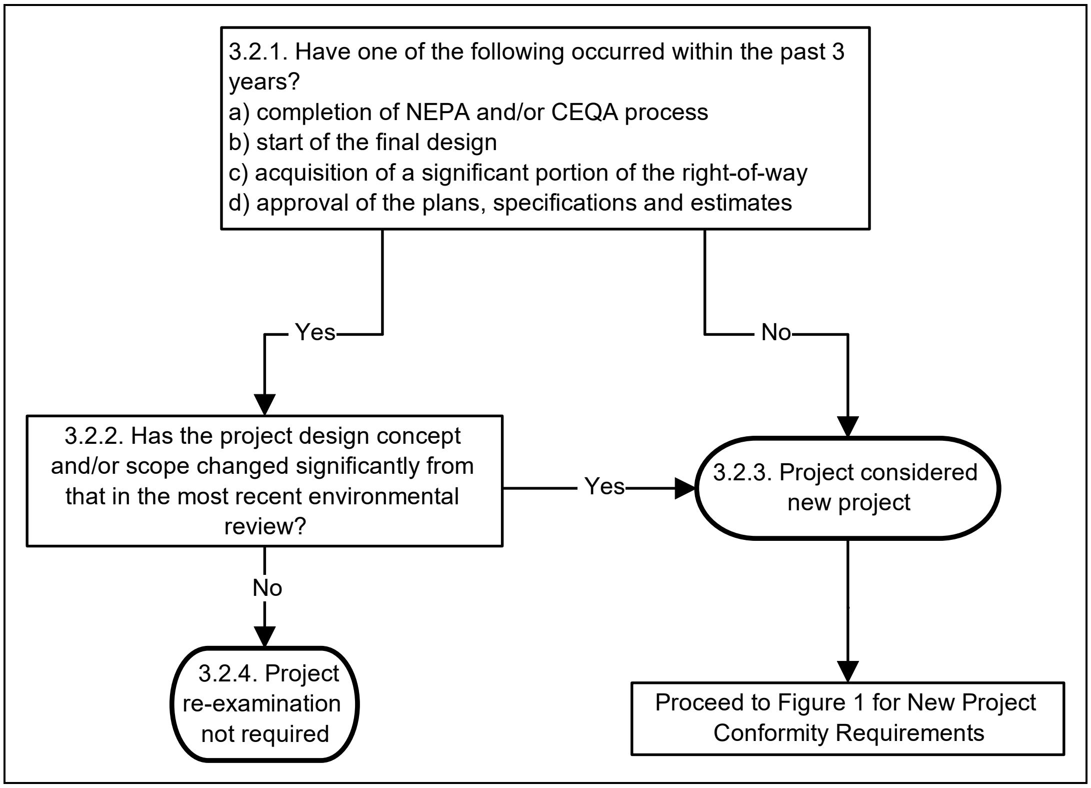

Figure 2. Project Re-examinations

3.2.1 Have one of the following occurred within the past 3 years?

As a first test as to whether or not the project requires a project-level CO analysis, one of the four events in the box must have occurred.

3.2.2 Has the project design concept and/or scope changed significantly from that in the most recent environmental review?

If there is no significant (see Section 2.9) change in project design concept and/or scope from that in the most recent environmental review, and the certified NEPA and/or CEQA document includes sufficient and appropriate information to support an affirmative CO conformity determination, then the project may proceed.

3.2.3 Project considered new project

Projects that fail to meet the above requirements will be considered a new project from the standpoint of project-level air quality analysis and must pass all the requirements outlined in Section 3.1 before the project may proceed.

3.2.4 Project re-examination not required

A project-level (or local) air quality analysis/re-analysis is not required and the project sponsor(s) may proceed with the project.

4 LOCAL ANALYSIS

The determination of project-level CO impacts should be carried out according to the Local Analysis flow chart shown in Figure 3 (following Section 4.7.5). Additional comments and explanatory remarks for every step of the local analysis are given below.

4.1 Designation of Project Area {Level 1 in Figure 3}

There is an increased need to examine project effects in nonattainment areas. The local analysis provided in this Protocol recommends slightly different approaches according to the designation of the area in which the project is located, as explained in the following subsections. Information regarding area designations is provided in "Amendments to the Area Designations for State Ambient Air Quality Standards with Maps of Area Designations for the State and National Ambient Air Quality Standards" as updated by CARB, or in consultation with the local Air District. Federal attainment designations are applicable to conformity and NEPA analysis; state attainment designation are applicable to CEQA analysis.

4.1.1 Projects in nonattainment areas

Projects located in nonattainment areas should proceed to Section 4.2 (LEVEL 2 in Figure 3). Projects located in attainment or unclassified areas should proceed to Section 4.1.2.

4.1.2 Projects in attainment or unclassified areas

Projects located in areas that have been proposed by CARB for federal redesignation to attainment after the 1990 CAA must have a Maintenance Plan and should proceed to Section 4.1.3. Projects located in areas not designated as nonattainment when the 1990 CAA was approved or in unclassified areas should proceed to Section 4.7 (LEVEL 7 in Figure 3).

4.1.3 Attainment verification according to the Maintenance Plan

Project sponsors should contact the local Air District to verify continued attainment. CARB conducts an annual review of the air quality monitoring data which may also be used for this purpose. Projects in areas where continued attainment has been verified (or where proposed redesignation is so recent that the annual review of monitoring data has not yet occurred) should proceed to Section 4.7 (LEVEL 7 in Figure 3). Projects in areas where continued attainment cannot be verified should proceed to section 4.2 (LEVEL 2 in Figure 3).

4.2 Projects In Areas With Approved CO Attainment or Maintenance Plans {Level 2 in Figure 3}

Projects may be deemed satisfactory if it can be determined that the project does not lead to an increase in emissions. For projects involving more than one intersection or roadway segment, emissions must not increase in any of them individually. Comparison of the “build” and “no build” scenarios according to the criteria set forth below provide a basis for deciding if the changes in emissions are acceptable:

a. Project does not significantly increase the percentage of vehicles operating in cold start mode. Increasing the number of vehicles operating in cold start mode by as little as 2% should be considered potentially significant.
b. Project does not significantly increase traffic volumes. Increases in traffic volumes in excess of 5% should be considered potentially significant. Increasing the traffic volume by less than 5% may still be potentially significant if there is a corresponding reduction in average speeds.
c. Project improves traffic flow. For uninterrupted roadway segments, higher average speeds (up to 50 mph) should be regarded as an improvement in traffic flow. For intersection segments, higher average speeds and a decrease in average delay should be considered an improvement in traffic flow.
d. In addition, a project that causes an insignificant increase in emissions may only be deemed satisfactory if the project does not move traffic closer to a receptor. By satisfying this requirement the project will not cause an increase in ambient concentration at a receptor-site. (see Section B.4.3 in Appendix B for a discussion of suitable receptor locations.)

The criteria should be applied on an hourly basis for the time periods when the highest 1-hr and 8-hr CO concentrations are expected to occur.

The example percentage changes associated with traffic volumes and vehicle operating modes provided here are meant to guide analysts in their assessment of whether a project significantly changes emissions; these figures are not absolute guidelines. If there is any doubt concerning a project’s significance, the project sponsor should consult with the local air district to determine whether a project would have a significant impact on pollutant emissions.

4.3 Projects in Areas Without Approved CO Attainment or Maintenance Plans, and Projects that Significantly Increase Emissions {Level 3 in Figure 3}

Screening criteria are provided in this section for projects that either result in significant emissions increases, or are projects located in areas that do not yet have an approved CO attainment or maintenance plan. The screening criteria provided in this section are based on comparing the project under study with intersections modeled in the area’s attainment or maintenance plan.

4.3.1 Analysis detail and findings

A comparison between intersections can only be made if the following conditions are satisfied:

a. The intersection analysis in the CO attainment plan was performed in sufficient detail to establish CO concentrations.

b. The impacts were acceptable (see section 5).

4.3.2 Estimating the difference in carbon monoxide concentrations

Carbon monoxide concentrations at an intersection would be lower than those reported for an intersection analyzed in the CO attainment plan if all of the following conditions are satisfied:

a. The receptor locations at the intersection under study are at the same distance or farther from the traveled roadway than the receptor locations used in the intersection in the attainment plan.

b. The two intersection traffic volumes and geometries are not significantly different. Or, if they are different, then when comparing the project under study to an intersection modeled in the approved plan:

   For the study intersection's worst approach and for the intersection as a whole, during the morning and evening peak periods, the intersection meets one of the following criteria:

   - the project experiences approximately the same traffic volume as the modeled intersection, but has more lanes; or
   - the project has less traffic, but the same number of lanes; or
   - the project has less traffic, fewer lanes, and the same or better LOS as what was modeled.

c. Appropriately assumed meteorology for the intersection under study is the same or better than the assumed meteorology for the intersection in the attainment plan. Relevant meteorology includes: wind speed, wind direction, temperature and stability class.

d. Traffic lane volumes for all approach and departure segments are lower for the intersection under study than those assumed for the intersection in the attainment plan.

e. Percentages of vehicles operating in cold start mode are the same or lower for the intersection under study compared to those used for the intersection in the attainment plan.

f. Percentage of Heavy Duty Gas Trucks in the intersection under study is the same or lower than the percentage used for the intersection in the attainment plan.

g. Average delay and queue length for each approach is the same or smaller for the intersection under study compared to those found in the intersection in the attainment plan.

h. Background concentration in the area where the intersection under study is located is the same or lower than the background concentration used for the intersection in the attainment plan.

A project shall be considered satisfactory if it meets the above criteria. If the project does not meet the above criteria, a comparison should be made of the CO concentrations resulting from the "build" and "no build" scenarios; the screening methodology in Appendix A should be used to conduct the analysis (see "Screening Analysis," Section 4.4). See section 5 for determining acceptability of impacts.

4.4 Screening Analysis {Level 4 in Figure 3}

Screening procedures are used to quantitatively estimate CO concentrations. These procedures normally consist of a set of tables and/or figures, along with guidelines on how to use them to obtain a concentration estimate. Screening procedures provide a relationship among CO concentrations and the most important parameters that affect those concentrations. Ideally, screening procedures incorporate assumptions that result in conservative concentration estimates. A direct advantage of assuming input parameters is that less information is required from the user. In addition, screening procedures are especially convenient because the user does not need to run the emission factor and dispersion models. Instead, the screening procedure presents those results for a specific range of conditions. In most cases, not having to run emission factor and dispersion models results in substantial time savings. A screening procedure for projects involving intersections is included in Appendix A. See section 5 for determining acceptability of impacts.

4.5 Detailed Analysis {Level 5 in Figure 3}

A detailed analysis is performed when it is necessary to obtain more robust estimates of CO concentrations than those obtained using a screening procedure. The recommended emission factor and dispersion models are CT-EMFAC and CALINE4, respectively. CT-EMFAC is recommended because it incorporates the most recent version of EMFAC. (At the time of writing of the protocol the latest version was 7F1.1). There is one restriction to the recommendation of CALINE4. The *intersection link* option is not recommended because it makes use of a modal emissions algorithm developed for an outdated vehicle fleet. Guidelines for performing a detailed analysis using these models are given in Appendix B. See section 5 for determining acceptability of impacts.

4.6 Reference to Standing Committee {Level 6 in Figure 3}

If the CO impacts are found to be unacceptable (see Section 5) based on a detailed analysis, the project is deemed unsatisfactory and should not proceed unless modifications can be made leading to its acceptability. The project sponsor may elect to refer the project to a standing committee composed of the local Air District, local MPO, project sponsor, CARB and Caltrans to evaluate model inputs. The standing committee will recommend project-specific guidance that may or may not require a new detailed analysis. A list of MPOs and Air Districts is provided in Appendix C.

4.7 Screening Projects in Attainment or Unclassified Areas {Level 7 in Figure 3}

Air quality in attainment (proposed attainment) and unclassified areas is just as important as in nonattainment areas. In attainment (proposed attainment) or unclassified areas, the project sponsor(s) is primarily concerned with intersections where air quality may be getting worse. Other conditions may also necessitate consideration of project-level CO air quality impacts.

4.7.1 Projects that are likely to worsen air quality

Only those projects that are likely to worsen air quality necessitate further analysis. The following criteria should be used to determine whether a project is likely to worsen air quality for the area substantially affected by the project:

a. The project significantly increases the percentage of vehicles operating in cold start mode. Increasing the number of vehicles operating in cold start mode by as little as 2% should be considered potentially significant.

b. The project significantly increases traffic volumes. Increases in traffic volumes in excess of 5% should be considered potentially significant. Increasing the traffic volume by less than 5% may still be potentially significant if there is also a reduction in average speeds.

c. The project worsens traffic flow. For uninterrupted roadway segments, a reduction in average speeds (within a range of 3 to 50 mph) should be regarded as worsening traffic flow. For intersection segments, a reduction in average speed or an increase in average delay should be considered as worsening traffic flow.

The above criteria should be applied on an hourly basis to the “build” and “no build” scenarios for the time periods when the highest 1-hr and 8-hr CO concentrations are expected to occur. Note that it may be easier to “screen out” a project by proceeding directly to Section 4.7.2 and therefore, the analyst is encouraged to look ahead at the criteria given therein.

4.7.2 Projects suspected of resulting in higher CO concentrations than those existing within the region at the time of attainment demonstration

Projects potentially creating CO concentrations higher than those existing within the region at the time of attainment demonstration should proceed to Section 4.7.3; other projects should be deemed satisfactory and no further analysis is needed. Project sponsors may use the following criteria to determine the potential existence of higher CO concentrations in the region. Select one of the worst locations in the region having a similar configuration and compare it to the "build" scenario of the location under study according to the following conditions:

a. The receptors at the location under study are at the same distance or farther from the traveled roadway than the receptors at the location where attainment has been demonstrated.

b. The roadway geometry of the two locations is not significantly different. An example of a significant difference would be a larger number of lanes at the location under study compared to the location where attainment has been demonstrated.

c. Expected worst-case meteorology at the location under study is the same or better than the worst-case meteorology at the location where attainment has been demonstrated. Relevant meteorological variables include: wind speed, wind direction, temperature and stability class.

d. Traffic lane volumes at the location under study are the same or lower than those at the location where attainment has been demonstrated.

e. Percentages of vehicles operating in cold start mode at the location under study are the same or lower than those at the location where attainment has been demonstrated.

f. Percentage of Heavy Duty Gas Trucks at the location under study is the same or lower than the percentage at the location where attainment has been demonstrated.

g. For projects involving intersections, average delay and queue length for each approach is the same or smaller for the intersection under study compared to those found in the intersection where attainment has been demonstrated.

h. Background concentration at the location under study is the same or lower than the background concentration at the location where attainment has been demonstrated.

If all of the above conditions are satisfied there is no reason to expect higher concentrations at the location under study.

4.7.3 Projects that involve signalized intersections at LOS E, or F

Projects that are likely to worsen air quality at signalized intersections having a level of service E, or F, represent a potential for a CO violation and need further analysis. Those projects should proceed to LEVEL 4 (Section 4.4) to perform a screening analysis.

4.7.4 Projects that result in worsening of signalized intersection LOS to E, or F

Projects that would lead to worsening the level of service of a signalized intersection to E, or F, represent a potential for a CO violation and require further analysis. Those projects should proceed to LEVEL 4 (Section 4.4) to perform a screening analysis. For example, a project that would change the level of service of a signalized intersection from D to E would require further analysis.

4.7.5 Other reasons causing adverse air quality impacts

Under certain special conditions, there still may be cause for concern about the air quality impacts of the project even if no further analysis was required according to Sections 4.7.3 and 4.7.4. These conditions require that the project sponsor(s), in consultation with the MPO and the local Air District, determine the potential air quality impacts of the particular project being reviewed. Examples of such special conditions include:

a. Urban street canyons

b. High percentage of Heavy Duty Gas Trucks in the vehicle mix (for example, in manufacturing or industrial areas)

c. High percentage of vehicles operating in cold start mode coupled with high traffic volumes

d. Locations near a significant stationary source of CO

e. Locations with high background CO concentrations. Note that due to motor vehicle fleet turnover to cleaner cars, the budget for acceptable background CO concentrations increases over time as vehicle CO emissions drop over time. For LOS D intersections, background concentrations over the following values would be considered high:

   In the year 1997: 3.0 ppm
   In the year 2000: 4.0 ppm
   In the year 2005: 5.0 ppm
   In the year 2010: 6.0 ppm

f. LOS D intersections which experience meteorological conditions favorable to the formation of higher CO concentrations, *and*, where the intersections have pre-timed signals (as opposed to actuated signals that minimize vehicle queueing).

Meteorology favorable to higher CO concentrations can be characterized as stable air conditions (atmospheric stability of “E” or “F”), relatively slow wind speeds (less than 1.5 meters per second, or 3.5 mph) that persist for at least six hours, and with consistent wind direction having greater than a 50% frequency of occurrence into a single 45 degree sector during an inclusive 8-hr period (i.e., the wind blows into the same 45 degree sector at least 4 hours out of any given inclusive 8-hr period). Intersection projects with pre-timed signals need to show that representative fall (beginning in October) and winter meteorological data are not favorable to high CO; otherwise, proceed to Section 4.4 (Level 4 in Figure 3).

g. LOS D actuated intersections (as opposed to pre-timed) which experience meteorological conditions favorable to the formation of higher CO concentrations, *and*, where enough traffic is queued to create problematic CO emissions. Traffic queueing can result in a CO problem when the number of vehicles queued at a read light exceeds 1206 vehicle-sec of red time. The vehicle-sec of red time is computed by measuring, for each “critical movement” or priority link (i.e., lane group), the highest vehicle-sec of red time for the approach with the longest delay during the peak 1-hr period (i.e., for one leg of an intersection, the red time multiplied by the number of vehicles queued in the priority lane(s) is 1206 vehicle-sec or greater). Meteorology favorable to higher CO concentrations can be characterized as stable air conditions (atmospheric stability of “E” or “F”), relatively slow wind speeds (less than 1.5 meters per second, or 3.5 mph) that persist for at least six hours, and with consistent wind direction having greater than a 50% frequency of occurrence into a single 45 degree sector during an inclusive 8-hr period (i.e., the wind blows into the same 45degree sector at least 4 hours out of any given inclusive 8-hr period). Intersection projects exceeding 1206 vehicle-sec of red time need to show that representative fall (beginning in October) and winter meteorological data are not favorable to high CO; otherwise, proceed to Section 4.4 (Level 4 in Figure 3).

Further information is available describing how LOS affects CO concentrations, and why LOS E or F intersections are generally the most appropriate candidates for detailed analyses. See Meng and Niemeier (1997): “Modeling Carbon Monoxide Concentrations at Level-of-Service D Intersections” for a detailed discussion (copies available either from UC Davis, Department of Civil and Environmental Engineering; or from Caltrans).

Further analysis is required if it is determined that the project has the potential to negatively affect air quality even in a CO attainment area. Those projects should proceed to LEVEL 4 (Section 4.4) to perform a screening analysis.

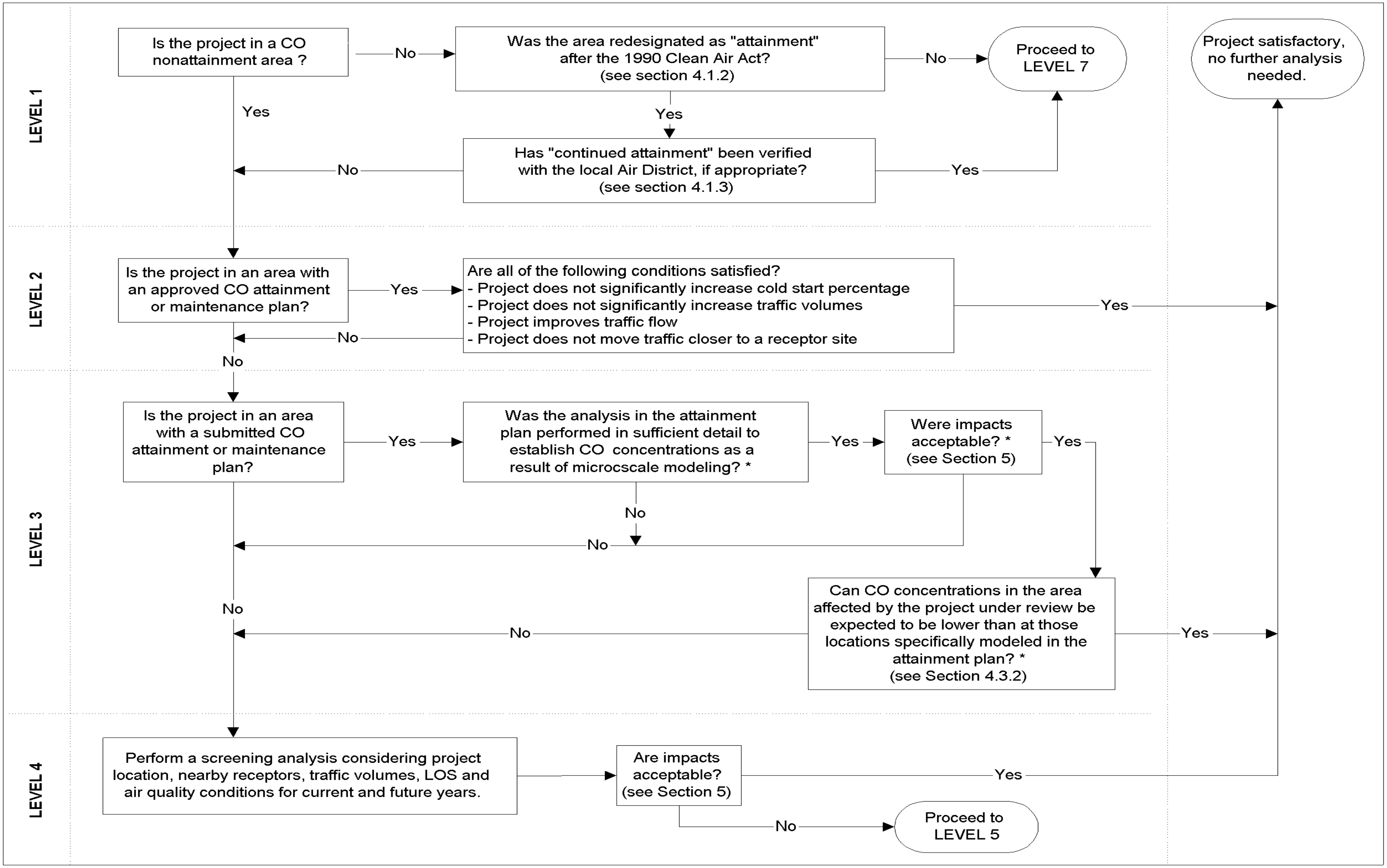

Figure 3. Local CO Analysis

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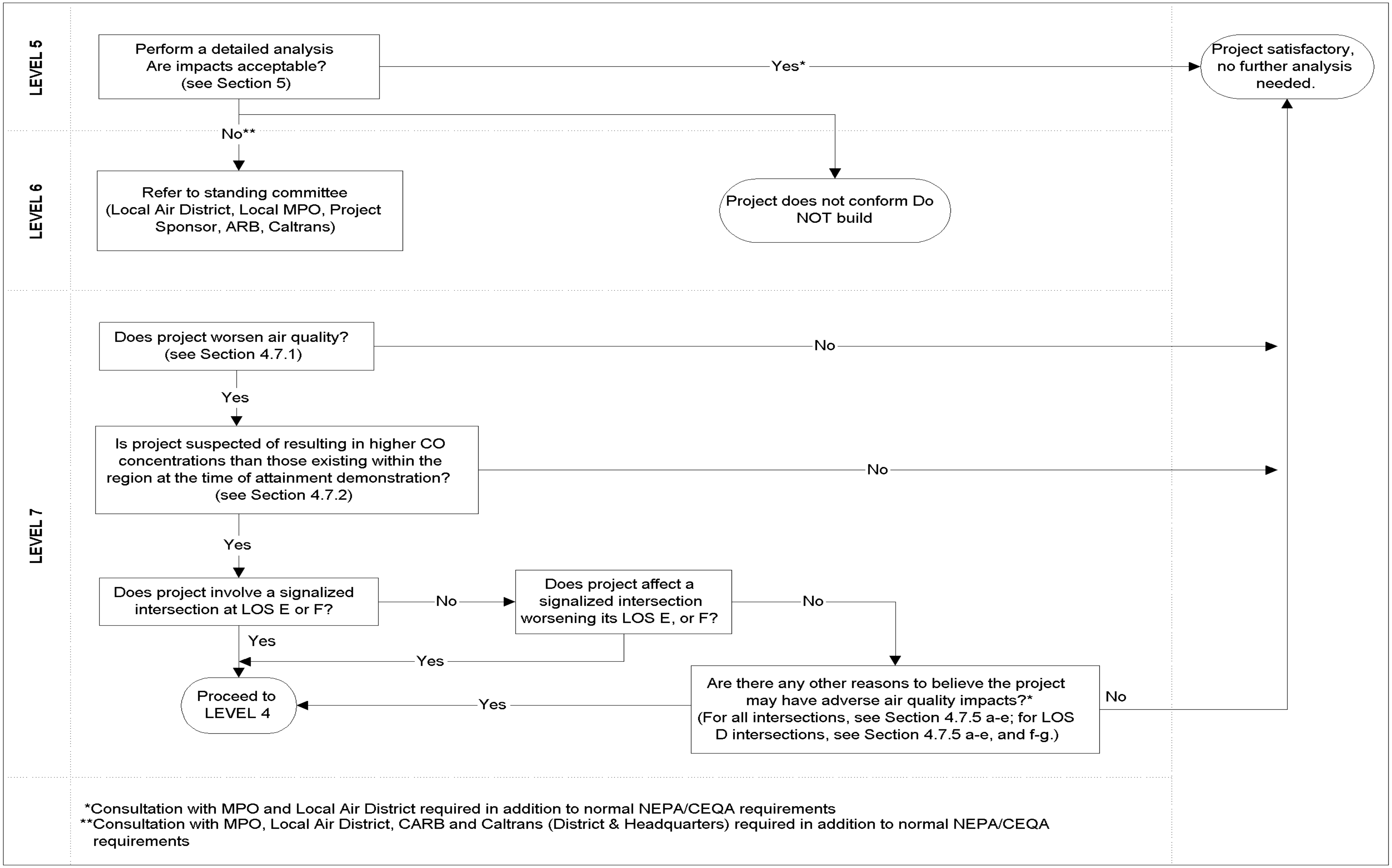

Figure 3 (cont.). Local CO Analysis

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5 ACCEPTABILITY OF IMPACTS

5.1 California Regulation (CEQA)

All projects are subject to CEQA. According to the California Code of Regulations (Title 17, Section 1509), a determination must be made of whether a project may have a significant effect on the environment. An example, cited in the regulations, of when a transportation project may be deemed to have a significant effect on the environment is: when the project violates any California ambient air quality standard, contributes substantially to an existing or projected air quality violation, or exposes sensitive receptors to substantial pollutant concentrations.

California ambient air quality standards for carbon monoxide are shown in Table 3.

Table 3. California Air Quality Standards for CO

Averaging Period	Concentration (ppm)
1 hour	20 *
8 hour	9.0 *
8 hour †	6 **

† - Applicable only in the Lake Tahoe Air Basin

** - These standards are violated when concentrations exceed the given value.*

*** - This standard is violated when concentrations equal or exceed the given value.*

5.2 Federal Regulation

5.2.1 National Ambient Air Quality Standards (NAAQS)

The National Ambient Air Quality Standards shown in Table 4, should be used to determine the acceptability of impacts under federal conformity and NEPA (see Sections 5.2.2 and 5.2.3, respectively).

When summarizing data for comparison with the standards, the CO concentrations expressed in parts per million shall be made in terms of integers with fractional parts of 0.5 or greater rounded up.

Table 4. National Ambient Air Quality Standards for CO

Averaging Period	Concentration (ppm)
1 hour	35 *
8 hour	9 *

** - These standards are violated when concentrations exceed the given value.*

5.2.2 Federal Conformity

All projects involving federal funding and/or approval, and not otherwise exempt, require a federal conformity determination.

Within Federal CO nonattainment and maintenance areas, a project, must not cause or contribute to any new localized CO violations or increase the frequency or severity of any existing CO violations [40 CFR § 93.116 and 42 USC § 7506 (c)(3)]. These criteria apply during all periods.

In addition, during the time period prior to federal approval of a region's CO attainment plan, projects are required to eliminate or reduce the severity and number of localized CO violations in the area substantially affected by the project [40 CFR § 93.116 and 42 USC § 7506 (c)(3)(B)].

Occasionally, a project will transfer an existing violation from one location to another within the area substantially affected by the project. The relocation of a violation is not considered a new violation. Furthermore, if the severity of the exceedance at the new location is less than the severity at the old location, the relocation is considered a reduction of an existing violation.

Multiple relocations or changes in carbon monoxide hot spots should be examined in the context of the project takes as a whole. The relocation of multiple violations or changes is not considered to result in new violations provided that the changes or movements from the old to the new locations produce a net air quality benefit for the project considered as a whole.

5.2.3 National Environmental Policy Act (NEPA)

All projects involving federal funding and/or approval are subject to NEPA. According to NEPA, the project must not violate any national ambient air quality standard or the project must incorporate all practicable means to avoid or minimize expected exceedances of national ambient air quality standards.

6 CERTIFICATION

The “project sponsor(s) will be required to perform the necessary carbon monoxide analysis prior” to acting to approve the final environmental document or conducting a re-evaluation thereof. “In most cases, the project sponsor will perform and document the analysis as part of its documentation of the environmental impacts of the project in accordance with the requirements of the National Environmental Policy Act (NEPA) and/or the California Environmental Quality Act (CEQA)” [SCAG 1993, p. 17].

6.1 Items to Document

At the time of project review or approval, the project sponsor(s) should document several items related to the review of the project-level CO analysis as given below.

- For a regionally significant project, document that the project was modeled in the regional emissions analysis for a currently conforming RTP and TIP (see Section 3.1.6), and that the design concept and scope have not changed significantly from the project described and listed in the currently conforming RTP and TIP [40 CFR § 93.115(b)(1)]; or that a project-specific regional analysis was accomplished.
- Document the acceptability of the impacts analyzed in Section 4 and described in Section 5.
- Document project level TCMs and mitigation measures as discussed in Sections 2.11 and 2.12 [40 CFR § 93.123(c)(4)].
- If the project is exempt from project-level CO analysis, note that fact in the project’s environmental document.
- Once the project sponsor has used the protocol, identified which analyses are appropriate, and conducted the analyses, the sponsor should briefly document the information used to support the analyses, as well as the findings reached by applying the protocol. Special attention should be paid to documenting information supporting the ability of the project sponsor to use the protocol’s screening approaches, rather than conducting detailed project analyses. A copy of such documentation should be included with the project’s environmental files.
- The project sponsor should also document all consultation proceedings, include the participants, meeting dates, and agreements reached. It is recommended that the sponsor distribute the documentation of these consultation efforts to all participants shortly after the consultation has been completed, to insure an accurate record of agreements reached with the participating agencies. A copy of such documentation should be included with the project’s environmental files.

Certification of regional impacts of the project are outside the scope of this protocol.

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7 REFERENCES

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8 GLOSSARY

Approach “A set of lanes accommodating all left-turn, through and right-turn movements arriving at an intersection from a given direction.

Approach Links Those links used to model a signalized intersection located near the center of the intersection.

Arterial Segment “A one-way length of arterial from one signal to the next, including the downstream signalized intersection but not the upstream signalized intersection”**

Average running speed “The average speed of a traffic stream computed as the length of a highway segment divided by the average running time of vehicles traversing the segment, in miles per hour”**

Average running time “The average time vehicles are in motion while traversing a highway segment of given length, excluding stopped-time delay, in seconds per vehicle or minutes per vehicle”**

CAA “Clean Air Act as amended”* in 1990.

Caltrans California Department of Transportation.

CARB California Air Resources Board.

CEQA California Environmental Quality Act.

Delay “Additional travel time experienced by a driver, passenger, or pedestrian beyond what would reasonably be desired for a given trip”**

Design concept “Design concept refers to the type of facility identified by the project, e.g., freeway, expressway, arterial highway, grade-separated highway, reserved right-of-way rail transit, mixed-traffic rail transit, exclusive busway, etc.”*

Design scope “Design Scope refers to the design aspects that will affect the proposed facility’s impact on emissions, usually as they relate to carrying capacity and control, e.g., the number of lanes or tracks to be constructed or added, length of project, signalization, access control including approximate number and location of interchanges, preferential treatment for high-occupancy vehicles, etc.”*

Environmental Documents "*Environmental documents* includes Initial Studies, Negative Declarations, draft and final EIRs and Negative Declarations under a program certified pursuant to [California] Public Resources Code Section 21080.5, and documents prepared under NEPA and used by a state or local agency in the place of an Initial Study, Negative Declaration, or an EIR"[†].

External Links Those links used to model a signalized intersection located farther away from the intersection signal in relation to approach and departure links.

FHWA "Federal Highway Administration" of the U.S. Department of Transportation.[*]

Free-flow speed "(1) The theoretical speed of traffic when density is zero, that is, when no vehicles are present; (2) the average speed of vehicles over an arterial segment not close to signalized intersections under conditions of low volume"[**]

FTA "FTA means the Federal Transit Administration of" the U.S. Department of Transportation.[*]

Link A portion of a road in a highway network. Usually defined by nodes at each end-point.

Maintenance area "Maintenance area refers to any geographic region of the United States previously designated nonattainment pursuant to the CAA Amendments of 1990 and subsequently redesignated to attainment subject to the requirement to develop a maintenance plan under section 175A of the CAA, as amended."[*]

MPO Metropolitan Planning Organization. The MPO "is that organization designated as being responsible, together with the State, for conducting the continuing, cooperative, and comprehensive planning process under 23 U.S.C. 134 and 49 U.S.C. 1607. It is the forum for cooperative transportation decision-making."[*]

NEPA "National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.)."[*]

Nonattainment area "Nonattainment area means any geographic region of the United States which has been designated as nonattainment under section 107 of the CAA for any pollutant for which a national ambient air quality standard exists."[*]

Regionally significant project "Regionally significant project refers to 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."[*] The conformity regulations allow regions to extend this definition pursuant to 40 CFR § 93.105(c)(1)(ii).

RTP Regional Transportation Plan. "...the official intermodal metropolitan transportation plan that is developed through the metropolitan planning process for the metropolitan planning area, developed pursuant to 23 CFR part 450."[*]

Saturation Flow Rate "The equivalent hourly rate at which vehicles can traverse an intersection approach under prevailing conditions, assuming that the green signal is available at all times and no lost times are experienced, in vehicles per hour of green or vehicles per hour of green per lane"[**]

SIP State Implementation Plan. "... the portion (or portions) of an applicable implementation plan approved or promulgated, or the most recent revision thereof, under sectoins 110, 301(d) and 175A of the Clean Air Act."[‡]

Surface Roughness The characteristic height of obstructions in the path of the wind near the surface, such as the height of trees and buildings.

TCM Transportation Control Measure "... is any measure that is specifically identified and committed to in the applicable implementation plan that is either one of the types listed in § 108 of the CAA, or any other measure for the purpose of reducing emissions or concentrations of air pollutants from transportation sources by reducing vehicle use or changing traffic flow or congestion conditions. Notwithstanding the above, vehicle technology-based, fuel-base, and maintenance-based measures which control the emissions from vehicles under fixed traffic conditions are not TCMs for the purposes of" Project-level conformity.[*]

TIP Transportation Improvement Plan and is "a staged, multiyear, intermodal program of transportation projects covering a metropolitan planning area which is consistent with the metropolitan transportation plan, and developed pursuant to 23 CFR part 450."*

* *Source: 40 CFR § 93.101.*
** *Source: Highway Capacity Manual (1994).*
† *Source: CEQA, Public Resources Code § 15361.*
‡ *Source: 23 CFR Section 450.208.*

APPENDICES

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Appendix A
Screening Procedure

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A Screening Procedure

A.1 General

The screening procedure presented in this section has been designed to estimate 8-hour CO concentrations for projects involving signalized intersections. Screening procedures for additional types of projects were under development at the time this document was being printed and will be released as supplements to this protocol.

The purpose of the screening procedure is to allow the analyst to obtain conservative estimates of CO concentrations without having to run the computational models, i.e., EMFAC and CALINE4 (as for the detailed analysis procedure described in Appendix B). Appendix A has two additional subsections: one titled *Methodology* containing step-by-step instructions on how to use the screening procedure; and one titled *Screening Procedure Assumptions*, presenting brief descriptions of the development and assumptions used in the screening procedure. Additional background for some of the assumptions are contained in technical support documents ([Garza, 1995a], [Garza, 1995b], and [Young and Chang, 1995]) and in Benson and Wood [1988].

This screening procedure is not intended to be applicable to all projects. If the assumptions made in the development of the screening procedure (see Section A.4) are not appropriate for the project under study then the screening procedure is not applicable and a detailed analysis must be performed. The main limitations of the screening procedure are shown in Table A.1.

Table A.1 Scenarios that should NOT be modeled using the screening procedure

Vehicles in cold start mode > 50 %
Percentage of Heavy Duty Gas Trucks > 1.2 %
Traffic volumes > 1000 vphpl
January mean minimum temperature < 35 ºF

The analyst should also note that according to 40 CFR § 93.123(c), “Hot-spot analysis assumptions must be consistent with those in the regional emissions analysis for those inputs which are required for both analyses.”

Using the screening methodology to calculate an 8-hour average CO concentration as prescribed in the following section, it is not possible for a project to result in a modeled 1-hour exceedance of the 1-hour CO standard without also causing a violation of the 8-hour standard. This is a consequence of the use of a persistence factor methodology, applied to the modeled 1-hour concentration, in order to obtain the 8-hour concentration. For that reason, the protocol explicitly addresses only the calculation of the 8-hour standard even though projects must meet both standards. In the case of the California CO standard, it is still highly unlikely that the 1-hour standard can be violated without causing a violation of the 8-hour standard.

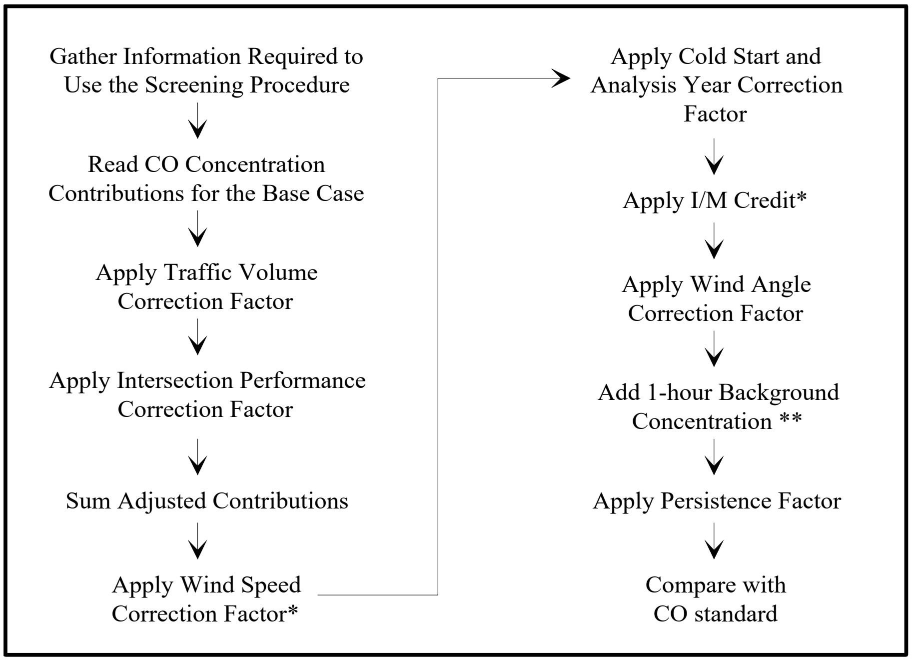
EPA's established policy is that CO concentration for 8-hour analyses should be estimated at a distance of 3 m for the minimum distance to the nearest roadway. The 3 m distance reflects the concentration in the "mixing zone" above and surrounding the traveled way and is the closest distance for which modeled concentrations are considered valid. The location at which CO concentrations are estimated is known as a model "receptor", i.e., a point at which a representative person could receive some dose of carbon monoxide from the ambient air. U.C. Davis researchers have evaluated appropriate receptor siting distances based on studies available at the time this protocol was being developed. A complete discussion of the results of these analyses are included in a technical support document for this protocol (Young and Chang, 1995). The U.C. Davis analysis of available scientific studies suggests that receptor locations for a 1-hour analysis should be 3 m, and receptor locations for an 8-hour analysis need not be located closer than 7 m except in the case of sensitive receptors where added conservative concentration predictions are desirable (Young and Chang, 1995). These results are based on data such as the length of time individuals remain near intersections, exposures and carbon monoxide dose experienced by these individuals, and the relationship between carbon monoxide dose and carboxy-hemoglobin (COHb) levels for individuals exposed to CO concentrations in excess of current health standards. Much of the work by Young and Chang is based on the results of a physical-stochastic model of population exposure and dose applied to individuals in Denver, Colorado.

If a site fails the 3 m test, the analysts should conduct a 7 m test. If the site fails the 3 m test, but passes the 7 m test, the analysts should discuss the findings with the local air district, the local MPO, the project sponsor, CARB and Caltrans. The discussion should be conducted to insure that, prior to conducting modeling analyses, the analysis assumptions were accurate, and the 3 m test was appropriately evaluated. It is recommended that consultation be accomplished as early as possible in the process.

A.2 Methodology

The methodology for estimation of the 8-hour CO concentrations is given in this section. In simple terms, the methodology uses estimates of the contributions to CO concentrations for a 'base case' characterized by a specific intersection configuration, meteorology, traffic volume and measures related to the intersection performance. The base case is described in Section A.4 of this Appendix. A series of correction factors is then applied to adjust the initial estimates of CO concentrations for the specific conditions of the intersection under study. The appropriate correction factors are selected from the relevant tables in this section. The contribution of the project to the 1-hour CO concentration is obtained, and subsequently, added to the background concentration. The 8-hour CO concentration is then estimated by applying the appropriate persistence factor to the total 1-hour CO concentration. Finally, the 8-hour CO concentration is compared with the 8-hour CO standard or to the CO concentration for another scenario. An overview of the methodology is shown in Figure A.1.

An example is included in Section A.3 of this Appendix to show the application of this screening procedure and to facilitate the correct interpretation of the methodology described below.



* These factors are applied only under special conditions as described in the text

** If only 8-hour Background Concentrations are available, please consult with the local Air District and see Section 5 in Appendix B.

Figure A.1 Overview of Screening Procedure Methodology

A.2.1 Information Required of the Analyst for Screening Procedure

Table A.2 lists the information about the project that is required to be supplied by the analyst for the screening procedure. A more detailed explanation of the use of each parameter is given below.

a. Intersection Type

Choose the intersection that best represents the project. Intersection types are given in terms of the total number of lanes of each intersecting road (not including short left or right turn lanes). For example, a 6-lane road (3 approach and 3 departure lanes) intersecting a 4-lane road (2 approach and 2 departure lanes) is considered a 6x4 intersection.

b. Geographic Location

Determine the geographic location that best represents the project area. Mountain areas should be modeled using the Coastal/Coastal Valley type.

c. Average Cruise Speed

The analyst supplies the average cruise speed (the speed of the vehicle when it is not delayed by the signal) for each direction of each road. The screening procedure requires only one representative average cruise speed for each road. If a two-directional road has different average cruise speeds on each direction, the lowest of the two values should be used. Guidance on the selection of average cruise speed is provided in Section B.3.6 of Appendix B.

d. Percentage of Red Time

The screening procedure requires a representative percentage of red time for the through movement of each road (e.g., one for N-S and one for W-E). If the two approach segments of the road (e.g., west and east) have different percentages of red time, the one with the highest percentage should be used.

e. Analysis Year

Determine the desired analysis year. Guidance on the selection of analysis year is provided in Section B.3.5 of Appendix B.

Table A.2. Project Characteristics Required to Perform a Screening Analysis

Characteristic	Alternatives	
Intersection Type	• 6 x 6 • 6 x 2 • 4 x 2	• 6 x 4 • 4 x 4 • 2 x 2
Geographic Location	• Central Valley • Coastal or Coastal Valley	
Average Cruise Speed	• 40 mph • 30 mph • 20 mph	• 35 mph • 25 mph • 15 mph
Percentage of Red Time	• 90% • 70% • 50% • 30%	• 80% • 60% • 40%
Percentage of Vehicles Operating in Cold Start Mode	• 50% • 30% • 10%	• 40% • 20%
Analysis Year	• 1996, 2000, 2004, 2008, 2012	
Traffic Volume (vehicles per hour per lane)	• 1000 • 800 • 600 • 400 • 200	• 900 • 700 • 500 • 300
Distance to nearest receptor	• From 3 to 50 m from the edge of traveled road	

f. Percentage of Vehicles Operating in Cold Start Mode

Estimate the percentage of vehicles operating in cold start mode and choose the value in the table that is closest to the estimated value, but not lower. If the percentage is larger than 50% then the screening procedure is not applicable. For guidance on estimating the percentage of vehicles operating in cold start mode refer to Section B.3.2 in Appendix B.

g. Traffic Volume

Determine the traffic volume for each road (i.e., one for the E-W road and one for the N-S road) as follows. First, estimate the approach volume in vehicles per hour per lane (vphpl) for each direction of each road. The approach volume should include turning and through movements. If the traffic volume is different in each direction of the same road, (for example, west-bound traffic heavier than east-bound traffic) use the highest of the two volumes if the receptor is located on the side with greater traffic volume. Use the average of the two traffic volumes if the receptor is located on the side with lower traffic volume. Choose the value from Table A.2 that is closest to the estimate obtained for each road, but not lower. A conservative, *representative* traffic volume is obtained for each road by using this procedure.

h. Distance to Nearest Receptor

Determine the distance from the edge of the traveled road to the nearest receptor. For guidance on locating receptors refer to Section B.4.3 of Appendix B.

A.2.2 Initial Estimates of CO Concentration Contributions

Having compiled the information and completed parts (a) through (h) of Section A.2.1, the analyst can now determine the 'base case' CO estimates. Read four initial estimates of CO concentration contributions from either Table A.3 (Central Valley) or from Table A.4 (Coastal/Coastal Valley) depending upon part (b) of section A.2.1. When applying this information, the analyst may interpolate between the values reported in the tables. As an alternative, the distance to the nearest receptor may be taken as the value reported in the table that is less than the distance from the traveled way to the nearest receptor. Each intersection will have four concentration contributions; an approach and a departure contribution for each road. For example, for a 4x2 intersection two values should be read from the row labeled 2-lane road (one for approach and one for departure) and two from the row labeled 4-lane road. The receptor distance from each road need not be the same. The initial estimates of CO concentrations contributed by the project are for the base case (described in Section A.4 of this Appendix), and are subsequently adjusted by the correction factors introduced in the following sections.

Table A.3. Concentration Contributions in ppm for Projects Located in Central Valley Areas

Contribution from		Distance from edge of traveled way (m)											
		3	4	5	6	7	8	9	10	15	20	25	50
2-lane road	approach	48.0	38.0	30.9	26.9	24.2	22.0	20.3	18.8	14.5	11.8	10.2	6.4
	departure	23.0	21.4	20.1	18.9	17.6	16.7	15.8	15.2	12.0	10.5	9.3	6.1
4-lane road	approach	74.0	62.1	51.9	45.2	40.6	37.0	34.6	32.2	24.8	20.6	17.7	11.4
	departure	24.3	26.8	27.1	25.5	24.0	23.5	22.3	21.9	18.7	16.5	15.0	10.3
6-lane road	approach	86.9	76.6	68.2	60.3	53.9	48.8	45.2	42.3	33.2	27.5	24.0	15.6
	departure	25.0	28.4	28.6	28.6	28.3	27.7	26.7	25.6	22.4	20.7	18.9	13.5

Table A.4. Concentration Contributions in ppm for Projects Located in Coastal and Coastal Valley Areas

Contribution from		Distance from edge of traveled way (m)											
		3	4	5	6	7	8	9	10	15	20	25	50
2-lane road	approach	30.1	32.0	27.0	23.7	21.2	19.5	18.1	16.9	13.0	10.9	9.5	6.2
	departure	20.1	19.1	17.8	16.7	15.6	14.7	14.1	13.5	11.3	9.7	8.6	5.9
4-lane road	approach	59.6	53.0	46.8	41.7	37.6	34.5	31.8	29.8	23.1	19.3	16.7	10.9
	departure	25.2	25.4	24.4	23.5	22.7	21.7	21.0	20.2	17.3	15.4	14.2	9.9
6-lane road	approach	73.3	66.9	61.6	55.6	50.7	46.7	43.3	40.5	31.3	26.2	23.0	14.9
	departure	27.4	28.3	26.8	26.4	25.9	24.9	24.4	24.4	21.8	19.7	17.8	13.1

A.2.3 Traffic volume correction

Where the approach volumes are different from those assumed in the base case, traffic volume correction factors need to be applied to the CO contributions from above. Use the *representative* traffic volumes found in part (g) of Section A.2.1 to correct each contribution from Section A.2.2 by multiplying by the appropriate values given in Table A.5. The correction factor chosen should be for a traffic volume greater than or equal to the actual traffic volume.

Table A.5. Traffic Volume Correction Factors

Vehicles per Hour per Lane (vphpl)	Correction Factor
200	0.27
300	0.37
400	0.47
500	0.58
600	0.67
700	0.76
800	0.85
900	0.93
1000	1.0

A.2.4 Intersection performance correction

Use cruise speed, percentage red time and traffic volume information (the representative volumes found in part (g) of Section A.2.1) to read an intersection performance correction factor from Table A.6 (for approach contributions) and from Table A.7 (for departure contributions). Interpolation between the discrete values of cruise speed, percentage red time and/or traffic volume may be carried out, if desired. Apply the appropriate correction factor to the contributions obtained in the previous step.

A.2.5 Total contribution from approaches and departures

Add all four adjusted contributions to obtain a total contribution for the intersection.

A.2.6 Worst-case wind speed correction

The total contribution obtained in the previous step is based on a worst-case wind speed of 0.5 m/s. If a worst-case wind speed of 1 m/s is more suitable for the location under study, multiply the total contribution obtained in Section A.2.5 by 0.7.

A.2.7 Cold start and analysis year correction

Use the percentage of vehicles operating in cold start mode, along with the desired analysis year to obtain a correction factor from Table A.8. Apply this correction factor to the total contribution obtained in the previous step.

A.2.8 SCAQMD post-EMFAC7F1.1 credit

Projects located within the South Coast Air Quality Management District (SCAQMD), which become operational in or after the year 2000, should apply an additional factor of 0.86 to account for a post-EMFAC7F1.1 credit of 14.5%. These credits include enhanced I/M, new state measures and local/regional measures. The post-EMFAC7F1.1 credit was provided by CARB and is consistent with the revised SCAQMD Federal Attainment Plan for CO.

In future years, the project analyst should check with the SCAQMD regarding whether the specific reductions attributed to the measures in the CO SIP have been modified.

Table A.6. Intersection Performance Correction Factors for Approach Contributions

Cruise Speed	% Red Time	Traffic Volume (vehicles per hour per lane) 200	300	400	500	600	700	800	900	1000
15	30	0.29	0.31	0.31	0.31	0.35	0.35	0.39	0.45	0.62
15	40	0.35	0.35	0.35	0.39	0.39	0.45	0.52	0.76	1.00
15	50	0.39	0.39	0.45	0.45	0.52	0.62	1.00	1.00	1.00
15	60	0.45	0.45	0.52	0.62	1.00	1.00	1.00	1.00	1.00
15	70	0.52	0.62	0.76	1.00	1.00	1.00	1.00	1.00	1.00
15	80	0.76	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	30	0.24	0.24	0.26	0.26	0.29	0.31	0.35	0.39	0.52
20	40	0.29	0.29	0.31	0.31	0.35	0.39	0.52	0.76	1.00
20	50	0.35	0.35	0.39	0.39	0.45	0.62	1.00	1.00	1.00
20	60	0.39	0.45	0.45	0.62	1.00	1.00	1.00	1.00	1.00
20	70	0.45	0.52	0.76	1.00	1.00	1.00	1.00	1.00	1.00
20	80	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	30	0.21	0.23	0.23	0.24	0.24	0.29	0.31	0.39	0.52
25	40	0.24	0.26	0.29	0.29	0.31	0.35	0.45	0.62	1.00
25	50	0.31	0.31	0.35	0.39	0.45	0.62	1.00	1.00	1.00
25	60	0.35	0.39	0.45	0.52	1.00	1.00	1.00	1.00	1.00
25	70	0.45	0.52	0.76	1.00	1.00	1.00	1.00	1.00	1.00
25	80	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	30	0.19	0.20	0.21	0.21	0.23	0.26	0.29	0.35	0.45
30	40	0.23	0.24	0.26	0.26	0.29	0.35	0.45	0.62	1.00
30	50	0.29	0.31	0.31	0.35	0.39	0.62	1.00	1.00	1.00
30	60	0.35	0.39	0.39	0.52	0.76	1.00	1.00	1.00	1.00
30	70	0.45	0.52	0.76	1.00	1.00	1.00	1.00	1.00	1.00
30	80	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
35	30	0.18	0.19	0.19	0.20	0.21	0.24	0.29	0.35	0.45
35	40	0.21	0.23	0.24	0.26	0.29	0.31	0.45	0.62	1.00
35	50	0.26	0.29	0.31	0.35	0.39	0.52	1.00	1.00	1.00
35	60	0.35	0.35	0.39	0.52	0.76	1.00	1.00	1.00	1.00
35	70	0.39	0.45	0.76	1.00	1.00	1.00	1.00	1.00	1.00
35	80	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
35	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	30	0.17	0.17	0.18	0.19	0.21	0.23	0.26	0.31	0.45
40	40	0.21	0.21	0.23	0.24	0.26	0.31	0.39	0.62	1.00
40	50	0.26	0.26	0.29	0.31	0.39	0.52	1.00	1.00	1.00
40	60	0.31	0.35	0.39	0.52	0.76	1.00	1.00	1.00	1.00
40	70	0.39	0.45	0.76	1.00	1.00	1.00	1.00	1.00	1.00
40	80	0.62	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A.7. Intersection Performance Correction Factors for Departure Contributions

Cruise Speed	% Red Time	Traffic Volume (vehicles per hour per lane) 200	300	400	500	600	700	800	900	1000
15	30	0.23	0.23	0.23	0.23	0.23	0.23	0.24	0.24	0.26
15	40	0.23	0.23	0.23	0.24	0.24	0.24	0.26	0.29	0.35
15	50	0.24	0.24	0.24	0.24	0.24	0.26	0.31	0.45	0.62
15	60	0.24	0.24	0.24	0.26	0.31	0.45	0.62	1.00	1.00
15	70	0.26	0.26	0.29	0.45	0.76	1.00	1.00	1.00	1.00
15	80	0.29	0.45	0.76	1.00	1.00	1.00	1.00	1.00	1.00
15	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
20	30	0.17	0.18	0.18	0.18	0.18	0.18	0.19	0.19	0.21
20	40	0.18	0.18	0.18	0.18	0.19	0.19	0.20	0.23	0.29
20	50	0.19	0.19	0.19	0.19	0.20	0.23	0.29	0.39	0.62
20	60	0.19	0.20	0.20	0.21	0.26	0.39	0.62	1.00	1.00
20	70	0.20	0.21	0.24	0.39	0.62	1.00	1.00	1.00	1.00
20	80	0.23	0.39	0.76	1.00	1.00	1.00	1.00	1.00	1.00
20	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
25	30	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.16	0.18
25	40	0.14	0.14	0.15	0.15	0.15	0.16	0.18	0.20	0.26
25	50	0.15	0.15	0.16	0.16	0.17	0.20	0.24	0.39	0.52
25	60	0.16	0.17	0.17	0.19	0.23	0.35	0.62	1.00	1.00
25	70	0.17	0.18	0.21	0.35	0.62	1.00	1.00	1.00	1.00
25	80	0.20	0.35	0.76	1.00	1.00	1.00	1.00	1.00	1.00
25	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30	30	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.14	0.15
30	40	0.12	0.12	0.13	0.13	0.13	0.14	0.15	0.18	0.24
30	50	0.13	0.13	0.13	0.14	0.14	0.17	0.23	0.35	0.52
30	60	0.14	0.14	0.15	0.16	0.21	0.35	0.62	1.00	1.00
30	70	0.15	0.16	0.19	0.35	0.62	1.00	1.00	1.00	1.00
30	80	0.18	0.31	0.76	1.00	1.00	1.00	1.00	1.00	1.00
30	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
35	30	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.14
35	40	0.11	0.11	0.11	0.11	0.12	0.12	0.14	0.16	0.23
35	50	0.11	0.12	0.12	0.12	0.13	0.16	0.21	0.35	0.52
35	60	0.12	0.13	0.13	0.14	0.20	0.31	0.62	1.00	1.00
35	70	0.13	0.14	0.18	0.31	0.62	1.00	1.00	1.00	1.00
35	80	0.16	0.31	0.76	1.00	1.00	1.00	1.00	1.00	1.00
35	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
40	30	0.09	0.09	0.09	0.09	0.10	0.10	0.11	0.11	0.13
40	40	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.15	0.23
40	50	0.10	0.11	0.11	0.11	0.12	0.14	0.20	0.31	0.52
40	60	0.11	0.11	0.12	0.14	0.19	0.31	0.45	1.00	1.00
40	70	0.12	0.13	0.17	0.31	0.62	1.00	1.00	1.00	1.00
40	80	0.14	0.31	0.76	1.00	1.00	1.00	1.00	1.00	1.00
40	90	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A.8. Correction Factor for % Cold Starts and Analysis Year

Percentage of Cold Starts (%)	Analysis Year				
	1996	2000	2004	2008	2012
10	0.37	0.26	0.19	0.15	0.13
20	0.53	0.38	0.26	0.20	0.17
30	0.68	0.49	0.34	0.25	0.21
40	0.84	0.60	0.41	0.30	0.25
50	1.0	0.71	0.48	0.35	0.29

A.2.9 Traffic volume ratio and receptor location correction

Calculate the ratio of the *representative* traffic volumes for each road, as determined in part (g) of Section A.2.1 (e.g., E-W road to N-S road). Use the highest traffic volume in the numerator to make sure a number greater than or equal to one is obtained. Use the traffic volume ratio and the longest of the distances from each road to the receptor to read a wind angle correction factor from Table A.9. Apply this correction factor to the result obtained in the previous step. At this point, the result is the project contribution to the 1-hour CO concentration.

Table A.9. Wind Angle Correction Factor

Leg-to-Leg Traffic Ratio	Longest Distance from Receptor to Either Road (m)							
	3	4	5	6	7	8	9	10
Equal to 1	0.76	0.78	0.82	0.85	0.87	0.89	0.90	0.91
Greater than 1 but less than or equal to 2	0.81	0.84	0.86	0.89	0.91	0.92	0.93	0.94
Greater than 2 but less than or equal to 4	0.86	0.89	0.91	0.93	0.95	0.96	0.97	0.98
Greater than 4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Note: For receptor distances greater than 10 m use a factor of 1.0

A.2.10 Background CO concentration

Determine the background CO concentration. For guidance on estimating the background CO concentration level refer to Section B.4.1 of Appendix B.

A.2.11 Total 1-hour CO concentration at intersection

Add the project's contribution to the 1-hour CO concentration obtained in Section A.2.9 to the background concentration from Section A.2.10 to get the total 1-hour CO concentration.

A.2.12 Conversion from 1-hour to 8-hour CO contribution

Use a persistence factor to convert the 1-hour CO concentration to an 8-hour CO concentration and determine if the impacts are acceptable according to Section 5. For guidance on estimating the persistence factor refer to Section B.5.1 of Appendix B.

A.3 Example of Screening Procedure

Problem:

A project sponsor wants to determine if the intersection shown in the Figure A.2 will lead to an exceedance of the 8-hour standard in the year 1996 for a receptor located 5 m away from the 4-lane road and 10 m away from the 2-lane road. The intersection is located in a geographic area typical of Central Valley with an 1-hour background concentration of 3 ppm.

In addition to the information shown in the figure, traffic engineers have provided the project sponsor with the following data. The percentage red time for the N-S through movement is 70%, and is 50% for the E-W through movement. The percentage of vehicles operating in the cold start mode is 20%. The average cruise speeds are 30 mph for both north and south-bound traffic; 40 mph for east-bound traffic; and 35 mph for west-bound traffic.

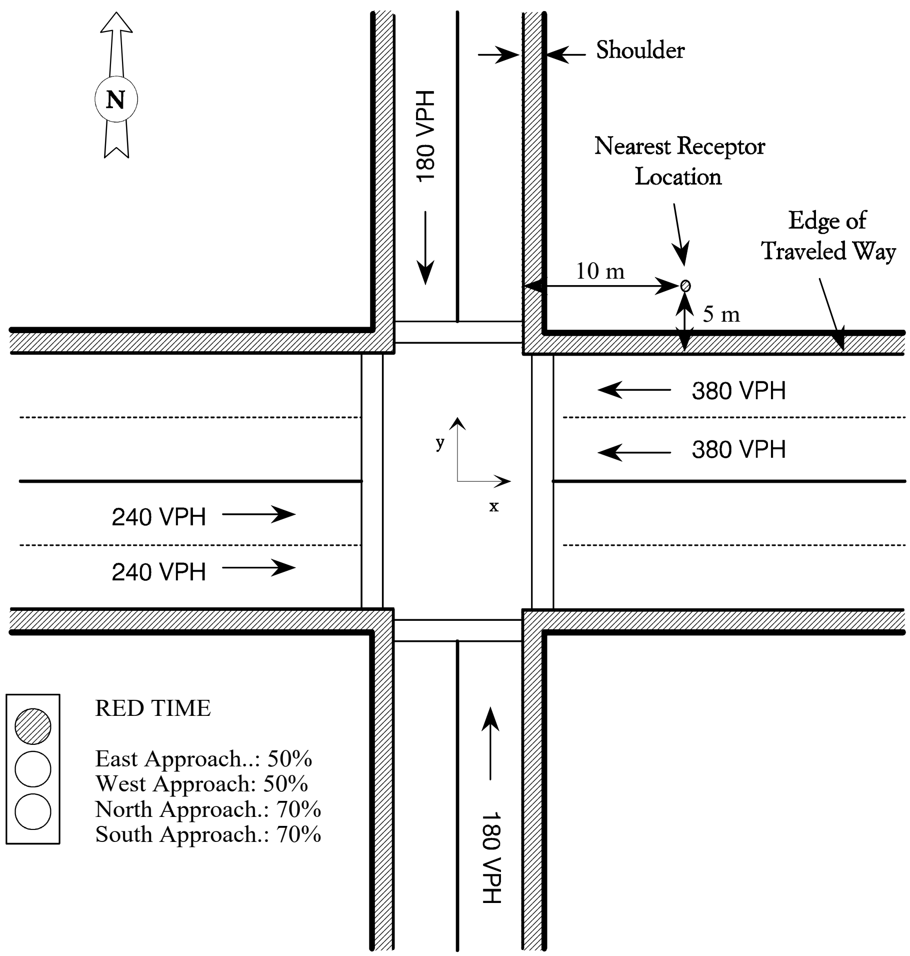


Figure A.2 Intersection Diagram Used in Screening Procedure Example.

Solution:

The first step involves obtaining a representative average cruise speed for each road. For the N-S road, the average cruise speeds are the same so we use:

N-S road average cruise speed .... 30 mph

The average cruise speeds for the E-W road are different in the two directions so we use the lower value:

E-W road average cruise speed .... 35 mph

N-S road through movement red time 70%
E-W road through movement red time 50%

The *representative* traffic volumes for each road of the intersection are found as follows. For the N-S road the volume is the same in both directions and so the representative volume used is 180 vphpl. The E-W leg has different traffic volumes in each direction. Since the receptor is located on the side of the road with greater traffic volume, the traffic volume is taken as the highest of the two volumes, i.e., 380 vphpl.

Table A.2 presents discrete values for the traffic volumes and we must choose the one closest to our estimates but not lower.

N-S road *representative* traffic volume .... 200 vphpl
E-W road *representative* traffic volume .... 400 vphpl

The next step is to read the four initial estimates of CO concentration contributions from the appropriate table, according to Section A.2.1. We use Table A.3 for Central Valley areas. For the N-S road we read an approach and departure value from the table for a 2-lane road with receptor to road distance of 10 m.

N-S road approach contribution .... 18.8 ppm
N-S road departure contribution.................... 15.2 ppm

For the E-W road we read an approach and departure value from the table for a 4-lane road with receptor to road distance of 5 m.

E-W road approach contribution .... 51.9 ppm
E-W road departure contribution................... 27.1 ppm

These concentration contributions must be adjusted for the representative traffic volumes determined above. From Table A.5, the adjustment factor for 200 vphpl (N-S road) is 0.27 and 0.47 for 400 vphpl (E-W road). The adjusted concentration contributions become:

N-S road approach contribution .... 5.1 ppm
N-S road departure contribution.................... 4.1 ppm
E-W road approach contribution .... 24.4 ppm
E-W road departure contribution................... 12.7 ppm

The intersection performance correction factors are obtained from Table A.6 (for approaches) and Table A.7 (for departures) using the cruise speed, percentage red time and *representative* traffic volume information determined above.

N-S road approach correction factor 0.45
N-S road departure correction factor............ 0.15
E-W road approach correction factor 0.31
E-W road departure correction factor........... 0.12

Application of these correction factors gives:

N-S road approach contribution ....2.3 ppm
N-S road departure contribution....................0.6 ppm
E-W road approach contribution ....7.6 ppm
E-W road departure contribution..................1.5 ppm

Section A.2.5 requires that the above contributions are summed:

Sum of contributions ....12.0 ppm

Assuming a worst-case wind speed of 1.0 m/s, we multiply the total contribution by 0.7 giving a corrected contribution of 8.4 ppm.

The next correction factor to be applied is for cold starts (20%) and analysis year (1996). The factor is obtained according to Section A.2.6 with Table A.8, and is found to be 0.53. The resulting corrected total contribution is 4.5 ppm.

A wind angle correction factor (as a function of traffic volume ratio and receptor location) must also be applied, according to Section A.2.9 and using Table A.9. The traffic volume ratio is calculated by dividing 400 by 200, giving a ratio of 2. The receptor location parameter is the longest distance from either road to the receptor; i.e. 10 m for this example. Hence, the correction factor from Table A.9 is 0.94 giving a new total contribution of 4.2 ppm. This result is the project contribution to the 1-hour CO concentration.

The total 1-hour CO concentration is obtained by adding the project contribution (4.2 ppm) to the 1-hour background (3 ppm) giving 7.2 ppm.

A persistence factor must be applied to convert the total 1-hour concentration to the 8-hour CO concentration. Applying a persistence factor of 0.7 (for urban areas) gives an 8-hour CO concentration of 5.0 ppm.

A.4 Screening Procedure Assumptions

A brief description of the development of the screening procedure is presented in this section. A more detailed description is provided in a technical support document titled “Development of a Screening Procedure for CO Intersection Analysis” [Garza, 1995a].

A.4.1 Overview

The first step in the development of the screening procedure was to obtain 1-hour CO concentration estimates for a specific set of conditions, referred to herein as the 'base case.' The second step involved the calculation of the ratio of emission factors for a wide range of conditions to the emission factors for the base case. These ratios are referred to as correction factors. The screening procedure takes advantage of the direct proportionality that exists between predicted CO concentrations and emission factors. The direct proportionality makes it possible to calculate the CO concentration for different conditions by multiplying the concentration estimate for the base case by an appropriate correction factor. A summary of the most relevant input parameters that characterize the base case is shown in Table A.10. A more detailed description of the models and the input parameters used to obtain emission factors and 1-hour CO concentration estimates is given in Sections A.4.2 and A.4.3.

Table A.10 Summary of the Most Relevant Input Parameters that Characterize the Base-Case Used in the Screening Procedure.

Input Parameter	Value
Analysis Year	1996
Temperature	40 ºF
Average Speed of Approach Segments	3 mph
Average Speed of Departure Segments	3 mph
Percentage of Vehicles in Cold Start Mode	50 %
Traffic Volume	1000 vphpl
Wind Speed	0.5 m/s
Stability Class	G
Wind Direction	worst angle

A.4.2 Estimation of emission factors

General

Emission factors were obtained using CT-EMFAC release 2.01 which uses EMFAC7F1.1 dated November 19, 1993. CT-EMFAC requires the following input parameters: vehicle mix, percentage of vehicles operating in cold and hot start mode, season and temperature.

Vehicle Mix

The vehicle mix used to perform all screening procedure calculations is shown in Table A.11. The selected vehicle mix is representative of all public roads in California and was provided by the Office of Travel Forecasting and Analysis of the California Department of Transportation.

Table A.11 Vehicle Mix Distribution Used in the Screening Procedure

Light Duty Automobiles (LDA)	69.0 %
Light Duty Trucks (LDT)	19.4 %
Medium Duty Trucks (MDT)	6.4 %
Heavy Duty Gas Trucks (HDG)	1.2 %
Heavy Duty Diesel Trucks (HDD)	3.6 %
Motorcycles (MC)	0.5 %

Season
Emission factors were obtained for the winter season.

Inspection and Maintenance
Credit for Inspection/Maintenance was selected.

Temperature
A temperature of 40 ºF was used in all screening procedure calculations. This temperature is representative of a large number of sites in California and was obtained by examination of reported January mean minimum temperatures during a three year period (1991-1993) of data from monitoring stations throughout the state.

Average Speed
Average approach and departure speeds were calculated using the computer program Signalized and unsignalized Intersection Design and Research Aid (SIDRA) version 4.07. SIDRA incorporates the algorithms of the Highway Capacity Manual (TRB, 1985). Average approach and departure speeds were calculated for a wide range of conditions that included traffic volumes in the range 200 to 1000 vphpl, average cruise speeds in the range 15 to 40 mph and percentages of red time in the range 30 to 90%.

Average approach and departure speeds were needed to calculate the intersection performance correction factors shown in Tables A.6 and A.7. The intersection performance correction factor is defined as the ratio of the emission factor at an average speed corresponding to a specific traffic volume, cruise speed and percentage of red time to the emission factor at a speed of 3 mph.

A.4.3 Estimation of 1-hour CO concentrations
Base case 1-hour CO concentrations were obtained using the June 1989 version of CALINE4 (Benson, 1989). A brief description of each input parameter is presented next.

Link configuration
An intersection was modeled as the sum of two independent straight road segments. Road segments having 2, 4, and 6 lanes were analyzed. All road segments were assumed to have traffic flowing in two directions with exactly half the number of lanes going in one direction. In

addition, each directional segment was divided into four links: one approach, one departure and two external links (see Figure A.3).

Each lane was assumed to be four meters wide. An extra three meters were added on each side of the road to account for the turbulence mixing zone generated by the vehicles wake as recommended in the CALINE4 manual (Benson, 1989).

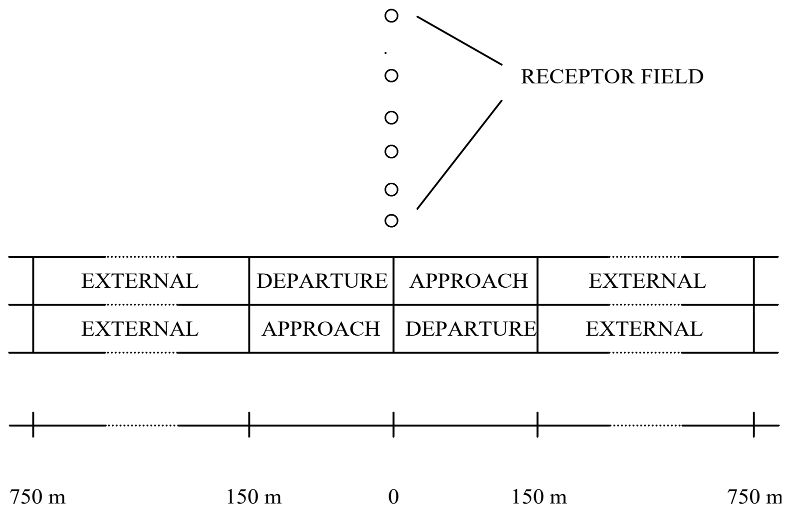


Figure A.3 Link Network Used to Calculate Road Concentration Contributions.

Emission Factors
Idle emission factors (i.e., for speeds of 3 mph) were used for the approach and departure links of the base case. Emission factors corresponding to a speed of 20 mph were used for the external links. Details regarding other input parameters used to obtain base case emission factors are given in Section A.4.2.

Wind Speed
An expected worst-case wind speed of 0.5 m/s was used as a base case. The rationale for selecting 0.5 m/s was as follows:

- A study by Nokes and Benson (1985) that examined the meteorology at nine sites in California showed the existence of speeds as low as 0.5 m/s.

- Unlike CALINE3 (and CAL3QHC), the lowest allowable wind speed in CALINE4 is 0.5 m/s (Benson, 1989).

A worst-case wind speed of 1 m/s has been widely used (mostly because it is the lowest allowable value of CALINE3) and has been recommended by the USEPA. The screening methodology allows the user to obtain an estimate based on a 1 m/s instead of 0.5 m/s by applying a correction factor. The correction factor was obtained by running several cases using both values and examining the concentration ratios.

Wind Direction
The worst wind angle search option of CALINE4 was used to obtain the highest expected concentration at each receptor location.

Modeling the intersection as two separate contributions from each leg (or roadway) results in two different worst-case wind angles at a given receptor for each contribution (or roadway). In a real scenario, a receptor location cannot experience two different wind angles at the same time. In order to correct for this condition, a worst-wind angle correction factor was developed. The worst-wind angle correction factor was obtained by examination of the ratio of the screening procedure estimates (modeling two roads in separate runs) to the real geometry estimates (modeling both roads in one run).

Temperature
A temperature of 40 ºF was used as input to CALINE4. Additional rationale for the selection of the 40 ºF is given in Section A.4.2.

Stability Class
A stability class G was used for the screening procedure calculations as recommended in a study by Nokes and Benson (1985).

Note that, unlike CALINE3 and CAL3QHC, CALINE4 is much less sensitive to stability class. The scenarios covered by the screening procedure were also run with stability class D and resulted in very minor differences.

Surface Roughness
A surface roughness of 100 cm was used in all calculations and was assumed to be representative of an urban setting. CALINE4 is not very sensitive to surface roughness and therefore slightly different values do not produce considerably different results.

Settling & Deposition velocities
Settling and deposition velocities for carbon monoxide were assumed to be zero.

Traffic Volume
The screening procedure covers traffic volumes ranging from 200 to 1000 vehicles per hour per lane. Traffic volumes were assumed to be the same for both directions within each intersection leg. Traffic volume correction factors shown in Table A.5 were obtained by running CALINE4 for each traffic volume and calculating the ratio of the 1-hour CO concentration estimates to a base case of 1000 vphpl.

Receptor Location
A receptor grid having receptors ranging from 3 to 50 meters from the edge of the traveled road was used in all calculations. A graphical representation of the receptor field is shown in Figure A.3.

Standard Deviation of Wind Direction (Sigma θ)

Two values of sigma theta were used in the preparation of the screening procedure. A value of 5 degrees was used for projects located in Central Valley areas and a value of 10 degrees was used for Coastal/Coastal Valley areas (see Tables A.3 and A.4).

Appendix B
Detailed Analysis

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FOREWORD

The guidance provided in this appendix was developed using the "Air Quality Technical Analysis Notes" (AQTAN) as a starting point. The guidance on some of the issues has been retained in its entirety, however, important modifications and extensions have been introduced in this appendix. The AQTAN was developed by the Office of Transportation Laboratory of the Department of Transportation in 1988. We would like to acknowledge the effort of the authors of the AQTAN, Paul Benson and Dick Wood.

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B.1 General Principles

The principles outlined below establish the modeling framework for the detailed local analysis of CO impacts. The first principle deals with the so-called “worst-case” assumption. Impacts are evaluated by estimating or assuming worst-case conditions for meteorology, traffic, and background concentration. These conditions must be concurrent. For example, it is incorrect to estimate an impact by combining peak afternoon traffic with worst-case morning meteorology.

The second principle helps define the scope of the analysis: the estimated impacts must be project-related. This simply means that the analysis should only include time periods when the project is making significant contributions to nearby pollutant levels. For instance, CO concentrations occurring at 2:00 AM should not be used in a 1-hour project-level impact analysis because transportation projects usually do not make significant contributions at that time.

The third principle concerns level of effort. In gathering information for a detailed analysis, a balanced approach should be followed. Effort should not be squandered obtaining very precise estimates of one variable at the expense of another. Consideration should be given to the sensitivity of the model output to each input variable. Very little time should be spent estimating the value of variables to which the model is insensitive. The analyst should strive to optimize the overall accuracy of the analysis by equalizing the level of effort spent on each variable in accordance with the model sensitivity.

Finally, the analyst must ensure that modeling methodologies are consistent over time and that input parameters reflect the most recent assumptions used in the RTP and TIP. “Hot-spot analysis assumptions must be consistent with those in the regional emissions analysis for those inputs which are required for both analyses” [40 CFR § 93.123(c)(3)].

B.2 Models Used in Detailed Analyses

Estimating CO concentrations generally requires running two types of models: an emission factor model and a microscale dispersion model. Traffic models, that incorporate the procedures of the Highway Capacity Manual, may also be used to obtain more refined estimates of some of the input parameters required by the microscale dispersion models.

B.3 Calculating Emission Factors

Emission factors are required as input to microscale dispersion models and must be calculated first. The recommended model to calculate emission factors in California is EMFAC. Caltrans has developed a model called CT-EMFAC that incorporates the EMFAC model and two other programs: WEIGHT and ENV028. The purpose of the ENV028 program is to summarize the output of the EMFAC program in a manner suitable for use in microscale dispersion models. The WEIGHT program estimates the activity fractions of every vehicle type for each inventory year.

Federal regulations require the use of the latest version of EMFAC. At the time of writing of the Protocol the latest version was EMFAC7F1.1. CT-EMFAC 2.01 incorporates EMFAC7F1.1. Guidance on the input parameters necessary to run CT-EMFAC 2.01 is presented in the remainder of this section. Other emission factor models, such as MOBILE, require the same or similar input parameters. Therefore, some of the guidance presented below may be applicable to them as well.

B.3.1 Vehicle Mix

In general, vehicle-type distribution is a required input parameter to emission factor models. The classification of vehicle-type may vary from one emission factor model to another. The classification used by EMFAC7F1.1 is shown in Table B.1.

Table B.1 Vehicle Classification Used in EMFAC7F

Vehicle Type	Gross Vehicle Weight (lb)
Light Duty Auto (LDA)	N/A
Light Duty Truck (LDT)	<6000
Medium Duty Truck (MDT)	6000 - 8500
Heavy Duty Gas Truck (HDGT)	>8500
Heavy Duty Diesel Truck (HDDT)	>8500
Motorcycle (MC)	N/A

As an initial estimate for both screening and detailed analyses, the distribution given in Table B.2 can be used. The distribution presented in Table B.2 is representative of the entire public road system in California as provided by the Caltrans Office of Travel Forecasting and Analysis.

An alternative method that should provide a more accurate estimate of the vehicle mix, for analyses involving state highways only, is based on the "Annual Truck Traffic Reports," available from Caltrans which contain the average daily percentage of trucks on state highways. Time period adjustment factors must be applied to these percentages to more accurately reflect the targeted time period of the air quality analysis. The method focuses on the accurate prediction of the heavy duty truck (HDT) percentage because emissions are particularly sensitive to that parameter.

Table B.2 Recommended Vehicle Type Distribution.

Category	TOTAL (%)*
Light Duty Auto	69.0
Light Duty Trucks	19.4
Medium Duty Trucks	6.4
Heavy Duty Trucks (Gas)	1.2
Heavy Duty Trucks (Diesel)	3.6
Buses	0.0
Motorcycles	0.5

** Total distribution doesn't add up to exactly 100% due to rounding*

The Annual Truck Traffic Report contains the average daily percentage of truck and non-truck traffic by route for the complete state system. It is based on a variety of sample truck counts including partial day, 24-hour and 7-day counts. The truck percentages are divided into four axle groups, from 2-axle to 5+-axle. The 2-axle classification includes 1 ½-ton trucks with dual rear wheels and excludes all pickups and vans with only four wheels. This division is assumed to coincide with EMFAC7's HDT definition.

The user should extract truck percentages (by axle category) from the most recent annual report available for the appropriate route segment. Combined percentages for both HDT axle categories and non-HDT vehicles must then be determined. Since the axle category percentages are for HDT's only, they must be multiplied by the total HDT percentage (expressed as a decimal fraction) to arrive at a combined percentage. The percent non-HDT is determined by simply subtracting the total HDT percentage from 100%.

Tables B.3 and B.4 give the time period adjustment factors to apply to the combined daily averaged percentages determined above. Multiply each percentage by the corresponding factor that best fits the conditions of the analysis. For instance, for a morning period analysis of a freeway segment in-bound to a central business district, multiply percent non-HDT by 2.20, percent 2-Axle HDT by 1.35, etc.

Table B.3 Time Period Adjustment Factors for Urban Areas.

	Morning		Midday	Evening		Nocturnal
	Inbound	Outbound	Both*	Inbound	Outbound	Both
Non- HDT	2.20	1.15	1.36	1.64	2.57	0.13
2- axle	1.35	1.71	1.74	1.78	1.58	0.23
3- axle	1.10	1.67	1.82	1.69	1.08	0.34
4- axle	0.84	1.50	1.55	1.05	1.06	0.52
5+- axle	0.98	1.06	1.23	0.91	1.12	0.89

** Both = Inbound and Outbound*

Table B.4 Time Period Adjustment Factors for Non-Urban Areas.

	Morning	Midday	Evening	Nocturnal
	Both*	Both	Both	Both
Non- HDT	1.36	1.53	1.79	0.16
2- axle	1.41	1.72	1.66	0.29
3- axle	1.47	1.54	1.39	0.44
4- axle	1.20	1.52	1.33	0.48
5+- axle	0.87	1.08	1.07	1.04

** Both = Inbound and Outbound*

Once all five percentages have been adjusted, the results are summed and each adjusted percentage is divided by this sum and multiplied by 100% to arrive at the final adjusted HDT (by axle count) and non-HDT percentage. To convert these five percentages to the six categories needed by EMFAC7, apply the equations given in Table B.5.

Table B.5 Vehicle Mix Conversion Formulas

% LDA = 0.80(% Non-HDT)
% LDT = 0.14(% Non-HDT)
% MDT = 0.05(% Non-HDT)
% HDGT = 0.50(% 2-Axle) + 0.25(% 3-Axle) + 0.10(% 4-Axle)
% HDDT = 0.50(% 2-Axle) + 0.75(% 3-Axle) + 0.90(% 4-Axle) + 1.0(% 5+-Axle)
% MC = 0.01(% Non-HDT)

More accurate estimates of vehicle mix can be obtained with a project-specific analysis and may be utilized as long as they are adequately documented.

Example of Vehicle Mix Calculation

Problem: Calculate the morning vehicle mix for the following non-urban location data which have been extracted from the Annual Average Daily Truck Traffic report.

VEHICLE AADT TOTAL	TRUCK AADT TOTAL	TRUCK % TOT VEH	TRUCK AADT TOTAL ----------BY AXLE-------------				% TRUCK AADT -----------BY AXLE---------------				EAL 1-WAY (1000)	YEAR VER/ EST
			2	3	4	5+	2	3	4	5+		
22600	5039	22.3	1028	650	428	2933	20.4	12.9	8.5	58.2	1171	85E

```
-----------------------------------------------------------------------------------------------
STEP 1. Find the mix for the given AADT.
-----------------------------------------------------------------------------------------------
 Non-HDT is equal to
 100% minus the                            a. Non-HDT :              100% - 22.3%  =  77.7%
 TRUCK % TOT

 The percent of each
 axle class is the                         b.  2-Axle:          22.3%(20.4%) / 100 =   4.5%
 TRUCK % TOT VEH times                     c.  3-Axle:          22.3%(12.9%) / 100 =   2.9%
 % TRUCK AADT BY AXLE                      d.  4-Axle:          22.3%( 8.5%) / 100 =   1.9%
 divided by 100:                           e. 5+-Axle:          22.3%(58.2%) / 100 =  13.0%
                                                                                     ------
                                                                              Sum =   100%
-----------------------------------------------------------------------------------------------
 STEP 2. Adjust the mix for time of day.
-----------------------------------------------------------------------------------------------
 Multiply the percent of
 each class from Step 1                   a. Non-HDT:                  77.7%(1.36) = 105.7
 by the non-urban,                        b.  2-Axle:                   4.5%(1.41) =   6.3
 morning factors from                     c.  3-Axle:                   2.9%(1.47) =   4.3
 Table B.4:                               d.  4-Axle:                   1.9%(1.20) =   2.3
                                          e. 5+-Axle:                  13.0%(0.87) =  11.3
                                                                                   ------
                                          f. Sum the results:                  sum = 129.9

 Normalize back to unity                  g. Non-HDT:                105.7 / 129.9 =  81.4%
 by dividing each class                   h.  2-Axle:                  6.3 / 129.9 =   4.8%
 by the sum:                              i.  3-Axle:                  4.3 / 129.9 =   3.3%
                                          j.  4-Axle:                  2.3 / 129.9 =   1.8%
                                          k. 5+-Axle:                 11.3 / 129.9 =   8.7%
                                                                                    ------
                                                                             sum =   100%
-----------------------------------------------------------------------------------------------
 STEP 3. Convert to the vehicle classes used in EMFAC7.
-----------------------------------------------------------------------------------------------
 Substitute the          a. % LDA : 0.80 X 81.4%                                  = 65.1%
 percentages from Step 2 b. % LDT : 0.14 X 81.4%                                  = 11.4%
 g-k into the equations  c. % MDT : 0.05 X 81.4%                                  =  4.1%
 in Table B.5            d. % HDGT: 0.50(4.8%) + 0.25(3.3%) + 0.10(1.8%)          =  3.4%
                         e. % HDDT: 0.50(4.8%) + 0.75(3.3%) + 0.90(1.8%) + 8.7%   = 15.2%
                         f. % MC  :  0.01 X 81.4%                                 =  0.8%
                                                                                  -------
                                                                           Sum =  100%
-----------------------------------------------------------------------------------------------
```

If construction of the project is expected to change the current vehicle mix, apply the same methodology to whatever truck/non-truck split is appropriate. If a future split by axle group is not available, prorate the existing split (from the annual report) over the projected truck fraction.

B.3.2 Percentage of Cold & Hot Start Operation

Vehicle emissions are especially sensitive to the percentage of vehicles operating in cold start mode within the vehicle mix. To a much lesser extent, emissions are also sensitive to hot start operation. Table B.6 shows suggested ranges of cold start operation for various conditions of time and location (EPA, 1977).

Table B.6 Suggested Ranges of Values of the Percentage of Vehicles Operating in the Cold Mode for Various Conditions of Time and Location.

Case	General Location	Morning Peak Hours (%)	Midday Off-peak Hours (%)	Evening Peak Hours (%)	Evening & Early Morning Off-peak Hours (%)	Total Day (%)
III	Central Business District (CBD)	1-6	5-20	25-40	15-25	15-25
	Fringe Areas	1-15	10-20	15-40	10-40	10-30
	Outer Arterials	5-15	10-15	15-30	10-35	15-20
	Local/Collector Streets	5-15	10-15	15-25	10-60	10-25
	Expressways:					
	Within core area and fringes: inbound	1-3	10-15	10-20	10-15	10-15
	Within core area and fringes: outbound	1-3	10-15	10-15	5-10	10-15
	Outer portion of urban area: inbound	1-3	1-3	1-3	2-4	2-4
	Outer portion of urban area: outbound	1-3	1-3	10-15	10-15	10-15
	Special generators outside the CBD	15-20	10-20	20-30	25-35	20-30

Note: Case III corresponds to a 2.5 minute additional access time and it is appropriate for the very densely developed portions of an urban area that are characterized by congested traffic and generally low travel speeds.

More accurate estimates of cold and hot start operation can be obtained with a project-specific analysis, and may be utilized as long as they are adequately documented.

B.3.3 Temperature

The ambient air temperature has a significant effect on the emissions of vehicles, and it is particularly important for vehicles operating in cold start mode. For a worst-case 1-hour analysis the following procedure is adequate.

Add a temperature adjustment (see Table B.7) to the lowest January mean minimum temperature over a representative three-year period.

Table B.7 Worst-Case CO Temperature Adjustment.

Time Period	Temperature Adjustment
Morning (06:00-10:00)	+5 ºF
Midday (10:00-17:00)	+10 ºF
Evening (17:00-21:00)	+5 ºF
Nocturnal (21:00-06:00)	0 ºF

B.3.4 Inspection and Maintenance (I/M) Programs

Projects located in areas that have implemented inspection and maintenance programs should select the "I/M" option of CT-EMFAC. In addition, projects located within the South Coast Air Quality Management District (SCAQMD) which become operational in or after the year 2000, should apply an additional factor of 0.86 to the emission factors output by CT-EMFAC. The additional credit was provided by CARB and is consistent with the credits applied in the revised SCAQMD Federal Attainment Plan for CO.

In future years, the project analyst should check with the SCAQMD regarding whether the specific reductions attributed to the measures in the CO SIP have been modified.

B.3.5 Analysis Year

The analysis year(s) to be used for project-level evaluations are as follows. The project build year should be used for all projects. The build year being the time following project completion when traffic on the new facility is projected to stabilize. For projects whose design year is within two years of the attainment year, predicted concentrations should also be calculated for the region's attainment year.

For projects whose construction-related activities last longer than five years and cause increases in emissions, the analysis should include an additional year corresponding to the sixth year of the project's construction phase. [40 CFR §93.123(c)(5)]

B.3.6 Average Cruise Speed

The average cruise speed is the speed of the vehicle when it is not delayed by the signal and it is also known as the average running speed (TRB, 1994). The average cruise speed is dependent on the degree of congestion and the segment length. At very low volume-to-capacity ratios the average cruise speed approximates the free-flow speed and decreases as the volume-to-capacity ratio increases.

Average cruise speeds may be obtained by field observations or from a traffic engineer with knowledge of the intersection under study. In the absence of these information sources, average cruise speeds may be estimated based on free-flow speeds and arterial classification as follows:

a. Determine arterial functional category and design category according to Table B.8

b. Determine arterial classification according to Table B.9

c. Use the arterial classification and free-flow speed to estimate the average cruise speed according to Table B.10.

Free-flow speed is the average speed of vehicles that are not close to the signal, as observed during very low traffic volume conditions while drivers are not constrained by other vehicles or by the traffic signal. Free-flow speeds may be measured by test cars or by spot speed observations away from the intersections (TRB, 1994).

Table B.8 Aid in Establishing Arterial Classification

	FUNCTIONAL CATEGORY	
CRITERION	PRINCIPAL ARTERIALS	MINOR ARTERIALS
Mobility function	Very important	Important
Access function	Very minor	Substantial
Points connected	Freeways, important activity centers, major traffic generators	Principal arterials
Predominant Trips Served	Relatively long trips	Trips of moderate lengths within relatively small geographical areas

	DESIGN CATEGORY		
CRITERION	SUBURBAN	INTERMEDIATE	URBAN
Driveway access density	Low density	Moderate density	High density
Arterial type	Multilane divided; undivided or two-lane with shoulders	Multilane divided or undivided; one way; two lane	Undivided one way; two way, two or more lanes
Parking	No	Some	Much
Separate left-turn lanes	Yes	Usually	Some
Signals per mile	1 to 5	4 to 10	6 to 12
Speed limits	40 to 45 mph	30 to 40 mph	25 to 35 mph
Pedestrian activity	Little	Some	Usually
Roadside development	Low to medium density	Medium/moderate density	High density

Source: Highway Capacity Manual (TRB, 1994)

Table B.9 Arterial Classification According to Their Functional and Design Categories

	FUNCTIONAL CATEGORY	
DESIGN CATEGORY	PRINCIPAL ARTERIAL	MINOR ARTERIAL
Typical suburban	I	II
Intermediate	II	II or III
Typical Urban	II or III	III

Source: Highway Capacity Manual (TRB, 1994)

Table B.10 Average Cruise Speed as a Function of Arterial Classification and Free-Flow Speed

ARTERIAL CLASSIFICATION	I			II		III		
FREE-FLOW SPEED (MPH)	45	40	35	35	30	35	30	25
AVERAGE CRUISE SPEED (MPH)	33	31	29	28	27	28	24	22

Derived from Table 11-4 of the Highway Capacity Manual (TRB, 1994)

NOTE: It is best to have an estimate of free-flow speed. If one is lacking, however, use the above table assuming the following default values:

For Classification	Free-Flow Speed (mph)
I	40
II	35
III	30

B.4 Calculating 1-Hour CO Concentrations

Microscale dispersion models are used to calculate 1-hour CO concentrations. The protocol recommends the use of CALINE4, a model that has been widely used in California[3]. There is one restriction to the use of CALINE4. The *intersection link* option of CALINE4 should not be used because it calculates modal emissions based on an algorithm developed for an outdated vehicle fleet. Guidance on the input parameters required by CALINE4 is presented in the remainder of this section, including guidance on how to set up the link network for intersection analyses (see Sections B.4.4 and B.4.5).

B.4.1 Present Background Concentration

Background concentration is a very important element in a microscale CO analysis. The background concentration is added to the project contribution to assess the impact of the project on the air quality. The methodology shown in Figure B.1 should be used to

[3] The recommendation to use CALINE4 does not preclude the use of other models approved by EPA such as CAL3QHC.

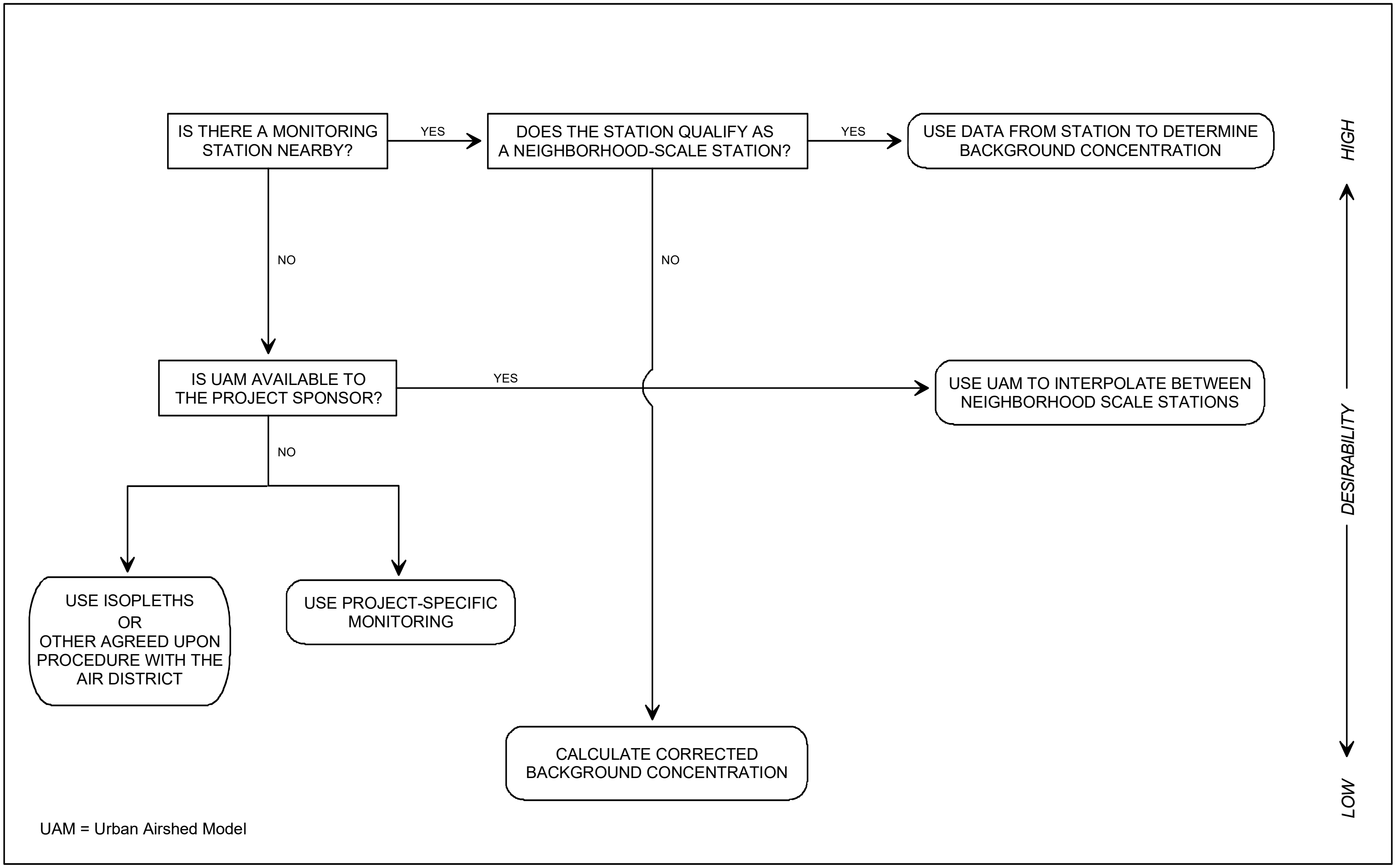


Figure B.1 Recommended Protocol for the Estimation of Background Concentration

B-10

estimate the background concentration. Determination of the background concentration should be made in consultation with the local Air District.

Background concentrations should be determined in a manner consistent with the way CARB and EPA determine CO design values for a given area.

CARB's criteria should be used to estimate CO concentrations for the purpose of determining the acceptability of impacts according to CEQA (see Section 5.1). CARB's criteria are described in the document titled "Amendments to the Area Designations for State Ambient Air Quality Standards with Maps of Area Designations for the State and National Ambient Air Quality Standards" [ARB, 1994].

EPA's criteria should be used to estimate CO concentrations for the purpose of determining the acceptability of impacts according to federal conformity or NEPA (see Section 5.2). EPA's criteria are as follows: for each of the most recent two years, find the second maximum (non-overlapping) 8-hour CO background concentration and choose the highest of the two as the 8-hour CO background concentration for the site.

Application of the above criteria is especially relevant to selection of background concentrations using data from a permanent monitoring station (see below) or for the construction of isopleths.

Other key aspects that must be considered when estimating background concentrations are:

a. Background CO concentration used in the analysis must be reflective of the same time of day as the traffic volumes used in the project analysis.
b. Background CO estimation procedure should minimize duplication of CO concentrations (also known as double counting).
c. Background CO concentration estimates should have corresponding time periods as the analysis being performed. For example, a 1-hour background concentration estimate should not be used in an 8-hour CO analysis.

Permanent monitoring stations

The background CO concentration can be determined using the CO concentration levels measured by a nearby permanent monitoring station provided that the station satisfies the neighborhood scale criteria. A neighborhood scale station is not significantly affected by individual microscale sources. The following excerpts from 44 FR 27571 provide additional guidance in the determination of a neighborhood scale station:

"Neighborhood scale - defines concentrations within some extended area of the city that has relatively uniform land use with dimensions in the 0.5 to 4.0 kilometers range. ... Measurements in this category would represent conditions throughout some reasonably homogeneous urban subregions, with dimensions of a few kilometers and generally more regularly shaped than the middle scale. Homogeneity refers to CO concentration, but it probably also applies to land use."

Even if the nearest station does not satisfy neighborhood scale criteria it may still be utilized. However, the analyst should be aware that the value will be "conservative" because it is likely to be impacted by other local sources besides those from the project. In such a case, if a project has unacceptable impacts because of the addition of the background it is recommended that the analyst consult the air district to obtain a recommendation for a more representative station for determination of background. Measured background concentration levels by a permanent monitoring station that is suspected to be affected by a project's contributions can be corrected as follows for the purposes of the protocol:

a. Use CALINE4 with the "no build" scenario to predict the CO concentration at the monitoring station. The background concentration input parameter should be set to zero for this calculation.
b. Correct the measured background concentration at the monitoring station by subtracting the contribution from the project area obtained in step a.
c. Use CALINE4 with the "build" scenario with the corrected background concentration to estimate CO concentrations at critical receptors.

Before using the above "correction" methodology, refer to Figure B.1 for alternative methods of background determination.

Urban Airshed Model (UAM)

Determination of the background CO concentration can be made using an areawide model such as the Urban Airshed Model (UAM). The project sponsor should contact the local Air District to determine the availability of the areawide model. If an areawide model is used to determine the background concentration it should be done according to the steps outlined in "Guideline for Regulatory Application of the Urban Airshed Model for Areawide Carbon Monoxide. Volume I: Technical Report" (EPA, 1992b). One note of caution, most areas have not maintained the UAM for CO planning purposes.

Isopleths

Isopleths are contour lines of constant background concentration usually drawn on a map of a specific geographic area. Contour lines are usually obtained by interpolation of measured background concentrations at permanent monitoring stations and those from special studies. The accuracy of the isopleths as a valid alternative for the determination of background concentration lies on the representativeness of the selected monitoring stations, i.e., how well they satisfy the neighborhood scale criteria, and the quality of the interpolation. The project sponsor should contact the local Air District to check on the availability of isopleths for the project area.

Project-specific monitoring

Unless otherwise agreed to by the project sponsor(s) and the local Air District, a project-specific monitoring program shall consist of 4 months of continuous sampling during the winter CO season (November through February). The sampling should be in accordance with 40 CFR 58; Appendices A, D, and E; and should achieve a 90% data completeness. Sampling should be at location(s) consistent with neighborhood scale siting so as to minimize the impact of the project on the monitor(s) but also so as to appropriately account for CO concentration levels from other major sources.

B.4.2 Future Background Concentration

Background concentration estimates for future years should reflect the expected trend of background CO levels in the region. The recommended procedure to incorporate the expected trend in CO levels in nonattainment, maintenance, and attainment areas is to make a prediction based on the estimated future emissions.

Future background estimates based on estimated future emissions. Future background concentrations can be estimated by application of *factors* to a base year background level. These *factors* should be directly proportional to the estimated future year total CO emissions within each air quality analysis zone. Future CO emissions should be estimated using an areawide model. The project sponsor should contact the local Air District to check for the availability of these factors.

If factors based on estimated future emissions are not available then other procedures, agreed upon with the local Air District, should be followed. The following alternatives can be considered:

Linear adjustment based on CO attainment. An adjustment to the present background concentration level can be made by application of a factor proportional to the expected reduction in CO concentration levels in the area. The factor can be obtained by using a linear relation between the 1990 peak CO concentration used to determine non-attainment and the CO standard for the year when attainment is expected.

Future background estimates based on present trend. Future background concentrations can be estimated by extrapolating the trend of CO background concentrations. Use of ten years of data is recommended. The uncertainty in the trend should be taken into consideration in the determination of the extrapolated value.

For remote areas or other unique locations, the approaches described above may prove to be inadequate (for example, if regional VMT trends are not applicable in a more remote area). In these cases, it may be more useful to estimate future background concentrations by carrying forward present trends in background concentration levels. Project analysts should consult with the local air district to determine an appropriate approach.

B.4.3 Meteorological Inputs

Dispersion models, such as CALINE4, are sensitive to meteorological input parameters. The meteorological input parameters for CALINE4 are wind speed, wind direction, standard deviation of the wind angle (i.e., sigma theta) and stability class. Dispersion models are also indirectly sensitive to temperature through the emission factors that are used to predict emission source strength. Meteorological input parameters used in a detailed analysis should be representative of the project location. The meteorological input parameters should represent the conditions, reasonably expected to exist, at the project location that would lead to the highest concentration estimates. Such conditions are normally referred to as "worst-case" conditions. If local worst-case conditions are not available, then the values given in Table B.11 may be used and should provide a conservative estimate. Additional comments specific to each meteorological parameter are given below.

Wind speed

The worst-case wind speeds recommended in Table B.11 were based on observations. Even though some sites exhibited wind speeds of less than 0.5 m/s, the minimum worst-case wind speed was set to this value because it represents the lowest allowable value in the CALINE4 model (Benson, 1989).

EPA (1992) recommends the use of a worst-case wind speed of 1 m/s. A worst-case wind speed of 1 m/s may be used, instead of the values reported in Table B.11, if it is found to be more suitable or appropriate for a given project location. This determination should be made in consultation with the local Air District.

Wind direction

The CALINE4 option to search for the worst wind angle should be used unless there are sufficient meteorological data to substantiate the use of specific ranges of wind direction.

Table B.11 Generalized Worst-Case Meteorology for the Estimation of 1-hour CO Concentrations (Nokes and Benson, 1985).

Time Period	Geographic Location	Wind Speed (m/s)	Sigma Theta (degrees)	Stability Class	ΔT (ºF)	ΔT (ºC)
MORNING	Coastal	0.5	10	G	+5	+2.8
(06:00-10:00)	Coastal Valley	0.5	20	G	+5	+2.8
	Central Valley	0.5	5	G	+5	+2.8
	Mountain	0.5	30	G	+5	+2.8
MIDDAY	Coastal	1.0	25	D	+10	+5.6
(10:00-17:00)	Coastal Valley	0.6	30	D	+10	+5.6
	Central Valley	0.5	20	D	+10	+5.6
	Mountain	0.9	30	D	+10	+5.6
EVENING	Coastal	0.5	10	G	+5	+2.8
(17:00-21:00)	Coastal Valley	0.5	10	G	+5	+2.8
	Central Valley	0.5	5	G	+5	+2.8
	Mountain	0.5	30	G	+5	+2.8
NOCTURNAL	Coastal	0.5	5	G	0	0
(21:00-06:00)	Coastal Valley	0.5	15	G	0	0
	Central Valley	0.5	10	G	0	0
	Mountain	0.5	20	G	0	0

Note: Add ΔT to lowest Jan. mean minimum temperature for the last three years

B.4.4 Receptor Locations

Protection of public health is the ultimate objective of receptor selection when conducting project-level dispersion modeling impact analysis on air quality. Two averaging periods, 1-hour and 8-hour, have been adopted by the EPA and the CARB for the purposes of determining ambient air quality with respect to CO. EPA has established a policy that receptors for 8-hour analyses should be placed at a distance of 3 m for the minimum distance to the nearest receptor. The 3 m receptor distance reflects the concentration in the "mixing zone" above and surrounding the traveled way and is the closest distance for which modeled concentrations are considered valid. U.C. Davis researchers have evaluated appropriate receptor siting distances based on studies available at the time this protocol was being developed. A complete discussion of the results of these analyses are included in a technical support document for this protocol (Young and Chang, 1995). The U.C. Davis analysis of available scientific studies suggests that receptor locations for a 1-hour analysis should be 3 m, and receptor locations for an 8-hour analysis need not be located closer than 7 m except in the case of sensitive receptors where added conservative concentration predictions are desirable (Young and Chang, 1995). These results are based on data such as the length of time individuals remain near intersections, exposures and carbon monoxide dose experienced by these individuals, and the relationship between carbon monoxide dose and carboxy-hemoglobin (COHb) levels for individuals exposed to CO concentrations in excess of current health standards. Much of the work by Young and Chang is based on the results of a physical-stochastic model of population exposure and dose applied to individuals in Denver, Colorado.

At the time this protocol was prepared, EPA was reluctant to alter its 3 m receptor siting policy until further scientific information became available to better define the relationship between receptor distance and carbon monoxide exposures. Therefore, until such information becomes publicly available, and is considered in the context of EPA's overall CO requirements, the following recommendations for receptor-siting are provided for use with the Protocol[4]. [The technical support document (Young and Chang, 1995) is available to those interested in reviewing the rationale for receptor siting for averaging times of 8 hours.]

a. Use a height of 1.8 m and a distance of 3 m for the distance to the nearest receptor for both the 1-hour and the 8-hour standard. The receptor should be located at a location accessible to the public. The 3 m receptor distance reflects the concentration in the "mixing zone" above and surrounding the traveled way and is the closest distance for which modeled concentrations are considered valid (see Table B.12).

b. If a site fails the 3 m test, the analysts should conduct a 7 m test. If the site fails the 3 m test, but passes the 7 m test, the analysts should discuss the findings with the local air district, the local MPO, the project sponsor, CARB and Caltrans. The discussion should be conducted to insure that, prior to conducting modeling analyses, the analysis assumptions were accurate, and the 3 m test was appropriately evaluated. It is recommended that consultation be accomplished as early as possible in the process.

Caltrans plans to continue to explore with EPA the appropriateness of the 3 m analysis policy. Caltrans and EPA will evaluate whatever scientific information becomes available on this issue, and, as necessary, the Protocol will be appropriately modified.

Frequently, it is necessary to analyze multiple receptor-sites in order to identify the site(s) with the highest CO concentrations with and/or without the proposed project. Once identified, the changes in modeled CO concentrations at those receptor-site(s) may be used to judge the acceptability of the proposed project subject to applicable regulations.

[4] In the opinion of the authors of this report, current EPA guidance does not fully account for trajectories through space and time of real receptors. Nevertheless the current guidance is conservative with respect to dose received by real receptors.

If the receptor-siting used in the CO analysis appears to have the potential to be a deciding issue as to whether the project is allowed to proceed, sponsors should consult with the local Air District regarding selection of the receptor-site(s). It is recommended that consultation be accomplished as early as possible in the process.

Table B.12 Examples of typical receptor-sites and those to be avoided.

Receptor-site	1-hour receptor	8-hour receptor
Median strips or roadways	avoid	avoid
Within intersections or on crosswalks at intersections	avoid	avoid
On short segments of pedestrian or bicycle access paths such as bridges, overpasses, under-crossings, etc.	avoid	avoid
Sidewalks to which general public has access, e.g., bus stop	yes	yes
Portions of a parking lot to which pedestrians have access	yes	yes
On the property lines of hospitals, rest homes, schools and playgrounds	yes	yes
On the property lines of residences	yes	yes
Notes:	*1-hr and 3-hr receptors should not be located closer than 3 m to the traveled way in any case*	*The user should refer to the text in Section B.4.4 for a complete discussion on receptor siting issues*

B.4.5 Link Coordinates

CALINE4 represents the roadway as a series of straight line segments called links. Link coordinates are necessary to define their location on the modeling domain. The following guidelines should be used to establish the link network.

a. Directional splits (i.e., separate links for opposite directions on a single route) are recommended for all multilane divided roadways.

b. Links should coincide with the centerline of the traveled way for straight roadway segments.

c. For curved roadway segments, the deviation between the link and the traveled roadway centerline should not exceed 3 meters when possible. When a deviation greater that 3 meters is modeled, care should be taken with respect to the orientation of the modeled receptor and roadway links which deviate by more than 3 meters.

d. No more than the minimum number of links consistent with guideline (c) should be used to define a curved alignment.

e. There should be few instances where distances greater than 1 km from a link to a receptor require modeling. The distance between any link and any receptor shall not exceed 10 km in any case.

f. When a deviation from a straight roadway segment occurs beyond 1 km from the nearest receptor, no further link assignments are required in that direction.
g. The link network may extend beyond the limits of the project under consideration, but should not exceed the limits imposed by guidelines (e) and (f).
h. Depressed or elevated sections of roadway used for grade separation of two or more rights-of-way require the assignment of a new link.
i. Highway width and height inputs assume much less importance as link/receptor distances increase. Therefore, guideline (h) may be relaxed for sections of roadway with no adjacent receptors.
j. Assign a new link whenever there is a change in emissions factor (usually attributable to a speed change) or traffic volume.
k. Approach and departure segments of an intersection should be modeled using separate links. An example of a link network for a single intersection with no dedicated left-turn lanes is shown in Figure B.2.
l. Approach segments having a dedicated left-turn lane with a separate phase should be modeled using separate links for the through and left-turn movements. An example of a link network for an intersection with short left-turn lanes is shown in Figure B.3.
m. The recommended length for approach and departure links is 150 m.

B.4.6 Emission Factors

Emission factors should be calculated according to the guidelines provided in the section titled "Calculating Emission Factors" contained in this appendix. In addition, intersection analyses should adhere to the following guidelines:

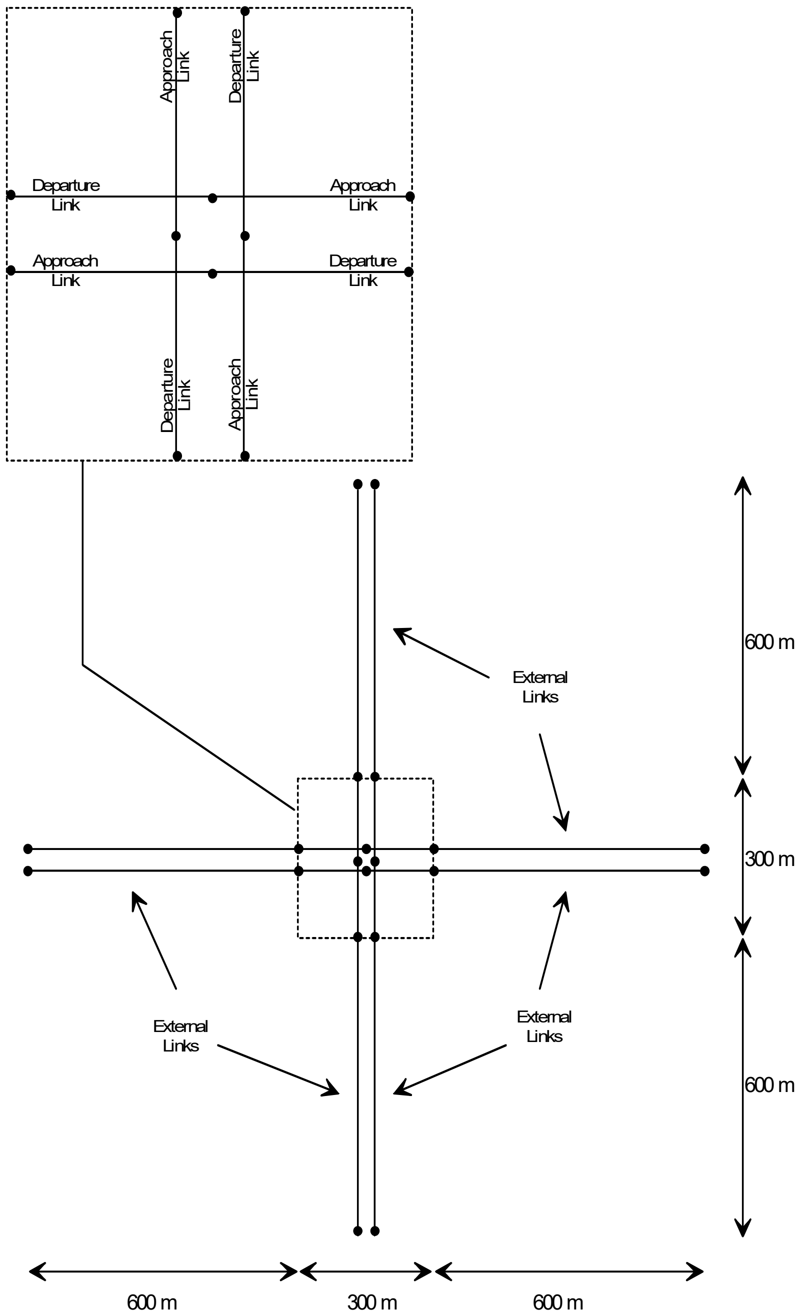
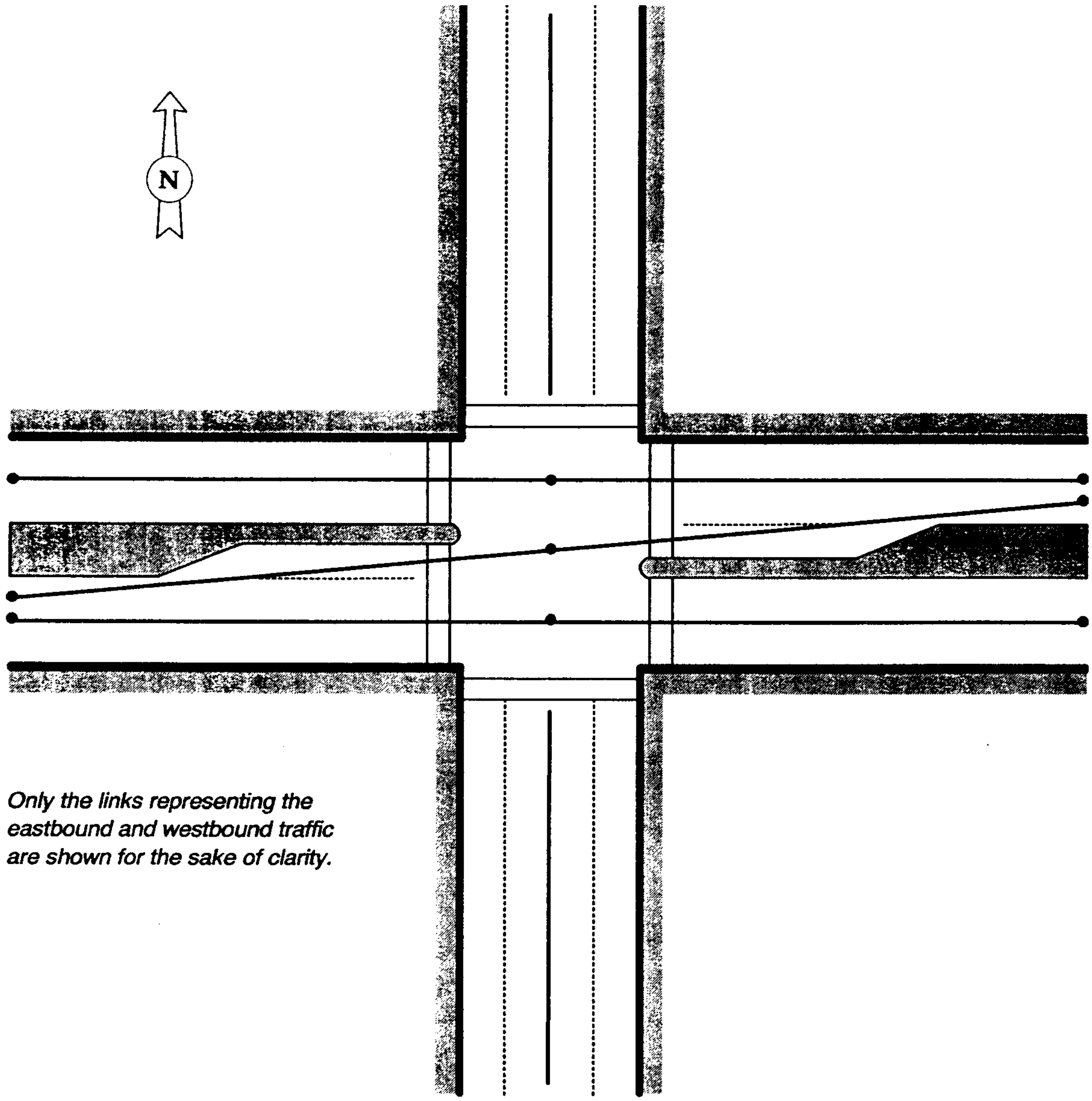


Figure B.2 Link Network for a Single Intersection with no Dedicated Left Turn Lanes.



NOTES:

1. The endpoint of the link representing the left-turn movement should be located at the center of the adjacent through lane.

2. The link representing the left-turn movement should extend as far back as the link representing the adjacent through movement.

3. The traffic volume associated with the approach link of the through movement should not include the volume of vehicles turning left.

Figure B.3 Link Network for a Single Intersection with Short Left-Turn Lanes.

a. Emission factors for approach and departure links should be based on approach and departure average speeds. Tables B.13 and B.14 provide average speeds for approach and departure links as a function of traffic volume, average cruise speed and percentage of red time.
b. Emission factors for external links (see Figure B.2) should be based on the average cruise speed.
c. Approach segments having a dedicated left-turn lane with a separate phase, should be assigned two different average approach speeds and therefore, two different emission factors; one for the through movement and one for the left-turn movement (see also guideline (l) of Section B.4.5). The differences in average approach speeds occur due to differences in the percentage of red time and the traffic volume between the two movements.
d. Values shown in Tables B.13 and B.14 may be interpolated linearly if necessary.
e. The minimum average speed value used for modeling should be 3 mph. Lower values have been included in the tables only for interpolation purposes.

B.4.7 Traffic Volume

Estimates of traffic volume for future years should be based on the most recent planning assumptions. "Assumptions must be derived from the estimates of current and future population, employment, travel, and congestion most recently developed by the MPO or other agency authorized to make such estimates and approved by the MPO" [40 CFR §93.110(b)].

B.5 Calculating 8-Hour CO Concentrations

Estimates of 8-hour CO concentrations are usually based on the 1-hour CO concentrations. A "persistence factor" is used to relate the two concentrations. Guidance on how to estimate persistence factors is given below.

B.5.1 Persistence Factors

The persistence factor is the ratio between the 8-hour and 1-hour CO concentration. When available, persistence factors provide a rapid method to estimate 8-hour CO concentrations based on 1-hour estimates. Persistence factors should be based on values obtained using the 10-highest non-overlapping 8-hour concentrations acquired from the latest three CO seasons of monitoring data. The ratio of the 8-hour to 1-hour

Table B.13 Average Speeds in mph for Approach Segments [Garza, 1995a]

Cruise	% Red	Traffic Volume (vehicles per hour per lane)								
Speed	Time	200	300	400	500	600	700	800	900	1000
15	30	10.7	10.4	10.2	9.9	9.4	8.7	7.9	6.9	5.4
15	40	9.4	9.0	8.8	8.3	7.8	7.0	5.8	4.1	2.5*
15	50	8.1	7.8	7.4	6.9	6.1	4.6	2.8*	1.6*	0.9
15	60	7.0	6.6	6.1	5.0	3.1	1.6*	0.9	0.5	0.3
15	70	5.9	5.3	3.6	1.6*	0.7*	0.4	0.2	0.1	0.1

Table B.13 Average Speeds in mph for Approach Segments [Garza, 1995a]

Cruise Speed	% Red Time	Traffic Volume (vehicles per hour per lane) 200	300	400	500	600	700	800	900	1000
15	80	4.4	1.6*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
15	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	30	13.0	12.6	12.3	11.8	11.2	10.2	9.1	7.8	6.0
20	40	11.1	10.7	10.3	9.7	9.0	7.9	6.4	4.4	2.6*
20	50	9.4	9.0	8.5	7.8	6.8	5.0	2.9*	1.6*	0.9
20	60	7.9	7.4	6.7	5.5	3.3	1.6*	0.9	0.5	0.3
20	70	6.6	5.8	3.8	1.6*	0.7*	0.4	0.2	0.1	0.1
20	80	4.7	1.6*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
20	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	30	15.0	14.5	14.0	13.4	12.6	11.4	10.0	8.4	6.4
25	40	12.5	12.0	11.4	10.8	9.9	8.6	6.9	4.6	2.6*
25	50	10.4	9.8	9.2	8.4	7.3	5.2	3.0	1.6*	1.0
25	60	8.6	8.0	7.2	5.8	3.4	1.7*	0.9*	0.5	0.3
25	70	7.0	6.1	4.0	1.7*	0.7*	0.4	0.2	0.1	0.1
25	80	5.0	1.7*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
25	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	30	16.7	16.1	15.5	14.7	13.7	12.4	10.7	8.9	6.7
30	40	13.7	13.1	12.4	11.6	10.6	9.2	7.2	4.8	2.7*
30	50	11.1	10.5	9.8	9.0	7.6	5.4	3.0	1.6*	1.0
30	60	9.1	8.5	7.6	6.1	3.5	1.7*	0.9*	0.5	0.3
30	70	7.4	6.4	4.1	1.7*	0.7*	0.4	0.2	0.1	0.1
30	80	5.1	1.7*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
30	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35	30	18.1	17.4	16.7	15.8	14.7	13.1	11.2	9.3	6.9
35	40	14.6	13.9	13.1	12.3	11.1	9.6	7.4	4.9	2.7*
35	50	11.8	11.0	10.3	9.3	7.9	5.5	3.1	1.6*	1.0
35	60	9.5	8.8	7.9	6.2	3.5	1.7*	0.9*	0.5	0.3
35	70	7.7	6.6	4.2	1.7*	0.7*	0.4	0.2	0.1	0.1
35	80	5.3	1.7*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
35	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40	30	19.4	18.6	17.8	16.8	15.5	13.7	11.7	9.6	7.1
40	40	15.4	14.6	13.8	12.8	11.6	9.9	7.7	4.9	2.7*
40	50	12.3	11.5	10.7	9.7	8.2	5.7	3.1	1.7*	1.0
40	60	9.8	9.1	8.1	6.4	3.6	1.7*	0.9*	0.5	0.3
40	70	7.9	6.8	4.2	1.7*	0.7*	0.4	0.2	0.1	0.1
40	80	5.4	1.7*	0.5*	0.2	0.1	0.1	0.0	0.0	0.0
40	90	0.2*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

** Values below 3 mph for interpolation purposes only*

Table B.14 Average Speeds in mph for Departure Segments [Garza, 1995a].

Cruise	% Red	Traffic Volume (vehicles per hour per lane)								
Speed	Time	200	300	400	500	600	700	800	900	1000
15	30	14.2	14.1	14.0	14.0	13.9	13.6	13.4	13.0	12.1
15	40	13.9	13.7	13.7	13.5	13.2	13.0	12.4	11.2	9.1
15	50	13.4	13.3	13.2	13.0	12.6	11.7	9.6	7.4	5.2
15	60	13.1	12.8	12.6	12.0	10.2	7.3	5.2	3.3	2.7*
15	70	12.4	11.9	10.7	7.2	3.9	3.2	1.6*	1.2*	0.9
15	80	11.3	7.0	3.8	2.2*	1.0*	0.3*	0.0	0.0	0.0
15	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
20	30	18.6	18.5	18.4	18.2	18.1	17.8	17.3	16.6	15.2
20	40	18.1	17.9	17.7	17.5	17.2	16.5	15.6	13.8	10.9
20	50	17.4	17.3	17.0	16.6	15.9	14.4	11.3	8.3	5.2
20	60	16.6	16.4	15.7	14.8	12.1	8.1	5.2	3.3	2.7*
20	70	15.8	15.2	12.8	8.0	5.1	3.2	1.6*	1.2*	0.9
20	80	14.1	7.8	3.8	2.2*	1.0*	0.3*	0.0	0.0	0.0
20	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
25	30	22.8	22.7	22.6	22.4	22.0	21.5	20.9	19.8	17.9
25	40	22.1	21.9	21.5	21.3	20.8	19.8	18.5	15.7	11.6
25	50	21.0	20.7	20.4	19.7	18.9	16.5	12.5	8.3	6.5
25	60	20.0	19.4	18.7	17.3	13.9	9.1	5.2	3.3	2.7*
25	70	18.6	17.6	14.9	9.0	5.1	3.2	1.6*	1.2*	0.9
25	80	16.2	8.7	3.8	2.2*	1.0*	0.3*	0.0	0.0	0.0
25	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
30	30	27.0	26.9	26.7	26.3	25.8	25.3	24.2	22.8	20.6
30	40	25.9	25.6	25.2	24.8	24.1	23.0	21.0	17.8	13.2
30	50	24.4	24.0	23.6	23.0	21.7	18.8	14.0	9.3	6.5
30	60	23.0	22.5	21.5	19.9	15.3	9.1	5.2	3.3	2.7*
30	70	21.5	20.0	16.7	9.0	5.1	3.2	1.6*	1.2*	0.9
30	80	18.2	9.7	3.8	2.2*	1.0*	0.3*	0.0	0.0	0.0
30	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
35	30	31.1	30.9	30.5	29.9	29.5	28.7	27.3	25.8	22.8
35	40	29.6	29.1	28.6	28.1	27.2	26.0	23.5	19.5	14.1
35	50	27.6	27.1	26.7	25.6	24.1	20.4	14.8	9.3	6.5
35	60	25.9	25.0	24.2	21.8	16.0	10.2	5.2	3.3*	2.7*
35	70	23.9	22.3	18.0	10.1	5.1	3.2	1.6*	1.2	0.9
35	80	20.4	9.7	3.8	2.2*	1.0*	0.3*	0.2	0.0	0.0
35	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0
40	30	35.1	34.7	34.3	33.6	33.0	31.9	30.3	28.4	24.7
40	40	33.0	32.5	32.0	31.2	30.3	28.5	25.7	20.8	14.1
40	50	30.6	30.2	29.4	28.2	26.6	22.1	15.7	10.5	6.5
40	60	28.5	27.7	26.4	23.4	16.8	10.2	6.6	3.3	2.7*
40	70	26.1	24.3	18.7	10.1	5.1	3.2	1.6*	1.2*	0.9
40	80	21.6	9.7	3.8	2.2*	1.0*	0.3*	0.2	0.0	0.0
40	90	1.8*	0.1*	0.0*	0.0	0.0	0.0	0.0	0.0	0.0

** Values below 3 mph for interpolation purposes only* concentration in each of the non-overlapping 8-hour periods is determined, and the average of the 10 values is used as the persistence factor (EPA, 1992a). In the event that there is a marked distinct evening/nighttime peak and a separate early morning CO peak, the persistence factor should be calculated from the applicable period and applied to the modeled 1-hour concentration for the period assumed representing the traffic volume. Failure to do so may result in an overestimate of the impact.

It is important that the 1-hour CO concentration estimates be made at the 8-hour receptor sites. Persistence factors can be classified according to their origin. The alternatives are listed below in order of preference:

a. Locally derived persistence factors.
b. Persistence factors from a location with similar characteristics.
c. Generalized persistence factors.

Locally derived persistence factors

Locally derived persistence factors are those calculated from the measurements of the nearest representative permanent monitoring station.

Persistence factors from a location with similar characteristics

Persistence factors calculated from a different location may be used if both locations have similar weather patterns and similar distribution of emissions.

Generalized persistence factors

Generalized persistence factors have been developed based on studies from several locations. Generalized persistence factors are likely to provide a conservative estimate in most situations. The generalized persistence factors given in Table B.15 are recommended for use with this Protocol.

Table B.15 Recommended Generalized Persistence Factors.

Rural and suburban	0.6
Urban Locations	0.7
Urban sites with a recognized tendency for persistent stagnant meteorological conditions and/or persistent traffic congestion	0.8

Appendix C
List Of MPOs and Air Districts

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Table C-1. List of the Local Air Districts in California

County	Air District	Address/Phone
Alameda	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Alpine	Great Basin Unified APCD	157 Short Street, Suite 6 Bishop, CA 93514 760/872-8211
Amador	Amador County APCD	500 Argonaut Ln. Jackson, CA 95642 209/223-6406
Butte	Butte County APCD	2525 Dominic Dr., Suite J Chico, CA 95928 530/891-2882
Calaveras	Calaveras County APCD	891 Mountain Ranch Road San Andreas, CA 95249-9709 209/754-6504
Colusa	Colusa County APCD	100 Sunrise Blvd., Suite F Colusa, CA 95932 530/458-5891
Contra Costa	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Del Norte	North Coast Unified AQMD	2300 Myrtle Avenue Eureka, CA 95501 707/443-3093
El Dorado	El Dorado County APCD	2850 Fair Lane Court, Building C Placerville, CA 95667 530/621-5300
Fresno	San Joaquin Valley Unified APCD	1999 Tuolumne St., Suite 200 Fresno, CA 93721-1638 209/497-1000
Glenn	Glenn County APCD	P.O. Box 351 720 North Colusa Street Willows, CA 95988 530/934-6500

County	Air District	Address/Phone
Humboldt	North Coast Unified AQMD	2389 Myrtle Avenue Eureka, CA 95501 707/443-3093
Imperial	Imperial County APCD	150 S. 9th Street El Centro, CA 92243-2801 760/339-4606
Inyo	Great Basin Unified APCD	157 Short Street, Suite 6 Bishop, CA 93514 619/872-8211
Kern	San Joaquin Valley Unified APCD	Southern Regional Office 2700 M St., Suite 275 Bakersfield, CA 93301 805/861-3682
Kern (Southeast Desert Air Basin)	Kern County APCD	2700 M. Street, Suite 302 Bakersfield, CA 93301 805/862-5250
Kings	San Joaquin Valley Unified APCD	1999 Tuolumne St., Suite 200 Fresno, CA 93721 209/497-1000
Lake	Lake County AQMD	883 Lakeport Blvd. Lakeport, CA 95453 707/263-7000
Lassen	Lassen County APCD	175 Russell Avenue Susanville, CA 96130 530/251-8110
Los Angeles (South Coast Air Basin)	South Coast AQMD	21865 E. Copley Drive Diamond Bar, CA 91765 909/396-2000
Los Angeles (South East Desert Air Basin)	Antelope Valley APCD	P.O. Box 4409 43301 Division St., Suite 206 Lancaster, CA 93539-4409 805/723-8070
Madera	San Joaquin Valley Unified APCD	1999 Tuolumne St., Suite 200 Fresno, CA 93721 209/497-1000

County	Air District	Address/Phone
Marin	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Mariposa	Mariposa County APCD	P.O. Box 2039 Mariposa, CA 95338 209/966-5151
Mendocino	Mendocino County APCD	306 E. Gobbi St. Ukiah, CA 95482 707/463-4354
Merced	San Joaquin Valley Unified APCD	Northern Regional Office 4230 Kiernan Ave., Suite 130 Modesto, CA 95356 209/545-7000
Modoc	Modoc County APCD	202 West 4th Street Alturas, CA 96101 530/233-6419
Mojave Desert	Mojave Desert AQMD	15428 Civic Drive, Suite 200 Victorville, CA 92392 760/245-1661
Mono	Great Basin Unified APCD	157 Short Street, Suite 6 Bishop, CA 93514 619/872-8211
Monterey Bay	Monterey Bay Unified APCD	24580 Silver Cloud Court Monterey, CA 93940 408/647-9411
Napa	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Nevada	Northern Sierra AQMD	P.O. Box 2509 Grass Valley, CA 95945 530/274-9360
Northern Sonoma	Northern Sonoma County APCD	150 Matheson Ave. Healdsburg, CA 95448 707/433-5911
Orange	South Coast AQMD	21865 E. Copley Drive Diamond Bar, CA 91765 909/396-2000

County	Air District	Address/Phone
Placer	Placer County APCD	11464 B Avenue Auburn, CA 95603 530/889-7130
Plumas	Northern Sierra AQMD	P.O. Box 2509 Grass Valley, CA 95945 916/274-9360
Riverside	South Coast AQMD	21865 E. Copley Drive Diamond Bar, CA 91765 909/396-2000
Sacramento Metropolitan Area	Sacramento Metropolitan AQMD	8411 Jackson Road Sacramento, CA 95826 916/386-6650
San Bernardino	South Coast AQMD	21865 E. Copley Drive Diamond Bar, CA 91765 909/396-2000
San Diego	San Diego County APCD	9150 Chesapeake Drive San Diego, CA 92123-1096 619/694-3307
San Francisco	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
San Joaquin	San Joaquin Valley Unified APCD	Northern Regional Office 4230 Kiernan Ave., Suite 130 Modesto, CA 95356 209/545-7000
San Luis Obispo	San Luis Obispo County APCD	3433 Roberto Court San Luis Obispo, CA 93401 805/781-5912
San Mateo	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Santa Barbara	Santa Barbara County APCD	23 Castilian Drive, Suite B-23 Goleta, CA 93117 805/961-8800
Santa Clara	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000

County	Air District	Address/Phone
Shasta County	Shasta County AQMD	1855 Placer Street, Suite 101 Redding, CA 96001 530/225-5674
Sierra	Northern Sierra AQMD	P.O. Box 2509 Grass Valley, CA 95945 916/274-9360
Siskiyou	Siskiyou County APCD	525 South Foothill Drive Yreka, CA 96097 530/841-4029
Solano	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Solano	Yolo - Solano County AQMD	1947 Galileo Court, Suite 103 Davis, CA 95616 530/757-3650
Sonoma	Bay Area AQMD	939 Ellis Street San Francisco, CA 94109 415/771-6000
Stanislaus	San Joaquin Valley Unified APCD	Northern Regional Office 4230 Kiernan Ave., Suite 130 Modesto, CA 95356 209/545-7000
Sutter	Feather River AQMD	938 14th Street Marysville, CA 95901 530/634-7659
Tehama	Tehama County APCD	P.O. Box 38 1750 Walnut Street Red Bluff, CA 96080 530/527-3717
Trinity	North Coast Unified AQMD	2389 Myrtle Avenue Eureka, CA 95501 707/443-3093
Tulare	San Joaquin Valley Unified APCD	Southern Regional Office 2700 M St., Suite 275 Bakersfield, CA 93301 805/861-3682

County	Air District	Address/Phone
Tuolumne	Tuolumne County APCD	2 South Green Street Sonora, CA 95370 209/533-5693
Ventura	Ventura County APCD	669 County Square Drive Ventura, CA 93003 805/645-1400
Yolo	Yolo - Solano County AQMD	1947 Gallileo Court, Suite 103 Davis, CA 95616 916/757-3650
Yuba	Feather River AQMD	463 Palora Avenue Yuba City, CA 95991 916/634-7659

Table C-2. List of the Metropolitan Planning Organizations in California

County	MPO	Address/Phone
Alameda	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Butte	Butte County Association of Governments (BCAG)	1849 Robinson Oroville, CA 95965 916/538-6866
Contra Costa	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
El Dorado (outside of Tahoe Basin)	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264
Fresno	Fresno Council of Local Governments (FCLG)	2100 Tulare Street, Suite 619 Fresno, CA 93721 209/233-4148
Imperial	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
Kern	Kern County Council of Governments (Kern COG)	Kress Building, Second Floor 1401 19th Street, Suite 200 Bakersfield, CA 93301 805/861-2191
Los Angeles	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
Marin	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Merced	Merced County Association of Governments (MCAG)	1770 M Street Merced, CA 95340 209/723-3153
Monterey	Association of Monterey Bay Area Governments (AMBAG)	445 Reservation Road, Suite G Marina, CA 93933-0838 408/373-6116

County	MPO	Address/Phone
Napa	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Orange	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
Placer (outside of Tahoe Basin)	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264
Riverside	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
Sacramento	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264
San Benito	Association of Monterey Bay Area Governments (AMBAG)	445 Reservation Road, Suite G Marina, CA 93933-0838 408/373-6116
San Bernadino	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
San Diego	San Diego Association of Governments (SANDAG)	First Interstate Plaza 401 B Street, Suite 800 San Diego, CA 92101 619/595-5300
San Francisco	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
San Joaquin	San Joaquin County Council of Governments (SJCCOG)	102 S. San Joaquin Street, 4th Floor P.O. Box 1010 Stockton, CA 95201-1010 209/468-3913
San Luis Obispo	San Luis Obispo Council of Governments	1150 Osos Street, Suite 202 San Luis Obispo, CA 93401 805/781-4219

County	MPO	Address/Phone
San Mateo	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Santa Barbara	Santa Barbara County Association of Governments	222 East Anapamu Street, Suite 11 Santa Barbara, CA 93101 805/568-2546
Santa Clara	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Santa Cruz	Association of Monterey Bay Area Governments (AMBAG)	445 Reservation Road, Suite G Marina, CA 93933-0838 408/373-6116
Shasta	Shasta County Regional Transportation Planning Agency	1855 Placer Street Redding, CA 96001
Solano	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Sonoma	Metropolitan Transportation Commission (MTC)	Metro Center 101 8th Street Oakland, CA 94607-4700 510/464-7700
Stanislaus	Stanislaus Area Association of Governments (SAAG)	1025 15th Street Modesto, CA 95354 209/558-7830
Sutter	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264
Ventura	Southern California Association of Governments (SCAG)	818 West 7th Street, 12th Floor Los Angeles, CA 90017 213/236-1800
Yolo	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264

County	MPO	Address/Phone
Yuba	Sacramento Area Council of Governments (SACOG)	3000 S Street, Suite 300 Sacramento, CA 95816 916/457-2264
Yuma (Winterhaven, CA)	Yuma Metropolitan Planning Organization	200 West 1st Street Yuma, AZ 85364 520/783-8911

Appendix D
US EPA Region IX Approval Correspondence

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