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PARTICULATE MATTER AND TRANSPORTATION PROJECTS, AN ANALYSIS PROTOCOL

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Particulate Matter and Transportation Projects, an Analysis Protocol

Paper # 70067

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ABSTRACT

Transportation conformity regulations require an evaluation of the impact of transportation projects on the concentration of particulate matter less than 10 microns in aerodynamic diameter (PM_{10}). As of early 2003, the U.S. Environmental Protection Agency (EPA) had not released quantitative assessment guidance; thus, the conformity regulations require only qualitative PM_{10} evaluations.[1] Absent analysis tools and guidance on how to conduct quantitative analyses, which is largely due to the complexity of the primary and secondary nature of PM_{10} problems, project analysts have struggled to determine project level impacts on localized PM_{10} concentrations. This paper describes a new protocol for qualitatively analyzing project-level PM_{10} effects to determine whether a transportation project will create a PM_{10} "hot spot" problem. University of California, Davis (U.C. Davis) created the protocol on behalf of the California Department of Transportation (Caltrans) and the U.S. Federal Highway Administration (FHWA). The protocol includes a four-part methodology to screen projects unlikely to contribute to exceedances of the PM_{10} air quality standards: (1) a "project comparison" approach for maintenance areas that allows users to compare the proposed project to pre-existing facilities, (2) a "project comparison" approach for nonattainment areas, (3) a "threshold screening" analysis that takes advantage of real-world measurements of the contribution of roadways to observed PM_{10} concentrations, and (4) a "relocate and reduce, build vs. no-build" approach that assesses whether a project will spatially reallocate traffic to reduce hot spot problems. Project analysts can use the protocol as a resource to comply with the transportation conformity regulations.

INTRODUCTION AND MOTIVATION

One of the most vexing air quality problems facing transportation and air quality planners involves meeting transportation conformity emission budget requirements for on-road mobile source primary emissions of particulate matter less than 10 microns in aerodynamic diameter

(PM_{10}). Estimated tailpipe emissions of pollutants such as carbon monoxide (CO), volatile organic compounds (VOCs), and oxides of nitrogen (NO_x) have exhibited a downward trend over time as cleaner-operating cars, trucks, and buses enter the vehicle fleet and replace aging and higher-polluting vehicles; reductions have been most pronounced for CO and VOC, although EPA documents declining on-road motor vehicle NO_x emissions since 1997.[2] In contrast, estimated primary on-road mobile source PM_{10} emissions, which are mostly composed of re-entrained road dust, plus minor contributions from tire wear, brake wear, and tailpipe exhaust, are trending upward over time (e.g., see 1996 through 2000 paved road emission data[2]).

Primary PM_{10} road dust emissions are estimated as a function of vehicle miles traveled (VMT): the greater the VMT, the higher the estimated primary PM_{10}. The U.S. Environmental Protection Agency (EPA) directly links estimated primary PM_{10} to VMT in its emission estimation methodology[3]:

Equation 1. EPA AP-42 road dust emissions methodology

$$E = k\,(sL/2)^{0.65}\,(W/3)^{1.5}$$

where
E = particulate emission factors (in g/VMT)

k = base emission factor (in g/ VMT) for PM equal or less than a given diameter

sL = road surface silt loading (in g/m^2)

W = average weight of the vehicles traveling the road (in tons)

Equation 1 has important implications for planners responsible for forecasting travel and expected emissions. Inevitably, regional transportation plans (RTPs) forecast VMT increases over time that parallel or exceed expected population growth rates. Metropolitan areas exceeding National Ambient Air Quality Standards (NAAQS) for PM_{10} have to offset increased primary emissions from on-road motor vehicles by reducing other primary PM_{10} sources, or by reducing secondary PM_{10} formation (that is reducing emissions of pollutants such as VOC and NO_x that contribute to atmospheric formation of aerosol particles).

Transportation conformity regulations require planners to demonstrate that proposed transportation projects will not “cause or contribute to any new localized” PM_{10} violations, or “increase the frequency or severity of any existing” PM_{10} violation in PM_{10} nonattainment and maintenance areas.[1] Conformity project-level, or hot spot analyses for PM_{10} are currently a qualitative requirement, pending EPA’s release of guidance on how to conduct quantitative analyses.[1]

In 2001, the Federal Highway Administration (FHWA) released general guidance for preparing transportation project-level PM_{10} conformity analyses.[4] The California Department of Transportation (Caltrans) and FHWA sought to build upon FHWA’s 2001 guidance document by providing planners with a step-by-step tool to assist those responsible for documenting transportation project-level, or hot spot, PM_{10} effects. This paper presents a step-by-step PM_{10}

qualitative analysis protocol prepared to assist Caltrans and FHWA. The protocol allows users to qualitatively screen projects from analyses that are unlikely to create PM_{10} hot spot problems. Although the protocol is based, in part, on California data, it may be applied in any PM_{10} nonattainment or maintenance area.

ELIGIBILITY CHECKLIST

The protocol is not appropriate for all transportation projects. Some transportation projects are exempt from conformity analyses, other projects may not yet be included in conforming transportation improvement programs (TIPs) or RTPs, and others may be quickly screened out without the effort of working through the more detailed protocol steps. Table 1 includes a checklist of eight questions to help analysts determine whether the protocol applies for their respective project analysis.

PROTOCOL STEP-BY-STEP PROCEDURES

Assuming the protocol is applicable for a particular project analysis and is not immediately screened out, analysts begin by proceeding through four roughly sequential steps. A project that screens out at any point in the process does not have to continue through subsequent steps. For each of the four analysis steps included in Figure 1, the discussion following outlines the underlying conceptual logic for the approach and briefly describes each analysis step.

Table 1. Applicability of the protocol for a specific project.

Eligibility Checklist

The project may be immediately screened out if

1. The project is exempt from conformity.[1]
2. The project is not in a federal PM_{10} nonattainment or maintenance area.
3. The project is not regionally significant or funded or approved by FHWA or the Federal Transit Administration (FTA).
4. The project "build" VMT is less than or equal to the "no-build" VMT.
5. There are no receptors within 100 m of the proposed project location.

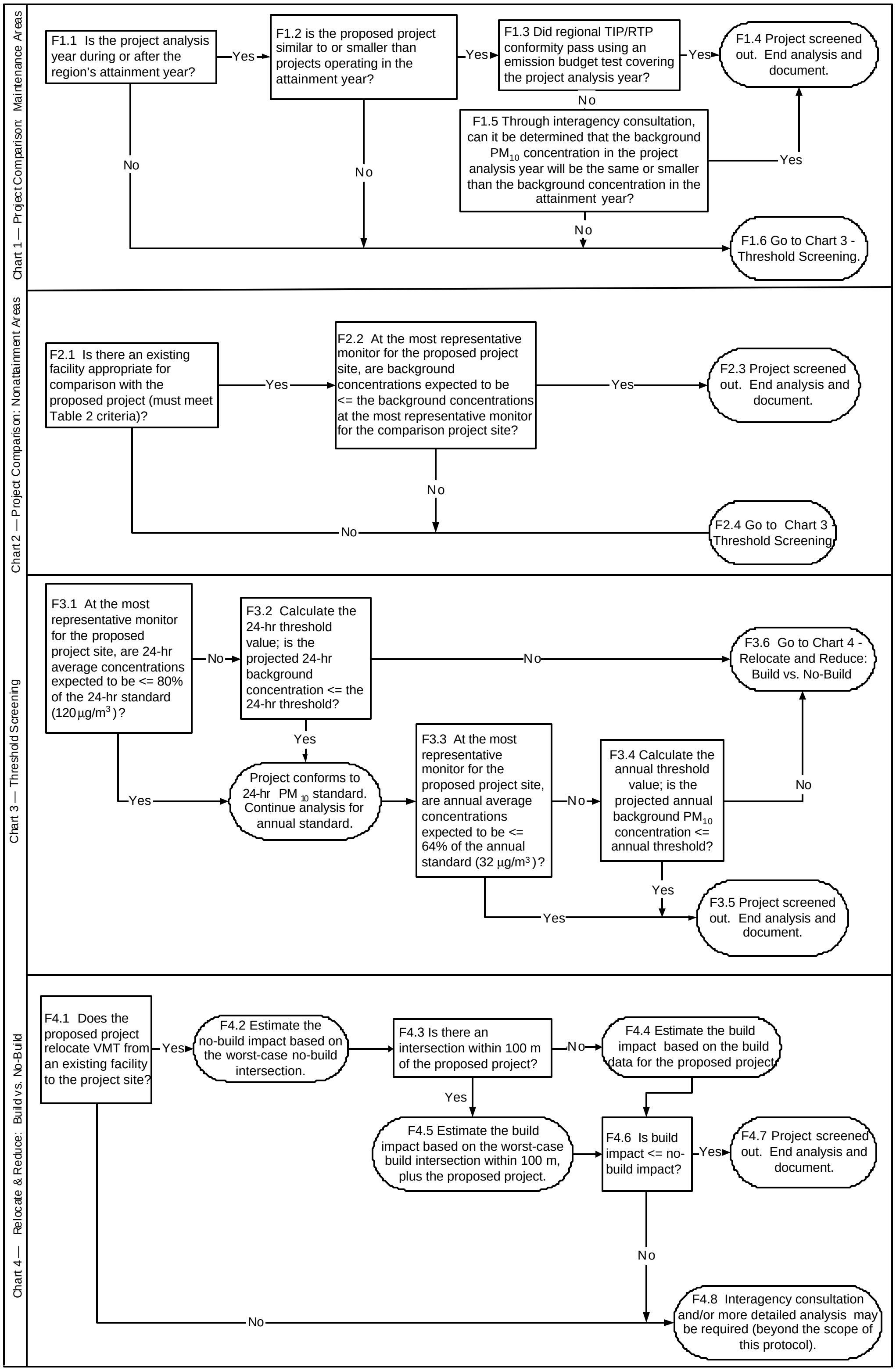
The protocol is not appropriate if any of the following conditions are met:

6. The project is not included in a conforming TIP or RTP.
7. PM_{10} concentrations at the project site are dominated by non-vehicular sources.
8. The expected proportion of heavy-duty diesel VMT for the proposed project differs from regional facilities of the same type (e.g., 20% of the vehicles forecasted to use the proposed project are anticipated to be diesel trucks, compared to similar regional facilities where diesel trucks constitute only 5% or 6% of the vehicle fleet).

Explanation of Checklist

- Conditions 1, 2, and 3 relate to specific elements of the transportation conformity requirements; if any of the conditions are true, no further analysis is required.
- Conditions 4 and 5 relate to situations that should not result in a hot spot problem. Current PM_{10} estimation procedures link emissions to VMT (Equation 1); identical or lower VMT effectively means no increased PM_{10}. Field studies indicate that roadway contributions to PM concentrations largely dissipate within 100 m from the road.[5-8]
- Conditions 6, 7 and 8 relate to situations best addressed through interagency consultation, rather than through use of the protocol.

Figure 1. Flowchart illustrating the step-by-step qualitative PM_{10} analysis protocol.



Step 1, Project Comparison: Maintenance Areas

Conceptual Logic of Step 1

This step compares the proposed project to other projects in the attainment year. Two elements are important to screening out projects in this step. First, the project cannot have higher average daily traffic volumes than other projects already in existence or projected to exist in the attainment year. Second, analysts need to show that background PM_{10} concentrations in the proposed project's *analysis year* are not expected to be greater than background concentrations in the *attainment year*. The underlying logic for this step is that an area that has achieved the air quality standards is, by definition, not experiencing PM_{10} violations. Thus, by induction, none of the projects from the set of transportation projects in the region at the time of attainment should be hot spot problems. Since a hot spot problem is a function of the incremental PM_{10} contribution from the project plus background PM_{10} concentrations, this analysis requires the analyst to document that, over time, background concentrations will not increase such that the proposed project results in a violation. This is a check to prevent future hot spot violations beyond the attainment year for the area.

Detailed Process

F1.1 begins by determining whether the project analysis year falls on or after the region's attainment date. For the project comparison approach to work in maintenance areas, the region must already have achieved attainment of the PM_{10} standards prior to the analysis year of the proposed project.

F1.2 checks whether there are appropriate comparison projects. To allow comparisons to existing projects, the proposed project cannot have higher average daily traffic volumes than, and must be similar in design concept and scope to, one of the projects included in the RTP or TIP for the attainment year. The attainment year comparison project should be a pre-existing project operating at the time of attainment, not a project that the RTP or TIP included among those planned for future construction.

F1.3 considers whether background PM_{10} concentrations are acceptable. A project's contribution to observed hot spot PM_{10} concentrations is a function of the incremental PM_{10} contribution from the project plus background PM_{10} concentrations. The project comparison approach assumes that for the project *analysis year*, background PM_{10} concentrations have not worsened (i.e., increased) compared to background concentrations assumed for the *attainment year*. Step F1.3 provides a quick check of this assumption by asking analysts to determine whether RTP or TIP conformity findings employed a PM_{10} emission budget test. Regional conformity determinations that meet PM_{10} emission budget tests for future years demonstrate that background PM_{10} concentrations are not problematically high when combined with incremental project contributions for the projects included in the RTP and TIP.

The F1.3 project comparison approach is conservative, meaning it errs on the side of being environmentally protective. An illustration helps explain the principles embedded in the approach. Assume:

1. A regional PM_{10} attainment year of 2006.
2. A proposed intersection (the *proposed project*) with a 2011 analysis year.
3. An existing intersection (the *comparison project*) which, in attainment year 2006, experiences similar traffic volumes and is otherwise comparable in design concept and scope to the proposed project in 2011.
4. An RTP that extends to year 2025 and a regional conformity analysis that met emission budget tests from 2006 through 2025.

Since the RTP met emission budgets from 2006 through 2025, by definition future-year background PM_{10} concentrations are projected to decrease enough to offset any rise in primary PM_{10} emissions due to increased VMT. By 2011, the comparison project will likely have higher VMT than experienced in 2006; however, the comparison project is still acceptable by 2011 since regional conformity was acceptable. Thus, comparing the 2011 proposed project to the comparison project's 2006 operating volumes is conservative because background concentrations will be lower in 2011; we could reasonably assume that the proposed project would be acceptable even if its traffic volumes resembled the year-2011 volumes for the comparison project, rather than the (probably lower) year-2006 traffic volumes used in the analysis.

F1.4 is the analysis end point; protocol users should document the analysis assumptions used to determine that the project will not create a PM_{10} hot spot problem. F.1.5 handles cases where regional conformity determinations are based on build vs. no-build tests, rather than a budget test. Analysts are directed to confirm analysis year background conditions through interagency consultation. Finally, F.1.6 directs users to continue to Step 3, Threshold Screening, in the event the proposed project was not screened out in Step 1.

Step 2, Project Comparison: Nonattainment Areas

Conceptual Logic of Step 2

In this step, which is analogous to Step 1, the PM_{10} protocol user is instructed to find a similar or larger-scale project that is already built and for which there are no recorded violations of the PM_{10} standards. The existing project must be located in a geographically and meteorologically similar area to the proposed project. Since the existing project has exhibited no violations, the proposed project can be screened from further analysis. The main difference between Step 2 and Step 1 is that Step 2 can be applied in nonattainment regions. Conceptually, this step allows for those unique situations where an entire metropolitan area may be nonattainment, but where some portions of the nonattainment region are either upwind or meteorologically isolated such that localized PM_{10} violations are not occurring in those upwind or isolated areas.

Detailed Process

F2.1 assists the analyst in finding an appropriate existing project to use for comparison purposes. The criteria are more restrictive than those used to identify a comparative project in Step 1 (Table 2). Since by definition the region is nonattainment, at least some parts of the region exceed the PM_{10} NAAQS, and, therefore, the set of eligible comparative projects in the region will be smaller.

Table 2. Criteria for identifying projects for comparison (nonattainment regions).

Criteria that Comparison Project Must Meet
1. Located in the same nonattainment area as the proposed project
2. Same facility type/silt loading as proposed project
3. Nearby monitored PM_{10} concentrations below the federal PM_{10} standards
4. Greater or equal traffic volumes as the proposed project's analysis year volumes
5. Similar fleet mix as proposed project, especially regarding heavy-duty diesel vehicles
6. Similar yearly rainfall as proposed project site
7. Similar wind patterns as proposed project site
8. Similar temperature ranges as proposed project site

F2.2 includes a check on background PM_{10} concentrations (analogous to step F1.5). F2.3 is the analysis end point; protocol users should document the analysis assumptions used to determine that the project will not create a PM_{10} hot spot problem. F2.4 directs users to continue to Step 3, Threshold Screening, in the event the proposed project was not screened out in Step 2.

Step 3, Threshold Screening

Conceptual Logic of Step 3

Field studies at several road sites have measured the difference between upwind and downwind PM_{10} concentrations. The studies document incremental PM_{10} contributions made by the road project (freeway, arterial, intersection) and identify traffic volumes and meteorological conditions associated with the observed PM_{10} concentrations. In this step, protocol users use the literature to determine whether the proposed project is similar enough in nature to be compared to projects identified in the literature. Protocol users also estimate the incremental PM_{10} contribution expected from the proposed project, based on comparisons to the findings in the literature. This process allows the user to document whether the incremental PM_{10} contribution plus the background PM_{10} concentration would be below the PM_{10} air quality standards. The protocol relies on two layers of analysis: first, the proposed project is screened against the 24-hr PM_{10} NAAQS, and second, the project is screened against the annual PM_{10} NAAQS.

Inherent in the Threshold Screening approach is an understanding that regional PM_{10} concentrations do not exceed the NAAQS in the project analysis year. Projects in areas exceeding the NAAQS must continue to Step 4, Relocate and Reduce.

Note that the literature is limited. Protocol users should compare the proposed project's design concept and scope to the projects observed in the literature and assess whether the proposed project may be reasonably compared to the projects documented in the literature.

Detailed Process

F3.1 serves to check whether the project passes the 24-hr PM$_{10}$ NAAQS screening test. The approach is conservative in that the protocol selects the highest incremental road contribution (29.7 μg/m^3) observed in the literature[8] and uses that value to establish an expected 24-hr increment from a proposed project. Table 3 includes a summary of the reported incremental PM$_{10}$ contribution from roads. In addition to being conservative by selecting the highest observed incremental contribution, the protocol also (conservatively) adopts the highest incremental contribution measured *over 3 hours* in the real-world to represent a *24-hr increment*; this likely overstates the actual road increment. Since the 24-hr PM$_{10}$ NAAQS is 150 μg/m^3, and the highest estimated roadway increment over all project types measured was 29.7 μg/m^3, proposed projects are considered not to cause a hot spot violation if they will be located in areas where the 24-hr background concentrations are less than 120 μg/m^3 (150 – 30).

F3.2 provides users with a methodology to refine the proposed project's estimated incremental contribution. Assuming the proposed project failed step F3.1, step F3.2 compares the proposed project to each of the projects observed in the literature. If the protocol user finds an appropriate match between the proposed project and a project documented in the literature, the user may then estimate the proposed project's incremental PM$_{10}$ contribution (Table 3). The difference between step F3.1 and step F3.2 is that F3.1 used the highest incremental value observed in the literature, independent of project design concept and scope. Step F3.2 provides the user an opportunity to substitute a lower 24-hr incremental value by finding an appropriate comparison project in the literature.

Table 3. Threshold table to estimate 24-hour PM$_{10}$ project-level incremental contribution.

Facility Type	**Veh/hr**	**Veh/day**	**Reported Incremental PM$_{10}$ Concentration Based on Maximum Field Measurements (μg/m^3)^{a,b,c}**	**Reference**
Intersection	4,517		29.7^d	Ashbaugh et al., 1996[8]
		68,000	5.8	Cowherd and Grelinger, 1998[9]
Freeway	5,517		5.3	Cahill et al., 1994[10]
		>150,000	8.0	Venkatram and Fitz, 1998[11]
Arterial	1000		21.0	Venkatram and Fitz, 1998[11]
Collector	200		15.9	Venkatram and Fitz, 1998[11]
Local	20		10.9	Venkatram and Fitz, 1998[11]

[a] The reported field measurements are based on various averaging times of 24 hours or less. To be conservative, the protocol does not adjust the values but uses them as-is to approximate 24-hr incremental contributions. For example, the 29.7 μg/m^3 value reported by Ashbaugh et al.[8] was

measured over a 3-hr sampling period. Presumably, 24-hr average values would be less than the 3-hr value.

[b] Protocol users should compare their proposed project's design concept and scope to the information in Table 3 and determine whether there is an appropriate comparison available; we recommend applying Table 3 findings in a manner that conservatively represents incremental PM_{10} contributions (i.e., in a way that likely over-estimates, rather than underestimates, the likely PM_{10} contribution from a proposed project).

[c] Table 3 values represent information available at the time the protocol was developed. Protocol users should substitute more recent information as it becomes available.

[d] The Ashbaugh et al.[8] 29.7 $\mu g/m^3$ value is the highest reported and was selected to create the screening level referred to in step F3.1 of the protocol (see Figure 1).

F3.3 assumes the project has passed the 24-hr screening test and serves as a check on whether the project passes the annual PM_{10} screening test. Field data were unavailable to directly estimate annual roadway incremental PM_{10} contributions. Consequently, the protocol estimates an annual increment by applying a conversion ratio (CR) to convert 24-hr values into annual values. The approach is conservative because the maximum 24-hr increment discussed in step F3.1 is selected as the initial value in this conversion. To develop a conversion ratio, we calculated the ratio between observed 24-hr and annual average PM_{10} concentrations using monitored 1999 and 2000 California data[12]:

Equation 2. Conversion ratio between 24-hr and annual average PM_{10} concentrations.

$$CR = PM_{Ann} / PM_{24\text{-}hr}$$

where for a specific monitor

CR = conversion ratio to adjust 24-hr values to represent annual values

PM_{Ann} = average of all quarterly mean PM_{10} concentrations

$PM_{24\text{-}hr}$ = 99th percentile value of all monitored 24-hr concentrations

For each county in California, we selected the monitor that yielded the highest CR value within that county. For protocol screening purposes, we then selected the highest CR value from among all the counties and used that value to represent the relationship between 24-hr and annual average PM_{10} values. In California, the highest CR value was 0.60, although values will differ by area of the country (in California, CR ranged from 0.08 to 0.60; see Table A-1). Applying the 0.60 CR value to the maximum observed 24-hr increment, we estimated a maximum annual roadway PM_{10} increment of 17.8 $\mu g/m^3$ (29.7×0.60). Step F3.3 establishes whether annual average background PM_{10} concentrations are expected to be less than or equal to 32 $\mu g/m^3$ (the annual standard of 50 $\mu g/m^3$, minus the maximum annual road increment of 17.8 $\mu g/m^3$). If annual background PM_{10} concentrations are sufficiently low, the project passes the annual screening test.

F3.4 provides users with a methodology to refine the estimated annual incremental contribution from a project if the project fails step F3.3. The protocol suggests two steps to develop a project-specific annual PM_{10} increment. First, the protocol directs analysts to select a 24-hr increment value that best represents the proposed project (analogous to step F3.2, which directs users to Table 3). Second, the protocol suggests that analysts use a CR that is appropriate for the region in the vicinity of the proposed project. Screening step F3.3 used the most conservative CR for California; projects proposed for other parts of California should use the CR that is specific to the project location. Table 4 includes example data used to estimate the CR for California counties; the Appendix includes CR values for all California counties. To use the protocol outside of California, analysts can compute a CR or select a surrogate from the California list.

Table 4. Example 24-hr-to-annual average PM_{10} conversion ratios (CR) for California counties.

Air Basin	**County**	**Monitor Location**	**Year**	**99th Percentile of 24-hr PM_{10} Concentrations (: g/m^3)**	**Average of Quarterly Mean PM_{10} Concentrations (: g/m^3)**	**CR by Year (1999 and 2000)**	**Ave. CR (1999 and 2000)**	**Max. CR (1999 or 2000)**
Lowest Estimated CR for all California Counties								
Great Basin Valleys	Inyo	INYX	1999	514	41.87	0.08	0.07	0.08
Great Basin Valleys	Inyo	INYX	2000	715	38.9	0.05		
Highest Estimated CR for all California Counties								
Mountain Counties	Sierra	SIEX	1999	68	25.01	0.37	0.48	0.60
Mountain Counties	Sierra	SIEX	2000	39	23.43	0.60		

Data source: California Air Resources Board[12] (see Appendix for more information and CR values for all California counties).

F3.5 is the analysis end point; protocol users should document the analysis assumptions used to determine that the project will not create a PM_{10} hot spot problem. F3.6 directs users to continue to Step 4, Relocate and Reduce: Build vs. No-Build, in the event the proposed project was not screened out in Step 3.

Step 4, Relocate and Reduce: Build vs. No-Build

Conceptual Logic of Step 4

Projects that are not screened out in previous steps will undertake the final protocol analysis step. In Step 4, the purpose is to estimate whether the proposed project would result in relocating existing traffic and whether, in the process of relocating that traffic, reduce the expected worst-case PM_{10} concentrations in the project area. Conceptually, the approach is best suited for projects that move existing traffic from roads with higher silt loads, such as local streets or arterials, to roads with lower silt loads such as freeways. For example, the proposed project may alleviate congestion on an existing facility by moving traffic from local streets and intersections onto a less congested major arterial or a highway. Studies indicate that on a per-vehicle basis, PM_{10} concentrations contributed by freeways can be up to an order of magnitude lower than intersection or arterial contributions of PM_{10}.[3,13] The approach is suitable for either PM_{10} nonattainment or maintenance areas.

The main analytical technique employed by the "relocate and reduce" approach is to convert build and no-build traffic volumes to common "freeway-equivalent" units. EPA and California Air Resources Board (CARB) document default silt loads by road type[3,13], with freeways having the lowest silt loads, and arterials and local streets having the highest silt loads. The protocol uses CARB default values for road-specific silt loads to derive "freeway-equivalent" road miles for each road type. For example, using CARB averaged silt load values, assuming similar vehicle weights on each road type, and using Equation 1, an estimate showing that local roads produce six times more PM_{10} on a g/mi basis than freeways was computed. Table 5 provides a summary of the freeway equivalents for the types of roads that can be estimated using this method. Converting build and no-build traffic volumes into common freeway-equivalent travel units facilitates quick comparisons to determine whether the proposed project improves or worsens worst-case PM_{10} conditions.

Table 5. Estimated PM_{10} "road equivalents" among different facilities.

These Types of Travel Can be Approximated as Equivalent	
1 local road vehicle-mile	6 freeway vehicle-miles
1 local road vehicle-mile	4.2 major street/highway or collector vehicle-miles
1 major street/highway or collector vehicle-mile	1.4 freeway vehicle-miles

Source: CARB[13] default silt load values, and Equation 1.

Detailed Process

F4.1 determines whether the proposed project relocates VMT from existing facilities to the proposed facility. Protocol users are asked to compare anticipated build and no-build traffic volumes in the vicinity of the proposed project and to determine whether the build scenario results in reallocation of volumes from existing roads to the proposed facility.

F4.2 directs users to approximate no-build PM_{10} conditions. The methodology includes two steps. First, users select the worst-case no-build intersection in the vicinity of the proposed project and forecast analysis year traffic volumes for that intersection. By using the worst-case intersection, a conservative estimate of the worst-case PM_{10} conditions can be approximated for the no-build scenario. Second, the user converts the intersection traffic volumes into freeway-equivalent miles. The end product is an estimate of freeway-equivalent miles of travel at the worst-case no-build intersection for the project analysis year.

F4.3 asks analysts to consider whether an intersection exists within 100 m of the proposed facility. The purpose of this step is to insure that in constructing a conservative screening analysis, the worst-case build conditions reflect the possibility that PM_{10} concentrations will be a function of both the project and other facilities within 100 m of the project. The literature (see Table 1) suggests that road impacts are most pronounced within 100 m of a facility. If there is no intersection within 100 m of the proposed facility, the user is directed to step F4.4. If there is an intersection, users proceed to step F4.5.

F4.4 instructs users to estimate the build impact of the project. The analyst uses projected build traffic volumes for the analysis year and converts those volumes to freeway-equivalent miles.

F4.5 covers situations where intersections are located within 100 m of the proposed facility. The user must forecast traffic volumes for the proposed facility's analysis year and convert those volumes into freeway-equivalent miles. Users then estimate analysis year traffic volumes for the worst-case (highest volume) intersection within 100 m of the proposed project and convert those miles to freeway-equivalents. The sum of the project under analysis and the worst-case intersection freeway-equivalent miles can then be computed.

F4.6 is a test to determine whether the number of freeway-equivalent miles is greater in the build or no-build case. F4.7 is the analysis end point; protocol users should document the analysis assumptions used to determine that the project will not create a PM_{10} hot spot problem. F4.8 directs projects that fail the process to conduct more detailed analyses or work through interagency consultation to determine whether PM_{10} will be a problem.

EXAMPLE APPLICATIONS

"Threshold screening" Analysis for an Intersection Project (Step 3)

Hypothetical Project Facts

Assume a project is proposed for Sacramento, California that is an intersection improvement expected to result in "build" traffic volumes of 30,000 vehicles per day (VPD). Worst-case background 24-hr average PM_{10} concentrations are currently 130 $\mu g/m^3$, and annual average concentrations are 42 $\mu g/m^3$ at the proposed project site. Based on discussions with the local air quality management district, the protocol user estimates that the proposed project site is expected to experience steady or declining background PM_{10} concentrations in future years. Abbreviated text from the Figure 1 flowchart descriptions is reproduced here in italics, with example results following.

Qualitative Analysis with Flowchart Step 3 - Threshold Screening

F3.1. Are 24-hr background PM_{10} concentrations near the proposed project site below 120 mg/m^3?

> Concentrations are not below 120 $\mu g/m^3$, the screening threshold based on observed worst-case conditions. Background concentrations are estimated to be 130 $\mu g/m^3$; the project continues on to Step F3.2.

F3.2. Is the 24-hr incremental PM_{10} contribution from the project less than the allowable threshold?

> Yes, the project increment is less than the allowable threshold. The protocol user reaches this conclusion by estimating the project's incremental 24-hr PM_{10} contribution from data in Table 3. In this example, the Table 3 entry for 68,000 VPD is the closest selection and is conservative since the anticipated traffic volumes are less than 68,000 VPD. Based on the Table 3 data, the incremental concentration assumed for the 24-hr PM_{10} analysis is 5.8 $\mu g/m^3$. The analyst then estimates an allowable 24-hr threshold value for the intersection project by subtracting the expected 24-hr background concentration from the PM_{10} 24-hr NAAQS (150 $\mu g/m^3$ – 130 $\mu g/m^3$). The estimated project increment of 5.8 $\mu g/m^3$ is less than the allowable threshold of 20 $\mu g/m^3$. From this, it can be qualitatively concluded that a PM_{10} hot spot violation of the 24-hr standard will not occur as a result of this project. The analyst continues through the flowchart to check the annual standard.

F3.3 and F3.4. Is the proposed project's estimated annual PM_{10} incremental contribution below the acceptable threshold?

> The project fails the general annual screening test but passes the more specific annual threshold test (steps F3.3 and F3.4 respectively). Since expected annual average background concentrations are 42 $\mu g/m^3$, the project does not screen out with step F3.3 (42 $\mu g/m^3$exceeds the allowable 32 $\mu g/m^3$). The threshold for the annual check must then be computed and compared against the annual project increment (F3.4). To conduct this comparison, first, the analyst determines the 24-hr project increment and then, using Equation 3, converts the 24-hr increment (Table 3) to an annual increment by applying the CR (Table A-1 in the Appendix includes the CR for Sacramento County).
>
> **Equation 3.** Conversion of 24-hr increment to annual increment.
>
> $$\text{Increment}_{\text{Ann}} = \text{Increment}_{\text{Proj}} \times \text{CR}$$
>
> where
>
> $\text{Increment}_{\text{Ann}}$ = Project's annual incremental PM_{10} concentration

$\text{Increment}_{\text{Proj}}$ = Project's 24-hr incremental contribution (from Table 3)

CR = Conversion ratio (from Table A-1 or local data)

In this example, the project's estimated 24-hr PM_{10} increment is 5.8 μg/m^3 (F3.2), the CR is 0.31 (from Table A-1), and the resulting estimated annual project increment is 1.8 μg/m^3 (Equation 4).

Equation 4. Estimating an annual increment of 1.8 μg/m^3.

$$\text{Increment}_{\text{Ann}} = 5.8\, mg/\text{m}^{\mathbf{3}} \times 0.31 = 1.8 mg/\text{m}^3$$

Next, the analyst computes the allowable annual threshold based on the specific project location using Equation 5.

Equation 5. Estimating an allowable annual threshold.

$$\text{Thresh}_{\text{Ann}} = \text{NAAQS}_{\text{Ann}} - \text{Background}_{\text{Ann}}$$

where

$\text{Thresh}_{\text{Ann}}$ = Allowable annual project increment (: g/m^3)

$\text{NAAQS}_{\text{Ann}}$ = Annual PM_{10} NAAQS (50 : g/m^3)

$\text{Background}_{\text{Ann}}$ = Annual background concentration (: g/m^3)

In this example, the estimated background PM_{10} concentration is 42 μg/m^3; by subtracting the background concentration from the annual NAAQS of 50 μg/m^3, the analyst estimates an allowable annual project increment of 8 μg/m^3. In the final step, the estimated project increment is compared to the allowable threshold. The forecasted project increment is 1.8 μg/m^3; the allowable increment is 8 μg/m^3. It can be qualitatively concluded that a PM_{10} hot spot violation of the annual standard will not occur as a result of this project.

F3.5. Project screens out; end analysis and document findings.

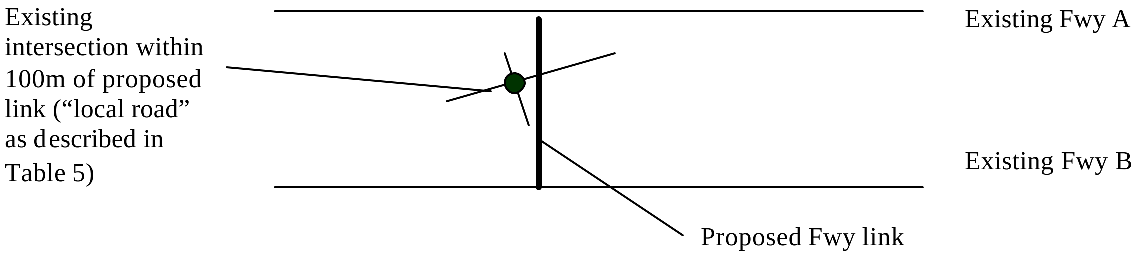
The proposed project has passed the conformity hot spot test. The protocol user should document the assumptions used during the analysis to support a project-level conformity determination.

Relocate and Reduce Analysis, Build vs. No-Build Approach (Step 4)

Hypothetical Project Facts

The proposed project will connect two existing freeways with a new, elevated freeway segment and associated ramps (Figure 2). The project will be built within 100 m of an existing intersection with 18,000 VPD prior to the project's construction. Projections show that the new freeway segment will relocate 8,000 VPD from the existing intersection onto the new freeway segment. In addition, it is estimated that the new freeway segment will add 72,000 more VPD to the traffic that passes through the area. Total expected volumes on the new freeway will be 80,000 VPD (8,000 VPD relocated from the existing intersection, plus 72,000 new VPD).

Figure 2. New freeway link and existing intersection within 100 m.



Background concentrations are very high near the project site, and the project has failed the other qualitative analysis steps. Table 6 shows the anticipated build and no-build traffic volumes.

Table 6. Build vs. no-build conditions for hypothetical "relocate and reduce" example.

Facility	**No-Build Volumes (VPD)**	**Build Volumes (VPD)**
Freeway	0	80,000
Intersection (road type)	18,000 (local road)	10,000 (local road)

Qualitative Analysis with Flowchart Step 4 – Relocate and Reduce

F4.1. Does the proposed project relocate vehicles from an existing site to the project site?

Yes, the identified intersection will have reduced volumes in the build case.

F4.2. Estimate the no-build PM_{10} impacts (in freeway-equivalent units per day) based on the worst-case (highest VPD) no-build intersection.

The worst-case no-build intersection is projected to carry 18,000 VPD. The no-build road type is "local road" for the intersection. For qualitative analysis purposes, we assume that intersection VPD estimates are proportional to vehicle miles per day. We make this assumption based on the AP-42 PM_{10} estimation methodology, which is VMT based (see Equation 1). In addition, neither EPA nor CARB define silt loads for intersections. Thus, to facilitate converting all road use into freeway-equivalents, we assume intersections are equivalent to the road type associated with the approaches to the intersection, which for this project are “local roads.” From Table 5, 1.0 local-road miles is equivalent to 6.0 freeway-miles. Therefore, traffic at the no-build intersection is equivalent to 108,000 freeway-miles (6.0 freeway-miles/1.0 local road-miles multiplied by 18,000 local-road miles).

F4.3. Is there an intersection within 100 m of the proposed project facility?

Yes, as shown in Figure 2, there is an intersection within 100 m of the freeway.

F4.5. Estimate the build impact based on the worst-case build intersection within 100 m, plus the proposed project facility.

The intersection illustrated in Figure 2 is the only intersection within 100 m of the freeway, and, in this simplified example, it is therefore also the worst-case build intersection. The build road type is “local road” for the intersection, meaning the intersection has not been improved as part of the new freeway project. Given expected build traffic volumes of 10,000 VPD, the build scenario results in 60,000 freeway-mile equivalents (6.0 freeway-miles/1.0 local road-miles multiplied by 10,000 local road miles; from Table 5). The new freeway produces 80,000 freeway-miles. The total project build impact is, thus, 140,000 freeway-equivalent miles (80,000 from the freeway, plus 60,000 from the intersection).

F4.6. Is build impact less than the no-build impact?

No, the build impact is not less than the no-build impact (140,000 is greater than 108,000).

F4.8. Interagency consultation or more detailed analysis is needed.

The proposed project has not passed the conformity hot spot test and further analysis or consultation is necessary. Note, however, that a minor change to this example illustrates how potential mitigation strategies can offset PM_{10} problems. If the intersection is improved in the build scenario, the project passes the screening test. Assume, for example, that the intersection in Figure 2 was, as part of the freeway project, improved so that its approaches became “major streets.” Also assume that the traffic volumes in the build scenario remained the same as projected in Table 6; in other words, the new freeway segment would reduce the intersection traffic volumes to 10,000 VPD in the build scenario. The improved intersection would be assumed to have 14,000 freeway-equivalent miles, rather than 60,000 freeway-equivalent miles (silt loadings would reflect major-street conditions, rather than local-road conditions; see Table 5). Total build freeway-equivalent miles would equal 94,000 (80,000 from the freeway plus 14,000 from the intersection), a reduction from the no-build forecast of 108,000 miles. Given the analysis results, planners might be motivated to modify the proposed project to incorporate intersection improvements that reduce silt loads and PM_{10}.

CONCLUSIONS

The qualitative PM_{10} analysis protocol is a new method for conducting a step-by-step screening to identify projects unlikely to contribute to violations of the PM_{10} NAAQS. The protocol was designed to be conservative and serves as a resource for transportation analysts responsible for preparing project-level transportation conformity PM_{10} hot spot analyses. Although some of the underlying data used to create the protocol is California-specific, methods detailed in the protocol have wide applicability, and users have the ability to substitute local data more appropriate to the proposed project.

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APPENDIX

Step 3 of the PM_{10} protocol, Threshold Screening, employs a conversion ratio (CR) to estimate a transportation project's annual incremental contribution to PM_{10} concentrations. The CR is based on observed relationships between 24-hr and annual PM_{10} concentrations in each of California's 58 counties. The text (flowchart F3.3 discussion) explains how the CR was estimated. Table A-1 provides CR values for all California counties.

Table A-1. 24-hr-to-annual average PM_{10} concentration conversion ratios (CR) for all California counties.

County Name	Monitor Location[a]	CR[b]
Alameda	ALAX	0.30
Butte	BUTX	0.34
Calaveras	CALX	0.51
Colusa	COLX	0.42
Contra Costa	CCX	0.32
Del Norte	DNX	0.44
El Dorado	EDGX	0.48
El Dorado	EDJX	0.44
Fresno	FREX	0.33
Glenn	GLEX	0.34
Humboldt	HUMX	0.41
Imperial	IMPX	0.15
Inyo	INYX	0.08
Kern	KEIX	0.43
Kern	KEUX	0.37
Kings	KINX	0.38
Lake	LAKX	0.49
Lassen	LASX	0.37
Los Angeles	LAIX	0.34
Los Angeles	LAXX	0.55
Marin	MRNX	0.49
Mariposa	MPAX	0.33
Mendocino	MENX	0.46
Merced	MERX	0.36
Modoc	MODX	0.28
Mono	MNOX	0.09
Monterey	MONX	0.40
Napa	NAPX	0.36
Nevada	NEVX	0.36
Orange	ORAX	0.44
Placer	PLQX	0.41
Plumas	PLUX	0.44
Riverside	RIRX	0.44
Riverside	RIXX	0.47
Sacramento	SACX	0.31
San Benito	SBTX	0.39
San Bernardino	SBIX	0.42
San Bernardino	SBXX	0.42
San Diego	SDCX	0.43

County Name	Monitor Location[a]	CR[b]
San Francisco	SFX	0.38
San Joaquin	SJX	0.31
San Luis Obispo	SLOX	0.31
San Mateo	SMX	0.40
Santa Barbara	SBX	0.56
Santa Clara	SCLX	0.35
Santa Cruz	SCRX	0.52
Shasta	SHAX	0.48
Sierra	SIEX	0.60
Siskiyou	SISX	0.32
Solano	SLQX	0.39
Solano	SLTX	0.28
Sonoma	SNMX	0.33
Sonoma	SNTX	0.40
Stanislaus	STAX	0.33
Sutter	SUTX	0.40
Tehama	TEHX	0.48
Trinity	TRIX	0.37
Tulare	TULX	0.41
Ventura	VENX	0.37
Yolo	YOLX	0.32

[a] The location is the monitor site with the highest observed 99th percentile 24-hr concentration in the county.[12]

[b] CR is based on data from the monitor in each county that reported the maximum 24-hr value. The 99th percentile 24-hr value was identified for each of 1999 and 2000. For each of 1999 and 2000, the average of quarterly mean PM_{10} concentrations was estimated for each monitor in the county and then divided by the highest 99th percentile 24-hr value for the county. CR = (average of quarterly means) / (99th percentile of 24-hr concentrations). To be conservative, the highest of the two CR values (1999 and 2000) was selected to represent the CR for a given county.