Item 5
Additional Info.

RECON

An Employee-Owned Company

February 1, 2016

Mr. Jeff Steichen
Development Services Department
City of Chula Vista
276 Fourth Avenue
Chula Vista, CA 91910

Reference: 701 D Street Air Quality Analysis – Environmental Health Coalition Comment Letter (RECON Number 7937)

Dear Mr. Steichen:

Thank you for your comments on the Air Quality Analysis prepared for 701 D Street in Chula Vista, California.

RECON has reviewed the comment letter submitted by the Environmental Health Coalition (EHC) on the 701 D Apartment Project. This letter provides the City with additional information relative to our Air Quality Analysis.

1. The EHC comment letter identified the wording of the Chula Vista General Plan Policy E 6.10. The EHC statement that the policy has not been met is incorrect. A Health Risk Assessment (HRA) was prepared for the project, and the attendant health risks were mitigated to the extent feasible and maximum extent practicable.

2. An EHC comment stated "[t]he health risk assessment in incomplete and does not reflect current of future expected conditions", as it does not include modeling for the widening of the I-5 freeway between the 905 and 54 freeways. However, the Health Risk Assessment uses the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) to model vehicular emissions from the freeway. AERMOD is the current regulatory model and has been designed to provide as accurate an analysis as possible and is used for health risk assessments throughout the United States as well as the state of California. It is necessary to represent the freeway spatially within AERMOD. Thus, the freeway is characterized as a series of partially overlapped volume sources, e.g., cubes. The emissions from the freeway were assigned to each volume source, which were given dimensions adequate to cover the entire width of the freeway, which provides a reasonable prediction of the dispersion of diesel particulate matter (PM) for the evaluation of potential risk to future residents of the project. While widening the freeway may move traffic closer to some residents, it would also move traffic farther from the residents on the other side of the freeway. Furthermore, the emissions used in the analysis are based on current emission rates. However, emission rates from diesel engines will decrease due to increasingly stringent emission standards and phase-out of older vehicles. Based on the emission estimates included in the California Air Resources Board's (CARB) current Emissions Factor Model (EMFAC), emissions rates between 2015 and 2020 would be reduced by approximately 44 percent by 2020, 80.5 percent by 2030, and 90.5 percent by 2050. As the widening of the freeway would not occur until 2035, the analysis is based on the freeway configuration during the highest risk period and evaluates potential health risks from traffic in a reasonable manner.

The EHC comment letter further states that "the cancer risk analysis is based on diesel particulate only." This is correct. As stated in the report, the region-wide risk from diesel PM is approximately 420 in a million, thus CARB states "diesel PM poses the greatest health risk ....".* Therefore, the health risk assessment addresses the risk-driving substance, diesel PM, and used segment-specific traffic information to calculate the risk from the risk-driving substance. Additionally, the comment attempts to adjust to the risk results based on general information about contributions from other pollutants. It is not appropriate to simply adjust the risk estimates without site-specific information. Therefore, regardless of whether or not the impacts from benzene, 1,3-butadiene, and ethylbenzene were included in the analysis, the conclusions and mitigation provided in the analysis would be unchanged.

3. An EHC comment indicates that background levels of pollutants are underestimated. The analysis presents background air quality data from the nearest air quality monitoring station to the project site as recommended by the San Diego Air Pollution Control District. This is the only source of valid data in the project vicinity and is therefore appropriate for this project and adequate to characterize the air pollution at the site. It is not feasible, necessary, nor required to conduct ambient monitoring at every project site. Furthermore, the air quality analysis assesses the potential health risk from the freeway, i.e., the nearest air pollution source to the project.

4. An EHC comment states that an "acute health hazard analysis is missing." This is a correct statement. However, as there is no state or federal acute reference exposure level for diesel PM, which as noted is the risk-driving substance, the analysis could not conduct this evaluation. The comment also noted that California does not have a reference exposure level (REL) for diesel PM. This is incorrect, as California has identified an inhalation REL of 5 micrograms per cubic meter ($\mu g/m^3$)†, which was used in the analysis.

5. A comment states that "effectiveness of mitigations is not established." The comment implies that modeling is required to indicate how a wall or vegetation would alter the pollution plumes or cancer risks downwind of the freeway. This statement indicates a lack of understanding as to how air dispersion models such as AERMOD function. There is no means of inserting a wall or vegetation within the model to demonstrate reductions in concentrations. The model is a Gaussian plume model and does not recognize barriers or vegetation in its calculation of downwind concentrations. It is therefore not possible to model the effectiveness of the mitigation measures as suggested by the comment. The analysis therefore must rely on published studies showing the effectiveness of mitigation measures, which were based on the recommendations of the California Air Pollution Control Officers Association (CAPCOA) in their 2009 guidance *Health Risk Assessments for Proposed Land Use Projects*‡.

6. A comment states that "threshold of significance for exposure of sensitive receptors to toxic air contaminants should be no higher than background." While this is a laudable goal, it is not realistic nor is it consistent with federal or state standards for health risk assessments for other sources. As the state and federal levels of governments have identified acceptable levels of risk, the City relies on the expertise of CARB and the U.S. Environmental Protection Agency. Additionally, it should be noted as stated in the air quality analysis:

---

* *The California Almanac of Emissions and Air Quality – 2009 Edition*. http://www.arb.ca.gov/aqd/almanac/almanac09/pdf/chap509.pdf.

† Air Toxicology and Epidemiology. *OEHHA Acute, 8-hour and Chronic Reference Exposure Level (REL) Summary*. http://www.oehha.ca.gov/air/allrels.html.

‡ *Health Risk Assessments for Proposed Land Use Projects* http://www.capcoa.org/wp-content/uploads/2012/03/CAPCOA_HRA_LU_Guidelines_8-6-09.pdf.

> This analysis is considered to be conservative as the potential methods used tend to overestimate rather than underestimate health risks . . . . A first tier (Tier 1) evaluation uses the high-end point estimate (i.e., the 95th percentiles) breathing rates for the inhalation . . . . These higher breathing rates result in incremental cancer risk estimates that represent the upper-range of predictions and therefore health risks that may be associated with exposure to vehicles.

Therefore, the City's reliance on the methods and standards of these agencies is appropriate.

7. An EHC comment states that the "project fails to heed the science-based guidance in the ARB *Air Quality and Land Use Handbook*." The comment goes on to state that the project should not be located within 500 feet of the freeway. However, as stated by CARB when the *Handbook* was prepared (2004):

   > . . . long-term goal [of CARB] is to reduce diesel PM emissions 85% by 2020. However, cleaning up diesel engines will take time as new engine standards phase in and programs to accelerate fleet turnover or retrofit existing engines are implemented.

   At this point in time, the majority of CARB's diesel PM reduction regulations have been implemented, which have reduced and will continue to reduce diesel PM emissions, as discussed under response 2. Thus, the 500-foot set-back is based on older emissions data and is offered as precautionary distance based on the set-back required for schools unless an analysis is conducted. Based on the mitigation provided, the 500-foot set-back is not necessary. However, as stated by CARB:

   > . . . any recommendations or considerations contained in the Handbook are voluntary and do not constitute a requirement or mandate for either land use agencies or local air districts."

8. An EHC comment states the "HRA does not include all feasible mitigations." The analysis has provided mitigation sufficient to reduce the impacts to the extent feasible and practicable. As the impacts were mitigated to less than significant, the project does not need to implement all feasible mitigation measures. The identified mitigation would be included in the project requirements and in rental disclosures. Furthermore, the suggestion that the project move all future residents 500 feet from the freeway is not a feasible measure, as the entire site is located within 500 feet of the freeway, and this measure would, by definition, create a different project. In addition, as the project site is zoned R3P (Apartment Residential Precise Plan) and is designated as RH (Residential–High) in the General Plan, the project would be consistent with the General Plan land use designation and with the growth anticipated by the General Plan and San Diego Association of Governments.

Please let me know if you have any questions or require any further information.

Sincerely,

William A. Maddux

William Maddux
Senior Technical Specialist

WAM:eab

Meeting of the City Council
February 2, 2016

ITEM 5

ATTACHED IS ADDITIONAL INFORMATION RECEIVED SUBSEQUENT TO THE FILING OF THE APPEAL BY THE APPELLANT ON DECEMBER 15, 2015.

Jeff Steichen

From:	Patricia Aguilar
Sent:	Friday, January 15, 2016 1:44 PM
To:	[redacted]
Cc:	Jeff Steichen
Subject:	FW: Environmental Health Coalition comments on condo proposal at 701 D Street
Attachments:	EHC_toCouncil_CondoProject_Final.pdf

Dear Mr. Spooner; I wanted to make you aware of the attached correspondence members of the City Council received from the Environmental Health Coalition (EHC) regarding the 701 D St. project. City staff is looking into the health-related issues raised in EHC's letter. I am writing to let you know this may cause a delay in the date your appeal will be heard by the city council, which was tentatively set for February 2.

We will try to keep you informed. And of course you can always reach out to the project manager, Jeff Steichen, for information.

Let us know if you have any questions. Best,

Councilmember Patricia Aguilar
City of Chula Vista
(619) 691-5044
paguilar@chulavistaca.gov

From: Laura Hunter [redacted]
Sent: Thursday, January 14, 2016 3:15 PM
To: Mary Salas; Pamela Bensoussan; Patricia Aguilar; John McCann; Steve Miesen
Subject: Environmental Health Coalition comments on condo proposal at 701 D Street

Dear Mayor Salas and City Council,
We hope you had a great New Year! I will be contacting all of you soon to request a meeting about a few issues in Chula Vista.
In the meantime, Environmental Health Coalition has asked me to transmit this comment letter regarding the proposed development at 701 D street. There are very significant deficiencies in the Health Risk Assessment that should be resolved before this project is considered. Further, given the very serious health risks posed by freeway air pollution to children, this should be evaluated for consistency with the recently adopted Healthy Chula Vista Action Plan initiative.
As Joy Williams will be on vacation for several weeks, please direct any comments or questions to me.
Thank you for considering these comments.
Laura Hunter

ENVIRONMENTAL HEALTH COALITION
2727 HOOVER AVE. SUITE 202 NATIONAL CITY, CA 91950 (619) 474-0220 WWW.ENVIRONMENTALHEALTH.ORG

January 14, 2016

Mayor Salas and City Council
Chula Vista City Council
Chula Vista, CA

RE: Opposition to location of residential uses within 500 feet of a freeway

Dear Mayor Salas and City Council members,

Environmental Health Coalition (EHC) was involved in the creation of the Chula Vista General Plan Update and the Specific Plan. One of the significant improvements to the General plan policies was the inclusion of policy E 6.10. that attempted to reflect the guidance from the Air Resources Board that homes and other sensitive uses should not be located within 500 feet of a freeway.

General Plan Policy E 6.10 reads: *The siting of new sensitive receivers within 500 feet of highways resulting from development or redevelopment projects shall require the preparation of a health risk assessment as part of the CEQA review of the project. Attendant health risks identified in the Health Risk Assessment (HRA) shall be feasibly mitigated to the maximum extent practicable, in accordance with CEQA, in order to help ensure that applicable federal and state standards are not exceeded.*

We have recently learned of a project that is proposed that would put people in harm's way by locating residences within this buffer zone.

While a project Health Risk Assessment (HRA) has been drafted, this policy has not been met. It is important to remember the point of a HRA is to assess the situation so that the project can be revised to prevent health risks to future residents. There are several deficiencies with the HRA listed below and there are mitigation measures that should be adopted that have not been.

Due to major health concerns for future residents living there and the precedent this action may set, Environmental Health Coalition unequivocally opposes the location of condos within the 500 foot zone from the freeway and the off-ramp.

There are several reasons for this position.

1. The Health Risk Assessment in incomplete and does not reflect current or future expected conditions.

The SANDAG Phased Revenue Constrained Network plan for 2035 includes two additional lanes on the I-5 freeway in Chula Vista between the 905 and the 54 freeways.[1] If these lanes are added to the outer lanes of the freeway, the edge of the freeway will be even closer to residences. The new lanes will increase capacity on the roadway, ultimately resulting in additional VMT on this segment of roadway, as induced demand increases the volume of traffic. The HRA must address this potentially major impact on the freeway and the resulting exposure to traffic pollutants.

Immediately to the north, the I-5 will be expanded with two additional managed lanes and two additional general purpose lanes. The impacts of these expansions on the Chula Vista portion of the I-5 must be examined as well, as a bottleneck resulting from the southbound flow of traffic from National City into Chula Vista may create congestion and added traffic pollutant exposure to the residents at 701 D Street.

It also does not appear that the flow of traffic in the off-ramp to 54 is included in the analysis.

2. The Cancer Risk Analysis is Based on Diesel Only

Even without the estimates of future freeway impacts, the estimated cancer hazards of freeway traffic impacts are over 10/million for the most exposed residential receptors:

- 44.8 per million for a 70-year exposure;
- 38.1 per million for a 30-year exposure;
- 27.2 per million for 9 years of childhood exposure.

Based on the discussion of cancer risk on page 32 of the draft air quality analysis, the cancer risk analysis was based exclusively on diesel inhalation. It is true that diesel is the dominant health hazard in California's air and accounts for approximately 70% of the cancer risk hazard from ambient air pollution, according to California ARB. However, it is not the sole cancer-causing agent in traffic pollution. Other pollutants such as benzene, ethylbenzene, and butadiene also add to the hazard. The 100% cancer risks to the most exposed residential receptors, then, would be:

- 64 per million for a 70-year exposure;
- 54 per million for a 30-year exposure; and
- 38.8 per million for 9 years of childhood exposure.

The conclusion of the cancer risk analysis, that health hazards are below 10 per million, is clearly untrue.

3. Background Pollution Levels are Underestimated

---

[1] http://www.sdforward.com/pdfs/RP_final/AppendixA-TransportationProjectsCostsandPhasing.pdf

Further, the background level of pollution for residents in this area is underestimated. The HRA should have analyzed the site as a 'localized hotspot' not as part of the region. People who live in the project will be directly adjacent to significant air pollution. These are the levels of pollution they will breathe, not the air at the station at 80 E. J street (over 2 miles away) where the pollution has already diluted.

4. Acute Health Hazard Analysis is Missing

The hazards of short-term impacts of high levels of exposure, such as happens during rush hours and other periods of high traffic levels, are not addressed at all. It should be noted in the analysis that California does not have a REL for diesel[2] and the question of shorter term impacts, such as asthma exacerbations, is outstanding. Placement of residential housing within 500 feet of a freeway creates an obvious question about potential impacts of exposure to peak periods of traffic pollution, and the RECON analysis does not answer that question, or even acknowledge that decision makers and potential residents might reasonably want this information.

5. Effectiveness of Mitigations is Not Established

The document asserts that mitigations such as sound walls and vegetation will reduce the health hazard to levels considered acceptable by agencies. However, no modeling is included to indicate how a wall or vegetation would alter the pollution plumes or risk isopleths downwind of the freeway. A related question is whether a sound wall makes pollution levels further from the freeway **higher**, as at least some modeling shows.[3] No recommendations are provided on how high a wall would be needed to effectively reduce levels of traffic pollution to background levels. No mitigations are proposed that would locate the residential buildings beyond 500 feet of the freeway, such as by siting the parking areas on the side of the parcel that is closest to the freeway.

6. Threshold of Significance For Exposure of Sensitive Receptors to Toxic Air Contaminants Should Be No Higher Than Background

The Lead Agency for a project has the legal authority and, in fact, is encouraged under CEQA Guidelines §15064.7 to develop and publish its own thresholds of significance. In determining whether an effect will be adverse or beneficial, **the lead agency shall consider the views held by members of the public in all areas affected as expressed in the whole record before the lead agency.** (§ 15064.7(c)) Lead agencies may also consider thresholds of significance previously adopted or recommended by other public agencies, or recommended by experts, **provided the decision of the lead agency to adopt such thresholds is supported by substantial evidence.** (§15064.7(b))

---

[2] http://www.oehha.ca.gov/air/allrels.html

[3] Neng et al., 2010, summarized in http://www.aqmd.gov/docs/default-source/technology-research/Technology-Forums/near-road-mitigation-measures/ucr-venkatram.pdf?sfvrsn=2

CEQA Guidelines recognize that the level of impacts and their significance depends upon a multitude of factors such as project setting, design, construction, etc. CEQA Guidelines also call for careful judgment based on scientific and factual data to the extent possible and explain, "For example, an activity which may not be significant in an urban area may be significant in a rural area." (§ 15064(b)).

The census tract in which the site is located ranks high on California's screening model for environmental justice, CalEnviroScreen. The census tract ranks in the top 86-90% statewide, meaning that it scores higher on combined indicators for environmental pollution and socioeconomic vulnerability than 86 to 90% of all census tracts within the state. Within the San Diego region, this tract is the 10th highest, out of 628 tracts. A CalEnviroScreen indicator of particular relevance is the traffic density indicator; on this measure of traffic impact, the site census tract is at the 91.85 percentile statewide. Clearly, residents in this census tract are already exposed to traffic at higher than normal levels, even for California. Other indicators on which this tract has high CalEnviroScreen percentiles include Cleanup Sites, Hazardous Waste, Low Birth Weight, Education levels, Linguistic Isolation, Poverty, and Unemployment.

According to the most recent APCD Air Quality Network Analysis, *The city of Chula Vista has one of the highest rates of respiratory ailments in the County.* [4]

Table 3.1 Health Risks Summary by Station in the Network Assessment notes that the Chula Vista area has "*Very high rates for this location/station and surrounding area...*" The maximum ranking is 10 (the worst). Chula Vista is a 9.

Residents of this community need affordable housing that does not create illness or worsen their health status. EHC recommends that additional analysis be completed to fully elucidate the health hazards of this site, and develop site-specific mitigations that will reduce health hazards to background levels.

7. Project fails to heed the science-based guidance in the ARB *Air Quality and Land Use Handbook.*

Another serious deficiency is the location of homes within 500-1,000 feet of the freeway. The Air Resources Board *Air Quality and Land Use Handbook: A Community Health Perspective* is relevant here. The ARB guidelines recommend a **minimum** separation between residential development and freeways of 500 **feet to avoid increased cancer and non-cancer risks.**[5]

Further, the Handbook finds that additional non-cancer health risks are attributable to proximity within 1,000 feet.[6] The project directly contravenes the Air Resources Board

[4] http://www.sdapcd.org/air/reports/2015_Network_Assessment.pdf, page 5.
[5] 2005_April http://www.arb.ca.gov/ch/handbook.pdf
[6] 2005_Ibid, ARB Land Use Guidelines, Table 1-2

Land Use guidance. Any homes within this area should be abandoned as they are too close to the freeway for good health of the residents.

We understand that this guidance is not regulation. However, it is the guidance of the air regulators based on the abundant science, is clear—**locating homes within 500-1000 feet of a freeways is unhealthful.**

The developers are urged to examine their conscience to see if they really want to be the vehicle by which future residents, including pregnant women, children, and elderly are at high risk of asthma, birth defects, cancer, and other health hazards due to their poor planning. The City should evaluate this as well as a matter of policy. If no change is made, then this issue is a significant and unmitigated impact and the Council should deny the project altogether.

To better protect future residents, the project should be revised to remove all homes from the known unhealthful areas within 1,000 feet of the freeway. We hope the City will require the developers to move residents out of harm's way.

8. HRA does not include all feasible mitigations.

The most obvious and feasible mitigation is to move all homes out of the 500 foot zone. The filters cannot be assumed to protect residents since there is no guarantee they will be run or maintained. To be effective, the planning would have to have a filtration system that could not be controlled by individual owners and was maintained as a mitigation measure. Such a mitigation is not included so any benefits of the filters are not guaranteed. There are many reason why future residents may not run their filters—cost, desire to reduce energy use, etc...

Even if the electrostatic filters remove all particulates, children will be playing outside where the air is unfiltered. The project should be re-designed to move all residential and playground areas away from the freeway.

Thank you for the opportunity to comment on this matter.

Sincerely,

Joy Williams

Joy Williams, MPH
Research Director

Jeff Steichen

From:	Valorie Thompson <[redacted]
Sent:	Monday, January 18, 2016 12:38 PM
To:	Jeff Steichen
Subject:	RE: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)
Attachments:	701 D AQ Comment Letter 011816.docx

Jeff,

Here are my preliminary thoughts on the letter that was sent. In my opinion the only issue that has potential merit is the issue regarding other pollutants (benzene, 1,3-butadiene, and ethylbenzene); however, I do not believe that the conclusions of the study would change, nor would the mitigation measures.

Let me know if you want to discuss

Valorie

From: Jeff Steichen [mailto:Jsteichen@chulavistaca.gov]
Sent: Friday, January 15, 2016 2:05 PM
To: Valorie Thompson
Subject: RE: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)
Importance: High

Valerie,

Per my voicemail message to you, I've been asked by our director to have you review the attached letter that was just sent to the Mayor and City Council questioning the adequacy of the health risk assessment that was prepared for the 701 "D" Street project, for which you conducted the third party review. Could you please review and comment on this letter at the earliest convenience. We will pay you for the time you spend on this.

Thanks,

Jeff

From: Valorie Thompson [redacted]
Sent: Tuesday, October 13, 2015 9:22 AM
To: Jeff Steichen
Subject: RE: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)

Jeff,

I have two minor comments, please see the attached letter. Otherwise I am satisfied that the report has been corrected.

Valorie

From: Jeff Steichen [mailto:Jsteichen@chulavistaca.gov]
Sent: Monday, October 12, 2015 11:47 AM
To: Valorie Thompson
Subject: RE: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)

Valorie,

Attached is response to comment letter and revised Air Quality Analysis. Please confirm receipt.

Thanks,

Jeff

From: Valorie Thompson [redacted]
Sent: Wednesday, October 07, 2015 8:20 AM
To: Jeff Steichen
Subject: RE: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)

Jeff,

I have no additional comments on the GHG analysis. I do, however, have continued concerns about the Air Quality Analysis with regard to the air toxics analysis that has been conducted for the project. Please see the attached letter and let me know if you have any questions. Thanks.

Valorie

From: Jeff Steichen [mailto:Jsteichen@chulavistaca.gov]
Sent: Tuesday, October 06, 2015 2:13 PM
To: Valorie Thompson
Subject: FW: Air Quality Analysis, 701 D Street, City of Chula Vista (RECON Number 7937)

Valorie,

Attached please find response to previous comments and revised Air Quality Report. Please review this revised document and provide comments (revised GHG Analysis will be sent in separate email).

Thank You,

Jeff

Scientific Resources Associated

January 18, 2016

Mr. Jeff Steichen
Development Services Department
City of Chula Vista
276 Fourth Avenue
Chula Vista, CA 91910

RE: 701 D Street Air Quality Analysis
EHC Comment Letter

Dear Mr. Steichen:

Scientific Resources Associated (SRA) has reviewed the comment letter submitted by the Environmental Health Coalition on the 701 D Apartment Project. We are providing this letter to provide the City with additional information relative to our review of the Air Quality Analysis.

1. The EHC has stated that the health risk assessment is incomplete because it does not consider widening of the I-5 freeway between the 905 and 54 freeways. The Health Risk Assessment relies on use of the AERMOD model to represent traffic on the freeway. Within the model, the freeway is treated as a series of volume sources. The AERMOD model is a tool that is designed to provide as accurate an analysis as possible, and is used for health risk assessments throughout the state of California. It is necessary within the model to represent the freeway spatially. The emissions from the freeway were allocated to the volume sources, which cover the width of the freeway and provide a reasonable evaluation of risk to residents at the project. Widening of the freeway may move some traffic closer to the residents, but will also move traffic farther from residents on the other side of the freeway. Furthermore, because the emissions are highest in the early part of the exposure period due to increasingly stringent emission standards and phase-out of older vehicles, and the widening of the freeway would not occur until 2035, the analysis takes into account the freeway configuration during the highest risk period. The analysis therefore accounts for impacts from traffic in a reasonable manner.

2. The comment states that the health risk assessment is lacking because it does not address risks from pollutants other than diesel particulate; and further attempts to adjust the risk results based on general information about contributions from other pollutants. The health risk assessment addresses the risk-driving substance, diesel particulate matter, and used segment-specific traffic information to calculate the risk from the risk-driving substance. It is not appropriate to simply adjust the risk estimates without site-specific information.

   Regardless of whether the impacts from benzene, 1,3-butadiene, and ethylbenzene are added to the analysis, the conclusions of the study would be unchanged.

3. The comment indicates that background levels of pollutants are underestimated. The analysis presents background air quality data from the closest monitoring station to the project site, which is the only data in the immediate vicinity of the site and is therefore appropriate for this project. It is not necessary nor required to conduct ambient monitoring at every project site. Furthermore, the analysis does present an evaluation of impacts from the freeway, which is the closest air pollution source to the site.

4. The comment states that an acute risk analysis was not conducted. As the comment correctly points out, there is no acute reference exposure level for diesel particulate matter, the risk-driving substance. The analysis did look at impacts from PM10 emissions, which were analyzed on a short-term basis.

5. The comment states that the effectiveness of the mitigation was not analyzed. The comment that no modeling is included to indicate how a wall or vegetation would alter the pollution plumes or risk isopleths downwind of the freeway indicates a lack of understanding as to how air dispersion models such as AERMOD work. There is no means of inserting a wall or vegetation within the model to demonstrate reductions in concentrations. The model is a Gaussian plume model and does not recognize barriers or vegetation in its calculation of downwind concentrations. It is therefore not possible to model the effectiveness of the mitigation measures as suggested by the comment. The analysis therefore must rely on published studies showing the effectiveness of mitigation measures proposed for the project.

The remaining comments deal with policies established by the City of Chula Vista, and are not technical in nature. We have therefore responded to the technical comments on the health risk assessment.

We appreciate the opportunity to work with you on this project. Please let me know if you have any questions or require any further information.

Sincerely,

Valorie L. Thompson

Valorie L. Thompson, Ph.D.
Principal

Jeff Steichen

From:	Kelly Broughton
Sent:	Tuesday, February 02, 2016 12:27 PM
To:	Jeff Steichen
Subject:	FW: Additional studies on health risks and living near a freeway
Attachments:	ehp.1408865.alt.pdf; ehp.1409430.alt.pdf

Here's the recent correspondence.

-----Original Message-----
From: Pamela Bensoussan [PBensoussan@chulavistaca.gov]
Received: Monday, 01 Feb 2016, 4:48PM
To: Gary Halbert [GHalbert@chulavistaca.gov]
CC: Kelly Broughton [kbroughton@chulavistaca.gov]
Subject: FW: Additional studies on health risks and living near a freeway

FYI - this just came in this afternoon. -PB

From: Laura Hunter [redacted]
Sent: Monday, February 01, 2016 3:01 PM
To: Pamela Bensoussan
Subject: Additional studies on health risks and living near a freeway

HI Pamela,
I know there has been a response to our letter but it is highly flawed. Here is just one quick follow up...here are two studies hot off the presses that discuss more health impacts from living near a freeway. The one about near-roadway pollution includes a statement that health risks from traffic will rise even as the level of exposure goes down, because the population will be aging – a response to the consultant's statement that health risks in 2035 will be less.

The other one is about kids and noise. I don't remember what the HRA says about noise and the extent to which it will be prevented by a sound wall. It just adds to our concerns about the lack of envl review and the lack of comprehensiveness of the analysis that was done.

Last the consultants site the need to rely on 'studies' but we cannot find any in the record that they are referring to.
More soon
Thanks
Laura

Near-Roadway Air Pollution and Coronary Heart Disease: Burden of Disease and Potential Impact of a Greenhouse Gas Reduction Strategy in Southern California

Rakesh Ghosh,[1] Frederick Lurmann,[2] Laura Perez,[3,4] Bryan Penfold,[2] Sylvia Brandt,[5] John Wilson,[6] Meredith Milet,[7] Nino Künzli,[3,4] and Rob McConnell[1] [1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA; [2]Sonoma Technology Inc., Petaluma, California, USA; [3]Swiss Tropical and Public Health Institute, Basel, Switzerland; [4]University of Basel, Basel, Switzerland; [5]University of Massachusetts Amherst, Amherst, Massachusetts; [6]Spatial Sciences Institute, Dana and David Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, California, USA; [7]California Department of Public Health, Richmond, California, USA
Background: Several studies have estimated the burden of coronary heart disease (CHD) mortality from ambient regional particulate matter ≤ 2.5 μm ($PM_{2.5}$). The burden of near-roadway air pollution (NRAP) generally has not been examined, despite evidence of a causal link with CHD. Objective: We investigated the CHD burden from NRAP and compared it with the $PM_{2.5}$ burden in the California South Coast Air Basin for 2008 and under a compact urban growth greenhouse gas reduction scenario for 2035. Methods: We estimated the population attributable fraction and number of CHD events attribut-able to residential traffic density, proximity to a major road, elemental carbon (EC), and $PM_{2.5}$ compared with the expected disease burden if the population were exposed to background levels of air pollution. Results: In 2008, an estimated 1,300 CHD deaths (6.8% of the total) were attributable to traffic density, 430 deaths (2.4%) to residential proximity to a major road, and 690 (3.7%) to EC. There were 1,900 deaths (10.4%) attributable to $PM_{2.5}$. Although reduced exposures in 2035 should result in smaller fractions of CHD attributable to traffic density, EC, and $PM_{2.5}$, the numbers of estimated deaths attributable to each of these exposures are

anticipated to increase to 2,500, 900, and 2,900, respectively, due to population aging. A similar pattern of increasing NRAP-attributable CHD hospitalizations was estimated to occur between 2008 and 2035. Conclusion: These results suggest that a large burden of preventable CHD mortality is attributable to NRAP and is likely to increase even with decreasing exposure by 2035 due to vulnerability of an aging population. Greenhouse gas reduction strategies developed to mitigate climate change offer unexploited opportunities for air pollution health co-benefits. Citation: Ghosh R, Lurmann F, Perez L, Penfold B, Brandt S, Wilson J, Milet M, Künzli N, McConnell R. 2016. Near-roadway air pollution and coronary heart disease: burden of disease and potential impact of a greenhouse gas reduction strategy in Southern California. Environ Health Perspect 124:193–200; http://dx.doi.org/10.1289/ehp.1408865

Near-Roadway Air Pollution and Coronary Heart Disease: Burden of Disease and Potential Impact of a Greenhouse Gas Reduction Strategy in Southern California

Rakesh Ghosh,[1] Frederick Lurmann,[2] Laura Perez,[3,4] Bryan Penfold,[2] Sylvia Brandt,[5] John Wilson,[6] Meredith Milet,[7] Nino Künzli,[3,4] and Rob McConnell[1]

[1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA; [2]Sonoma Technology Inc., Petaluma, California, USA; [3]Swiss Tropical and Public Health Institute, Basel, Switzerland; [4]University of Basel, Basel, Switzerland; [5]University of Massachusetts Amherst, Amherst, Massachusetts; [6]Spatial Sciences Institute, Dana and David Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, California, USA; [7]California Department of Public Health, Richmond, California, USA

Background: Several studies have estimated the burden of coronary heart disease (CHD) mortality from ambient regional particulate matter ≤ 2.5 μm ($PM_{2.5}$). The burden of near-roadway air pollution (NRAP) generally has not been examined, despite evidence of a causal link with CHD.

Objective: We investigated the CHD burden from NRAP and compared it with the $PM_{2.5}$ burden in the California South Coast Air Basin for 2008 and under a compact urban growth greenhouse gas reduction scenario for 2035.

Methods: We estimated the population attributable fraction and number of CHD events attributable to residential traffic density, proximity to a major road, elemental carbon (EC), and $PM_{2.5}$ compared with the expected disease burden if the population were exposed to background levels of air pollution.

Results: In 2008, an estimated 1,300 CHD deaths (6.8% of the total) were attributable to traffic density, 430 deaths (2.4%) to residential proximity to a major road, and 690 (3.7%) to EC. There were 1,900 deaths (10.4%) attributable to $PM_{2.5}$. Although reduced exposures in 2035 should result in smaller fractions of CHD attributable to traffic density, EC, and $PM_{2.5}$, the numbers of estimated deaths attributable to each of these exposures are anticipated to increase to 2,500, 900, and 2,900, respectively, due to population aging. A similar pattern of increasing NRAP-attributable CHD hospitalizations was estimated to occur between 2008 and 2035.

Conclusion: These results suggest that a large burden of preventable CHD mortality is attributable to NRAP and is likely to increase even with decreasing exposure by 2035 due to vulnerability of an aging population. Greenhouse gas reduction strategies developed to mitigate climate change offer unexploited opportunities for air pollution health co-benefits.

Citation: Ghosh R, Lurmann F, Perez L, Penfold B, Brandt S, Wilson J, Milet M, Künzli N, McConnell R. 2016. Near-roadway air pollution and coronary heart disease: burden of disease and potential impact of a greenhouse gas reduction strategy in Southern California. Environ Health Perspect 124:193–200; http://dx.doi.org/10.1289/ehp.1408865

Introduction

Emerging evidence suggests a causal link between near-roadway air pollution (NRAP) and coronary heart disease (CHD) mortality and morbidity (Gan et al. 2010, 2011; Hoffmann et al. 2006; Kan et al. 2008). The 2010 American Heart Association scientific statement on ambient particles noted that NRAP "as a whole appears to be a specific source associated with cardiovascular risk" (Brook et al. 2010). Since then, additional longitudinal studies have demonstrated consistent associations between NRAP and CHD, using traffic density, proximity to roadways, and a near-roadway pollutant surrogate, elemental carbon (Gan et al. 2010, 2011; Kan et al. 2008). Although the specific pollutants in NRAP responsible for health effects are not entirely clear, evidence suggests that NRAP effects are independent of those of particulate matter ≤ 2.5 μm ($PM_{2.5}$) (Hoffmann et al. 2006). However, in contrast to $PM_{2.5}$, there has been little examination of the NRAP-attributable disease burden. Furthermore, although regional PM levels have been declining in most of the United States over several decades (Motallebi et al. 2003) due to effective regulatory policy, some indicators of NRAP exposure such as vehicle miles traveled have increased markedly over the same period (U.S. Department of Transportation 2013). There is a need to assess the NRAP-attributable burden of disease.

We assessed the burden of CHD attributable to NRAP relative to $PM_{2.5}$ in Southern California, which has high regional $PM_{2.5}$ levels and a dense network of high-volume traffic corridors in close proximity to residences. We also estimated the CHD health co-benefits of California's landmark legislation (SB 375) to reduce greenhouse gas emissions (more than one-third of which come from cars and trucks) by 16% in 2035. The Southern California Association of Governments (SCAG) has developed a regional plan that aims to reduce per capita vehicle miles traveled, because this has substantial impact on greenhouse gas emissions (SCAG 2012a). This is to be accomplished with a land use development strategy designed to reduce the need for automobile travel by encouraging denser residential development in already developed urban areas that are served by public transport and by discouraging new development in currently undeveloped areas (SCAG 2012a). To support compact urban development conducive to walking and use of public transportation, transportation investment will focus on improving public transport by increasing service frequency and transit connections, and creating bicycle and pedestrian infrastructure. The California Air Resource Board's and the U.S. Environmental Protection Agency's (EPA) stricter vehicle exhaust emission standards, requirements for increased proportions of zero emission vehicles, and higher fuel economy standards are expected to substantially reduce future conventional and greenhouse gas emissions per mile of vehicle travel. We estimated the population exposure to NRAP and $PM_{2.5}$, which will be associated with implementation of these changes, and the corresponding pollution-attributable CHD.

Address correspondence to R. McConnell, 2001 N. Soto St., Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA 90089 USA. Telephone: (323) 442-1096. E-mail: rmcconne@usc.edu

Supplemental Material is available online (http://dx.doi.org/10.1289/ehp.1408865).

H. Kan provided helpful analytical advice. M. Raman assisted with the literature review.

This study was partially supported by funds from an air quality violations settlement agreement between the South Coast Air Quality Management District, a California state regulatory agency, and BP (British Petroleum). Other funding support included National Institutes of Health grants P01ES022845, P01ES011627, P30ES007048, and R01ES016535; U.S. Environmental Protection Agency grant RD83544101; and the Hastings Foundation (Pasadena, California).

F. Lurmann and B. Penfold are employed by Sonoma Technology Inc., Petaluma, California. The other authors declare they have no other actual or potential competing financial interests.

Received: 24 June 2014; Accepted: 15 June 2015; Advance Publication: 7 July 2015; Final Publication: 1 February 2016.

Methods

Concentration–response functions. There are only a few studies of associations of CHD mortality and hospitalization with NRAP conducted in North America and therefore more likely to be relevant to Southern California than studies from other parts of the world. We used concentration–response functions (CRF) from studies of two surrogates of NRAP exposure: traffic density and residential proximity to a major road (Table 1). The traffic density CRF was based on a four-communities study in the Midwestern and Eastern United States (Kan et al. 2008). We used a CRF for residential elemental carbon (EC), based on black carbon, derived from an administrative data set covering the entire Vancouver, Canada, population (Gan et al. 2011). (For estimating EC-attributable burden of disease, black carbon was converted to EC, as described in the Supplemental Material, "Methods.") EC is an indicator of diesel exhaust exposure in Southern California (Geller et al. 2005) and is commonly considered a near-roadway pollutant (Wu et al. 2009). EC may provide a lattice for toxicologically relevant metals and adsorbed organics that are inhaled deep into the lung (Bell et al. 2009; Janssen et al. 2012). We selected the CRF from the Vancouver study, because it was estimated from a network of measurements reflective of fine-scale spatial variation heavily influenced by roadway sources, and was derived for a similar age distribution and for CHD outcomes comparable to the CRFs for other NRAP indicators used in this analysis. For consistency, we used a CRF for proximity to a major road derived from the Vancouver study (Gan et al. 2010). For comparison with the NRAP effects, we also estimated the burden of regional $PM_{2.5}$ exposure, based on a CRF that is used in mortality risk assessment for regulatory purposes by the U.S. EPA (Krewski et al. 2009; U.S. EPA 2009).

Population data spatial allocation. The geographic domain for our study was California's South Coast Air Basin (SoCAB), comprising the southern part of Los Angeles County, western portions of Riverside and San Bernardino counties, and all of Orange County (Figure 1), a region with historically high air pollution levels. Data for the total population, households, land use, and boundary polygons of the legally defined real estate parcels were acquired from the regional planning agency, SCAG, for 2008. The population and household data were spatially resolved in approximately 11,000 travel activity zones (TAZs) that are used in the agency's travel demand models (SCAG 2012b). The TAZ populations were assigned to residential-zoned parcels within each TAZ. If all parcels within a TAZ were single-family residences, the population per household was assigned uniformly. If all parcels within a TAZ were multi-family residences, the parcel populations were apportioned based on parcel areas. If both existed, the single-family residence parcels were assigned the county-average number of persons per household, and the remainder of the TAZ population was assigned based on the areas of the multi-family parcels. The population was assumed to reside at the centroid of the land parcel, which is more accurate than traditional methods of locating population at census-block centroids or block-group centroids.

We estimated the 2035 population distribution based on the 2035 scenario of the Sustainable Communities Strategy of the regional transportation plan that was designed to maximally reduce greenhouse gas emissions in Southern California (SCAG 2012a). The population and number of households by TAZ were acquired from SCAG along with the General Plan land use for future development areas (SCAG 2012a). The population assignment method for existing parcels was the same for 2035 as 2008. To avoid assigning large populations to the center of large areas designated for future residential growth in the General Plan, we used a grid-like approach to define potential new parcels near existing and future roadways, and to apportion the future population to these parcels. The result of this procedure was total population estimates for about 4 million existing and potential new parcels in the SoCAB in 2008 and 2035.

Because the epidemiological studies of effects of air pollution on CHD were consistently conducted on the population ≥ 45 years of age, we estimated the 2008 and 2035 parcel populations in this age group using the relative age distributions from the 2010 Census tract data and 2035 county-level projection, respectively, obtained from the California Department of Finance (2013).

CHD mortality and hospitalization. Cause-specific mortality and hospitalization for 2008 were available by ZIP code from the California Department of Public Health by age group (45–54, 55–64, 65–74, 75–84, and ≥ 85 years). Deaths in *International Classification of Diseases, 10th Revision* (ICD-10) codes I20–I25, based on those used in the studies from which the EC and proximity to a major road CRFs were derived (Gan et al. 2010, 2011), were used to estimate CHD mortality rates for the population aggregated to the ZIP code level. We used these same ICD outcomes and rates in estimating the traffic density–attributable deaths, even though the CRF for traffic density was obtained from a study that included additional

Table 1. Study characteristics and the concentration–response functions (CRF) used in the attributable fraction estimation.

Study characteristics	Kan et al. 2008	Gan et al. 2010	Gan et al. 2011		Krewski et al. 2009
			Hospitalizations	Mortality	
Geographic area	Forsyth, NC; Jackson, MS; Minneapolis, MN; Washington, MD, USA	Vancouver, Canada	Vancouver, Canada	Vancouver, Canada	USA (nationwide)
Study year	Recruitment 1987–1989, Follow-up through 2002	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	Exposure 1999–2000, follow-up 1982–2000
Mean age (± SD) range (years)	55.8 ± 5.6 45–64	58.7 ± 10.4 45–83	58.7 ± 10.4 45–83	58.7 ± 10.4 45–83	56.5 ± 10.5
Exposure	Traffic density count per day[a] (per 1 log unit)	Residence ≤ 150 m from a highway or ≤ 50 m from a major road compared with all others	Black carbon[a] (per 0.94×10^{-5}/m)	Black carbon[a] (per 0.94×10^{-5}/m)	$PM_{2.5}$ (per 10 μg/m³)
n (cases)	13,309 (976 deaths)	414,793 (3,133 deaths)	452,735 (10,312 hospitalizations)	452,735 (3,104 deaths)	488,370 (29,989 deaths)
Outcome	Myocardial infarction/coronary revascularization/CHD death[b]	CHD mortality[c]	CHD hospitalizations[c]	CHD mortality[c]	CHD mortality[d]
CRF[e] (95% CI)	1.03 (mortality) (1.01, 1.05)	1.29 (mortality) (1.19, 1.41)	1.03 (hospitalization) (1.01, 1.05)	1.06 (mortality) (1.03, 1.09)	1.15 (mortality) (1.13, 1.20)

[a]Traffic density values were proportional to proximity-weighted vehicles per day where one density unit corresponded to 295 vehicles per day at 10 m from the roadway. It declines linearly with distance to zero vehicles per day at 300 m from the roadway. Black carbon scaled to interquartile-range increase in absorbance. [b]ICD-9 codes 402, 410–414, 427, 423, 518.4; ICD-10 codes E10–14, I10–I1, I21–25, I45–51, I70, I97, J81, J96, R96, R98–99. [c]ICD-9 codes 410–414, 429.2; ICD-10 codes I20–I25. [d]ICD-9 codes 410–414. [e]Estimates are hazard ratios (95% CIs), which were scaled to the population-weighted mean exposures for 2008 and 2035 and used in the attributable fraction calculation.

ICD codes (E10–14, I10–11, I46–51, I70, I97, J81, J96, R96, R98–99) (Kan et al. 2008). Although using the reduced number of ICD codes likely resulted in underestimated traffic density–attributable CHD deaths, it made it possible to compare the traffic density estimates with those for EC and proximity to major road. Hospitalizations for ICD-9 (*9th Revision*) codes 410–414 and 429.2 were used to calculate CHD hospitalization rates (Gan et al. 2011).

Because the projected 2035 age distribution was available only at the county level, the 2008 age-specific mortality and hospitalization rates were aggregated to the county level and applied to the projected 2035 age-specific population in each SoCAB county to estimate the corresponding death and hospitalization counts (and rates in the ≥ 45-year age group) in 2035. Because SoCAB comprises only a portion of some counties, this calculation assumed that the projected 2035 population age distribution for the geographic portion of each county in the SoCAB will be the same as that of the entire county. The estimates of mortality and hospitalization also assumed that the age-specific rates in 2008 will be the same in 2035.

Exposure assessment. The approach for exposure assessment involved characterization of near-road exposures using traffic density and traffic proximity markers and applications of regional- and local-scale air quality dispersion models to estimate parcel level annual average EC and $PM_{2.5}$ mass concentrations. Regional exposure across Southern California was estimated using the Community Multiscale Air Quality model, version 4.7.1 (http://www.epa.gov/scram001/) (Carter 2000), and the Weather Research and Forecasting model version 3.3 meteorological fields (http://www.wrf-model.org/). The model analyses were conducted for a large Southern California domain extending from 160 km west of the port of Los Angeles to the Colorado River in the east, and from Bakersfield in the north to 100 km south of San Diego in the south. Model simulations were run by the South Coast Air Quality Monitoring District as part of the Air Quality Management Plan (SCAQMD 2013). The domain was spatially resolved using 4 km × 4 km horizontal grids and 18 vertical layers. Model simulations were run by the South Coast Air Quality Monitoring District as part of the Air Quality Management Plan (SCAQMD 2013). Annual conditions were simulated for a 2008 baseline and for 2035 with the regional transportation plan elements (SCAG 2012a). The emissions and meteorological inputs, modeling procedures, outputs, and model performance are described elsewhere [SCAQMD (2013), Appendices V and VI]. The regional model's gridded estimates for annual average EC and $PM_{2.5}$ mass concentrations were assigned to all parcels with centroids within each 4 × 4 km grid.

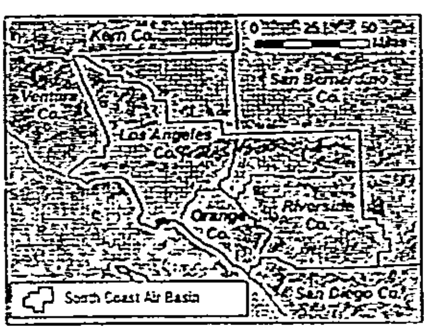


Figure 1. Geographical coverage of the study area is shown by the thick black border. Thin blue lines show the county boundaries and the coastline.

Because regional models cannot resolve local pollutant gradients near roadways, a line source dispersion model, Caline4 (Benson 1992), was applied to characterize the local-scale impacts of on-road mobile source EC emissions from roads within 2 km of each parcel. The Caline4 model's estimates of annual average EC incremental concentrations from local roadway sources were superimposed on the regional model estimates for each parcel. The Caline4 model was applied using local surface wind data from the nearest monitoring station, light-duty and heavy-duty vehicle emission factors from the EMFAC2011 model (CARB 2011, 2013b), and roadway geometry and annual average traffic volumes from the SCAG travel-demand model.

The SCAG travel-demand model for roadways was used to simulate traffic for the 2008 baseline and 2035 future scenario with the regional transportation plan control measures (SCAG 2012b). The model uses geographically accurate roadway locations for freeways and expressways (group 1), major arterials (group 2), and minor arterials and major collectors (group 3). Each travel direction was represented separately for large roads, and the smaller roads were bidirectional. SCAG developed separate traffic demand models and traffic volumes for light-duty and heavy-duty vehicles on all roadway links. Average daily traffic volumes were determined by aggregating the simulated traffic volumes for morning, midday, afternoon, evening, and nighttime traffic. SCAG applied the models to simulate traffic for the 2008 baseline and 2035 future year with the regional transportation plan control measures. The estimated future emission inventory included growth and emission controls based on the South Coast Air Quality Monitoring District's Air Quality Management Plan (SCAQMD 2013) and SCAG's regional transportation plan (SCAG 2012a).

Other exposure markers were the distance to nearest roads and traffic density. The distances from the center of each residential parcel to the nearest road in groups 1–2 (freeway or major arterial) were computed using ESRI's ArcGIS tools. This is consistent with the CRF corresponding to the distance to freeways or major roads marker (150 m from the closest freeway or 50 m from the closest major road) (Gan et al. 2010).

The traffic density marker represents distance-decayed annual average daily traffic volume surrounding each residential parcel location. The SCAG roadway geometry and link-based traffic volumes were used with a ArcGIS density function that linearly decayed traffic volumes from 100% at the roadway centerline to 10% at 300 m perpendicular to the roadway. This decay rate is consistent with the observed primary pollutant concentration gradients near roadways (Karner et al. 2010; Zhu et al. 2002, 2006). The traffic density beyond the 300-m radius buffer was assigned a value of zero. Because the marker was initially developed for CHD and traffic density CRF in 1987–1989 (Kan et al. 2008), and vehicle emission rates per kilometer of travel have declined substantially since this time period, the traffic density marker was adjusted based on the EMFAC2011 model (CARB 2013a) estimates of the changes in fleet average $PM_{2.5}$ emission rates between 1989 and 2008 (–62.1%) and projected for 2035 (–76.4%).

Using the modeled exposures for each of the three continuous exposures (traffic density, EC, and $PM_{2.5}$), the population-weighted mean exposure was calculated by multiplying the population ≥ 45 years of age in each parcel with the exposure assigned to that parcel (p_i). The summation of this product over all parcels was divided by the total population, as shown in Equation 1 (by county and for the entire SoCAB).

Population-weighted mean exposure =

$$\frac{\sum_{p_i=1}^{n} \left(Population_{p_i} \times Exposure_{p_i} \right)}{\sum Total\ population}. \qquad [1]$$

Attributable burden estimation. For the population ≥ 45 years, we estimated the CHD population-attributable fraction (PAF) due to residential proximity to major roadways in 2008 and 2035 based on the proportion exposed (p_{exp}) and the corresponding CRF from the original study, in the standard PAF formula (Equation 2).

$$PAF = p_{exp}(CRF - 1) / [p_{exp}(CRF - 1) + 1]. \qquad [2]$$

Traffic density, EC, and $PM_{2.5}$ CRFs (Table 1) were originally reported per 1 log unit (proximity-weighted vehicles per day), per 1 interquartile range (IQR = 0.94×10^{-5}/m of black carbon reflectance), or per 10 μg/m^3, respectively. The population-weighted mean exposure estimated using Equation 1 was divided by the respective IQR (EC) or 10 μg/m^3 ($PM_{2.5}$) and this value was used to rescale the CRF to the population-weighted mean value by exponentiation (Equation 3). EC (micrograms per cubic meter) was converted to black carbon (10^{-5}/m) to match with the original CRF. (See Supplemental Material, "Methods.")

$$CRF_{\text{population-weighted mean exposure}} = (CRF_{\text{per unit exposure}})^{\text{population-weighted mean exposure}} \quad [3]$$

Because the PAFs for traffic density, EC, and $PM_{2.5}$ were calculated for a population-weighted mean exposure for the entire population, the proportion exposed (p_{exp}) in Equation 2 becomes unity and Equation 2 reduces to Equation 4:

$$PAF = (CRF - 1)/CRF. \quad [4]$$

We selected a background level above which the impact was quantified. For EC and $PM_{2.5}$, PAFs were estimated for the reduction of the population-weighted mean levels to background levels of 0.12 and 5.6 μg/m^3, respectively, based on measurements in a clean Central California coastal community (Lompoc) for the period 1994–2001 (Peters et al. 2004). Previous studies used similar background levels and methodology (Anenberg et al. 2010; Evans et al. 2013). Because traffic is entirely anthropogenic, the background level for traffic density was 1.0, as increased CHD risk (Table 1) was only observed at exposures > 1 (log traffic density of zero).

The 2008 and 2035 attributable numbers were estimated by multiplying the population ≥ 45 years by the CHD mortality or hospitalization rates and the PAF (Equation 5).

$$\text{Population-attributable number}_{\text{mortality/hospitalization}} = \text{Population}_{\geq 45} \times \text{Rate}_{\text{mortality/hospitalization}} \times \text{PAF}_{\text{mortality/hospitalization}}. \quad [5]$$

We calculated the PAF and the attributable number for the portion of each county within the SoCAB and also for the entire SoCAB region. The PAF and the attributable number for the distance to roadways marker of NRAP exposure can be interpreted as the proportion and number of deaths, respectively, that could be prevented if no one lived within 150 m from a freeway or 50 m from a major road. For EC and $PM_{2.5}$, the PAF (or number of attributable events) can be interpreted as the proportion (number) that could be prevented if the population-weighted mean exposures were reduced to background levels.

To distinguish the impact of the projected change in exposure in 2035 from the impact of the projected change in the population age distribution in 2035, we estimated the attributable events for 2035 for a hypothetical scenario in which the 2008 age distribution were applied to the 2035 population.

Statistical uncertainty analysis. We constructed the 95% uncertainty interval (UI) around the point estimates accounting for the uncertainty in each of the parameters used to calculate the PAF, as suggested by Greenland (2004). The UI for the traffic density, EC, and $PM_{2.5}$ PAF was calculated by incorporating the uncertainty of the rescaled CRF, that is, the hazard ratio exponentiated to the population-weighted mean. The UI for the proximity PAF was estimated accounting for the uncertainty in both parameters (proximity CRF and the proportion exposed).

Results

The total SoCAB population was 15.5 million in 2008 and is projected to increase by approximately 3 million in 2035. However, the proportion ≥ 45 years at risk for CHD is expected to increase from 35% in 2008 to 43% in 2035 (Table 2). As a result, the increase in the CHD mortality rates, which reflect the change in the population age distribution, are projected to increase disproportionately with the population increase, from 3.4 to 4.9 deaths per 1,000 population. SoCAB CHD hospitalization rates are projected to increase from 8.9 per 1,000 in 2008 to 11.3 per 1,000 in 2035.

Annual average population-weighted traffic density was markedly skewed (see Supplemental Material, Figure S1a). The median 2008 traffic density was 14.4 (IQR = 3.9–30.1), after correcting for the fleet average $PM_{2.5}$ emission reduction, and is projected to decrease to 11.6 (IQR = 4.1–22.3) in 2035 (from geometric mean of 10.8 in 2008 to 9.3 in 2035). In contrast, the proportion of the population living within 150 m from a freeway or 50 m from a major road is expected to increase from 8.3% to 10.9% from 2008 to 2035 (see Supplemental Material, Figure S1b). The mean (± SD) population-weighted EC level was 1.1 ± 0.4 μg/m^3 in 2008 and is expected to decrease to 0.7 ± 0.3 μg/m^3 in 2035 (see Supplemental Material, Figure S1c). The corresponding medians for the two periods were identical to the mean, 1.1 μg/m^3 (IQR = 0.8–1.4) and 0.7 μg/m^3 (IQR = 0.5–0.9), respectively. (The anticipated decrease is primarily due to the expected reduction of EC emissions from diesel-fueled vehicles.) The population mean $PM_{2.5}$ exposure was 13.2 ± 4.2 μg/m^3 in 2008, and is projected to decrease to 10.9 ± 3.7 μg/m^3 in 2035 (see Supplemental Material, Figure S1d).

In 2008, an estimated 6.8% (95% UI: 2.4, 11.0) of the total CHD deaths among the population ≥ 45 years could be attributed to traffic density (Figure 2A). The PAF is expected to decrease to 6.4% (95% UI: 2.2, 10.3) in 2035, reflecting the expected decrease in population-weighted traffic density. The estimated 2008 PAF for residential distance of ≤ 150 m from freeways or ≤ 50 m from major roadways (2.4%; 95% UI: 1.4, 3.3) was smaller than the PAF for either traffic density or EC, but was projected to increase in 2035 to 3.1% (95% UI: 2.1, 4.0), reflecting the increase in proportion living close to major roadways. Based on estimated burden of EC exposure, 3.7% (95% UI: 1.9, 5.5) of the total CHD deaths in the ≥ 45 years age group in 2008 could have been prevented if the population-weighted mean EC exposure levels had been at the background level of 0.12 μg/m^3 instead of 1.1 μg/m^3. Decreasing population-weighted mean EC level is expected to result in decreased PAF to 2.3% in 2035 (95% UI: 1.2, 3.4). The estimated regional $PM_{2.5}$ PAF was 10.4% (95% UI: 7.8, 12.9) in 2008 and is projected to fall to 7.5% (95% UI: 5.6, 9.3) in 2035.

Based on the NRAP PAFs for traffic density, an estimated 1,300 (95% UI: 440, 2,000) preventable deaths occurred in 2008, and 2,500 (95% UI: 860, 4,000) preventable deaths will occur in 2035 due to traffic density within 300 m of residences (Figure 2B). This large future increase is due to the projected increase in population, specifically to the disproportionate increase in the aging population at risk of CHD. This effect can be quantified using the hypothetical 2035 scenario

Table 2. Population ≥ 45 years and coronary heart disease (CHD) mortality and hospitalization rates overall for the South Coast Air Basin and by counties for 2008 and projected for 2035.

County	Population[a] ≥ 45 years (%)[b]		CHD mortality (per 1,000)		CHD hospitalizations (per 1,000)	
	2008	2035	2008	2035	2008	2035
Los Angeles	3,321,703 (35.4)	5,189,815 (44.8)	3.7	5.0	9.1	10.7
Orange	1,085,184 (37.3)	1,501,496 (45.1)	2.6	4.4	6.8	9.7
Riverside	554,656 (33.0)	768,170 (40.6)	4.1	4.5	13.3	13.1
San Bernardino	456,992 (31.6)	672,435 (40.3)	2.2	5.4	8.1	13.8
Total	5,428,535 (35.1)	8,005,152 (43.3)	3.4	4.9	8.9	11.3

[a]Population is for the portion of the county that is within the South Coast Air Basin boundary, except for Orange County where the entire county is within the air basin. [b]Percentage of the total (all ages) population.

in which the total population was increased as projected but was assigned the 2008 age distribution (essentially keeping the overall mortality rate unchanged). Under this hypothetical scenario, a much smaller number of deaths (1,700; 95% UI: 600, 2,800) would be attributable to traffic density. Based on the PAF for residential major road proximity (≤ 150 m from a freeway or ≤ 50 m from another major road), there were 430 preventable CHD deaths (95% UI: 270, 600) in 2008 and a projected 1,200 (95% UI: 820, 1,600) in 2035, compared with 830 (95% UI: 570, 1,100) that would be anticipated if the 2035 age distribution were the same as in 2008. For EC, 690 CHD deaths were attributable to exposure above background levels (95% UI: 360, 1,000) in 2008, about half of the estimated traffic density–attributable deaths but more than 1.5 times the major road proximity–attributable deaths. The EC-attributable deaths were also projected to increase less than that for traffic density, to 900 (95% UI: 470, 1,300) in 2035. Most of the estimated increase attributable to EC is due to the aging population structure rather than just the increase in population, which by itself would result in a small decrease in deaths to 630 (95% UI: 330, 920) because the population-weighted exposure is projected to decrease over time. About 1,900 deaths (95% UI: 1,400, 2,400) in 2008 were estimated to be attributable to regional $PM_{2.5}$. A substantial increase to 2,900 (95% UI: 2,200, 3,600) is expected in 2035, despite a 25% decrease in PAF, due to the change in population and age distribution. In the hypothetical scenario in which only the population increases in 2035 without any change in age distribution, the $PM_{2.5}$-attributable deaths would still increase to 2,000 (95% UI: 1,500, 2,500).

The overall pattern of changing exposure and NRAP-attributable CHD was generally similar across all SoCAB counties. Traffic density and EC levels were highest in Los Angeles County and lowest in Riverside County and are projected to decrease in all four counties from 2008 to 2035. (see Supplemental Material, Table S1). In contrast, the proportion living near a major road is projected to increase in all counties during the same period. Los Angeles County consistently had the highest estimated PAF and Riverside County the lowest based on each exposure in both 2008 and in 2035 (see Supplemental Material, Table S2). The estimated population-attributable number was consistently highest in Los Angeles (see Supplemental Material, Table S3), but traffic density–, EC-, and $PM_{2.5}$-attributable numbers were each lowest in San Bernardino in 2008 and are expected to increase markedly by 2035, reflecting anticipated population increase under the compact urban development scenario.

The estimated PAF for CHD hospitalization attributable to EC exposure in the SoCAB was 1.9% (95% UI: 0.7, 3.1) in 2008, and is expected to decline to 1.2% (95% UI: 0.4, 1.9) in 2035 (see Supplemental Material, Table S4). The corresponding attributable number of hospitalizations was 920 (95% UI: 320, 1,500) for 2008 and is expected to increase slightly to 1,100 (95% UI: 380, 1,700) in 2035 after accounting for increases in population and hospitalization rate in an aging population. If the 2008 age distribution were applied to the 2035 population, the hypothetical number of hospitalizations might be expected to decrease to 840 (95% UI: 300, 1,400). The projected pattern of change over time in the county-specific estimates was generally similar to that for the entire SoCAB.

Discussion

This study is one of the first risk assessments of CHD mortality and hospitalization attributable to NRAP markers and the first, to our knowledge, to project future estimates of the burden in a large metropolitan region. Estimates of the 2008 preventable CHD mortality due to NRAP among the ≥ 45 years population in the SoCAB varied from 2.4% (430 deaths), based on effects of residential proximity to a major road, to 6.8% (1,300 deaths), based on emissions-weighted traffic density. The traffic density–related burden in 2008 was about two-thirds the burden (10.4%, 1,900 deaths) attributable to regulated regional $PM_{2.5}$. Thus, to the extent that NRAP and $PM_{2.5}$ effects are independent, because regional $PM_{2.5}$ does not characterize the sharp gradient in effects of the near-roadway pollutant mixture, a risk assessment based on $PM_{2.5}$ alone is likely to be a substantial underestimate of the true pollution-attributable CHD mortality. The 2035 greenhouse gas reduction–planning scenario is projected to result in reduced population exposure and reduced PAF for $PM_{2.5}$, traffic density, and EC (but not for residential proximity to major roadways). However, a surprising finding was that the attributable number of CHD deaths due both to $PM_{2.5}$ and to each NRAP exposure, even under the optimistic planning scenario considered, is

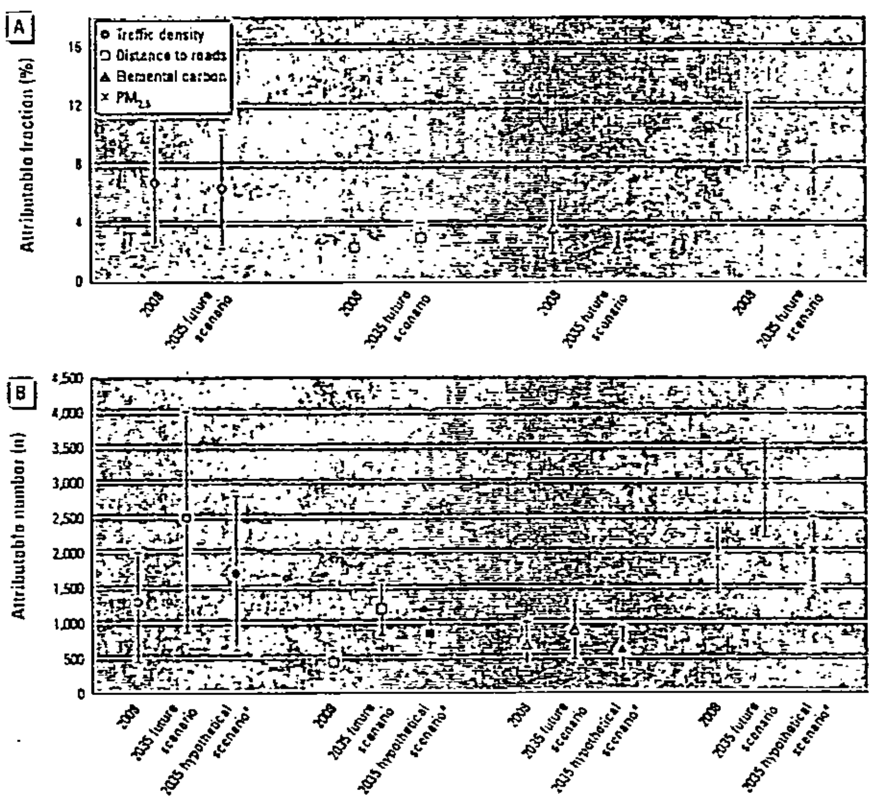


Figure 2. Population-attributable fractions (*A*) and population-attributable numbers (*B*) and 95% uncertainty intervals for coronary heart disease mortality in the South Coast Air Basin in 2008 and 2035,[a] attributed to traffic density within 300-m buffer from residence, residential distance to nearest freeway (≤ 150 m) or major road (≤ 50 m), elemental carbon, and regional $PM_{2.5}$ above background levels of 1 for traffic density, 0% for proximity, 0.12 μg/m³ for EC, and 5.6 μg/m³ for $PM_{2.5}$. Population-weighted mean exposures in 2008 and 2035 were 10.8 and 9.3 for traffic density, 1.1 and 0.7 μg/m³ for EC, and 13.2 and 10.9 μg/m³ for $PM_{2.5}$, respectively.
[a]Population-attributable number that might be expected in 2035 if the age distribution of the 2035 population were the same as in 2008.

expected to increase substantially by 2035, largely due to vulnerability of an aging population. The proportion ≥ 65 years, at highest risk of CHD (Ford and Capewell 2007), is projected to double over the next two decades.

These results have important implications for health and urban planning policy. CHD accounts for most of the mortality attributable to $PM_{2.5}$ levels in excess of the national standard (12 μg/m³) and therefore for the largest pollution-attributable annual economic costs, approximately $4.6 billion (adjusted to 2014 using the U.S. Bureau of Labor Statistics Consumer Price Index inflation calculator) (U.S. EPA 2013). Accounting for the effects of NRAP is likely to markedly increase estimates of economic cost of pollution. The increasing population-attributable number due to an aging population means that additional hospital beds and other health facilities will be needed for CHD treatment.

National air pollution regulations already adopted will have impacts over the next 20 years; examples include Tier-2 and Tier-3 vehicle standards (U.S. EPA 2014), and non-road diesel requirements (U.S. EPA 2004). These and the likely ongoing evolution of control technology requirements will contribute to reduced $PM_{2.5}$ and EC emissions, and likely will reduce the impact of roadway proximity and traffic density (CRC 2013). We have not estimated the impact specific to greenhouse gas–reduction measures, independent of other pollution-reduction strategies. However, our results suggest that there are as yet unexploited opportunities for health benefits that would result from regulation of NRAP, and that additional health co-benefits could be obtained from the 2035 greenhouse gas reduction–planning process. The 2035 compact growth scenario used for this study will promote urban redevelopment with multifamily homes in corridors with good public transport to reduce reliance on private automobiles. The plan will promote investment in bicycling and walking infrastructure, and assumes that there will be increased vehicular fleet fuel efficiency and reduced emissions. However, if this planning scenario increases the population exposed to NRAP by placing people closer to busy roadways, they may be put at increased CHD risk, unless vehicle emissions were to decrease more substantially than currently anticipated. Variants on the planning scenario, such as policies to develop a zero- or close-to-zero-emission vehicle fleet, could optimize health co-benefits of greenhouse gas reduction. Another approach might be to encourage buffers between major traffic corridors and high-density development through zoning and other land use policies. Because markers for the NRAP mixture decrease sharply with distance to traffic, buffers of even a few 10s to 150 m are likely to decrease markedly the exposure and associated population burden of CHD morbidity and mortality, particularly for the elderly.

There are uncertainties in the estimates. The statistical uncertainty intervals are large. The estimated attributable burden also varied depending on the marker for NRAP. The 2008 traffic density–attributable CHD mortality was largest (6.8%) and the major roadway proximity-attributable mortality was smallest (2.4%). The traffic density burden was based on a CRF that used continuous exposure and accounted for volume of vehicles on all nearby roadways (Kan et al. 2008), and it was corrected for changing vehicles emissions over time. The smaller burden estimated from major roadway proximity might be expected because the CRF was based on a dichotomous classification that does not account for these factors (Gan et al. 2010), and therefore is the crudest surrogate for the NRAP mixture. Neither of these exposures accounts for meteorology and dispersion of a biologically relevant traffic pollutant such as EC, for which the number of attributable deaths in 2008 (n = 690) was between that for major roadway proximity exposure (n = 430) and traffic density (n = 1,300). EC had the smallest increase in 2035 NRAP-attributable mortality (which would be expected to decline if the population were not aging). The smaller EC-attributable burden in 2035 was due to an anticipated cleaner burning diesel vehicle fleet. EC- (and $PM_{2.5}$-) attributable burden were also based on an assumption that no CHD effects would occur below background levels of 0.12 μg/m³ (EC) and 5.6 μg/m³ ($PM_{2.5}$), which may have resulted in an underestimated burden.

EC is a toxicologically relevant component of particulate matter (Janssen et al. 2012) substantially influenced by pollution from heavy duty (diesel) vehicles in Southern California (Manchester-Neesvig et al. 2003). In this study, the estimated parcel level EC exposure used in calculating the burden accounted for the influence of meteorology on dispersion from local roadways, unlike the other two NRAP markers. However, the estimated EC exposure included both transported and local NRAP EC. Most (~ 90%) of the total EC exposure was regional and was common to all parcels in each 4 km × 4 km EC exposure grid. Thus, the estimated burden for EC reflected both regional and near-roadway effects, and EC effects may not be entirely independent of the burden assigned to the $PM_{2.5}$ pollution, modeled solely on the regional scale. Therefore, the simple addition of the EC- and $PM_{2.5}$-attributable events may overestimate the effect of these pollutants. It is difficult to assess the degree of such double counting, as there has been little study of the joint effects of exposure to EC and $PM_{2.5}$ and the extent to which their effects are independent.

The uncertainty of the estimates based on future exposure scenario is likely to be greater than for the current estimates. For example, we corrected the traffic-density CRF based on an assumption that the effect of each vehicle exposure would decline in proportion to the decrease in fleet average $PM_{2.5}$ vehicle emission rates per kilometer of travel since the original epidemiological study was conducted, equivalent to 15% from 2008 to 2035. The cruder traffic proximity exposure indicator was not adjusted for changes in vehicular emissions and therefore may overestimate the effect of this indicator. Alternatively, the proximity-attributable burden may reflect effects not scalable to changes in PM mass—for example, if the more toxic components of the mixture of fresh vehicular emissions changed to a different proportion than $PM_{2.5}$ mass, or if components of resuspended road dust that might not change at all were the relevant hazard (Schwartz 1999). The uncorrected traffic density is actually projected to increase (by 6.5%) from 2008 to 2035, as is the population living near a major road [from 8.3% to 10.9% (see Supplemental Material, Figure S1b)]. Because the burden and costs of NRAP are large, additional research is warranted to reduce these sources of uncertainty.

Another important assumption is that the age-specific CHD rates will remain unchanged from 2008 to 2035. CHD mortality rates have fallen markedly over the last several decades in the United States (Ford et al. 2007) due to several factors. However, increased prevalence of obesity and its metabolic consequences are likely to slow this decline in CHD mortality rates and could potentially reverse them. Therefore, it is difficult to quantify the net impact of these trends on the estimates of NRAP-attributable burden of disease.

A limitation to the comparison of the NRAP- and $PM_{2.5}$-attributable burden of CHD is that the original source CRFs were estimated for different age distributions. The $PM_{2.5}$ CRF was developed for a population ≥ 30 years (Krewski et al. 2009), which we assigned to the population ≥ 45 years in order to be comparable to the population for the CRFs for all three indices of NRAP (Gan et al. 2010, 2011; Kan et al. 2008). $PM_{2.5}$-attributable burden was considerably larger if applied to ≥ 30 years age group (3,100 fatal CHD events in 2008, e.g., compared with the 1,900 estimated based on the population ≥ 45 years). The larger estimate is generally consistent with other studies examining the burden of $PM_{2.5}$-attributable CHD mortality statewide (CARB 2010). If the CRFs for NRAP were applied to the population ≥ 30 years, the estimated burden also increased markedly (data not shown). We have elected to use the common NRAP CRF age distribution for all estimates because NRAP is the exposure of primary interest. However, the estimated burden for both NRAP and $PM_{2.5}$ restricted to the ≥ 45 year population is likely to be conservative.

Traffic-related noise has been associated with CHD, but whether it confounds, mediates, or interacts with near-roadway pollution is unclear (Fritschi et al. 2011). A recent review suggested that the two are likely independent risk factors of CHD (Davies and Kamp 2012), but this conclusion was based on only four studies. The CRFs we used were not adjusted for noise, so the near-roadway pollution-attributable burden could be independent or partially overlapping with the noise burden.

The health benefit from reduction in NRAP is unlikely to be limited to reductions in CHD mortality. We have not estimated burden of NRAP-attributable mortality associated with other outcomes, such as stroke and chronic obstructive pulmonary disease in the elderly, for which the causal relationships are less clear (HEI 2010). However, asthma and asthma exacerbation in children are likely caused by NRAP and have a large associated burden (Perez et al. 2012).

We calculated the PAF using the standard PAF formula (Equation 2). However, this estimate may be biased in the presence of confounding by characteristics in the study from which the CRF is derived if these covariates are not available for the target population (Darrow and Steenland 2011). There was little confounding of the CRFs for traffic density and EC by available covariates in the studies from which they were derived (Gan et al. 2011; Kan et al. 2008). However, the crude CRF associated with living near a major road was 1.69 and reduced to 1.29 after adjusting for confounders (age, sex, socioeconomic status, and co-morbidities) (Gan et al. 2010). These covariates are not available in our Southern California population data set. However, for a crude CRF/adjusted CRF of 1.69/1.29 (i.e., 1.3) and an exposure prevalence of 8.3% (the proportion of the 2008 SoCAB population living near a major road), our estimated traffic proximity PAF is likely to underestimate the true proximity PAF (Darrow and Steenland 2011).

Our results are likely to be relevant to other large North American cities with dispersed populations and high traffic volumes. We conclude that *a*) air pollution–attributable burden of CHD mortality may have been underestimated in most existing $PM_{2.5}$-based risk assessments because they ignore NRAP effects, *b*) greenhouse gas–reduction planning offers additional opportunities for improving future cardiac health, if the NRAP risks are mitigated, and *c*) NRAP- (and $PM_{2.5}$-) attributable CHD is likely to increase even if population exposure is reduced because of increased vulnerability of an aging population.

References

Anenberg SC, Horowitz LW, Tong DQ, West J. 2010. An estimate of the global burden of anthropogenic ozone and fine particulate matter on premature human mortality using atmospheric modeling. Environ Health Perspect 118:1189–1195; doi:10.1289/ehp.0901220.

Bell ML, Ebisu K, Peng RD, Samet JM, Dominici F. 2009. Hospital admissions and chemical composition of fine particle air pollution. Am J Respir Crit Care Med 179:1115–1120.

Benson PE. 1992. A review of the development and application of the CALINE3 and 4 models. Atmos Environ 26:379–390.

Brook RD, Rajagopalan S, Pope CA III, Brook JR, Bhatnagar A, Diez-Roux AV, et al. 2010. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. Circulation 121:2331–2378; doi:10.1161/CIR.0b013e3181dbece1.

California Department of Finance. 2013. Report P-2: State and County Population Projections - Race/Ethnicity and 5-Year Age Groups, 2010–2060 (by Year). Available: http://www.dof.ca.gov/research/demographic/reports/projections/P-2/ [accessed 10 September 2013].

CARB (California Environmental Protection Agency California Air Resources Board). 2010. Estimate of Premature Deaths Associated with Fine Particle Pollution ($PM_{2.5}$) in California Using a U.S. Environmental Protection Agency Methodology. Available: http://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf [accessed 5 January 2014].

CARB. 2011. EMFAC2011-HD User's Guide. Sacramento, CA:CARB. Available: http://www.arb.ca.gov/msei/emfac2011-hd-users-guide-final.pdf [accessed 5 February 2013].

CARB. 2013a. EMFAC2011 Technical Documentation. Available: http://www.arb.ca.gov/msei/emfac2011-documentation-final.pdf [accessed 17 October 2014].

CARB. 2013b. EMFAC2011-LDV User's Guide. Sacramento, CA:CARB. Available: http://www.arb.ca.gov/msei/emfac2011-ldv-users-guide-final.pdf [accessed 5 February 2013].

Carter WP. 2000. Documentation of the SAPRC-99 Chemical Mechanism for VOC Reactivity Assessment. Final Report to California Air Resources Board, Contract No. 92-329 and (in Part) 95-308. Available: http://www.engr.ucr.edu/~carter/pubs/s99doc.pdf [accessed 5 February 2013].

CRC (Coordinating Research Council Inc). 2013. Effects of Light-Duty Vehicle Emissions on Ozone and PM With Past, Present, and Future Controls: Tier 0 versus Other Scenarios. CRC Report No. A-76-2. Alpharetta, GA:Coordinating Research Council Inc. Available: http://www.crcao.org/reports/recentstudies2013/A-76-2/CRC Project A76-2 Final Report.pdf [accessed 1 April 2013].

Darrow LA, Steenland NK. 2011. Confounding and bias in the attributable fraction. Epidemiology 22:53–58.

Davies H, Kamp IV. 2012. Noise and cardiovascular disease: a review of the literature 2008–2011. Noise Health 14:287–291.

Evans J, van Donkelaar A, Martin RV, Burnett R, Rainham DG, Birkett NJ, et al. 2013. Estimates of global mortality attributable to particulate air pollution using satellite imagery. Environ Res 120:33–42.

Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, et al. 2007. Explaining the decrease in U.S. deaths from coronary disease, 1980–2000. N Engl J Med 356:2388–2398; doi:10.1056/NEJMsa053935.

Ford ES, Capewell S. 2007. Coronary heart disease mortality among young adults in the U.S. from 1980 through 2002: concealed leveling of mortality rates. J Am Coll Cardiol 50:2128–2132; doi:10.1016/j.jacc.2007.05.056.

Fritschi L, Brown AL, Kim R, Schwela D, Kephalopolous S, eds. 2011. Burden of Disease from Environmental Noise: Quantification of Healthy Life Years Lost in Europe. Copenhagen, Denmark:World Health Organization, Regional Office for Europe.

Gan WQ, Koehoorn M, Davies HW, Demers PA, Tamburic L, Brauer M. 2011. Long-term exposure to traffic-related air pollution and the risk of coronary heart disease hospitalization and mortality. Environ Health Perspect 119:501–507; doi:10.1289/ehp.1002511.

Gan WQ, Tamburic L, Davies HW, Demers PA, Koehoorn M, Brauer M. 2010. Changes in residential proximity to road traffic and the risk of death from coronary heart disease. Epidemiology 21:642–649.

Geller MD, Sardar SB, Phuleria H, Fine PM, Sioutas C. 2005. Measurements of particle number and mass concentrations and size distributions in a tunnel environment. Environ Sci Technol 39:8653–8663; doi:10.1021/es050360s.

Greenland S. 2004. Interval estimation by simulation as an alternative to and extension of confidence intervals. Int J Epidemiol 33:1389–1397.

HEI (Health Effects Institute). 2010. Traffic-related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. HEI Special Report 17. Boston, MA:HEI. Available: http://pubs.healtheffects.org/getfile.php?u=553 [accessed 27 June 2014].

Hoffmann B, Moebus S, Stang A, Beck EM, Dragano N, Möhlenkamp S, et al. 2006. Residence close to high traffic and prevalence of coronary heart disease. Eur Heart J 27:2696–2702.

Janssen NA, Gerlofs-Nijland ME, Lanki T, Salonen RO, Cassee F, Hoek G, et al. 2012. Health effects of black carbon. Copenhagen, Denmark:World Health Organization, Regional Office for Europe. Available: http://www.euro.who.int/__data/assets/pdf_file/0004/162535/e96541.pdf [accessed 22 January 2014].

Kan H, Heiss G, Rose KM, Whitsel EA, Lurmann F, London SJ. 2008. Prospective analysis of traffic exposure as a risk factor for incident coronary heart disease: the Atherosclerosis Risk in Communities (ARIC) study. Environ Health Perspect 116:1463–1468; doi:10.1289/ehp.11290.

Karner AA, Eisinger DS, Niemeier DA. 2010. Near-roadway air quality: synthesizing the findings from real-world data. Environ Sci Technol 44:5334–5344.

Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, et al. 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. HEI Research Report 140. Boston, MA:Health Effects Institute. Available: http://pubs.healtheffects.org/getfile.php?u=478 [accessed 24 November 2013].

Manchester-Neesvig JB, Schauer JJ, Cass GR. 2003. The distribution of particle-phase organic compounds in the atmosphere and their use for source apportionment during the Southern California Children's Health Study. J Air Waste Manag Assoc 53:1065–1079.

Motallebi N, Taylor CA Jr, Croes BE. 2003. Particulate matter in California: Part 2—spatial, temporal, and compositional patterns of $PM_{2.5}$, $PM_{10-2.5}$, and PM_{10}. J Air Waste Manag Assoc 53:1517–1530.

Perez L, Lurmann F, Wilson J, Pastor M, Brandt SJ, Künzli N, et al. 2012. Near-roadway pollution and childhood asthma: implications for developing "win–win" compact urban development and clean vehicle strategies. Environ Health Perspect 120:1619–1626; doi:10.1289/ehp.1104785.

Peters JM, Avol E, Berhane K, Gauderman WJ, Gilliland F, Jerrett M, et al. 2004. Epidemiologic Investigation to Identify Chronic Effects of Ambient Air Pollutants in Southern California. Prepared for the California Air Resources Board and the California Environmental Protection Agency, Contract No. 94-331. Available: http://www.arb.ca.gov/research/apr/past/94-331a.pdf [accessed 2 February 2014].

SCAG (Southern California Association of Governments). 2012a. Regional Transportation Plan 2012–2035. Sustainable Communities Strategy. Towards a Sustainable Future. Los Angeles, CA:SCAG. Available: http://rtpscs.scag.ca.gov/Documents/2012/final/f2012RTPSCS.pdf [accessed 5 February 2013].

SCAG. 2012b. SCAG Regional Travel Demand Model and 2003 Model Validation. Los Angeles, CA:SCAG. Available: http://www.scag.ca.gov/DataAndTools/Documents/ValidationSummaryReport_SCAG2005Val_2012_06_05.pdf [accessed 27 May 2015].

SCAQMD (South Coast Air Quality Management District). 2013. Final 2012 Air Quality Management Plan South Coast Air Quality Management District, Diamond Bar, CA, February. Available: http://www.aqmd.gov/home/library/clean-air-plans/air-quality-mgt-plan/final-2012-air-quality-management-plan [accessed 5 February 2013].

Schwartz J. 1999. Air pollution and hospital admissions for heart disease in eight U.S. counties. Epidemiology 10:17–22.

U.S. Department of Transportation. 2013. Table 1-35. In: National Transportation Statistics. Washington, DC:U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Available: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/NTS_Entire_1304.pdf [accessed 10 February 2014].

U.S. EPA (U.S. Environmental Protection Agency). 2004. 40 CFR Part 1039—Control of emissions from new and in-use nonroad compression-ignition engines. Fed Reg 69:39213–39259.

U.S. EPA. 2009. Integrated Science Assessment for Particulate Matter (Final Report). Washington, DC:U.S. EPA. EPA/600/R-08/139F. Available: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=216546&CFID=44366345&CFTOKEN=30481599 [accessed 5 January 2014].

U.S. EPA. 2013. Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter. Research Triangle Park, NC. Available: http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf [accessed 18 March 2014].

U.S. EPA. 2014. EPA Sets Tier 3 Motor Vehicle Emission and Fuel Standards. EPA-420-F14-009. Available: http://www.epa.gov/otaq/tier3.htm [accessed 1 March 2014].

Wu J, Houston D, Lurmann F, Ong P, Winer A. 2009. Exposure of $PM_{2.5}$ and EC from diesel and gasoline vehicles in communities near the ports of Los Angeles and Long Beach, California. Atmos Environ 43:1962–1971; doi:10.1016/j.atmosenv.2009.01.009.

Zhu Y, Hinds WC, Kim S, Shen S, Sioutas C. 2002. Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmos Environ 36:4323–4335.

Zhu Y, Kuhn T, Mayo P, Hinds WC. 2006. Comparison of daytime and nighttime concentration profiles and size distributions of ultrafine particles near a major highway. Environ Sci Technol 40:2531–2536.

Jeff Steichen

From: Kelly Broughton
Sent: Tuesday, February 02, 2016 12:27 PM
To: Jeff Steichen
Subject: FW: Additional studies on health risks and living near a freeway
Attachments: ehp.1408865.alt.pdf; ehp.1409430.alt.pdf

Here's the recent correspondence.

-----Original Message-----
From: Pamela Bensoussan [PBensoussan@chulavistaca.gov]
Received: Monday, 01 Feb 2016, 4:48PM
To: Gary Halbert [GHalbert@chulavistaca.gov]
CC: Kelly Broughton [kbroughton@chulavistaca.gov]
Subject: FW: Additional studies on health risks and living near a freeway

FYI - this just came in this afternoon. -PB

From: Laura Hunter [redacted]
Sent: Monday, February 01, 2016 3:01 PM
To: Pamela Bensoussan
Subject: Additional studies on health risks and living near a freeway

HI Pamela,
I know there has been a response to our letter but it is highly flawed. Here is just one quick follow up...here are two studies hot off the presses that discuss more health impacts from living near a freeway. The one about near-roadway pollution includes a statement that health risks from traffic will rise even as the level of exposure goes down, because the population will be aging – a response to the consultant's statement that health risks in 2035 will be less.

The other one is about kids and noise. I don't remember what the HRA says about noise and the extent to which it will be prevented by a sound wall. It just adds to our concerns about the lack of envl review and the lack of comprehensiveness of the analysis that was done.

Last the consultants site the need to rely on 'studies' but we cannot find any in the record that they are referring to.
More soon
Thanks
Laura

Near-Roadway Air Pollution and Coronary Heart Disease: Burden of Disease and Potential Impact of a Greenhouse Gas Reduction Strategy in Southern California

Rakesh Ghosh,[1] Frederick Lurmann,[2] Laura Perez,[3,4] Bryan Penfold,[2] Sylvia Brandt,[5] John Wilson,[6] Meredith Milet,[7] Nino Künzli,[3,4] and Rob McConnell[1] [1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA; [2]Sonoma Technology Inc., Petaluma, California, USA; [3]Swiss Tropical and Public Health Institute, Basel, Switzerland; [4]University of Basel, Basel, Switzerland; [5]University of Massachusetts Amherst, Amherst, Massachusetts; [6]Spatial Sciences Institute, Dana and David Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, California, USA; [7]California Department of Public Health, Richmond, California, USA Background: Several studies have estimated the burden of coronary heart disease (CHD) mortality from ambient regional particulate matter ≤ 2.5 μm ($PM_{2.5}$). The burden of near-roadway air pollution (NRAP) generally has not been examined, despite evidence of a causal link with CHD. Objective: We investigated the CHD burden from NRAP and compared it with the $PM_{2.5}$ burden in the California South Coast Air Basin for 2008 and under a compact urban growth greenhouse gas reduction scenario for 2035. Methods: We estimated the population attributable fraction and number of CHD events attribut-able to residential traffic density, proximity to a major road, elemental carbon (EC), and $PM_{2.5}$ compared with the expected disease burden if the population were exposed to background levels of air pollution. Results: In 2008, an estimated 1,300 CHD deaths (6.8% of the total) were attributable to traffic density, 430 deaths (2.4%) to residential proximity to a major road, and 690 (3.7%) to EC. There were 1,900 deaths (10.4%) attributable to $PM_{2.5}$. Although reduced exposures in 2035 should result in smaller fractions of CHD attributable to traffic density, EC, and $PM_{2.5}$, the numbers of estimated deaths attributable to each of these exposures are anticipated to increase to 2,500, 900, and 2,900, respectively, due to population aging. A similar pattern of increasing NRAP-attributable CHD hospitalizations was estimated to occur between 2008 and 2035. Conclusion: These results suggest that a large burden of preventable CHD mortality is attributable to NRAP and is likely to increase even with decreasing exposure by 2035 due to vulnerability of an aging population. Greenhouse gas reduction strategies developed to mitigate climate change offer unexploited opportunities for air pollution health co-benefits. Citation: Ghosh R, Lurmann F, Perez L, Penfold B, Brandt S, Wilson J, Milet M, Künzli N, McConnell R. 2016. Near-roadway air pollution and coronary heart disease: burden of disease and potential impact of a greenhouse gas reduction strategy in Southern California. Environ Health Perspect 124:193–200; http://dx.doi.org/10.1289/ehp.1408865

Sheree Kansas

From: Pamela Bensoussan
Sent: Tuesday, February 02, 2016 2:16 PM
To: Donna Norris
Cc: David Miller
Subject: FW: Additional studies on health risks and living near a freeway
Attachments: ehp.1408865.alt.pdf; ehp.1409430.alt.pdf

Donna,

Here is correspondence I received today regarding the agenda item #5. I am sending it to you for the record and in part in response to David Miller's request by email earlier today.

Thanks, Pamela

From: Laura Hunter [redacted]
Sent: Tuesday, February 02, 2016 11:11 AM
To: Mary Salas; Pamela Bensoussan; John McCann; Steve Miesen; Patricia Aguilar
Cc: Gary Halbert
Subject: Additional studies on health risks and living near a freeway

Hi Mayor Salas and Councilmembers,
In preparation for today, please note these two recent health studies that discuss more health impacts from living near a freeway.
The one about near-roadway pollution includes a statement that health risks from traffic will rise even as the level of exposure goes down, because the population will be aging – a response to the consultant's statement that health risks in 2035 will be less.

The other one is about kids and noise. Thank you for your consideration of these important issues.
Laura

Near-Roadway Air Pollution and Coronary Heart Disease: Burden of Disease and Potential Impact of a Greenhouse Gas Reduction Strategy in Southern California

Rakesh Ghosh,[1] Frederick Lurmann,[2] Laura Perez,[3,4] Bryan Penfold,[2] Sylvia Brandt,[5] John Wilson,[6] Meredith Milet,[7] Nino Künzli,[3,4] and Rob McConnell[1] [1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA; [2]Sonoma Technology Inc., Petaluma, California, USA; [3]Swiss Tropical and Public Health Institute, Basel, Switzerland; [4]University of Basel, Basel, Switzerland; [5]University of Massachusetts Amherst, Amherst, Massachusetts; [6]Spatial Sciences Institute, Dana and David Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, California, USA; [7]California Department of Public Health, Richmond, California, USA
Background: Several studies have estimated the burden of coronary heart disease (CHD) mortality from ambient regional particulate matter ≤ 2.5 µm ($PM_{2.5}$). The burden of near-roadway air pollution (NRAP) generally has not been examined, despite evidence of a causal link with CHD. **Objective:** We investigated the CHD burden from NRAP and compared it with the $PM_{2.5}$ burden in the California South Coast Air Basin for 2008 and under a compact urban growth greenhouse gas reduction scenario for 2035. **Methods:** We estimated the population attributable fraction and number of CHD events attribut-able to residential traffic density, proximity to a major road, elemental carbon (EC), and $PM_{2.5}$ compared with the expected disease burden if the population were exposed to background levels of air pollution. **Results:** In 2008, an estimated 1,300 CHD deaths (6.8% of the total) were attributable to traffic density, 430 deaths (2.4%) to residential proximity to a major road, and 690 (3.7%) to EC. There were 1,900 deaths (10.4%) attributable to $PM_{2.5}$. Although reduced exposures in 2035 should result in smaller fractions of CHD attributable to traffic density, EC, and $PM_{2.5}$, the numbers of estimated deaths attributable to each of these exposures are anticipated to increase to 2,500, 900, and 2,900, respectively, due to population aging. A similar pattern of increasing NRAP-attributable CHD hospitalizations was estimated to occur between 2008 and 2035. **Conclusion:** These results suggest that a large burden of preventable CHD mortality is attributable to NRAP and is likely to increase even with decreasing exposure by 2035 due to vulnerability of an aging population. Greenhouse gas reduction strategies developed to mitigate climate change offer unexploited opportunities for air pollution health co-benefits.
Citation: Ghosh R, Lurmann F, Perez L, Penfold B, Brandt S, Wilson J, Milet M, Künzli N, McConnell R. 2016. Near-roadway air pollution and coronary heart disease: burden of disease and potential impact of a greenhouse gas reduction strategy in Southern California. Environ Health Perspect 124:193–200; http://dx.doi.org/10.1289/ehp.1408865

A Section 508–conformant HTML version of this article
is available at http://dx.doi.org/10.1289/ehp.1408865.

Near-Roadway Air Pollution and Coronary Heart Disease: Burden of Disease and Potential Impact of a Greenhouse Gas Reduction Strategy in Southern California

Rakesh Ghosh,[1] Frederick Lurmann,[2] Laura Perez,[3,4] Bryan Penfold,[2] Sylvia Brandt,[5] John Wilson,[6] Meredith Milet,[7] Nino Künzli,[3,4] and Rob McConnell[1]

[1]Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, California, USA; [2]Sonoma Technology Inc., Petaluma, California, USA; [3]Swiss Tropical and Public Health Institute, Basel, Switzerland; [4]University of Basel, Basel, Switzerland; [5]University of Massachusetts Amherst, Amherst, Massachusetts; [6]Spatial Sciences Institute, Dana and David Dornsife College of Letters, Arts, and Sciences, University of Southern California, Los Angeles, California, USA; [7]California Department of Public Health, Richmond, California, USA

BACKGROUND: Several studies have estimated the burden of coronary heart disease (CHD) mortality from ambient regional particulate matter ≤ 2.5 μm ($PM_{2.5}$). The burden of near-roadway air pollution (NRAP) generally has not been examined, despite evidence of a causal link with CHD.

OBJECTIVE: We investigated the CHD burden from NRAP and compared it with the $PM_{2.5}$ burden in the California South Coast Air Basin for 2008 and under a compact urban growth greenhouse gas reduction scenario for 2035.

METHODS: We estimated the population attributable fraction and number of CHD events attributable to residential traffic density, proximity to a major road, elemental carbon (EC), and $PM_{2.5}$ compared with the expected disease burden if the population were exposed to background levels of air pollution.

RESULTS: In 2008, an estimated 1,300 CHD deaths (6.8% of the total) were attributable to traffic density, 430 deaths (2.4%) to residential proximity to a major road, and 690 (3.7%) to EC. There were 1,900 deaths (10.4%) attributable to $PM_{2.5}$. Although reduced exposures in 2035 should result in smaller fractions of CHD attributable to traffic density, EC, and $PM_{2.5}$, the numbers of estimated deaths attributable to each of these exposures are anticipated to increase to 2,500, 900, and 2,900, respectively, due to population aging. A similar pattern of increasing NRAP-attributable CHD hospitalizations was estimated to occur between 2008 and 2035.

CONCLUSION: These results suggest that a large burden of preventable CHD mortality is attributable to NRAP and is likely to increase even with decreasing exposure by 2035 due to vulnerability of an aging population. Greenhouse gas reduction strategies developed to mitigate climate change offer unexploited opportunities for air pollution health co-benefits.

CITATION: Ghosh R, Lurmann F, Perez L, Penfold B, Brandt S, Wilson J, Milet M, Künzli N, McConnell R. 2016. Near-roadway air pollution and coronary heart disease: burden of disease and potential impact of a greenhouse gas reduction strategy in Southern California. Environ Health Perspect 124:193–200; http://dx.doi.org/10.1289/ehp.1408865

Introduction

Emerging evidence suggests a causal link between near-roadway air pollution (NRAP) and coronary heart disease (CHD) mortality and morbidity (Gan et al. 2010, 2011; Hoffmann et al. 2006; Kan et al. 2008). The 2010 American Heart Association scientific statement on ambient particles noted that NRAP "as a whole appears to be a specific source associated with cardiovascular risk" (Brook et al. 2010). Since then, additional longitudinal studies have demonstrated consistent associations between NRAP and CHD, using traffic density, proximity to roadways, and a near-roadway pollutant surrogate, elemental carbon (Gan et al. 2010, 2011; Kan et al. 2008). Although the specific pollutants in NRAP responsible for health effects are not entirely clear, evidence suggests that NRAP effects are independent of those of particulate matter ≤ 2.5 μm ($PM_{2.5}$) (Hoffmann et al. 2006). However, in contrast to $PM_{2.5}$, there has been little examination of the NRAP-attributable disease burden. Furthermore, although regional PM levels have been declining in most of the United States over several decades (Motallebi et al. 2003) due to effective regulatory policy, some indicators of NRAP exposure such as vehicle miles traveled have increased markedly over the same period (U.S. Department of Transportation 2013). There is a need to assess the NRAP-attributable burden of disease.

We assessed the burden of CHD attributable to NRAP relative to $PM_{2.5}$ in Southern California, which has high regional $PM_{2.5}$ levels and a dense network of high-volume traffic corridors in close proximity to residences. We also estimated the CHD health co-benefits of California's landmark legislation (SB 375) to reduce greenhouse gas emissions (more than one-third of which come from cars and trucks) by 16% in 2035. The Southern California Association of Governments (SCAG) has developed a regional plan that aims to reduce per capita vehicle miles traveled, because this has substantial impact on greenhouse gas emissions (SCAG 2012a). This is to be accomplished with a land use development strategy designed to reduce the need for automobile travel by encouraging denser residential development in already developed urban areas that are served by public transport and by discouraging new development in currently undeveloped areas (SCAG 2012a). To support compact urban development conducive to walking and use of public transportation, transportation investment will focus on improving public transport by increasing service frequency and transit connections, and creating bicycle and pedestrian infrastructure. The California Air Resource Board's and the U.S. Environmental Protection Agency's (EPA) stricter vehicle exhaust emission standards, requirements for increased proportions of zero emission vehicles, and higher fuel economy standards are expected to substantially reduce future conventional and greenhouse gas emissions per mile of vehicle travel. We estimated the population exposure to NRAP and $PM_{2.5}$, which will be associated with implementation of these changes, and the corresponding pollution-attributable CHD.

Address correspondence to R. McConnell, 2001 N. Soto St., Department of Preventive Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA 90089 USA. Telephone: (323) 442-1096. E-mail: rmcconne@usc.edu

Supplemental Material is available online (http://dx.doi.org/10.1289/ehp.1408865).

H. Kan provided helpful analytical advice. M. Raman assisted with the literature review.

This study was partially supported by funds from an air quality violations settlement agreement between the South Coast Air Quality Management District, a California state regulatory agency, and BP (British Petroleum). Other funding support included National Institutes of Health grants P01ES022845, P01ES011627, P30ES007048, and R01ES016535; U.S. Environmental Protection Agency grant RD83544101; and the Hastings Foundation (Pasadena, California).

F. Lurmann and B. Penfold are employed by Sonoma Technology Inc., Petaluma, California. The other authors declare they have no other actual or potential competing financial interests.

Received: 24 June 2014; Accepted: 15 June 2015; Advance Publication: 7 July 2015; Final Publication: 1 February 2016.

Methods

Concentration–response functions. There are only a few studies of associations of CHD mortality and hospitalization with NRAP conducted in North America and therefore more likely to be relevant to Southern California than studies from other parts of the world. We used concentration–response functions (CRF) from studies of two surrogates of NRAP exposure: traffic density and residential proximity to a major road (Table 1). The traffic density CRF was based on a four-communities study in the Midwestern and Eastern United States (Kan et al. 2008). We used a CRF for residential elemental carbon (EC), based on black carbon, derived from an administrative data set covering the entire Vancouver, Canada, population (Gan et al. 2011). (For estimating EC-attributable burden of disease, black carbon was converted to EC, as described in the Supplemental Material, "Methods.") EC is an indicator of diesel exhaust exposure in Southern California (Geller et al. 2005) and is commonly considered a near-roadway pollutant (Wu et al. 2009). EC may provide a lattice for toxicologically relevant metals and adsorbed organics that are inhaled deep into the lung (Bell et al. 2009; Janssen et al. 2012). We selected the CRF from the Vancouver study, because it was estimated from a network of measurements reflective of fine-scale spatial variation heavily influenced by roadway sources, and was derived for a similar age distribution and for CHD outcomes comparable to the CRFs for other NRAP indicators used in this analysis. For consistency, we used a CRF for proximity to a major road derived from the Vancouver study (Gan et al. 2010). For comparison with the NRAP effects, we also estimated the burden of regional $PM_{2.5}$ exposure, based on a CRF that is used in mortality risk assessment for regulatory purposes by the U.S. EPA (Krewski et al. 2009; U.S. EPA 2009).

Population data spatial allocation. The geographic domain for our study was California's South Coast Air Basin (SoCAB), comprising the southern part of Los Angeles County, western portions of Riverside and San Bernardino counties, and all of Orange County (Figure 1), a region with historically high air pollution levels. Data for the total population, households, land use, and boundary polygons of the legally defined real estate parcels were acquired from the regional planning agency, SCAG, for 2008. The population and household data were spatially resolved in approximately 11,000 travel activity zones (TAZs) that are used in the agency's travel demand models (SCAG 2012b). The TAZ populations were assigned to residential-zoned parcels within each TAZ. If all parcels within a TAZ were single-family residences, the population per household was assigned uniformly. If all parcels within a TAZ were multi-family residences, the parcel populations were apportioned based on parcel areas. If both existed, the single-family residence parcels were assigned the county-average number of persons per household, and the remainder of the TAZ population was assigned based on the areas of the multi-family parcels. The population was assumed to reside at the centroid of the land parcel, which is more accurate than traditional methods of locating population at census-block centroids or block-group centroids.

We estimated the 2035 population distribution based on the 2035 scenario of the Sustainable Communities Strategy of the regional transportation plan that was designed to maximally reduce greenhouse gas emissions in Southern California (SCAG 2012a). The population and number of households by TAZ were acquired from SCAG along with the General Plan land use for future development areas (SCAG 2012a). The population assignment method for existing parcels was the same for 2035 as 2008. To avoid assigning large populations to the center of large areas designated for future residential growth in the General Plan, we used a grid-like approach to define potential new parcels near existing and future roadways, and to apportion the future population to these parcels. The result of this procedure was total population estimates for about 4 million existing and potential new parcels in the SoCAB in 2008 and 2035.

Because the epidemiological studies of effects of air pollution on CHD were consistently conducted on the population ≥ 45 years of age, we estimated the 2008 and 2035 parcel populations in this age group using the relative age distributions from the 2010 Census tract data and 2035 county-level projection, respectively, obtained from the California Department of Finance (2013).

CHD mortality and hospitalization. Cause-specific mortality and hospitalization for 2008 were available by ZIP code from the California Department of Public Health by age group (45–54, 55–64, 65–74, 75–84, and ≥ 85 years). Deaths in *International Classification of Diseases, 10th Revision* (ICD-10) codes I20–I25, based on those used in the studies from which the EC and proximity to a major road CRFs were derived (Gan et al. 2010, 2011), were used to estimate CHD mortality rates for the population aggregated to the ZIP code level. We used these same ICD outcomes and rates in estimating the traffic density–attributable deaths, even though the CRF for traffic density was obtained from a study that included additional

Table 1. Study characteristics and the concentration–response functions (CRF) used in the attributable fraction estimation.

Study characteristics	Kan et al. 2008	Gan et al. 2010	Gan et al. 2011		Krewski et al. 2009
			Hospitalizations	Mortality	
Geographic area	Forsyth, NC; Jackson, MS; Minneapolis, MN; Washington, MD; USA	Vancouver, Canada	Vancouver, Canada	Vancouver, Canada	USA (nationwide)
Study year	Recruitment 1987–1989, Follow-up through 2002	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	5-year exposure (1994–1998), 4-year follow-up (1999–2002)	Exposure 1999–2000, follow-up 1982–2000
Mean age (± SD), range (years)	55.8 ± 5.6 45–64	58.7 ± 10.4 45–83	58.7 ± 10.4 45–83	58.7 ± 10.4 45–83	56.6 ± 10.5
Exposure	Traffic density count per day[a] (per 1 log unit)	Residence ≤ 150 m from a highway or ≤ 50 m from a major road compared with all others	Black carbon[a] (per 0.94×10^{-5}/m)	Black carbon[a] (per 0.94×10^{-5}/m)	$PM_{2.5}$ (per 10 μg/m^3)
n (cases)	13,309 (976 deaths)	414,793 (3,133 deaths)	452,735 (10,312 hospitalizations)	452,735 (3,104 deaths)	488,370 (29,989 deaths)
Outcome	Myocardial infarction/coronary revascularization/CHD death[b]	CHD mortality[c]	CHD hospitalizations[c]	CHD mortality[c]	CHD mortality[d]
CRF[e] (95% CI)	1.03 (mortality) (1.01, 1.05)	1.29 (mortality) (1.18, 1.41)	1.03 (hospitalization) (1.01, 1.05)	1.06 (mortality) (1.03, 1.09)	1.15 (mortality) (1.13, 1.20)

[a]Traffic density values were proportional to proximity-weighted vehicles per day where one density unit corresponded to 295 vehicles per day at 10 m from the roadway. It declines linearly with distance to zero vehicles per day at 300 m from the roadway. Black carbon scaled to interquartile-range increase in absorbance. [b]ICD-9 codes 402, 410–414, 427, 428, 518.4; ICD-10 codes E10–14, I10–11, I21–25, I46–51, I70, I97, J81, J96, R96, R98–99. [c]ICD-9 codes 410–414, 429.2; ICD-10 codes I20–I25. [d]ICD-9 codes 410–414. [e]Estimates are hazard ratios (95% CIs), which were scaled to the population-weighted mean exposures for 2008 and 2035 and used in the attributable fraction calculation.

ICD codes (E10–14, I10–11, I46–51, I70, I97, J81, J96, R96, R98–99) (Kan et al. 2008). Although using the reduced number of ICD codes likely resulted in underestimated traffic density–attributable CHD deaths, it made it possible to compare the traffic density estimates with those for EC and proximity to major road. Hospitalizations for ICD-9 (*9th Revision*) codes 410–414 and 429.2 were used to calculate CHD hospitalization rates (Gan et al. 2011).

Because the projected 2035 age distribution was available only at the county level, the 2008 age-specific mortality and hospitalization rates were aggregated to the county level and applied to the projected 2035 age-specific population in each SoCAB county to estimate the corresponding death and hospitalization counts (and rates in the ≥ 45-year age group) in 2035. Because SoCAB comprises only a portion of some counties, this calculation assumed that the projected 2035 population age distribution for the geographic portion of each county in the SoCAB will be the same as that of the entire county. The estimates of mortality and hospitalization also assumed that the age-specific rates in 2008 will be the same in 2035.

Exposure assessment. The approach for exposure assessment involved characterization of near-road exposures using traffic density and traffic proximity markers and applications of regional- and local-scale air quality dispersion models to estimate parcel level annual average EC and $PM_{2.5}$ mass concentrations. Regional exposure across Southern California was estimated using the Community Multiscale Air Quality model, version 4.7.1 (http://www.epa.gov/scram001/) (Carter 2000), and the Weather Research and Forecasting model version 3.3 meteorological fields (http://www.wrf-model.org/). The model analyses were conducted for a large Southern California domain extending from 160 km west of the port of Los Angeles to the Colorado River in the east, and from Bakersfield in the north to 100 km south of San Diego in the south. Model simulations were run by the South Coast Air Quality Monitoring District as part of the Air Quality Management Plan (SCAQMD 2013). The domain was spatially resolved using 4 km × 4 km horizontal grids and 18 vertical layers. Model simulations were run by the South Coast Air Quality Monitoring District as part of the Air Quality Management Plan (SCAQMD 2013). Annual conditions were simulated for a 2008 baseline and for 2035 with the regional transportation plan elements (SCAG 2012a). The emissions and meteorological inputs, modeling procedures, outputs, and model performance are described elsewhere [SCAQMD (2013), Appendices V and VI]. The regional model's gridded estimates for annual average EC and $PM_{2.5}$ mass concentrations were assigned to all parcels with centroids within each 4 × 4 km grid.

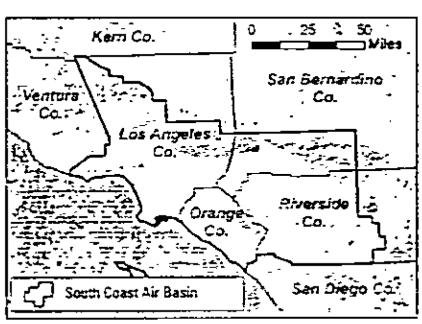


Figure 1. Geographical coverage of the study area is shown by the thick black border. Thin blue lines show the county boundaries and the coastline.

Because regional models cannot resolve local pollutant gradients near roadways, a line source dispersion model, Caline4 (Benson 1992), was applied to characterize the local-scale impacts of on-road mobile source EC emissions from roads within 2 km of each parcel. The Caline4 model's estimates of annual average EC incremental concentrations from local roadway sources were superimposed on the regional model estimates for each parcel. The Caline4 model was applied using local surface wind data from the nearest monitoring station, light-duty and heavy-duty vehicle emission factors from the EMFAC2011 model (CARB 2011, 2013b), and roadway geometry and annual average traffic volumes from the SCAG travel-demand model.

The SCAG travel-demand model for roadways was used to simulate traffic for the 2008 baseline and 2035 future scenario with the regional transportation plan control measures (SCAG 2012b). The model uses geographically accurate roadway locations for freeways and expressways (group 1), major arterials (group 2), and minor arterials and major collectors (group 3). Each travel direction was represented separately for large roads, and the smaller roads were bidirectional. SCAG developed separate traffic demand models and traffic volumes for light-duty and heavy-duty vehicles on all roadway links. Average daily traffic volumes were determined by aggregating the simulated traffic volumes for morning, midday, afternoon, evening, and nighttime traffic. SCAG applied the models to simulate traffic for the 2008 baseline and 2035 future year with the regional transportation plan control measures. The estimated future emission inventory included growth and emission controls based on the South Coast Air Quality Monitoring District's Air Quality Management Plan (SCAQMD 2013) and SCAG's regional transportation plan (SCAG 2012a).

Other exposure markers were the distance to nearest roads and traffic density. The distances from the center of each residential parcel to the nearest road in groups 1–2 (freeway or major arterial) were computed using ESRI's ArcGIS tools. This is consistent with the CRF corresponding to the distance to freeways or major roads marker (150 m from the closest freeway or 50 m from the closest major road) (Gan et al. 2010).

The traffic density marker represents distance-decayed annual average daily traffic volume surrounding each residential parcel location. The SCAG roadway geometry and link-based traffic volumes were used with a ArcGIS density function that linearly decayed traffic volumes from 100% at the roadway centerline to 10% at 300 m perpendicular to the roadway. This decay rate is consistent with the observed primary pollutant concentration gradients near roadways (Karner et al. 2010; Zhu et al. 2002, 2006). The traffic density beyond the 300-m radius buffer was assigned a value of zero. Because the marker was initially developed for CHD and traffic density CRF in 1987–1989 (Kan et al. 2008), and vehicle emission rates per kilometer of travel have declined substantially since this time period, the traffic density marker was adjusted based on the EMFAC2011 model (CARB 2013a) estimates of the changes in fleet average $PM_{2.5}$ emission rates between 1989 and 2008 (–62.1%) and projected for 2035 (–76.4%).

Using the modeled exposures for each of the three continuous exposures (traffic density, EC, and $PM_{2.5}$), the population-weighted mean exposure was calculated by multiplying the population ≥ 45 years of age in each parcel with the exposure assigned to that parcel (p_i). The summation of this product over all parcels was divided by the total population, as shown in Equation 1 (by county and for the entire SoCAB).

Population-weighted mean exposure =

$$\frac{\sum_{p_i=1}^{n} (Population_{p_i} \times Exposure_{p_i})}{\sum Total\ population}. \quad [1]$$

Attributable burden estimation. For the population ≥ 45 years, we estimated the CHD population-attributable fraction (PAF) due to residential proximity to major roadways in 2008 and 2035 based on the proportion exposed (p_{exp}) and the corresponding CRF from the original study, in the standard PAF formula (Equation 2).

$$PAF = p_{exp}(CRF - 1) / [p_{exp}(CRF - 1) + 1]. \quad [2]$$

Traffic density, EC, and $PM_{2.5}$ CRFs (Table 1) were originally reported per 1 log unit (proximity-weighted vehicles per day), per 1 interquartile range (IQR = 0.94 × 10^{-5}/m of black carbon reflectance), or per 10 μg/m^3, respectively. The population-weighted mean exposure estimated using Equation 1 was divided by the respective IQR (EC) or 10 μg/m^3 ($PM_{2.5}$) and this value was used to rescale the CRF to the population-weighted mean value by exponentiation (Equation 3). EC (micrograms per cubic meter) was converted to black carbon (10^{-5}/m) to match with the original CRF. (See Supplemental Material, "Methods.")

$$CRF_{\text{population-weighted mean exposure}} = (CRF_{\text{per unit exposure}})^{\text{population-weighted mean exposure}}. \quad [3]$$

Because the PAFs for traffic density, EC, and $PM_{2.5}$ were calculated for a population-weighted mean exposure for the entire population, the proportion exposed (p_{exp}) in Equation 2 becomes unity and Equation 2 reduces to Equation 4:

$$PAF = (CRF - 1)/CRF. \quad [4]$$

We selected a background level above which the impact was quantified. For EC and $PM_{2.5}$, PAFs were estimated for the reduction of the population-weighted mean levels to background levels of 0.12 and 5.6 μg/m^3, respectively, based on measurements in a clean Central California coastal community (Lompoc) for the period 1994–2001 (Peters et al. 2004). Previous studies used similar background levels and methodology (Anenberg et al. 2010; Evans et al. 2013). Because traffic is entirely anthropogenic, the background level for traffic density was 1.0, as increased CHD risk (Table 1) was only observed at exposures > 1 (log traffic density of zero).

The 2008 and 2035 attributable numbers were estimated by multiplying the population ≥ 45 years by the CHD mortality or hospitalization rates and the PAF (Equation 5).

$$\text{Population-attributable number}_{\text{mortality/hospitalization}} = \text{Population}_{\geq 45} \times \text{Rate}_{\text{mortality/hospitalization}} \times \text{PAF}_{\text{mortality/hospitalization}}. \quad [5]$$

We calculated the PAF and the attributable number for the portion of each county within the SoCAB and also for the entire SoCAB region. The PAF and the attributable number for the distance to roadways marker of NRAP exposure can be interpreted as the proportion and number of deaths, respectively, that could be prevented if no one lived within 150 m from a freeway or 50 m from a major road. For EC and $PM_{2.5}$, the PAF (or number of attributable events) can be interpreted as the proportion (number) that could be prevented if the population-weighted mean exposures were reduced to background levels.

To distinguish the impact of the projected change in exposure in 2035 from the impact of the projected change in the population age distribution in 2035, we estimated the attributable events for 2035 for a hypothetical scenario in which the 2008 age distribution were applied to the 2035 population.

Statistical uncertainty analysis. We constructed the 95% uncertainty interval (UI) around the point estimates accounting for the uncertainty in each of the parameters used to calculate the PAF, as suggested by Greenland (2004). The UI for the traffic density, EC, and $PM_{2.5}$ PAF was calculated by incorporating the uncertainty of the rescaled CRF, that is, the hazard ratio exponentiated to the population-weighted mean. The UI for the proximity PAF was estimated accounting for the uncertainty in both parameters (proximity CRF and the proportion exposed).

Results

The total SoCAB population was 15.5 million in 2008 and is projected to increase by approximately 3 million in 2035. However, the proportion ≥ 45 years at risk for CHD is expected to increase from 35% in 2008 to 43% in 2035 (Table 2). As a result, the increase in the CHD mortality rates, which reflect the change in the population age distribution, are projected to increase disproportionately with the population increase, from 3.4 to 4.9 deaths per 1,000 population. SoCAB CHD hospitalization rates are projected to increase from 8.9 per 1,000 in 2008 to 11.3 per 1,000 in 2035.

Annual average population-weighted traffic density was markedly skewed (see Supplemental Material, Figure S1a). The median 2008 traffic density was 14.4 (IQR = 3.9–30.1), after correcting for the fleet average $PM_{2.5}$ emission reduction, and is projected to decrease to 11.6 (IQR = 4.1–22.3) in 2035 (from geometric mean of 10.8 in 2008 to 9.3 in 2035). In contrast, the proportion of the population living within 150 m from a freeway or 50 m from a major road is expected to increase from 8.3% to 10.9% from 2008 to 2035 (see Supplemental Material, Figure S1b). The mean (± SD) population-weighted EC level was 1.1 ± 0.4 μg/m^3 in 2008 and is expected to decrease to 0.7 ± 0.3 μg/m^3 in 2035 (see Supplemental Material, Figure S1c). The corresponding medians for the two periods were identical to the mean, 1.1 μg/m^3 (IQR = 0.8–1.4) and 0.7 μg/m^3 (IQR = 0.5–0.9), respectively. (The anticipated decrease is primarily due to the expected reduction of EC emissions from diesel-fueled vehicles.) The population mean $PM_{2.5}$ exposure was 13.2 ± 4.2 μg/m^3 in 2008, and is projected to decrease to 10.9 ± 3.7 μg/m^3 in 2035 (see Supplemental Material, Figure S1d).

In 2008, an estimated 6.8% (95% UI: 2.4, 11.0) of the total CHD deaths among the population ≥ 45 years could be attributed to traffic density (Figure 2A). The PAF is expected to decrease to 6.4% (95% UI: 2.2, 10.3) in 2035, reflecting the expected decrease in population-weighted traffic density. The estimated 2008 PAF for residential distance of ≤ 150 m from freeways or ≤ 50 m from major roadways (2.4%; 95% UI: 1.4, 3.3) was smaller than the PAF for either traffic density or EC, but was projected to increase in 2035 to 3.1% (95% UI: 2.1, 4.0), reflecting the increase in proportion living close to major roadways. Based on estimated burden of EC exposure, 3.7% (95% UI: 1.9, 5.5) of the total CHD deaths in the ≥ 45 years age group in 2008 could have been prevented if the population-weighted mean EC exposure levels had been at the background level of 0.12 μg/m^3 instead of 1.1 μg/m^3. Decreasing population-weighted mean EC level is expected to result in decreased PAF to 2.3% in 2035 (95% UI: 1.2, 3.4). The estimated regional $PM_{2.5}$ PAF was 10.4% (95% UI: 7.8, 12.9) in 2008 and is projected to fall to 7.5% (95% UI: 5.6, 9.3) in 2035.

Based on the NRAP PAFs for traffic density, an estimated 1,300 (95% UI: 440, 2,000) preventable deaths occurred in 2008, and 2,500 (95% UI: 860, 4,000) preventable deaths will occur in 2035 due to traffic density within 300 m of residences (Figure 2B). This large future increase is due to the projected increase in population, specifically to the disproportionate increase in the aging population at risk of CHD. This effect can be quantified using the hypothetical 2035 scenario

Table 2. Population ≥ 45 years and coronary heart disease (CHD) mortality and hospitalization rates overall for the South Coast Air Basin and by counties for 2008 and projected for 2035.

County	Population[a] ≥ 45 years (%)[b]		CHD mortality (per 1,000)		CHD hospitalizations (per 1,000)	
	2008	2035	2008	2035	2008	2035
Los Angeles	3,321,703 (35.4)	5,189,815 (44.8)	3.7	5.0	9.1	10.7
Orange	1,085,184 (37.3)	1,501,496 (45.1)	2.6	4.4	6.8	9.7
Riverside	554,656 (33.0)	768,170 (40.6)	4.1	4.6	13.3	13.1
San Bernardino	466,992 (31.6)	672,435 (40.3)	2.2	5.4	8.1	13.8
Total	5,428,535 (35.1)	8,005,152 (43.3)	3.4	4.9	8.9	11.3

[a]Population is for the portion of the county that is within the South Coast Air Basin boundary, except for Orange County where the entire county is within the air basin. [b]Percentage of the total (all ages) population.

in which the total population was increased as projected but was assigned the 2008 age distribution (essentially keeping the overall mortality rate unchanged). Under this hypothetical scenario, a much smaller number of deaths (1,700; 95% UI: 600, 2,800) would be attributable to traffic density. Based on the PAF for residential major road proximity (≤ 150 m from a freeway or ≤ 50 m from another major road), there were 430 preventable CHD deaths (95% UI: 270, 600) in 2008 and a projected 1,200 (95% UI: 820, 1,600) in 2035, compared with 830 (95% UI: 570, 1,100) that would be anticipated if the 2035 age distribution were the same as in 2008. For EC, 690 CHD deaths were attributable to exposure above background levels (95% UI: 360, 1,000) in 2008, about half of the estimated traffic density–attributable deaths but more than 1.5 times the major road proximity–attributable deaths. The EC-attributable deaths were also projected to increase less than that for traffic density, to 900 (95% UI: 470, 1,300) in 2035. Most of the estimated increase attributable to EC is due to the aging population structure rather than just the increase in population, which by itself would result in a small decrease in deaths to 630 (95% UI: 330, 920) because the population-weighted exposure is projected to decrease over time. About 1,900 deaths (95% UI: 1,400, 2,400) in 2008 were estimated to be attributable to regional $PM_{2.5}$. A substantial increase to 2,900 (95% UI: 2,200, 3,600) is expected in 2035, despite a 25% decrease in PAF, due to the change in population and age distribution. In the hypothetical scenario in which only the population increases in 2035 without any change in age distribution, the $PM_{2.5}$-attributable deaths would still increase to 2,000 (95% UI: 1,500, 2,500).

The overall pattern of changing exposure and NRAP-attributable CHD was generally similar across all SoCAB counties. Traffic density and EC levels were highest in Los Angeles County and lowest in Riverside County and are projected to decrease in all four counties from 2008 to 2035. (see Supplemental Material, Table S1). In contrast, the proportion living near a major road is projected to increase in all counties during the same period. Los Angeles County consistently had the highest estimated PAF and Riverside County the lowest based on each exposure in both 2008 and in 2035 (see Supplemental Material, Table S2). The estimated population-attributable number was consistently highest in Los Angeles (see Supplemental Material, Table S3), but traffic density–, EC-, and $PM_{2.5}$-attributable numbers were each lowest in San Bernardino in 2008 and are expected to increase markedly by 2035, reflecting anticipated population increase under the compact urban development scenario.

The estimated PAF for CHD hospitalization attributable to EC exposure in the SoCAB was 1.9% (95% UI: 0.7, 3.1) in 2008, and is expected to decline to 1.2% (95% UI: 0.4, 1.9) in 2035 (see Supplemental Material, Table S4). The corresponding attributable number of hospitalizations was 920 (95% UI: 320, 1,500) for 2008 and is expected to increase slightly to 1,100 (95% UI: 380, 1,700) in 2035 after accounting for increases in population and hospitalization rate in an aging population. If the 2008 age distribution were applied to the 2035 population, the hypothetical number of hospitalizations might be expected to decrease to 840 (95% UI: 300, 1,400). The projected pattern of change over time in the county-specific estimates was generally similar to that for the entire SoCAB.

Discussion

This study is one of the first risk assessments of CHD mortality and hospitalization attributable to NRAP markers and the first, to our knowledge, to project future estimates of the burden in a large metropolitan region. Estimates of the 2008 preventable CHD mortality due to NRAP among the ≥ 45 years population in the SoCAB varied from 2.4% (430 deaths), based on effects of residential proximity to a major road, to 6.8% (1,300 deaths), based on emissions-weighted traffic density. The traffic density–related burden in 2008 was about two-thirds the burden (10.4%, 1,900 deaths) attributable to regulated regional $PM_{2.5}$. Thus, to the extent that NRAP and $PM_{2.5}$ effects are independent, because regional $PM_{2.5}$ does not characterize the sharp gradient in effects of the near-roadway pollutant mixture, a risk assessment based on $PM_{2.5}$ alone is likely to be a substantial underestimate of the true pollution-attributable CHD mortality. The 2035 greenhouse gas reduction–planning scenario is projected to result in reduced population exposure and reduced PAF for $PM_{2.5}$, traffic density, and EC (but not for residential proximity to major roadways). However, a surprising finding was that the attributable number of CHD deaths due both to $PM_{2.5}$ and to each NRAP exposure, even under the optimistic planning scenario considered, is

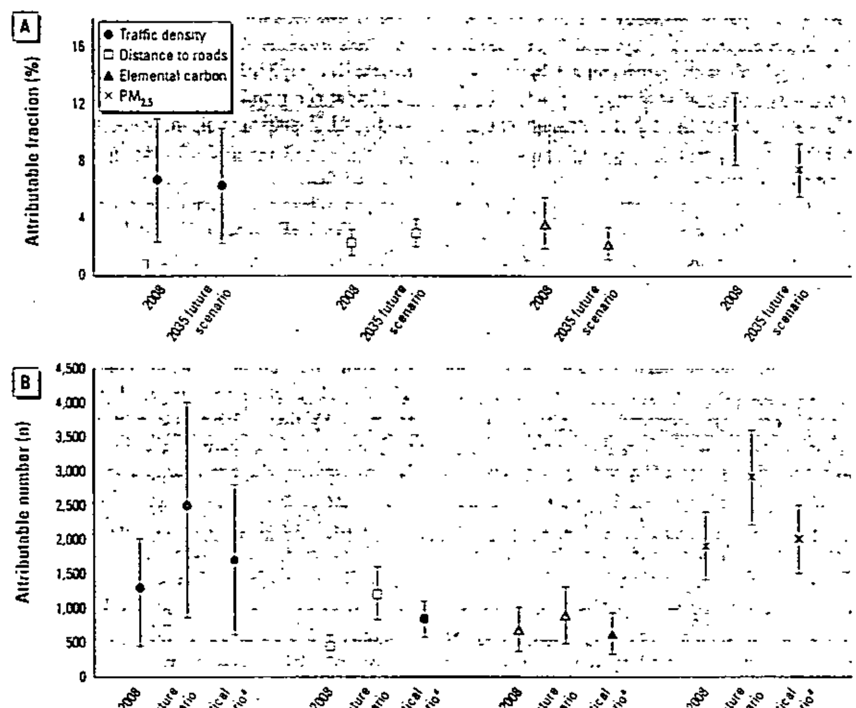


Figure 2. Population-attributable fractions (*A*) and population-attributable numbers (*B*) and 95% uncertainty intervals for coronary heart disease mortality in the South Coast Air Basin in 2008 and 2035,[a] attributed to traffic density within 300-m buffer from residence, residential distance to nearest freeway (≤ 150 m) or major road (≤ 50 m), elemental carbon, and regional $PM_{2.5}$ above background levels of 1 for traffic density, 0% for proximity, 0.12 μg/m³ for EC, and 5.6 μg/m³ for $PM_{2.5}$. Population-weighted mean exposures in 2008 and 2035 were 10.8 and 9.3 for traffic density, 1.1 and 0.7 μg/m³ for EC, and 13.2 and 10.9 μg/m³ for $PM_{2.5}$, respectively.
[a]Population-attributable number that might be expected in 2035 if the age distribution of the 2035 population were the same as in 2008.

expected to increase substantially by 2035, largely due to vulnerability of an aging population. The proportion ≥ 65 years, at highest risk of CHD (Ford and Capewell 2007), is projected to double over the next two decades.

These results have important implications for health and urban planning policy. CHD accounts for most of the mortality attributable to $PM_{2.5}$ levels in excess of the national standard (12 μg/m^3) and therefore for the largest pollution-attributable annual economic costs, approximately $4.6 billion (adjusted to 2014 using the U.S. Bureau of Labor Statistics Consumer Price Index inflation calculator) (U.S. EPA 2013). Accounting for the effects of NRAP is likely to markedly increase estimates of economic cost of pollution. The increasing population-attributable number due to an aging population means that additional hospital beds and other health facilities will be needed for CHD treatment.

National air pollution regulations already adopted will have impacts over the next 20 years; examples include Tier-2 and Tier-3 vehicle standards (U.S. EPA 2014), and non-road diesel requirements (U.S. EPA 2004). These and the likely ongoing evolution of control technology requirements will contribute to reduced $PM_{2.5}$ and EC emissions, and likely will reduce the impact of roadway proximity and traffic density (CRC 2013). We have not estimated the impact specific to greenhouse gas–reduction measures, independent of other pollution-reduction strategies. However, our results suggest that there are as yet unexploited opportunities for health benefits that would result from regulation of NRAP, and that additional health co-benefits could be obtained from the 2035 greenhouse gas reduction–planning process. The 2035 compact growth scenario used for this study will promote urban redevelopment with multifamily homes in corridors with good public transport to reduce reliance on private automobiles. The plan will promote investment in bicycling and walking infrastructure, and assumes that there will be increased vehicular fleet fuel efficiency and reduced emissions. However, if this planning scenario increases the population exposed to NRAP by placing people closer to busy roadways, they may be put at increased CHD risk, unless vehicle emissions were to decrease more substantially than currently anticipated. Variants on the planning scenario, such as policies to develop a zero- or close-to-zero-emission vehicle fleet, could optimize health co-benefits of greenhouse gas reduction. Another approach might be to encourage buffers between major traffic corridors and high-density development through zoning and other land use policies. Because markers for the NRAP mixture decrease sharply with distance to traffic, buffers of even a few 10s to 150 m are likely to decrease markedly the exposure and associated population burden of CHD morbidity and mortality, particularly for the elderly.

There are uncertainties in the estimates. The statistical uncertainty intervals are large. The estimated attributable burden also varied depending on the marker for NRAP. The 2008 traffic density–attributable CHD mortality was largest (6.8%) and the major roadway proximity-attributable mortality was smallest (2.4%). The traffic density burden was based on a CRF that used continuous exposure and accounted for volume of vehicles on all nearby roadways (Kan et al. 2008), and it was corrected for changing vehicles emissions over time. The smaller burden estimated from major roadway proximity might be expected because the CRF was based on a dichotomous classification that does not account for these factors (Gan et al. 2010), and therefore is the crudest surrogate for the NRAP mixture. Neither of these exposures accounts for meteorology and dispersion of a biologically relevant traffic pollutant such as EC, for which the number of attributable deaths in 2008 (n = 690) was between that for major roadway proximity exposure (n = 430) and traffic density (n = 1,300). EC had the smallest increase in 2035 NRAP-attributable mortality (which would be expected to decline if the population were not aging). The smaller EC-attributable burden in 2035 was due to an anticipated cleaner burning diesel vehicle fleet. EC- (and $PM_{2.5}$-) attributable burden were also based on an assumption that no CHD effects would occur below background levels of 0.12 μg/m^3 (EC) and 5.6 μg/m^3 ($PM_{2.5}$), which may have resulted in an underestimated burden.

EC is a toxicologically relevant component of particulate matter (Janssen et al. 2012) substantially influenced by pollution from heavy duty (diesel) vehicles in Southern California (Manchester-Neesvig et al. 2003). In this study, the estimated parcel level EC exposure used in calculating the burden accounted for the influence of meteorology on dispersion from local roadways, unlike the other two NRAP markers. However, the estimated EC exposure included both transported and local NRAP EC. Most (~ 90%) of the total EC exposure was regional and was common to all parcels in each 4 km × 4 km EC exposure grid. Thus, the estimated burden for EC reflected both regional and near-roadway effects, and EC effects may not be entirely independent of the burden assigned to the $PM_{2.5}$ pollution, modeled solely on the regional scale. Therefore, the simple addition of the EC- and $PM_{2.5}$-attributable events may overestimate the effect of these pollutants. It is difficult to assess the degree of such double counting, as there has been little study of the joint effects of exposure to EC and $PM_{2.5}$ and the extent to which their effects are independent.

The uncertainty of the estimates based on future exposure scenario is likely to be greater than for the current estimates. For example, we corrected the traffic-density CRF based on an assumption that the effect of each vehicle exposure would decline in proportion to the decrease in fleet average $PM_{2.5}$ vehicle emission rates per kilometer of travel since the original epidemiological study was conducted, equivalent to 15% from 2008 to 2035. The cruder traffic proximity exposure indicator was not adjusted for changes in vehicular emissions and therefore may overestimate the effect of this indicator. Alternatively, the proximity-attributable burden may reflect effects not scalable to changes in PM mass—for example, if the more toxic components of the mixture of fresh vehicular emissions changed to a different proportion than $PM_{2.5}$ mass, or if components of resuspended road dust that might not change at all were the relevant hazard (Schwartz 1999). The uncorrected traffic density is actually projected to increase (by 6.5%) from 2008 to 2035, as is the population living near a major road [from 8.3% to 10.9% (see Supplemental Material, Figure S1b)]. Because the burden and costs of NRAP are large, additional research is warranted to reduce these sources of uncertainty.

Another important assumption is that the age-specific CHD rates will remain unchanged from 2008 to 2035. CHD mortality rates have fallen markedly over the last several decades in the United States (Ford et al. 2007) due to several factors. However, increased prevalence of obesity and its metabolic consequences are likely to slow this decline in CHD mortality rates and could potentially reverse them. Therefore, it is difficult to quantify the net impact of these trends on the estimates of NRAP-attributable burden of disease.

A limitation to the comparison of the NRAP- and $PM_{2.5}$-attributable burden of CHD is that the original source CRFs were estimated for different age distributions. The $PM_{2.5}$ CRF was developed for a population ≥ 30 years (Krewski et al. 2009), which we assigned to the population ≥ 45 years in order to be comparable to the population for the CRFs for all three indices of NRAP (Gan et al. 2010, 2011; Kan et al. 2008). $PM_{2.5}$-attributable burden was considerably larger if applied to ≥ 30 years age group (3,100 fatal CHD events in 2008, e.g., compared with the 1,900 estimated based on the population ≥ 45 years). The larger estimate is generally consistent with other studies examining the burden of $PM_{2.5}$-attributable CHD mortality statewide (CARB 2010). If the CRFs for NRAP were applied to the population ≥ 30 years, the estimated burden also increased markedly (data not shown). We have elected to use the common NRAP CRF age distribution for all estimates because NRAP is the exposure of primary interest. However, the estimated burden for both NRAP and $PM_{2.5}$ restricted to the ≥ 45 year population is likely to be conservative.

Traffic-related noise has been associated with CHD, but whether it confounds, mediates, or interacts with near-roadway pollution is unclear (Fritschi et al. 2011). A recent review suggested that the two are likely independent risk factors of CHD (Davies and Kamp 2012), but this conclusion was based on only four studies. The CRFs we used were not adjusted for noise, so the near-roadway pollution-attributable burden could be independent or partially overlapping with the noise burden.

The health benefit from reduction in NRAP is unlikely to be limited to reductions in CHD mortality. We have not estimated burden of NRAP-attributable mortality associated with other outcomes, such as stroke and chronic obstructive pulmonary disease in the elderly, for which the causal relationships are less clear (HEI 2010). However, asthma and asthma exacerbation in children are likely caused by NRAP and have a large associated burden (Perez et al. 2012).

We calculated the PAF using the standard PAF formula (Equation 2). However, this estimate may be biased in the presence of confounding by characteristics in the study from which the CRF is derived if these covariates are not available for the target population (Darrow and Steenland 2011). There was little confounding of the CRFs for traffic density and EC by available covariates in the studies from which they were derived (Gan et al. 2011; Kan et al. 2008). However, the crude CRF associated with living near a major road was 1.69 and reduced to 1.29 after adjusting for confounders (age, sex, socioeconomic status, and co-morbidities) (Gan et al. 2010). These covariates are not available in our Southern California population data set. However, for a crude CRF/adjusted CRF of 1.69/1.29 (i.e., 1.3) and an exposure prevalence of 8.3% (the proportion of the 2008 SoCAB population living near a major road), our estimated traffic proximity PAF is likely to underestimate the true proximity PAF (Darrow and Steenland 2011).

Our results are likely to be relevant to other large North American cities with dispersed populations and high traffic volumes. We conclude that *a*) air pollution–attributable burden of CHD mortality may have been underestimated in most existing $PM_{2.5}$-based risk assessments because they ignore NRAP effects, *b*) greenhouse gas–reduction planning offers additional opportunities for improving future cardiac health, if the NRAP risks are mitigated, and *c*) NRAP- (and $PM_{2.5}$-) attributable CHD is likely to increase even if population exposure is reduced because of increased vulnerability of an aging population.

References

Anenberg SC, Horowitz LW, Tong DQ, West J. 2010. An estimate of the global burden of anthropogenic ozone and fine particulate matter on premature human mortality using atmospheric modeling. Environ Health Perspect 118:1189–1195; doi:10.1289/ehp.0901220.

Bell ML, Ebisu K, Peng RD, Samet JM, Dominici F. 2009. Hospital admissions and chemical composition of fine particle air pollution. Am J Respir Crit Care Med 179:1115–1120.

Benson PE. 1992. A review of the development and application of the CALINE3 and 4 models. Atmos Environ 26:379–390.

Brook RD, Rajagopalan S, Pope CA III, Brook JR, Bhatnagar A, Diez-Roux AV, et al. 2010. Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. Circulation 121:2331–2378; doi:10.1161/CIR.0b013e3181dbece1.

California Department of Finance. 2013. Report P-2: State and County Population Projections - Race/Ethnicity and 5-Year Age Groups, 2010–2060 (by Year). Available: http://www.dof.ca.gov/research/demographic/reports/projections/P-2/ [accessed 10 September 2013].

CARB (California Environmental Protection Agency California Air Resources Board). 2010. Estimate of Premature Deaths Associated with Fine Particle Pollution ($PM_{2.5}$) in California Using a U.S. Environmental Protection Agency Methodology. Available: http://www.arb.ca.gov/research/health/pm-mort/pm-report_2010.pdf [accessed 5 January 2014].

CARB. 2011. EMFAC2011-HD User's Guide. Sacramento, CA:CARB. Available: http://www.arb.ca.gov/msei/emfac2011-hd-users-guide-final.pdf [accessed 5 February 2013].

CARB. 2013a. EMFAC2011 Technical Documentation. Available: http://www.arb.ca.gov/msei/emfac2011-documentation-final.pdf [accessed 17 October 2014].

CARB. 2013b. EMFAC2011-LDV User's Guide. Sacramento, CA:CARB. Available: http://www.arb.ca.gov/msei/emfac2011-ldv-users-guide-final.pdf [accessed 5 February 20133].

Carter WP. 2000. Documentation of the SAPRC-99 Chemical Mechanism for VOC Reactivity Assessment. Final Report to California Air Resources Board, Contract No. 92-329 and (in Part) 95-308. Available: http://www.engr.ucr.edu/~carter/pubs/s99doc.pdf [accessed 5 February 2013].

CRC (Coordinating Research Council Inc). 2013. Effects of Light-Duty Vehicle Emissions on Ozone and PM With Past, Present, and Future Controls: Tier 0 versus Other Scenarios. CRC Report No. A-76-2. Alpharetta, GA:Coordinating Research Council Inc. Available: http://www.crcao.org/reports/recentstudies2013/A-76-2/CRC Project A76-2 Final Report.pdf [accessed 1 April 2013].

Darrow LA, Steenland NK. 2011. Confounding and bias in the attributable fraction. Epidemiology 22:53–58.

Davies H, Kamp IV. 2012. Noise and cardiovascular disease: a review of the literature 2008–2011. Noise Health 14:287–291.

Evans J, van Donkelaar A, Martin RV, Burnett R, Rainham DG, Birkett NJ, et al. 2013. Estimates of global mortality attributable to particulate air pollution using satellite imagery. Environ Res 120:33–42.

Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, et al. 2007. Explaining the decrease in U.S. deaths from coronary disease, 1980–2000. N Engl J Med 356:2388–2398; doi:10.1056/NEJMsa053935.

Ford ES, Capewell S. 2007. Coronary heart disease mortality among young adults in the U.S. from 1980 through 2002: concealed leveling of mortality rates. J Am Coll Cardiol 50:2128–2132; doi:10.1016/j.jacc.2007.05.056.

Fritschi L, Brown AL, Kim R, Schwela D, Kephalopolous S, eds. 2011. Burden of Disease from Environmental Noise: Quantification of Healthy Life Years Lost in Europe. Copenhagen, Denmark:World Health Organization, Regional Office for Europe.

Gan WQ, Koehoorn M, Davies HW, Demers PA, Tamburic L, Brauer M. 2011. Long-term exposure to traffic-related air pollution and the risk of coronary heart disease hospitalization and mortality. Environ Health Perspect 119:501–507; doi:10.1289/ehp.1002511.

Gan WQ, Tamburic L, Davies HW, Demers PA, Koehoorn M, Brauer M. 2010. Changes in residential proximity to road traffic and the risk of death from coronary heart disease. Epidemiology 21:642–649.

Geller MD, Sardar SB, Phuleria H, Fine PM, Sioutas C. 2005. Measurements of particle number and mass concentrations and size distributions in a tunnel environment. Environ Sci Technol 39:8653–8663; doi:10.1021/es050360s.

Greenland S. 2004. Interval estimation by simulation as an alternative to and extension of confidence intervals. Int J Epidemiol 33:1389–1397.

HEI (Health Effects Institute). 2010. Traffic-related Air Pollution: A Critical Review of the Literature on Emissions, Exposure, and Health Effects. HEI Special Report 17. Boston, MA:HEI. Available: http://pubs.healtheffects.org/getfile.php?u=553 [accessed 27 June 2014].

Hoffmann B, Moebus S, Stang A, Beck EM, Dragano N, Möhlenkamp S, et al. 2006. Residence close to high traffic and prevalence of coronary heart disease. Eur Heart J 27:2696–2702.

Janssen NA, Gerlofs-Nijland ME, Lanki T, Salonen RO, Cassee F, Hoek G, et al. 2012. Health effects of black carbon. Copenhagen, Denmark:World Health Organization, Regional Office for Europe. Available: http://www.euro.who.int/__data/assets/pdf_file/0004/162535/e96541.pdf [accessed 22 January 2014].

Kan H, Heiss G, Rose KM, Whitsel EA, Lurmann F, London SJ. 2008. Prospective analysis of traffic exposure as a risk factor for incident coronary heart disease: the Atherosclerosis Risk in Communities (ARIC) study. Environ Health Perspect 116:1463–1468; doi:10.1289/ehp.11290.

Karner AA, Eisinger DS, Niemeier DA. 2010. Near-roadway air quality: synthesizing the findings from real-world data. Environ Sci Technol 44:5334–5344.

Krewski D, Jerrett M, Burnett RT, Ma R, Hughes E, Shi Y, et al. 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. HEI Research Report 140. Boston, MA:Health Effects Institute. Available: http://pubs.healtheffects.org/getfile.php?u=478 [accessed 24 November 2013].

Manchester-Neesvig JB, Schauer JJ, Cass GR. 2003. The distribution of particle-phase organic compounds in the atmosphere and their use for source apportionment during the Southern California Children's Health Study. J Air Waste Manag Assoc 53:1065–1079.

Motallebi N, Taylor CA Jr, Croes BE. 2003. Particulate matter in California: Part 2—spatial, temporal, and compositional patterns of $PM_{2.5}$, $PM_{10-2.5}$, and PM_{10}. J Air Waste Manag Assoc 53:1517–1530.

Perez L, Lurmann F, Wilson J, Pastor M, Brandt SJ, Künzli N, et al. 2012. Near-roadway pollution and childhood asthma: implications for developing "win–win" compact urban development and clean vehicle strategies. Environ Health Perspect 120:1619–1626; doi:10.1289/ehp.1104785.

Peters JM, Avol E, Berhane K, Gauderman WJ, Gilliland F, Jerrett M, et al. 2004. Epidemiologic Investigation to Identify Chronic Effects of Ambient Air Pollutants in Southern California. Prepared for the California Air Resources Board and the California Environmental Protection Agency, Contract No. 94-331. Available: http://www.arb.ca.gov/research/apr/past/94-331a.pdf [accessed 2 February 2014].

SCAG (Southern California Association of Governments). 2012a. Regional Transportation Plan 2012–2035. Sustainable Communities Strategy. Towards a Sustainable Future. Los Angeles, CA:SCAG. Available: http://rtpscs.scag.ca.gov/Documents/2012/final/f2012RTPSCS.pdf [accessed 5 February 2013].

SCAG. 2012b. SCAG Regional Travel Demand Model and 2008 Model Validation. Los Angeles, CA:SCAG. Available: http://www.scag.ca.gov/DataAndTools/Documents/ValidationSummaryReport_SCAG2008Val_2012_06_05.pdf [accessed 27 May 2015].

SCAQMD (South Coast Air Quality Management District). 2013. Final 2012 Air Quality Management Plan South Coast Air Quality Management District, Diamond Bar, CA, February. Available: http://www.aqmd.gov/home/library/clean-air-plans/air-quality-mgt-plan/final-2012-air-quality-management-plan [accessed 5 February 2013].

Schwartz J. 1999. Air pollution and hospital admissions for heart disease in eight U.S. counties. Epidemiology 10:17–22.

U.S. Department of Transportation. 2013. Table 1–36. In: National Transportation Statistics. Washington, DC:U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics. Available: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/NTS_Entire_13Q4.pdf [accessed 10 February 2014].

U.S. EPA (U.S. Environmental Protection Agency). 2004. 40 CFR Part 1039—Control of emissions from new and in-use nonroad compression-ignition engines. Fed Reg 69:39213–39259.

U.S. EPA. 2009. Integrated Science Assessment for Particulate Matter (Final Report). Washington, DC:U.S. EPA. EPA/600/R-08/139F. Available: http://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=216546&CFID=44366845&CFTOKEN=80481999 [accessed 5 January 2014].

U.S. EPA. 2013. Regulatory Impact Analysis for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter. Research Triangle Park, NC. Available: http://www.epa.gov/ttnecas1/regdata/RIAs/finalria.pdf [accessed 18 March 2014].

U.S. EPA. 2014. EPA Sets Tier 3 Motor Vehicle Emission and Fuel Standards. EPA-420-F14-009. Available: http://www.epa.gov/otaq/tier3.htm [accessed 1 March 2014].

Wu J, Houston D, Lurmann F, Ong P, Winer A. 2009. Exposure of $PM_{2.5}$ and EC from diesel and gasoline vehicles in communities near the ports of Los Angeles and Long Beach, California. Atmos Environ 43:1962–1971; doi:10.1016/j.atmosenv.2009.01.009.

Zhu Y, Hinds WC, Kim S, Shen S, Sioutas C. 2002. Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmos Environ 36:4323–4335.

Zhu Y, Kuhn T, Mayo P, Hinds WC. 2006. Comparison of daytime and nighttime concentration profiles and size distributions of ultrafine particles near a major highway. Environ Sci Technol 40:2531–2536.

A Section 508–conformant HTML version of this article is available at http://dx.doi.org/10.1289/ehp.1409430.

Exposure to Road Traffic Noise and Behavioral Problems in 7-Year-Old Children: A Cohort Study

Dorrit Hjortebjerg,[1] Anne Marie Nybo Andersen,[2] Jeppe Schultz Christensen,[1] Matthias Ketzel,[3] Ole Raaschou-Nielsen,[1] Jordi Sunyer,[4] Jordi Julvez,[4] Joan Forns,[5] and Mette Sørensen[1]

[1]Danish Cancer Society Research Centre, Danish Cancer Society, Copenhagen, Denmark; [2]Section of Social Medicine, Department of Public Health, University of Copenhagen, Copenhagen, Denmark; [3]Department of Environmental Science, Aarhus University, Roskilde, Denmark; [4]Center for Research in Environmental Epidemiology, Barcelona, Spain; [5]Department of Genes and Environment, Norwegian Institute of Public Health, Oslo, Norway

BACKGROUND: Exposure to traffic noise has been associated with adverse effects on neuropsychological outcomes in children, but findings with regard to behavioral problems are inconsistent.

OBJECTIVE: We investigated whether residential road traffic noise exposure is associated with behavioral problems in 7-year-old children.

METHODS: We identified 46,940 children from the Danish National Birth Cohort with complete information on behavioral problems at 7 years of age and complete address history from conception to 7 years of age. Road traffic noise (L_{den}) was modeled at all present and historical addresses. Behavioral problems were assessed by the parent-reported Strengths and Difficulties Questionnaire (SDQ). Associations between pregnancy and childhood exposure to noise and behavioral problems were analyzed by multinomial or logistic regression and adjusted for potential confounders.

RESULTS: A 10-dB increase in average time-weighted road traffic noise exposure from birth to 7 years of age was associated with a 7% increase (95% CI: 1.00, 1.14) in abnormal versus normal total difficulties scores; 5% (95% CI: 1.00, 1.10) and 9% (95% CI: 1.03, 1.18) increases in borderline and abnormal hyperactivity/inattention subscale scores, respectively; and 5% (95% CI: 0.98, 1.14) and 6% (95% CI: 0.99, 1.12) increases in abnormal conduct problem and peer relationship problem subscale scores, respectively. Exposure to road traffic noise during pregnancy was not associated with child behavioral problems at 7 years of age.

CONCLUSIONS: Residential road traffic noise in early childhood may be associated with behavioral problems, particularly hyperactivity/inattention symptoms.

CITATION: Hjortebjerg D, Andersen AM, Christensen JS, Ketzel M, Raaschou-Nielsen O, Sunyer J, Julvez J, Forns J, Sørensen M. 2016. Exposure to road traffic noise and behavioral problems in 7-year-old children: a cohort study. Environ Health Perspect 124:228–234; http://dx.doi.org/10.1289/ehp.1409430

Introduction

Exposure to traffic noise is considerable in many parts of the world and has been associated with health effects among adults, including psychological symptoms such as anxiety and changes in mood (Stansfeld and Matheson 2003). Children are also suspected to be vulnerable to traffic noise, especially during sensitive stages of development (Stansfeld et al. 2005). Studies investigating effects on neuropsychological development due to traffic noise exposure in children have focused mainly on learning and cognitive performance, with consistent findings of impairment in reading and memory of aircraft noise exposure (Haines et al. 2001a, 2001b; Hygge et al. 2002; Stansfeld et al. 2005). The few studies that have investigated associations between exposure to traffic noise and parent-reported child behavioral problems are inconsistent (Haines et al. 2001a, 2001b; Stansfeld et al. 2009; Tiesler et al. 2013). Two small studies of schools near Heathrow airport found, respectively, no association and a weak association between school exposure to airport noise and hyperactivity and psychosocial morbidity (Haines et al. 2001a, 2001b). In 2009, a study of > 2,000 children from schools near airports in three European countries found that school exposure to airport noise was associated with an increased score of hyperactivity, whereas exposure to road traffic noise at the schools was not associated with hyperactivity, but with lower scores for conduct problems (i.e. fewer conduct problems) (Stansfeld et al. 2009). The only study investigating associations between residential exposure to road traffic noise and behavioral problems in children reported associations with hyperactivity and possibly emotional symptoms in a study of 900 German children (Tiesler et al. 2013).

Residential exposure to traffic noise might be a more relevant exposure window than exposure at school with regard to the investigated behavioral problems. First, children spend more time at home than at the school; and second, nighttime exposure might be very important, because traffic noise at normal urban levels has been associated with sleep disturbance, with regard to both quality and quantity (Pirrera et al. 2010). In children, sleep disturbance and sleep problems are suspected to affect child behavior (Gregory and Sadeh 2012; Quach et al. 2009), possibly through sleep deficits, which affect the frontal lobe—the part of the brain region that, among other functions, controls behavior and emotions (Quach et al. 2009).

No studies have investigated associations between exposure to traffic noise during pregnancy and behavioral problems. However, noise is an environmental stressor (Stansfeld and Matheson 2003), and maternal exposure to stress during pregnancy has been suggested to be associated with psychological effects in children, including cognitive, behavioral, and emotional development (Graignic-Philippe et al. 2014). A potential mechanism is activation of the maternal hypothalamic–pituitary–adrenal axis, leading to an increase in levels of maternal cortisol (Beijers et al. 2014). Cortisol can pass the fetal–placental barrier and might subsequently influence the fetal nervous system and emotional and cognitive functioning of the child (Davis and Sandman 2012; Seckl and Holmes 2007). Also, maternal sleep disturbance during pregnancy has been proposed to affect the neuroendocrine system (Beijers et al. 2014).

We used data from a large population-based birth cohort to investigate the associations between exposures to road traffic noise at the residence during pregnancy and early life and behavioral problems in 7-year-old children.

Materials and Methods

Study population. The study is based on the population-based Danish National Birth Cohort (DNBC) (Olsen et al. 2001). During

Address correspondence to D. Hjortebjerg, Danish Cancer Society Research Center, Danish Cancer Society, Strandboulevarden 49, 2100 Copenhagen Ø, Denmark. Telephone: 45 3525 7316. E-mail: dorhjo@cancer.dk

Supplemental Material is available online (http://dx.doi.org/10.1289/ehp.1409430).

The European Research Council, EU 7th Research Framework Programme supported this study (grant 281760). The Danish National Research Foundation established the Danish Epidemiology Science Centre that initiated and created the Danish National Birth Cohort. The cohort is furthermore a result of a major grant from this foundation. Additional support for the Danish National Birth Cohort is obtained from the Pharmacy Foundation, the Egmont Foundation, the March of Dimes Birth Defects Foundation, the Augustinus Foundation, and the Health Foundation. The 7-year follow-up received support from the Lundbeck Foundation (195/04) and the Danish medical Research Council (SSVF 0646).

The authors declare they have no actual or potential competing financial interests.

Received: 4 November 2014; Accepted: 25 June 2015; Advance Publication: 30 June 2015; Final Publication: 1 February 2016.

1996–2002, pregnant women who met the inclusion requirements of intending to carry their pregnancy to term, being able to speak Danish, and having a permanent address in Denmark were invited to participate in the DNBC. The invitation took place at the office of the general practitioner, where the women received written information and an informed consent to sign. All participating women provided informed consent.

Participation involved two prenatal computer-assisted telephone interviews conducted by trained interviewers. The first interview took place around the 12th pregnancy week and included, among others, questions related to maternal lifestyle factors during pregnancy, such as alcohol consumption and smoking habits as well as questions related to maternal mental health. Furthermore, when the child was 7 years old, a follow-up questionnaire was mailed to the parents of the child. This 7-year questionnaire included, among others, questions regarding behavioral problems of the child and was based on the Strengths and Difficulties Questionnaire (SDQ).

The DNBC was conducted in accordance with the Helsinki Declaration and approved by the Danish ethics committee.

Assessment of behavioral problems. Behavioral problems at 7 years of age were assessed by the Danish parent-reported version of the SDQ (SDQ-Dan) (Goodman 1997; Goodman et al. 2003; Obel et al. 2003). The SDQ is an internationally validated behavioral screening questionnaire for children and adolescents. It encompasses the child's behavior in the preceding 6 months and is used worldwide for clinical and research purposes.

The SDQ consists of 25 items and generates scores within five subscales: emotional symptoms, conduct problems, hyperactivity/inattention, peer relationship problems, and prosocial behaviors. Each subscale is covered by five items, which can be rated with a three-point scale option: "not true" (0), "somewhat true" (1), or "certainly true" (2), and each subscale score is generated by summing up the ratings. The total difficulties score is obtained by summing up all subscale score except the prosocial behavior score as described in detail elsewhere (Youth*in*Mind 2015). The higher the scores are within each scale, the more behavioral problems are indicated (except for the prosocial behavior score).

In the present study, the total difficulties score and the scores within the subscales of emotional symptoms, conduct problems, hyperactivity/inattention, and peer relationship problems were divided into the categories normal, borderline, or abnormal, by the use of the normative age- and sex-specific cut-off scores for Danish children (Niclasen et al. 2012; Youth*in*Mind 2015). Only children with no missing values on the items were included.

Exposure. Residential address history during pregnancy and from birth until 7 years of age was collected using the Danish civil registration system (Pedersen 2011). Road traffic noise exposure was calculated for the years 1995, 2000, 2005, and 2010 for all present and historical addresses using SoundPLAN, which calculates road traffic noise in accordance with the Nordic prediction method (Bendtsen 1999). Based on this, for each child we calculated time-weighted exposures (during pregnancy and childhood), taking all addresses the child had lived in during the period of interest into account, weighted by the time the child had lived at each address.

For each address, the geographical coordinates and height (floor), corresponding to the point of noise estimation were used as input variables for the noise model, including data on road lines, with information on yearly average daily traffic, vehicle distribution (light, heavy), traffic speed, and road type, obtained from DCE-Danish Centre for Environment and Energy, Aarhus University (http://www.dce.au.dk) and from The Danish Road Directorate (http://www.vejdirektoratet.dk), as described in detail elsewhere (Jensen et al. 2009). Topographical parameters included data on building polygons for all surrounding buildings, as well as data on building height, provided by the Danish Geodata Agency (http://www.eng.gst.dk). We assumed that the terrain was flat, which is a reasonable assumption in Denmark, and that urban areas, roads, and areas with water were hard surfaces, whereas all other areas were acoustically porous. No information was available on noise barriers or type of asphalt.

Road traffic noise was calculated as the equivalent continuous A-weighted sound pressure level (L_{Aeq}), at the most exposed facade of the dwelling at each address for the day (L_d; 0700–1900 hours), evening (L_e; 1900–2200 hours), and night (L_n; 2200–0700 hours). Road traffic noise was expressed as L_{den} by applying a 5-dB penalty for the evening and a 10-dB penalty for the night. Decibel is a logarithmic scale, which means that a 3-dB higher level of noise corresponds to a doubling in acoustical energy. All values < 40 dB were set to 40 dB because this was considered the lower limit of road traffic noise.

Residential exposure to railway traffic noise was calculated for the years 1995, 2000, 2005, and 2010 for all present and historical addresses using SoundPLAN, which calculates railway traffic noise in accordance with NORD2000, a Nordic calculation method for prediction of noise propagating for railway traffic noise (http://www.soundplan.dk). Geographical coordinates and height (floor) for each residential address were used in the noise model, including railway lines, with information on annual average daily train lengths, train types, and travel speed, which were obtained from the railway enterprise Banedanmark, operating and developing the Danish state railway network (http://www.bane.dk). The daily train lengths were given for 1997 and 2012. Furthermore, building polygons were included in the model as well as all noise barriers along the railway. Railway traffic noise was expressed as L_{den} at the most exposed facade of the dwelling. In the analyses, railway noise exposure < 20 dB was set to 0 because we estimated overall background noise to be no lower than 20 dB.

The noise impact from all Danish airports and airfields was determined from information about noise zones (5-dB categories) obtained from local authorities. The programs DANSIM (Danish Airport Noise Simulation Model) and INM3 (Integrated Noise Model), which fulfill the joint Nordic criteria for air traffic noise calculations were used (Liasjø and Granøien 1993). The curves for airport noise were transformed into digital maps and linked to each residential address history by geographical coordinates.

Air pollution at all geographical coordinates was calculated with the use of the Danish AirGIS modeling system, as described in detail elsewhere (Ketzel et al. 2011). This system allows calculation of air pollution as the sum of local air pollution from traffic in the streets based on the Operational Street Pollution Model (OSPM), the urban background contribution based on an area dispersion model, and contributions from the regional background (Berkowicz et al. 2008). We used levels of nitrogen oxides (NO_x) as an indicator of air pollution, which was calculated based on data for the relevant years about traffic data for individual road lines, emission factors for Danish car fleet, street and building geometry, including building height as well as meteorological data. Air pollution exposure was expressed as the yearly mean concentration of NO_x (micrograms per cubic meter). We focused on NO_x as proxy for air pollution from traffic because measured NO_x correlates strongly with other traffic-related pollutants in Danish streets including total particle number concentration (10–700 nm; $r = 0.93$) and PM_{10} (particulate matter ≤ 10 μm) ($r = 0.70$) (Ketzel et al. 2003).

Statistical analyses. The associations between exposure to residential road traffic and railway noise and behavioral problems at 7 years of age were analyzed by multinomial logistic regression models (for road traffic noise) and logistic regression models (for railway noise). Exposure to road traffic noise was modeled as time-weighted mean during two different exposure windows: *a*) pregnancy period, and *b*) from birth to 7 years of age, taking all present and historical addresses into account. Exposure to railway noise was modeled as continuous at the residential address at *a*) time of birth, and *b*) time of filling in the SDQ (7 years) and was analyzed as a categorical variable among all participants (unexposed, ≤ 60 dB, and > 60 dB) and as a linear trend (per 10 dB) in the subset of the children with railway noise exposure. The assumption of linearity of road traffic and railway noise for both exposure windows in relation to child behavioral problems was evaluated by fitting models with the exposure variables on continuous scale simultaneously with the quadratic term of the exposure variables. All were found to be linear ($p > 0.05$) except for the total difficulties score with regard to road traffic noise exposure from birth until 7 years of age, which was borderline linear ($p = 0.04$).

For road traffic noise, we estimated the associations as odds ratios (OR) with corresponding 95% confidence intervals (CI) for being classified in the borderline or in the abnormal category per 10-dB increase in L_{den} road using the normal category as a reference. For railway noise, we estimated OR for being classified as abnormal using the normal/borderline category as a reference. We calculated crude ORs and adjusted for potential confounders, selected *a priori*, using a two-stage approach. First, models were adjusted for sex, age at filling in the SDQ (years), gestational age (< 37, ≥ 37 weeks), birth weight (< 2,500, ≥ 2,500 g, from the Danish Medical Birth Registry), maternal age at delivery (years), parity (0, 1, ≥ 2), smoking during the first trimester of pregnancy (no/yes), average alcohol consumption (< 1, ≥ 1 drinks per week) during the first trimester of pregnancy, level of education [highest attained education 1 year before conception: basic (7–12 years of primary, secondary, and grammar-school education), vocational (10–12 years of education), and higher (≥ 13 years of education)], disposable income (quintiles; household income after taxation and interest per person, adjusted for number of persons in the household and deflated according to the 2000 value of the Danish crown), railway (no, ≤ 60 dB, > 60 dB) and airport noise (yes, no) at birth (for analyses of road traffic exposure during pregnancy) and at 7 years of age (for analyses of childhood exposure), and maternal mental health problems during the first trimester ("yes" or "no" based on the following two questions in the 12-week pregnancy interview: "Have you ever had psychological disorders or bad nerves?" and "have you had nuisance of this disorder during pregnancy?"). Second, analyses of road traffic noise were further adjusted for time-weighted mean of NO_x (micrograms per cubic meter) corresponding to each exposure window. All information on socioeconomic position (SEP)—maternal education and disposable income—was obtained from the national register, Statistics Denmark (http://www.dst.dk). Also, a categorical analysis with five road traffic noise categories of < 50, 50–55, 55–60, 60–65, and ≥ 65 dB was performed for the total difficulties score and the hyperactivity/inattention subscale.

Potential modification of the association between road traffic noise from birth until 7 years of age (per 10-dB increase in road traffic) and the total difficulties score as well as the hyperactivity/inattention subscale by sex, birth weight, educational level, income, and railway noise were evaluated by including interaction terms into a logistic regression model. Potential effect modifiers were selected *a priori* based on previous studies (Lercher et al. 2002). Both scales were dichotomized into abnormal versus normal/borderline behavior, and potential effect modifications were tested by the Wald test. An alpha level of 5% (two-sided) was used to define statistical significance. All analyses were done in SAS (version 9.3; SAS Institute Inc., Cary, NC, USA).

Results

Of the study base of participating mother–child pairs with information on SDQ ($n = 57,281$), we included only the first enrolled pregnancy to avoid non-independent observations ($n = 54,103$) and excluded 2,272 mothers with multiple pregnancies, 1,833 with incomplete information on behavioral problems, 170 with missing noise exposure data, and 2,888 with incomplete information on one or more potential confounders, leaving a study cohort of 46,940 children.

Characteristics of the study population and cases classified as borderline and abnormal on the total difficulties score are summarized in Table 1. Of the 46,940 children, 11% were classified as borderline and 8% were classified

Table 1. Characteristics of the study population by case status using the total difficulties score.

Covariates	Cohort (n = 46,940)	Borderline cases[a] (n = 5,309)	Abnormal cases[a] (n = 3,770)
Sex			
Boy	51.1	54.4	52.3
Girl	48.9	45.6	47.7
Age at SDQ (years)	7.13 (7.03–7.41)	7.14 (7.03–7.41)	7.14 (7.03–7.41)
Gestational age at birth (weeks)			
< 37	4.2	4.9	6.4
≥ 37	95.8	95.1	93.6
Birth weight (g)			
< 2,500	2.6	3.3	4.6
≥ 2,500	97.4	96.7	95.4
Maternal age at birth (years)	30.3 (23.9–37.9)	29.5 (23.1–37.3)	29.1 (22.0–37.3)
Parity			
Nulliparous	49.9	56.7	56.0
Uniparous	34.6	31.8	32.7
Multiparous	15.5	11.5	11.3
Maternal smoking during 1st trimester			
No	75.9	71.5	65.8
Yes	24.1	28.5	34.2
Maternal alcohol consumption during 1st trimester			
< 1 drinks per week	88.2	89.3	90.1
≥ 1 drinks per week	11.8	10.2	9.9
Highest attained education			
Basic (7–12 years)	13.3	18.7	26.9
Vocational (10–12 years)	52.8	54.8	53.9
Higher (≥ 13 years)	33.9	26.5	19.2
Disposable income			
Low	17.9	18.7	21.3
Medium	30.7	31.4	31.9
High	51.4	49.9	46.8
Maternal mental health problems during 1st trimester			
No	98.9	98.5	97.8
Yes	1.1	1.5	2.2
Road traffic noise (dB)[b]	57.9 (50.3–68.1)	58.1 (50.5–68.2)	58.6 (50.6–68.1)
Exposed to railway noise at 7 years of age			
No	86.9	87.0	86.8
Yes	13.1	13.0	13.2
Among exposed (dB)	48.4 (34.6–64.8)	47.7 (34.8–65.8)	49.6 (34.7–66.0)
Exposed to railway noise at birth			
No	84.3	84.3	83.9
Yes	15.7	15.7	16.1
Among exposed (dB)	50.5 (30.5–67.9)	50.4 (30.0–67.9)	51.2 (29.6–68.7)
Exposed to airport noise at 7 years of age	1.3	1.3	1.5
Air pollution (NO_x, μg/m^3)[b]	12.2 (10.9–34.5)	12.2 (10.9–33.5)	12.3 (10.9–33.3)

Values are percent or median (5th–95th percentiles).
[a]Total difficulties score. [b]Mean time-weighted exposure from birth until 7 years of age.

as abnormal. Compared with the cohort, borderline and abnormal cases were more likely to be boys, be the firstborn child, be exposed to maternal smoking during the first trimester, and have mothers with lower educational level and disposable income. The correlation (*R*) between L_{den} road during pregnancy and childhood was 0.74, and between L_{den} road and air pollution (NO_x) the correlation was 0.59 for the pregnancy period and 0.42 for the period from birth until 7 years of age. There was a high correlation between the L_{den} and L_n road for the pregnancy period (0.97) and during childhood (0.90). The correlation between L_{den} road and L_{den} railway among the participants exposed to railway noise (13.1% at 7 years of age) was very weak (0.03).

For time-weighted mean exposure from birth to 7 years of age, we estimated that a 10-dB higher exposure to road traffic noise was associated with a 7% increase in abnormal total difficulties scores (95% CI: 1.00, 1.14) (Table 2), which seemed to follow a monotonic exposure–response relationship until 60–65 dB, after which the curve leveled off (Figure 1A). On the hyperactivity/inattention subscale, a 10-dB higher road traffic noise exposure was associated with a 5% increase in borderline (95% CI: 1.00, 1.10) and a 10% increase in abnormal (95% CI: 1.03, 1.18) scores as compared with normal scores in the adjusted models (Table 2), which seemed to follow a monotonic exposure–response relationship until 60–65 dB, after which the curve leveled off (Figure 1B). A 10-dB higher exposure to road traffic noise was associated with a 5% increase in abnormal conduct problem scores (95% CI: 0.98, 1.14) and with a 6% increase in abnormal peer relationship scores (95% CI: 0.99, 1.12). Further adjustment for NO_x resulted in small increases in the estimates (results not shown). Also, NO_x exposure in itself (in models without adjustment for noise) was not associated with behavioral problems: For example, a 20-μg/m^3 increase in time-weighted mean exposure to NO_x from birth to 7 years was associated with ORs of 0.95 (95% CI: 0.90, 1.00) and 0.95 (95% CI: 0.89, 1.01) for scoring borderline and abnormal, respectively, on the total difficulties score, and of 0.97 (95% CI: 0.92, 1.02) and 0.99 (95% CI: 0.93, 1.06) for scoring borderline and abnormal, respectively, on the hyperactivity/inattention subscale. There were no clear associations between exposure to road traffic noise during pregnancy and behavioral problems (Table 2). Exposure during pregnancy was inversely associated with borderline total difficulties scores (OR = 0.95; 95% CI: 0.90, 0.99) but was not associated with abnormal total difficulties scores (OR = 0.99; 95% CI: 0.94, 1.05). For both exposure time windows, adjusting for airport and railway noise did not affect associations of road traffic noise with borderline or abnormal scores for total difficulties score or any of the subscales (see Supplemental Material, Table S1). Adjusting for road traffic and airport noise had no influence on odds ratios for railway noise at birth or at 7 years of age (see Supplemental Material, Table S2).

Among the subset of children with railway noise exposure at 7 years, a 10-dB increase in exposure was positively associated with abnormal scores for total difficulties (OR = 1.13; 95% CI: 1.02, 1.25) and peer relationship problems (OR = 1.13; 95% CI: 1.03, 1.25) (Table 3). We found no significant associations between this exposure and the

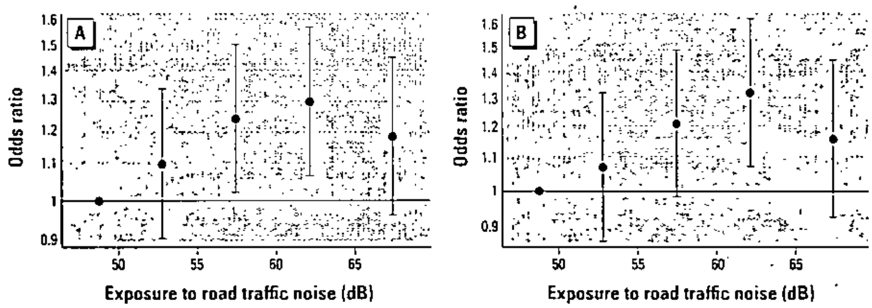


Figure 1. Associations between exposure to road traffic noise (L_{den}) at childhood and abnormal scores on the total difficulties score (*A*) and hyperactivity/inattention subscale (*B*). The vertical whiskers show odds ratios with 95% confidence intervals at the median of four exposure categories (50–55, 55–60, 60–65, and ≥ 65 dB) when compared with the reference category of < 50 dB.

Table 2. Associations between exposure to road traffic noise (L_{den}, per 10-dB increase) during pregnancy and early childhood and child behavioral borderline or abnormal scores.

	Exposure to road traffic noise (L_{den}) during pregnancy[a]			Exposure to road traffic noise (L_{den}) from birth to 7 years of age[a]		
Strengths and Difficulties Questionnaire (SDQ)	*n*	Crude OR (95% CI)	Adjusted OR (95% CI)[b]	*n*	Crude OR (95% CI)	Adjusted OR (95% CI)[b]
Total difficulties						
Normal	37,861	1.00	1.00	37,861	1.00	1.00
Borderline	5,309	0.99 (0.95, 1.04)	0.95 (0.90, 0.99)	5,309	1.07 (1.01, 1.13)	1.00 (0.95, 1.06)
Abnormal	3,770	1.05 (1.00, 1.11)	0.99 (0.94, 1.05)	3,770	1.17 (1.11, 1.25)	1.07 (1.00, 1.14)
Emotional symptoms						
Normal	40,245	1.00	1.00	40,245	1.00	1.00
Borderline	3,099	1.08 (1.02, 1.15)	1.00 (0.95, 1.06)	3,099	1.12 (1.05, 1.19)	1.03 (0.96, 1.10)
Abnormal	3,596	1.08 (1.02, 1.14)	0.97 (0.92, 1.03)	3,596	1.11 (1.04, 1.18)	0.98 (0.92, 1.05)
Conduct problems						
Normal	40,374	1.00	1.00	40,374	1.00	1.00
Borderline	4,045	0.99 (0.94, 1.04)	0.99 (0.94, 1.05)	4,045	1.02 (0.97, 1.09)	1.01 (0.96, 1.07)
Abnormal	2,521	0.98 (0.92, 1.05)	0.98 (0.92, 1.05)	2,521	1.10 (1.03, 1.18)	1.05 (0.98, 1.14)
Hyperactivity/inattention						
Normal	37,799	1.00	1.00	37,799	1.00	1.00
Borderline	6,097	1.03 (0.99, 1.08)	1.01 (0.96, 1.05)	6,097	1.09 (1.05, 1.15)	1.05 (1.00, 1.10)
Abnormal	3,044	1.04 (0.99, 1.11)	1.01 (0.96, 1.08)	3,044	1.18 (1.11, 1.26)	1.10 (1.03, 1.18)
Peer relationship problems						
Normal	37,690	1.00	1.00	37,690	1.00	1.00
Borderline	5,243	1.02 (0.98, 1.07)	1.01 (0.97, 1.06)	5,243	1.06 (1.01, 1.12)	1.05 (0.99, 1.10)
Abnormal	4,007	1.02 (0.97, 1.08)	0.99 (0.94, 1.04)	4,007	1.12 (1.06, 1.19)	1.06 (0.99, 1.12)

[a]Mean time-weighted exposure. [b]Adjusted for sex, age at SDQ, gestational age, birth weight, maternal age at delivery, parity, educational level, disposable income, smoking and alcohol consumption during 1st trimester, railway and airport noise at birth (for exposure during pregnancy) and at 7 years of age, and self-reported maternal mental health problems during 1st trimester (yes/no).

remaining outcomes, though for the hyperactivity/inattention subscale a 10-dB increase in railway noise was associated with a 9% increase in abnormal scores (95% CI: 0.97, 1.22). In the cohort as a whole, exposure to railway noise ≤ 60 dB at the time of birth was positively associated with abnormal emotional symptom scores (OR = 1.11; 95% CI: 1.00, 1.23 compared with unexposed children) but this outcome was not associated with railway noise > 60 dB (OR = 1.01; 95% CI: 0.83, 1.22). No other associations between exposure to railway noise at the time of birth and abnormal behavioral problems were observed.

We found no significant effect modification by sex, low birth weight, educational level, income, or railway noise, though for birth weight we found a borderline significant effect modification ($p = 0.06$), with stronger association between road traffic noise and hyperactivity/inattention for children with low birth weight (Table 4).

Discussion

Using a large national birth cohort study, we found that cumulative exposure during childhood to road traffic noise at home was positively associated with behavioral problems at 7 years of age, particularly hyperactivity/inattention symptoms. We found no consistent associations between exposure to either road traffic or railway noise at home during the pregnancy period and behavioral problems.

Our findings suggest that exposure to residential road traffic noise during childhood and potentially railway noise may increase the risk for hyperactivity/inattention

Table 4. Modification of associations between time-weighted mean exposure to road traffic noise (L_{den}) from birth to 7 years of age (per 10-dB increase)[a] and abnormal scores on the total difficulties score and the hyperactivity/inattention subscale by sex, birth weight, education, income, and railway noise.

	Total difficulties score			Hyperactivity/inattention		
Characteristic	Abnormal cases (*n*)	OR (95% CI)[b]	*p*-Interaction	Abnormal cases (*n*)	OR (95% CI)[b]	*p*-Interaction
Sex			0.49			0.10
Girl	1,798	1.09 (1.00, 1.19)		1,339	1.16 (1.05, 1.29)	
Boy	1,972	1.05 (0.97, 1.14)		1,705	1.04 (0.96, 1.14)	
Birth weight (g)			0.17			0.06
< 2,500	176	1.30 (0.97, 1.76)		140	1.49 (1.08, 2.05)	
≥ 2,500	3,596	1.06 (0.99, 1.13)		2,904	1.08 (1.01, 1.16)	
Parental educational level			0.98			0.31
Basic	1,016	1.07 (0.94, 1.22)		718	1.11 (0.97, 1.28)	
Vocational	2,030	1.06 (0.98, 1.15)		1,653	1.05 (0.96, 1.15)	
Higher	724	1.07 (0.94, 1.23)		673	1.19 (1.04, 1.36)	
Disposable income[c]			0.99			0.72
Low	1,352	1.07 (0.97, 1.19)		1,043	1.12 (1.00, 1.25)	
High	2,418	1.07 (0.99, 1.15)		2,001	1.09 (1.01, 1.18)	
Railway noise			0.67			0.23
Unexposed	3,270	1.06 (0.99, 1.13)		2,643	1.07 (1.00, 1.15)	
≤ 60 dB	420	1.13 (0.95, 1.35)		341	1.28 (1.06, 1.55)	
≥ 60 dB	80	0.95 (0.62, 1.45)		60	1.01 (0.63, 1.63)	

[a]Mean time-weighted exposure. [b]Adjusted for sex, age at SDQ, gestational age, birth weight, maternal age at delivery, parity, educational level, disposable income, smoking and alcohol consumption during 1st trimester, railway and airport noise at 7 years of age, and self-reported maternal mental health problems during 1st trimester (yes/no). [c]Cut point is median income of the Danish background population (age standardized), obtained from Statistics Denmark.

Table 3. Associations between exposure to railway noise at time of birth and at SDQ (7 years), and abnormal scores on the total difficulties score and subscales.

Strengths and Difficulties Questionnaire (SDQ)	Exposure to railway noise (L_{den}) at time of birth			Exposure to railway noise (L_{den}) 7-year SDQ		
	Abnormal cases (*n*)	Crude OR (95% CI)	Adjusted OR (95% CI)[a]	Abnormal cases (*n*)	Crude OR (95% CI)	Adjusted OR (95% CI)[a]
Total difficulties score (*n* = 3,770)						
Unexposed	3,164	1.00	1.00	3,270	1.00	1.00
≤ 60 dB	473	0.98 (0.88, 1.08)	0.98 (0.88, 1.06)	420	0.95 (0.96, 1.06)	0.94 (0.85, 1.06)
> 60 dB	133	1.04 (0.87, 1.25)	0.97 (0.81, 1.17)	80	1.20 (0.95, 1.52)	1.14 (0.90, 1.45)
Linear trend per 10 dB[b]	606	1.03 (0.89, 1.12)	1.01 (0.93, 1.10)	500	1.15 (1.04, 1.27)	1.13 (1.02, 1.25)
Emotional symptoms (*n* = 3,596)						
Unexposed	2,957	1.00	1.00	3,085	1.00	1.00
≤ 60 dB	509	1.14 (1.03, 1.26)	1.11 (1.00, 1.23)	439	1.17 (0.96, 1.19)	1.05 (0.94, 1.16)
> 60 dB	130	1.09 (0.91, 1.31)	1.01 (0.83, 1.22)	72	1.14 (0.89, 1.45)	1.10 (0.86, 1.41)
Linear trend per 10 dB[b]	639	1.03 (0.95, 1.12)	1.02 (0.94, 1.11)	511	1.01 (0.91, 1.12)	1.00 (0.90, 1.11)
Conduct problems (*n* = 2,521)						
Unexposed	2,128	1.00	1.00	2,174	1.00	1.00
≤ 60 dB	313	0.96 (0.86, 1.09)	0.98 (0.87, 1.11)	300	1.03 (0.91, 1.17)	1.05 (0.92, 1.18)
> 60 dB	80	0.92 (0.73, 1.16)	0.90 (0.71, 1.13)	47	1.04 (0.77, 1.41)	1.01 (0.75, 1.37)
Linear trend per 10 dB[b]	393	0.96 (0.87, 1.06)	0.94 (0.85, 1.04)	347	0.96 (0.85, 1.04)	0.95 (0.84, 1.07)
Hyperactivity/inattention (*n* = 3,044)						
Unexposed	2,570	1.00	1.00	2,643	1.00	1.00
≤ 60 dB	368	0.94 (0.84, 1.05)	0.94 (0.86, 1.05)	341	0.96 (0.85, 1.08)	0.94 (0.85, 1.07)
> 60 dB	106	1.02 (0.83, 1.25)	0.97 (0.79, 1.19)	60	1.10 (0.85, 1.44)	1.05 (0.80, 1.38)
Linear trend per 10 dB[b]	474	0.99 (0.90, 1.09)	0.98 (0.87, 1.07)	401	1.11 (0.99, 1.24)	1.09 (0.97, 1.22)
Peer relationship problems (*n* = 4,007)						
Unexposed	3,362	1.00	1.00	3,470	1.00	1.00
≤ 60 dB	509	0.99 (0.90, 1.09)	0.98 (0.89, 1.09)	446	0.96 (0.86, 1.06)	0.96 (0.86, 1.06)
> 60 dB	136	0.99 (0.83, 1.19)	0.97 (0.80, 1.16)	91	1.30 (1.04, 1.62)	1.27 (1.01, 1.58)
Linear trend per 10 dB[b]	645	0.98 (0.91, 1.07)	0.98 (0.90, 1.06)	537	1.15 (1.04, 1.27)	1.13 (1.03, 1.25)

[a]Adjusted for sex, age at SDQ, gestational age, birth weight, maternal age at delivery, parity, educational level, disposable income, smoking and alcohol consumption during 1st trimester, airport noise at birth (for exposure at birth) and at SDQ, road traffic noise during pregnancy (for exposure at birth) and from birth until 7 years of age, and self-reported maternal mental ill health during 1st trimester (yes/no). [b]Linear association among exposed.

symptoms at 7 years of age. Hyperactive children are normally more easily distracted by background noise (Gray et al. 2002), and it seems possible that traffic noise may exacerbate these children's difficulties, thereby making an existing tendency toward hyperactivity worse or more obvious. Our results are in line with those of most previous studies investigating associations between exposure to traffic noise either at home and in schools and behavioral problems (Haines et al. 2001b; Stansfeld et al. 2009; Tiesler et al. 2013). A similar though smaller German study (900 children) reported road traffic noise at home (for the address at time of SDQ) to be significantly associated with more hyperactivity/inattention symptoms in 10-year-old children (Tiesler et al. 2013). The published studies on airport and road traffic noise at schools are less consistent. Two studies reported positive associations between road traffic noise and hyperactivity/inattention symptoms (Haines et al. 2001a; Stansfeld et al. 2009), whereas the third study reported no association (Haines et al. 2001b). A possible explanation for this inconsistency might be that exposure to traffic noise at home is potentially more hazardous than school exposure, perhaps because children typically spend more time at home than at school, and that nighttime exposure to noise might be particularly hazardous because it disturbs sleep (Basner et al. 2011; Hume et al. 2012; Pirrera et al. 2010), which is suspected of affecting child behavior (Gregory and Sadeh 2012; Quach et al. 2009). However, we had no information on sleep disturbance among the children and could not separate the effects of nighttime exposure to road traffic noise from daytime exposure because of the high correlation between L_{den} and L_n; therefore, speculations regarding hazardous effects of nighttime noise in the present study are hypothetical.

One potentially important confounder in the present study is exposure to air pollution, because air pollution is correlated with road traffic noise and is also suspected of having damaging impact on the central nervous system (Block et al. 2012), possibly affecting the cognitive development of children (Guxens et al. 2014). However, NO_x, an indicator of traffic-related air pollution, was not associated with behavioral problems, and adjustment for it resulted in only minor changes in estimates.

To our knowledge, this is the first study to report a positive association between traffic noise—both road traffic and railway noise—and scoring abnormal on the total difficulties score, corresponding to an estimate of overall behavioral problems. None of the four previous studies investigating this for exposures to traffic noise at home or in school have found traffic noise associated with this score (Haines et al. 2001a, 2001b; Stansfeld et al. 2009; Tiesler et al. 2013). However, these previous studies are smaller than the present study (< 2,014 children), with less power to detect the rather small associations seen in the present study. The total difficulties score is a combination of four behavioral domains, and it seems likely that in our study the association with this score is driven mainly by the positive association found for the hyperactivity/inattention subscale.

We found no associations between road traffic noise and emotional symptoms, and weak, insignificant associations with conduct problem and peer relationship problems. These results are similar to those of studies on school exposure to traffic noise but in contrast with the study by Tiesler et al. on residential road traffic noise, which indicated an association with emotional symptoms (Tiesler et al. 2013). A possible explanation for the different results might be differences in adjustment for potential confounders, because we found positive associations with borderline and abnormal emotional symptom scores in our crude analysis. However, no associations were observed in the adjusted analyses.

Our study indicated that railway noise exposure at 7 years of age was positively associated with peer relationship problems in our study population. However, we have no explanation for this finding; it may be a chance finding, because we find no associations with road traffic noise.

Our results indicated that exposure during pregnancy was not associated with childhood behavior at 7 years of age. The only significant finding was an inverse association for scoring borderline on the total difficulties score, which we believe to be a chance finding because this is opposite our hypothesis and found only for the borderline score and not for the abnormal score. Associations between pregnancy exposure to traffic noise and behavioral problems in childhood have to our knowledge not been investigated before, but our results suggest that prenatal stress due to traffic noise is not important in relation to this outcome.

We found a borderline significant effect modification by birth weight, with stronger association between road traffic noise and hyperactivity/inattention for children with low birth weight. Previous studies on this are inconsistent. One study found that the association between ambient neighborhood noise (predominantly road and railway noise) and mental health problems in children was modified by low birth weight or being born premature, with strongest association among children with low birth weight or prematurity (Lercher et al. 2002). On the other hand, a recent study found no effect modification (interaction p-values > 0.05) by low birth weight or preterm birth in relation to the association between school exposure to airport or road traffic noise and children's mental health (Crombie et al. 2011). More studies in this area are needed.

Strengths of our study include the large study population, with information on various potential confounders obtained from questionnaires and nationwide registers, as well as modeled air pollution. Another major strength is access to residential address histories from conception to 7 years of age, which makes it possible to investigate different exposure time windows.

Some limitations have to be considered. We used the Nordic prediction method for noise estimation, and although the Nordic prediction method has been used for many years, estimation of noise may be associated with some degree of uncertainty. Noise estimation depends on accurate input data, and we had no information on noise barriers or road surface in the modeling of road traffic noise. This could have resulted in exposure misclassification, but such misclassification is believed to be nondifferential, and, in most situations, this would influence the estimates toward the neutral value. In addition, because the correlation between L_{den} and L_n was very high in the present study, we were not able to separate the effect of these two exposures. Another limitation is that we had information only on residential addresses of the child and not, for example, the address of a single parent, if the parents were divorced or living apart, with whom the child could be staying part of the time. Moreover, we had no information on whether the child's bedroom faced a busy road or backyard, or on noise insulation or window-opening habits, all of which influence the child's personal exposure to noise. Studies have found associations between noise and cardiovascular outcomes to be stronger when factors like these are considered (Foraster et al. 2014; Selander et al. 2009). Therefore, lack of this information might have contributed to underestimation of the effects of road traffic noise and railway noise on behavioral problems. Furthermore, behavioral problems were based on the parent-reported version of the SDQ and recalling of the child's behavior in the past 6 months, which may be associated with some recall bias. Also, the parental version of the SDQ has in community samples been suggested not to capture emotional symptoms as well as the other subscales, which may have affected the results of this subscale (Goodman et al. 2003). Moreover, maternal mental health problems were based on a combination of two items in the 12th-week pregnancy interview and may not have adequately captured maternal psychopathology. Reviewing medical records to obtain information on confirmed diagnoses and using a time interval longer than the first trimester might have improved the adjustment of this confounder. Last, there might be residual confounding by SEP. However, we have detailed information from questionnaires and registers on the most important confounders. Also, in Denmark a high proportion of highly educated people live in central urban areas with relatively high traffic noise, so differences in noise exposure according to SEP is not pronounced in the present study: Mothers with low, medium, and high levels of education were exposed to medians of 58.8, 57.9, and 57.7 dB road traffic noise, respectively, suggesting that residual confounding by SEP is not a major problem in the present study.

In conclusion, this study provides further insight into the relationship between traffic noise and behavior in children. The results indicate that, in our study population, exposure to residential road traffic noise from birth until 7 years of age was associated with parentally reported hyperactivity/inattention symptoms at 7 years, whereas exposure to noise during pregnancy was not associated with behavioral problems in childhood. More studies are needed to understand the mechanism through which traffic noise might affect children's behavior.

References

Basner M, Müller U, Elmenhorst EM. 2011. Single and combined effects of air, road, and rail traffic noise on sleep and recuperation. Sleep 34:11–23.

Beijers R, Buitelaar JK, de Weerth C. 2014. Mechanisms underlying the effects of prenatal psychosocial stress on child outcomes: beyond the HPA axis. Eur Child Adolesc Psychiatry 23:943–956.

Bendtsen H. 1999. The Nordic prediction method for road traffic noise. Sci Total Environ 331–338.

Berkowicz R, Ketzel M, Jensen SS, Hvidberg M, Raaschou-Nielsen O. 2008. Evaluation and application of OSPM for traffic pollution assessment for a large number of street locations. Environ Model Softw 23:296–303.

Block ML, Elder A, Auten RL, Bilbo SD, Chen H, Chen JC, et al. 2012. The outdoor air pollution and brain health workshop. Neurotoxicology 33:972–984.

Crombie R, Clark C, Stansfeld SA. 2011. Environmental noise exposure, early biological risk and mental health in nine to ten year old children: a cross-sectional field study. Environ Health 10:39; doi:10.1186/1476-069X-10-39.

Davis EP, Sandman CA. 2012. Prenatal psychobiological predictors of anxiety risk in preadolescent children. Psychoneuroendocrinology 37:1224–1233.

Foraster M, Künzli N, Aguilera I, Rivera M, Agis D, Vila J, et al. 2014. High blood pressure and long-term exposure to indoor noise and air pollution from road traffic. Environ Health Perspect 122:1193–1200; doi:10.1289/ehp.1307156.

Goodman R. 1997. The Strengths and Difficulties Questionnaire: a research note. J Child Psychol Psychiatry 38:581–586.

Goodman R, Ford T, Simmons H, Gatward R, Meltzer H. 2003. Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. Int Rev Psychiatry 15:166–172.

Graignic-Philippe R, Dayan J, Chokron S, Jacquet AY, Tordjman S. 2014. Effects of prenatal stress on fetal and child development: a critical literature review. Neurosci Biobehav Rev 43C:137–162.

Gray LC, Breier JI, Foorman BR, Fletcher JM. 2002. Continuum of impulsiveness caused by auditory masking. Int J Pediatr Otorhinolaryngol 66:265–272.

Gregory AM, Sadeh A. 2012. Sleep, emotional and behavioral difficulties in children and adolescents. Sleep Med Rev 16:129–136.

Guxens M, Garcia-Esteban R, Giorgis-Allemand L, Forns J, Badaloni C, Ballester F, et al. 2014. Air pollution during pregnancy and childhood cognitive and psychomotor development: six European birth cohorts. Epidemiology 25:636–647.

Haines MM, Stansfeld SA, Brentnall S, Head J, Berry B, Jiggins M, et al. 2001a. The West London Schools Study: the effects of chronic aircraft noise exposure on child health. Psychol Med 31:1385–1396.

Haines MM, Stansfeld SA, Job RF, Berglund B, Head J. 2001b. Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. Psychol Med 31:265–277.

Hume KI, Brink M, Basner M. 2012. Effects of environmental noise on sleep. Noise Health 14:297–302.

Hygge S, Evans GW, Bullinger M. 2002. A prospective study of some effects of aircraft noise on cognitive performance in schoolchildren. Psychol Sci 13:469–474.

Jensen S, Hvidberg M, Pedersen J, Storm L, Stausgaard L, Becker T, et al. 2009. GIS-based National Street and Traffic Data Base 1960–2005 [in Danish]. NERI Technical Report No. 678. Roskilde, Denmark:National Environmental Research Institute, Aarhus University.

Ketzel M, Berkowicz R, Hvidberg M, Jensen S, Raaschou-Nielsen O. 2011. Evaluation of AirGIS: a GIS-based air pollution and human exposure modelling system. Int J Environ Pollution 47; doi:10.1504/IJEP.2011.047337.

Ketzel M, Wåhlin P, Berkowicz R, Palmgren F. 2003. Particle and trace gas emission factors under urban driving conditions in Copenhagen based on street and roof-level observations. Atmos Environ 37:2735–2749.

Lercher P, Evans GW, Meis M, Kofler WW. 2002. Ambient neighbourhood noise and children's mental health. Occup Environ Med 59:380–386.

Liasjø KH, Granøien ILN. 1993. Sammenligning av flystøyberegningsprogrammerne INM-2/6, INM-3/9, INM-3/10, DANSIM og NOISEMAP (beregninger og målinger vedr. Fornebu) [in Norwegian]. Sintef Delab SFT40 A93043.

Niclasen J, Teasdale TW, Andersen AM, Skovgaard AM, Elberling H, Obel C. 2012. Psychometric properties of the Danish Strength and Difficulties Questionnaire: the SDQ assessed for more than 70,000 raters in four different cohorts. PLoSOne 7:e32025; doi:10.1371/journal.pone.0032025.

Obel C, Dalsgaard S, Stax HP, Bilenberg N. 2003. Strengths and Difficulties Questionnaire (SDQ-Dan). A new instrument for psychopathologic screening of children aged 4–16 years [in Danish]. Ugeskr Laeger 165:462–465.

Olsen J, Melbye M, Olsen SF, Sørensen TI, Aaby P, Andersen AM, et al. 2001. The Danish National Birth Cohort—its background, structure and aim. Scand J Public Health 29:300–307.

Pedersen CB. 2011. The Danish Civil Registration System. Scand J Public Health 39 (7 suppl):22–25.

Pirrera S, De Valck E, Cluydts R. 2010. Nocturnal road traffic noise: a review on its assessment and consequences on sleep and health. Environ Int 36:492–498.

Quach J, Hiscock H, Canterford L, Wake M. 2009. Outcomes of child sleep problems over the school-transition period: Australian population longitudinal study. Pediatrics 123:1287–1292.

Seckl JR, Holmes MC. 2007. Mechanisms of disease: glucocorticoids, their placental metabolism and fetal 'programming' of adult pathophysiology. Nat Clin Pract Endocrinol Metab 3:479–488.

Selander J, Nilsson ME, Bluhm G, Rosenlund M, Lindqvist M, Nise G, et al. 2009. Long-term exposure to road traffic noise and myocardial infarction. Epidemiology 20:272–279.

Stansfeld SA, Berglund B, Clark C, Lopez-Barrio I, Fischer P, Ohrström E, et al. 2005. Aircraft and road traffic noise and children's cognition and health: a cross-national study. Lancet 365:1942–1949.

Stansfeld SA, Clark C, Cameron RM, Alfred T, Head J, Haines MM, et al. 2009. Aircraft and road traffic noise exposure and children's mental health. J Environ Psychol 29:203–207.

Stansfeld SA, Matheson MP. 2003. Noise pollution: non-auditory effects on health. Br Med Bull 68:243–257.

Tiesler CM, Birk M, Thiering E, Kohlböck G, Koletzko S, Bauer CP, et al. 2013. Exposure to road traffic noise and children's behavioural problems and sleep disturbance: results from the GINIplus and LISAplus studies. Environ Res 123:1–8.

YouthinMind. 2015. SDQ: Information for Researchers and Professionals about the Strengths & Difficulties Questionnaires. [Strengths and Difficulties Questionnaire Homepage.] Available: http://www.sdqinfo.org/ [accessed 12 June 2015].

Sheree Kansas

From: Pamela Bensoussan
Sent: Tuesday, February 02, 2016 2:20 PM
To: Donna Norris; David Miller
Subject: FW: Environmental Health Coalition comments on condo proposal at 701 D Street
Attachments: EHC_toCouncil_CondoProject_Final.pdf

This is the original communication I received from Laura.
-Pamela

From: Laura Hunter [redacted]
Sent: Thursday, January 14, 2016 3:14 PM
To: Mary Salas; Pamela Bensoussan; Patricia Aguilar; John McCann; Steve Miesen
Subject: Environmental Health Coalition comments on condo proposal at 701 D Street

Dear Mayor Salas and City Council,
We hope you had a great New Year! I will be contacting all of you soon to request a meeting about a few issues in Chula Vista.
In the meantime, Environmental Health Coalition has asked me to transmit this comment letter regarding the proposed development at 701 D street. There are very significant deficiencies in the Health Risk Assessment that should be resolved before this project is considered. Further, given the very serious health risks posed by freeway air pollution to children, this should be evaluated for consistency with the recently adopted Healthy Chula Vista Action Plan initiative.
As Joy Williams will be on vacation for several weeks, please direct any comments or questions to me.
Thank you for considering these comments.
Laura Hunter

ENVIRONMENTAL HEALTH COALITION
2727 HOOVER AVE. SUITE 202 · NATIONAL CITY, CA 91950 · (619) 474-0220 · WWW.ENVIRONMENTALHEALTH.ORG

January 14, 2016

Mayor Salas and City Council
Chula Vista City Council
Chula Vista, CA

RE: Opposition to location of residential uses within 500 feet of a freeway

Dear Mayor Salas and City Council members,

Environmental Health Coalition (EHC) was involved in the creation of the Chula Vista General Plan Update and the Specific Plan. One of the significant improvements to the General plan policies was the inclusion of policy E 6.10. that attempted to reflect the guidance from the Air Resources Board that homes and other sensitive uses should not be located within 500 feet of a freeway.

General Plan Policy E 6.10 reads: *The siting of new sensitive receivers within 500 feet of highways resulting from development or redevelopment projects shall require the preparation of a health risk assessment as part of the CEQA review of the project. Attendant health risks identified in the Health Risk Assessment (HRA) shall be feasibly mitigated to the maximum extent practicable, in accordance with CEQA, in order to help ensure that applicable federal and state standards are not exceeded.*

We have recently learned of a project that is proposed that would put people in harm's way by locating residences within this buffer zone.

While a project Health Risk Assessment (HRA) has been drafted, this policy has not been met. It is important to remember the point of a HRA is to assess the situation so that the project can be revised to prevent health risks to future residents. There are several deficiencies with the HRA listed below and there are mitigation measures that should be adopted that have not been.

Due to major health concerns for future residents living there and the precedent this action may set, Environmental Health Coalition unequivocally opposes the location of condos within the 500 foot zone from the freeway and the off-ramp.

There are several reasons for this position.

1. The Health Risk Assessment in incomplete and does not reflect current or future expected conditions.

The SANDAG Phased Revenue Constrained Network plan for 2035 includes two additional lanes on the 1-5 freeway in Chula Vista between the 905 and the 54 freeways.[1] If these lanes are added to the outer lanes of the freeway, the edge of the freeway will be even closer to residences. The new lanes will increase capacity on the roadway, ultimately resulting in additional VMT on this segment of roadway, as induced demand increases the volume of traffic. The HRA must address this potentially major impact on the freeway and the resulting exposure to traffic pollutants.

Immediately to the north, the I-5 will be expanded with two additional managed lanes and two additional general purpose lanes. The impacts of these expansions on the Chula Vista portion of the 1-5 must be examined as well, as a bottleneck resulting from the southbound flow of traffic from National City into Chula Vista may create congestion and added traffic pollutant exposure to the residents at 701 D Street.

It also does not appear that the flow of traffic in the off-ramp to 54 is included in the analysis.

2. The Cancer Risk Analysis is Based on Diesel Only

Even without the estimates of future freeway impacts, the estimated cancer hazards of freeway traffic impacts are over 10/million for the most exposed residential receptors:

- 44.8 per million for a 70-year exposure;
- 38.1 per million for a 30-year exposure;
- 27.2 per million for 9 years of childhood exposure.

Based on the discussion of cancer risk on page 32 of the draft air quality analysis, the cancer risk analysis was based exclusively on diesel inhalation. It is true that diesel is the dominant health hazard in California's air and accounts for approximately 70% of the cancer risk hazard from ambient air pollution, according to California ARB. However, it is not the sole cancer-causing agent in traffic pollution. Other pollutants such as benzene, ethylbenzene, and butadiene also add to the hazard. The 100% cancer risks to the most exposed residential receptors, then, would be:

- 64 per million for a 70-year exposure;
- 54 per million for a 30-year exposure; and
- 38.8 per million for 9 years of childhood exposure.

The conclusion of the cancer risk analysis, that health hazards are below 10 per million, is clearly untrue.

3. Background Pollution Levels are Underestimated

[1] http://www.sdforward.com/pdfs/RP_final/AppendixA-TransportationProjectsCostsandPhasing.pdf

Further, the background level of pollution for residents in this area is underestimated. The HRA should have analyzed the site as a 'localized hotspot' not as part of the region. People who live in the project will be directly adjacent to significant air pollution. These are the levels of pollution they will breathe, not the air at the station at 80 E. J street (over 2 miles away) where the pollution has already diluted.

4. Acute Health Hazard Analysis is Missing

The hazards of short-term impacts of high levels of exposure, such as happens during rush hours and other periods of high traffic levels, are not addressed at all. It should be noted in the analysis that California does not have a REL for diesel[2] and the question of shorter term impacts, such as asthma exacerbations, is outstanding. Placement of residential housing within 500 feet of a freeway creates an obvious question about potential impacts of exposure to peak periods of traffic pollution, and the RECON analysis does not answer that question, or even acknowledge that decision makers and potential residents might reasonably want this information.

5. Effectiveness of Mitigations is Not Established

The document asserts that mitigations such as sound walls and vegetation will reduce the health hazard to levels considered acceptable by agencies. However, no modeling is included to indicate how a wall or vegetation would alter the pollution plumes or risk isopleths downwind of the freeway. A related question is whether a sound wall makes pollution levels further from the freeway **higher,** as at least some modeling shows.[3] No recommendations are provided on how high a wall would be needed to effectively reduce levels of traffic pollution to background levels. No mitigations are proposed that would locate the residential buildings beyond 500 feet of the freeway, such as by siting the parking areas on the side of the parcel that is closest to the freeway.

6. Threshold of Significance For Exposure of Sensitive Receptors to Toxic Air Contaminants Should Be No Higher Than Background

The Lead Agency for a project has the legal authority and, in fact, is encouraged under CEQA Guidelines §15064.7 to develop and publish its own thresholds of significance. In determining whether an effect will be adverse or beneficial, **the lead agency shall consider the views held by members of the public in all areas affected as expressed in the whole record before the lead agency.** (§ 15064.7(c)) Lead agencies may also consider thresholds of significance previously adopted or recommended by other public agencies, or recommended by experts, **provided the decision of the lead agency to adopt such thresholds is supported by substantial evidence.** (§15064.7(b))

---

[2] http://www.oehha.ca.gov/air/allrels.html

[3] Neng et al., 2010, summarized in http://www.aqmd.gov/docs/default-source/technology-research/Technology-Forums/near-road-mitigation-measures/ucr-venkatram.pdf?sfvrsn=2

CEQA Guidelines recognize that the level of impacts and their significance depends upon a multitude of factors such as project setting, design, construction, etc. CEQA Guidelines also call for careful judgment based on scientific and factual data to the extent possible and explain, "For example, an activity which may not be significant in an urban area may be significant in a rural area." (§ 15064(b)).

The census tract in which the site is located ranks high on California's screening model for environmental justice, CalEnviroScreen. The census tract ranks in the top 86-90% statewide, meaning that it scores higher on combined indicators for environmental pollution and socioeconomic vulnerability than 86 to 90% of all census tracts within the state. Within the San Diego region, this tract is the 10th highest, out of 628 tracts. A CalEnviroScreen indicator of particular relevance is the traffic density indicator; on this measure of traffic impact, the site census tract is at the 91.85 percentile statewide. Clearly, residents in this census tract are already exposed to traffic at higher than normal levels, even for California. Other indicators on which this tract has high CalEnviroScreen percentiles include Cleanup Sites, Hazardous Waste, Low Birth Weight, Education levels, Linguistic Isolation, Poverty, and Unemployment.

According to the most recent APCD Air Quality Network Analysis, *The city of Chula Vista has one of the highest rates of respiratory ailments in the County.* [4]

Table 3.1 Health Risks Summary by Station in the Network Assessment notes that the Chula Vista area has "*Very high rates for this location/station and surrounding area...*" The maximum ranking is 10 (the worst). Chula Vista is a 9.

Residents of this community need affordable housing that does not create illness or worsen their health status. EHC recommends that additional analysis be completed to fully elucidate the health hazards of this site, and develop site-specific mitigations that will reduce health hazards to background levels.

7. Project fails to heed the science-based guidance in the ARB *Air Quality and Land Use Handbook.*

Another serious deficiency is the location of homes within 500-1,000 feet of the freeway. The Air Resources Board *Air Quality and Land Use Handbook: A Community Health Perspective* is relevant here. The ARB guidelines recommend a **minimum** separation between residential development and freeways of **500 feet to avoid increased cancer and non-cancer risks.**[5]

Further, the Handbook finds that additional non-cancer health risks are attributable to proximity within 1,000 feet.[6] The project directly contravenes the Air Resources Board

[4] http://www.sdapcd.org/air/reports/2015_Network_Assessment.pdf, page 5.
[5] 2005_April http://www.arb.ca.gov/ch/handbook.pdf
[6] 2005_Ibid, ARB Land Use Guidelines, Table 1-2

Land Use guidance. Any homes within this area should be abandoned as they are too close to the freeway for good health of the residents.

We understand that this guidance is not regulation. However, it is the guidance of the air regulators based on the abundant science, is clear—**locating homes within 500-1000 feet of a freeways is unhealthful.**

The developers are urged to examine their conscience to see if they really want to be the vehicle by which future residents, including pregnant women, children, and elderly are at high risk of asthma, birth defects, cancer, and other health hazards due to their poor planning. The City should evaluate this as well as a matter of policy. If no change is made, then this issue is a significant and unmitigated impact and the Council should deny the project altogether.

To better protect future residents, the project should be revised to remove all homes from the known unhealthful areas within 1,000 feet of the freeway. We hope the City will require the developers to move residents out of harm's way.

8. HRA does not include all feasible mitigations.

The most obvious and feasible mitigation is to move all homes out of the 500 foot zone. The filters cannot be assumed to protect residents since there is no guarantee they will be run or maintained. To be effective, the planning would have to have a filtration system that could not be controlled by individual owners and was maintained as a mitigation measure. Such a mitigation is not included so any benefits of the filters are not guaranteed. There are many reason why future residents may not run their filters—cost, desire to reduce energy use, etc...

Even if the electrostatic filters remove all particulates, children will be playing outside where the air is unfiltered. The project should be re-designed to move all residential and playground areas away from the freeway.

Thank you for the opportunity to comment on this matter.

Sincerely,

Joy Williams

Joy Williams, MPH
Research Director

Sheree Kansas

From: Pamela Bensoussan
Sent: Tuesday, February 02, 2016 2:17 PM
To: Donna Norris
Subject: FW: Item 5 - Appeal of Design Review Permit DR15-0003

FYI - here's David's email.
-Pamela

From: David Miller
Sent: Tuesday, February 02, 2016 2:09 PM
To: Mary Salas; Patricia Aguilar; Pamela Bensoussan; John McCann; Steve Miesen
Cc: Glen Googins; Gary Halbert; Kelly Broughton; Ed Batchelder
Subject: Item 5 - Appeal of Design Review Permit DR15-0003

Honorable Mayor and Councilmembers,

Tonight you will be hearing an appeal of a Planning Commission decision which approved a Design Review Permit DR15-0003 for a development project to be located at 701 "D" Street. This is item 5 on the Council Agenda.

As many of you are aware, an appeal is a "quasi-judicial" hearing in which a trier of fact reviews only the information presented at the hearing when making his/her decision. If information is obtained outside of the hearing, it must be disclosed at the hearing and prior to consideration. Information includes written or oral communications, site visits, or independent investigation. This requirement ensures that an applicant or appellant is afforded due process and the opportunity to question such facts before a decision on the appeal is made.

With regards to this appeal, it has come to our attention that one or more of you may have obtained information about this project prior to the hearing from the applicant, the appellant or other third parties and/or by visiting the site. Following the staff presentation on this item and in order to ensure that the interested parties are afforded due process, the City Attorney will request that each of you disclose whether you have had conversations related to this project with outside parties, the content of such conversations, and any information acquired by other means, including site visits, if any.

Thank you in advance for your assistance in ensuring that the City has a proper record of the hearing and is thereby complying with the law.

If you have any questions, please feel free to contact, Glen R. Googins, Gary Halbert, or me to discuss.

Sincerely,

David E. Miller
Deputy City Attorney II
City of Chula Vista
(619) 691-5037 (p)
(619) 409-5823 (f)
dmiller@chulavistaca.gov

Sheree Kansas

From: Pamela Bensoussan
Sent: Tuesday, February 02, 2016 2:23 PM
To: David Miller; Donna Norris
Subject: RE: ARB Landuse Handbook

I will mention the emails during the meeting and refer to the documents that I submitted to the Clerk.
Thanks, Pamela

From: David Miller
Sent: Tuesday, February 02, 2016 2:20 PM
To: Pamela Bensoussan; Donna Norris
Subject: RE: ARB Landuse Handbook

Thank you. Glen will probably also ask that this be revealed on the record.

David E. Miller
Deputy City Attorney II
City of Chula Vista
(619) 691-5037 (p)
(619) 409-5823 (f)
dmiller@chulavistaca.gov

From: Pamela Bensoussan
Sent: Tuesday, February 02, 2016 2:19 PM
To: Donna Norris; David Miller
Subject: FW: ARB Landuse Handbook

FYI
-Pamela

From: Laura Hunter [earthlover@sbcglobal.net]
Sent: Thursday, January 28, 2016 11:31 AM
To: Pamela Bensoussan
Subject: ARB Landuse Handbook

HI Pamela,

I also wanted to be sure you saw this. The science is very clear on the health hazards of locating sensitive receptors (children etc...) within 100 feet of a freeway. Please see Page 4-11 of the attached document.
As always, please call with any questions. Thanks so much
Laura

Sheree Kansas

From:	Pamela Bensoussan
Sent:	Tuesday, February 02, 2016 2:19 PM
To:	Donna Norris; David Miller
Subject:	FW: ARB Landuse Handbook
Attachments:	ARB_Landuse_Guidance_Handbook.pdf

FYI
-Pamela

From: Laura Hunter [redacted]
Sent: Thursday, January 28, 2016 11:31 AM
To: Pamela Bensoussan
Subject: ARB Landuse Handbook

HI Pamela,
I also wanted to be sure you saw this. The science is very clear on the health hazards of locating sensitive receptors (children etc...) within 100 feet of a freeway. Please see Page 4-11 of the attached document.
As always, please call with any questions. Thanks so much
Laura

Sheree Kansas

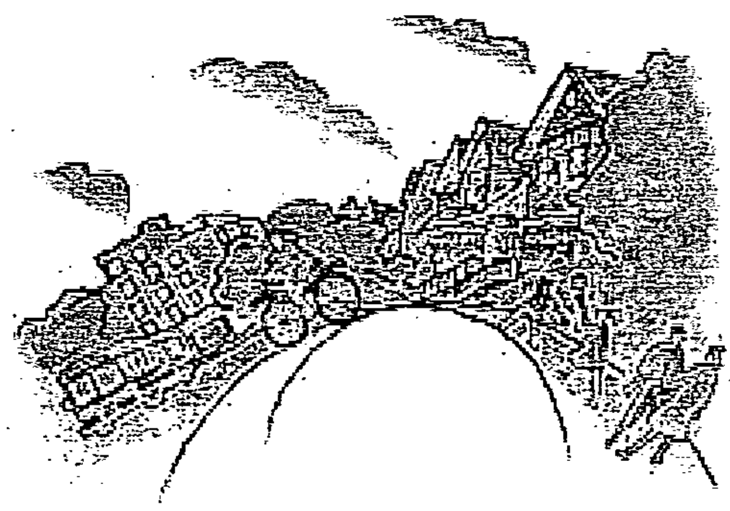
From:	Pamela Bensoussan
Sent:	Tuesday, February 02, 2016 2:19 PM
To:	Donna Norris; David Miller
Subject:	FW: ARB Landuse Handbook
Attachments:	ARB_Landuse_Guidance_Handbook.pdf

FYI
-Pamela

From: Laura Hunter [redacted]
Sent: Thursday, January 28, 2016 11:31 AM
To: Pamela Bensoussan
Subject: ARB Landuse Handbook

HI Pamela,
I also wanted to be sure you saw this. The science is very clear on the health hazards of locating sensitive receptors (children etc...) within 100 feet of a freeway. Please see Page 4-11 of the attached document.
As always, please call with any questions. Thanks so much
Laura

AIR QUALITY AND LAND USE HANDBOOK: A COMMUNITY HEALTH PERSPECTIVE



April 2005

California Environmental Protection Agency
California Air Resources Board

Air Agency Contacts

Federal-

U.S. EPA, Region 9
Phone: (866)-EPA-WEST
Website: www.epa.gov/region09
Email: r9.info@epa.gov

-State-

California Air Resources Board
Phone: (916) 322-2990 (public info)
(800) 363-7664 (public info)
(800) 952-5588 (complaints)
(866)-397-5462 (env. justice)
Website: www.arb.ca.gov
Email: helpline@arb.ca.gov

-Local-

Amador County APCD
Phone: (209) 257-0112
Website: www.amadorapcd.org
E-Mail: jharris@amadorapcd.org

Antelope Valley AQMD
Phone: (661) 723-8070
Complaint Line: (888) 732-8070
Website: www.avaqmd.ca.gov
E-Mail: bbanks@avaqmd.ca.gov

Bay Area AQMD
Phone: (415) 749-5000
Complaint Line: (800) 334-6367
Website: www.baaqmd.gov
E-Mail: webmaster@baaqmd.gov

Butte County AQMD
Phone: (530) 891-2882
Website: www.bcaqmd.org
E-Mail: air@bcaqmd.org

Calaveras County APCD
Phone: (209) 754-6504
E-Mail: lgrewal@co.calaveras.ca.us

Colusa County APCD
Phone: (530) 458-0590
Website: www.colusanet.com/apcd
E-Mail: ccair@colusanet.com

El Dorado County AQMD
Phone: (530) 621-6662
Website:
www.co.el-dorado.ca.us/emd/apcd
E-Mail: mcctaggart@co.el-dorado.ca.us

Feather River AQMD
Phone: (530) 634-7659
Website: www.fraqmd.org
E-Mail: fraqmd@fraqmd.org

Glenn County APCD
Phone: (530) 934-6500
http://www.countyofglenn.net/air_pollution_control
E-Mail: ktokunaga@countyofglenn.net

Great Basin Unified APCD
Phone: (760) 872-8211
Website: www.gbuapcd.org
E-Mail: gb1@greatbasinapcd.org

Imperial County APCD
Phone: (760) 482-4606
E-Mail: reyesromero@imperialcounty.net

Kern County APCD
Phone: (661) 862-5250
Website: www.kernair.org
E-Mail: kcapcd@co.kern.ca.us

Lake County AQMD
Phone: (707) 263-7000
Website: www.lcaqmd.net
E-Mail: bobr@pacific.net

Lassen County APCD
Phone: (530) 251-8110
E-Mail: lassenaq@psln.com

Mariposa County APCD
Phone: (209) 966-2220
E-Mail: air@mariposacounty.org

Mendocino County AQMD
Phone: (707) 463-4354
Website:
www.co.mendocino.ca.us/aqmd
E-Mail:
mcaqmd@co.mendocino.ca.us

Modoc County APCD
Phone: (530) 233-6419
E-Mail: modapcd@hdo.net

Mojave Desert AQMD
Phone: (760) 245-1661
(800) 635-4617
Website: www.mdaqmd.ca.gov

Monterey Bay Unified APCD
Phone: (831) 647-9411
(800) 253-6028 (Complaints)
Website: www.mbuapcd.org
E-Mail: dquetin@mbuapcd.org

North Coast Unified AQMD
Phone: (707) 443-3093
Website: www.ncuaqmd.org
E-Mail: lawrence@ncuaqmd.org

Northern Sierra AQMD
Phone: (530) 274-9360
Website: www.myairdistrict.com
E-Mail: office@myairdistrict.com

Northern Sonoma County APCD
Phone: (707) 433-5911
E-Mail: nsc@sonic.net

Placer County APCD
Phone: (530) 889-7130
Website:
http://www.placer.ca.gov/airpollution/airpolut.htm
E-Mail: pcapcd@placer.ca.gov

Sacramento Metro AQMD
Phone: (916) 874-4800
Website: www.airquality.org
E-Mail: kshearer@airquality.org

San Diego County APCD
Phone: (858) 650-4700
Website: www.sdapcd.org

San Joaquin Valley APCD
Phone: (559) 230-6000 (General)
(800) 281-7003
(San Joaquin, Stanislaus, Merced)
(800) 870-1037
(Madera, Fresno, Kings)
(800) 926-5550
(Tulare and Valley portion of Kern)
Website: www.valleyair.org
E-Mail: sjvapcd@valleyair.org

San Luis Obispo County APCD
Phone: (805) 781-5912
Website: www.slocleanair.org
E-Mail: info@slocleanair.org

Santa Barbara County APCD
Phone (805) 961-8800
Website: www.sbcapcd.org
Email us: apcd@sbcapcd.org

Shasta County AQMD
Phone: (530) 225-5789
Website:
www.co.shasta.ca.us/Departments/Resourcemgmt/drm/aqmain.htm
E-Mail: scdrm@snowcrest.net

Siskiyou County APCD
Phone: (530) 841-4029
E-Mail: ebeck@siskiyou.ca.us

South Coast AQMD
Phone: (909) 396-2000
Complaint Line: 1-800-CUT-SMOG
Website: www.aqmd.gov
Email: bwallerstein@aqmd.gov

Tehama County APCD
Phone: (530) 527-3717
Website: www.tehcoapcd.net
Email: general@tehcoapcd.net

Tuolumne County APCD
Phone: (209) 533-5693
E-Mail:
bsandman@co.tuolumne.ca.us

Ventura County APCD
Phone: (805) 645-1400
Complaint Line: (805) 654-2797
Website: www.vcapcd.org
E-Mail: info@vcapcd.org

Yolo-Solano AQMD
Phone: (530) 757-3650
Website: www.ysaqmd.org
Email: administration@ysaqmd.org

To My Local Government Colleagues....

I am pleased to introduce this informational guide to air quality and land use issues focused on community health. As a former county supervisor, I know from experience the complexity of local land use decisions. There are multiple factors to consider and balance. This document provides important public health information that we hope will be considered along with housing needs, economic development priorities, and other quality of life issues.

An important focus of this document is prevention. We hope the air quality information provided will help inform decision-makers about the benefits of avoiding certain siting situations. The overarching goal is to avoid placing people in harm's way. Recent studies have shown that public exposure to air pollution can be substantially elevated near freeways and certain other facilities. What is encouraging is that the health risk is greatly reduced with distance. For that reason, we have provided some general recommendations aimed at keeping appropriate distances between sources of air pollution and land uses such as residences.

Land use decisions are a local government responsibility. The Air Resources Board's role is advisory and these recommendations do not establish regulatory standards of any kind. However, we hope that the information in this document will be seriously considered by local elected officials and land use agencies. We also hope that this document will promote enhanced communication between land use agencies and local air pollution control agencies. We developed this document in close coordination with the California Air Pollution Control Officers Association with that goal in mind.

I hope you find this document both informative and useful.

Barbara Riordan

Mrs. Barbara Riordan
Interim Chairman
California Air Resources Board

TABLE OF CONTENTS

APPENDICES

Acknowledgments

The ARB staff would like to acknowledge the exceptional contributions made to this document by members of the ARB Environmental Justice Stakeholders Group. Since 2001, ARB staff has consistently relied on this group to provide critical and constructive input on implementing the specifics of ARB's environmental justice policies and actions. The Stakeholders Group is convened by the ARB, and comprised of representatives from local land use and air agencies, community interest groups, environmental justice organizations, academia, and business. Their assistance and suggestions throughout the development of this Handbook have been invaluable.

Executive Summary

The Air Resources Board's (ARB) primary goal in developing this document is to provide information that will help keep California's children and other vulnerable populations out of harm's way with respect to nearby sources of air pollution. Recent air pollution studies have shown an association between respiratory and other non-cancer health effects and proximity to high traffic roadways. Other studies have shown that diesel exhaust and other cancer-causing chemicals emitted from cars and trucks are responsible for much of the overall cancer risk from airborne toxics in California. Also, ARB community health risk assessments and regulatory programs have produced important air quality information about certain types of facilities that should be considered when siting new residences, schools, day care centers, playgrounds, and medical facilities (i.e., sensitive land uses). Sensitive land uses deserve special attention because children, pregnant women, the elderly, and those with existing health problems are especially vulnerable to the non-cancer effects of air pollution. There is also substantial evidence that children are more sensitive to cancer-causing chemicals.

Focusing attention on these siting situations is an important preventative action. ARB and local air districts have comprehensive efforts underway to address new and existing air pollution sources under their respective jurisdictions. The issue of siting is a local government function. As more data on the connection between proximity and health risk from air pollution become available, it is essential that air agencies share what we know with land use agencies. We hope this document will serve that purpose.

The first section provides ARB recommendations regarding the siting of new sensitive land uses near freeways, distribution centers, rail yards, ports, refineries, chrome plating facilities, dry cleaners, and gasoline dispensing facilities. This list consists of the air pollution sources that we have evaluated from the standpoint of the proximity issue. It is based on available information and reflects ARB's primary areas of jurisdiction – mobile sources and toxic air contaminants. A key air pollutant common to many of these sources is particulate matter from diesel engines. Diesel particulate matter (diesel PM) is a carcinogen identified by ARB as a toxic air contaminant and contributes to particulate pollution statewide.

Reducing diesel particulate emissions is one of ARB's highest public health priorities and the focus of a comprehensive statewide control program that is reducing diesel PM emissions each year. ARB's long-term goal is to reduce diesel PM emissions 85% by 2020. However, cleaning up diesel engines will take time as new engine standards phase in and programs to accelerate fleet turnover or retrofit existing engines are implemented. Also, these efforts are reducing diesel particulate emissions on a statewide basis, but do not yet capture every site where diesel vehicles and engines may congregate. Because living or going to school too close to such air pollution sources may increase both cancer and non-cancer health risks, we are recommending that proximity be considered in the siting of new sensitive land uses.

There are also other key toxic air contaminants associated with specific types of facilities. Most of these are subject to stringent state and local air district regulations. However, what we know today indicates that keeping new homes and other sensitive land uses from siting too close to such facilities would provide additional health protection. Chrome platers are a prime example of facilities that should not be located near vulnerable communities because of the cancer health risks from exposure to the toxic material used during their operations.

In addition to source specific recommendations, we also encourage land use agencies to use their planning processes to ensure the appropriate separation of industrial facilities and sensitive land uses. While we provide some suggestions, how to best achieve that goal is a local issue. In the development of these guidelines, we received valuable input from local government about the spectrum of issues that must be considered in the land use planning process. This includes addressing housing and transportation needs, the benefits of urban infill, community economic development priorities, and other quality of life issues. All of these factors are important considerations. The recommendations in the Handbook need to be balanced with other State and local policies.

Our purpose with this document is to highlight the potential health impacts associated with proximity to air pollution sources so planners explicitly consider this issue in planning processes. We believe that with careful evaluation, infill development, mixed use, higher density, transit-oriented development, and other concepts that benefit regional air quality can be compatible with protecting the health of individuals at the neighborhood level. One suggestion for achieving this goal is more communication between air agencies and land use planners. Local air districts are an important resource that should be consulted regarding sources of air pollution in their jurisdictions. ARB staff will also continue to provide updated technical information as it becomes available.

Our recommendations are as specific as possible given the nature of the available data. In some cases, like refineries, we suggest that the siting of new sensitive land uses should be avoided immediately downwind. However, we leave definition of the size of this area to local agencies based on facility specific considerations. Also, project design that would reduce air pollution exposure may be part of the picture and we encourage consultation with air agencies on this subject.

In developing the recommendations, our first consideration was the adequacy of the data available for an air pollution source category. Using that data, we assessed whether we could reasonably characterize the relative exposure and health risk from a proximity standpoint. That screening provided the list of air pollution sources that we were able to address with specific recommendations. We also considered the practical implications of making hard and fast recommendations where the potential impact area is large, emissions will be reduced with time, and air agencies are in the process of looking at options for additional emission control. In the end, we tailored our recommendations to minimize the highest exposures for each source category independently. Due to the large variability in relative risk in the source categories, we chose not to apply a uniform, quantified risk threshold as is typically done in air quality permitting programs. Instead, because these guidelines are not regulatory or binding on local agencies, we took a more qualitative approach in developing the distance-based recommendations.

Where possible, we recommend a minimum separation between a new sensitive land use and known air pollution risks. In other cases, we acknowledge that the existing health risk is too high in a relatively large area, that air agencies are working to reduce that risk, and that in the meantime, we recommend keeping new sensitive land uses out of the highest exposure areas. However, it is critical to note that our implied identification of the high exposure areas for these sources does not mean that the risk in the remaining impact area is insignificant. Rather, we hope this document will bring further attention to the potential health risk throughout the impact area and help garner support for our ongoing efforts to reduce health risk associated with air pollution sources. Areas downwind of major ports, rail yards, and other inter-modal transportation facilities are prime examples.

We developed these recommendations as a means to share important public health information. The underlying data are publicly available and referenced in this document. We also describe our rationale and the factors considered in developing each recommendation, including data limitations and uncertainties. These recommendations are advisory and should not be interpreted as defined "buffer zones." We recognize the opportunity for more detailed site-specific analyses always exists, and that there is no "one size fits all" solution to land use planning.

As California continues to grow, we collectively have the opportunity to use all the information at hand to avoid siting scenarios that may pose a health risk. As part of ARB's focus on communities and children's health, we encourage land use agencies to apply these recommendations and work more closely with air agencies. We also hope that this document will help educate a wider audience about the value of preventative action to reduce environmental exposures to air pollution.

1. ARB Recommendations on Siting New Sensitive Land Uses

Protecting California's communities and our children from the health effects of air pollution is one of the most fundamental goals of state and local air pollution control programs. Our focus on children reflects their special vulnerability to the health impacts of air pollution. Other vulnerable populations include the elderly, pregnant women, and those with serious health problems affected by air pollution. With this document, we hope to more effectively engage local land use agencies as partners in our efforts to reduce health risk from air pollution in all California communities.

Later sections emphasize the need to strengthen the connection between air quality and land use in both planning and permitting processes. Because the siting process for many, but not all air pollution sources involves permitting by local air districts, there is an opportunity for interagency coordination where the proposed location might pose a problem. To enhance the evaluation process from a land use perspective, section 4 includes recommended project related questions to help screen for potential proximity related issues.

Unlike industrial and other stationary sources of air pollution, the siting of new homes or day care centers does not require an air quality permit. Because these situations fall outside the air quality permitting process, it is especially important that land use agencies be aware of potential air pollution impacts.

The following recommendations address the issue of siting "sensitive land uses" near specific sources of air pollution; namely:

- High traffic freeways and roads
- Distribution centers
- Rail yards
- Ports
- Refineries
- Chrome plating facilities
- Dry cleaners
- Large gas dispensing facilities

The recommendations for each category include a summary of key information and guidance on what to avoid from a public health perspective.

Sensitive individuals refer to those segments of the population most susceptible to poor air quality (i.e., children, the elderly, and those with pre-existing serious health problems affected by air quality). Land uses where sensitive individuals are most likely to spend time include schools and schoolyards, parks and playgrounds, daycare centers, nursing homes, hospitals, and residential communities (sensitive sites or sensitive land uses).

We are characterizing sensitive land uses as simply as we can by using the example of residences, schools, day care centers, playgrounds, and medical facilities. However, a variety of facilities are encompassed. For example, residences can include houses, apartments, and senior living complexes. Medical facilities can include hospitals, convalescent homes, and health clinics. Playgrounds could be play areas associated with parks or community centers.

In developing these recommendations, ARB first considered the adequacy of the data available for each air pollution source category. We assessed whether we could generally characterize the relative exposure and health risk from a proximity standpoint. The documented non-cancer health risks include triggering of asthma attacks, heart attacks, and increases in daily mortality and hospitalization for heart and respiratory diseases. These health impacts are well documented in epidemiological studies, but less easy to quantify from a particular air pollution source. Therefore, the cancer health impacts are used in this document to provide a picture of relative risk. This screening process provided the list of source categories we were able to address with specific recommendations. In evaluating the available information, we also considered the practical implications of making hard and fast recommendations where the potential impact area is large, emissions will be reduced with time, and air agencies are in the process of looking at options for additional emission control. Due to the large variability in relative risk between the source categories, we chose not to apply a uniform, quantified risk threshold as is typically done in regulatory programs. Therefore, in the end, we tailored our recommendations to minimize the highest exposures for each source category independently. Additionally, because this guidance is not regulatory or binding on local agencies, we took a more qualitative approach to developing distance based recommendations.

Where possible, we recommend a minimum separation between new sensitive land uses and existing sources. However, this is not always possible, particularly where there is an elevated health risk over large geographical areas. Areas downwind of ports and rail yards are prime examples. In such cases, we recommend doing everything possible to avoid locating sensitive receptors within the highest risk zones. Concurrently, air agencies and others will be working to reduce the overall risk through controls and measures within their scope of authority.

The recommendations were developed from the standpoint of siting new sensitive land uses. Project-specific data for new and existing air pollution sources are available as part of the air quality permitting process. Where such information is available, it should be used. Our recommendations are designed to fill a gap where information about existing facilities may not be readily available. These recommendations are only guidelines and are not designed to substitute for more specific information if it exists.

A summary of our recommendations is shown in Table 1-1. The basis and references[1] supporting each of these recommendations, including health studies, air quality modeling and monitoring studies is discussed below beginning with freeways and summarized in Table 1-2. As new information becomes available, it will be included on ARB's community health web page.

[1]Detailed information on these references are available on ARB's website at: http://www.ARB.ca.gov/ch/landuse.htm.

Table 1-1

Recommendations on Siting New Sensitive Land Uses Such As Residences, Schools, Daycare Centers, Playgrounds, or Medical Facilities*

Source Category	Advisory Recommendations
Freeways and High-Traffic Roads	• Avoid siting new sensitive land uses within 500 feet of a freeway, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day.
Distribution Centers	• Avoid siting new sensitive land uses within 1,000 feet of a distribution center (that accommodates more than 100 trucks per day, more than 40 trucks with operating transport refrigeration units (TRUs) per day, or where TRU unit operations exceed 300 hours per week). • Take into account the configuration of existing distribution centers and avoid locating residences and other new sensitive land uses near entry and exit points.
Rail Yards	• Avoid siting new sensitive land uses within 1,000 feet of a major service and maintenance rail yard. • Within one mile of a rail yard, consider possible siting limitations and mitigation approaches.
Ports	• Avoid siting of new sensitive land uses immediately downwind of ports in the most heavily impacted zones. Consult local air districts or the ARB on the status of pending analyses of health risks.
Refineries	• Avoid siting new sensitive land uses immediately downwind of petroleum refineries. Consult with local air districts and other local agencies to determine an appropriate separation.
Chrome Platers	• Avoid siting new sensitive land uses within 1,000 feet of a chrome plater.
Dry Cleaners Using Perchloro-ethylene	• Avoid siting new sensitive land uses within 300 feet of any dry cleaning operation. For operations with two or more machines, provide 500 feet. For operations with 3 or more machines, consult with the local air district. • Do not site new sensitive land uses in the same building with perc dry cleaning operations.
Gasoline Dispensing Facilities	• Avoid siting new sensitive land uses within 300 feet of a large gas station (defined as a facility with a throughput of 3.6 million gallons per year or greater). A 50 foot separation is recommended for typical gas dispensing facilities.

*Notes:

- These recommendations are advisory. Land use agencies have to balance other considerations, including housing and transportation needs, economic development priorities, and other quality of life issues.

- Recommendations are based primarily on data showing that the air pollution exposures addressed here (i.e., localized) can be reduced as much as 80% with the recommended separation.
- The relative risk for these categories varies greatly (see Table 1-2). To determine the actual risk near a particular facility, a site-specific analysis would be required. Risk from diesel PM will decrease over time as cleaner technology phases in.
- These recommendations are designed to fill a gap where information about existing facilities may not be readily available and are not designed to substitute for more specific information if it exists. The recommended distances take into account other factors in addition to available health risk data (see individual category descriptions).
- Site-specific project design improvements may help reduce air pollution exposures and should also be considered when siting new sensitive land uses.
- This table does not imply that mixed residential and commercial development in general is incompatible. Rather it focuses on known problems like dry cleaners using perchloroethylene that can be addressed with reasonable preventative actions.
- A summary of the basis for the distance recommendations can be found in Table 1-2.

Table 1-2

Summary of Basis for Advisory Recommendations

Source Category	Range of Relative Cancer Risk[1,2]	Summary of Basis for Advisory Recommendations
Freeways and High-Traffic Roads	300 – 1,700	• In traffic-related studies, the additional non-cancer health risk attributable to proximity was seen within 1,000 feet and was strongest within 300 feet. California freeway studies show about a 70% drop off in particulate pollution levels at 500 feet.
Distribution Centers[3]	Up to 500	• Because ARB regulations will restrict truck idling at distribution centers, transport refrigeration unit (TRU) operations are the largest onsite diesel PM emission source followed by truck travel in and out of distribution centers. • Based on ARB and South Coast District emissions and modeling analyses, we estimate an 80 percent drop-off in pollutant concentrations at approximately 1,000 feet from a distribution center.
Rail Yards	Up to 500	• The air quality modeling conducted for the Roseville Rail Yard Study predicted the highest impact is within 1,000 feet of the Yard, and is associated with service and maintenance activities. The next highest impact is between a half to one mile of the Yard, depending on wind direction and intensity.
Ports	Studies underway	• ARB will evaluate the impacts of ports and develop a new comprehensive plan that will describe the steps needed to reduce public health impacts from port and rail activities in California. In the interim, a general advisory is appropriate based on the magnitude of diesel PM emissions associated with ports.
Refineries	Under 10	• Risk assessments conducted at California refineries show risks from air toxics to be under 10 chances of cancer per million.[4] • Distance recommendations were based on the amount and potentially hazardous nature of many of the pollutants released as part of the refinery process, particularly during non-routine emissions releases.
Chrome Platers	10-100	• ARB modeling and monitoring studies show localized risk of hexavalent chromium diminishing significantly at 300 feet. There are data limitations in both the modeling and monitoring studies. These include variability of plating activities and uncertainty of emissions such as fugitive dust. Hexavalent chromium is one of the most potent toxic air contaminants. Considering these factors, a distance of 1,000 feet was used as a precautionary measure.
Dry Cleaners Using Perchloro-ethylene (perc)	15-150	• Local air district studies indicate that individual cancer risk can be reduced by as much as 75 percent by establishing a 300 foot separation between a sensitive land use and a one-machine perc dry cleaning operation. For larger operations (2 machines or more), a separation of 500 feet can reduce risk by over 85 percent.

Source Category	Range of Relative Cancer Risk[1,2]	Summary of Basis for Advisory Recommendations
Gasoline Dispensing Facilities (GDF)[5]	Typical GDF: Less than 10 Large GDF: Between Less than 10 and 120	• Based on the CAPCOA Gasoline Service Station Industry-wide Risk Assessment Guidelines, most typical GDFs (less than 3.6 million gallons per year) have a risk of less than 10 at 50 feet under urban air dispersion conditions. Over the last few years, there has been a growing number of extremely large GDFs with sales over 3.6 and as high as 19 million gallons per year. Under rural air dispersion conditions, these large GDFs can pose a larger risk at a greater distance.

[1]For cancer health effects, risk is expressed as an estimate of the increased chances of getting cancer due to facility emissions over a 70-year lifetime. This increase in risk is expressed as chances in a million (e.g., 10 chances in a million).

[2]The estimated cancer risks are a function of the proximity to the specific category and were calculated independent of the regional health risk from air pollution. For example, the estimated regional cancer risk from air toxics in the Los Angeles region (South Coast Air Basin) is approximately 1,000 in a million.

[3]Analysis based on refrigerator trucks.

[4]Although risk assessments performed by refineries indicate they represent a low cancer risk, there is limited data on non-cancer effects of pollutants that are emitted from these facilities. Refineries are also a source of non-routine emissions and odors.

[5]A typical GDF in California dispenses under 3.6 million gallons of gasoline per year. The cancer risk for this size facility is likely to be less than 10 in a million at the fence line under urban air dispersion conditions.

A large GDF has fuel throughputs that can range from 3.6 to 19 million gallons of gasoline per year. The upper end of the risk range (i.e., 120 in a million) represents a hypothetical worst case scenario for an extremely large GDF under rural air dispersion conditions.

Freeways and High Traffic Roads

Air pollution studies indicate that living close to high traffic and the associated emissions may lead to adverse health effects beyond those associated with regional air pollution in urban areas. Many of these epidemiological studies have focused on children. A number of studies identify an association between adverse non-cancer health effects and living or attending school near heavily traveled roadways (see findings below). These studies have reported associations between residential proximity to high traffic roadways and a variety of respiratory symptoms, asthma exacerbations, and decreases in lung function in children.

One such study that found an association between traffic and respiratory symptoms in children was conducted in the San Francisco Bay Area. Measurements of traffic-related pollutants showed concentrations within 300 meters (approximately 1,000 feet) downwind of freeways were higher than regional values. Most other studies have assessed exposure based on proximity factors such as distance to freeways or traffic density.

These studies linking traffic emissions with health impacts build on a wealth of data on the adverse health effects of ambient air pollution. The data on the effects of proximity to traffic-related emissions provides additional information that can be used in land use siting and regulatory actions by air agencies. The key observation in these studies is that close proximity increases both exposure and the potential for adverse health effects. Other effects associated with traffic emissions include premature death in elderly individuals with heart disease.

Key Health Findings

- Reduced lung function in children was associated with traffic density, especially trucks, within 1,000 feet and the association was strongest within 300 feet. (Brunekreef, 1997)
- Increased asthma hospitalizations were associated with living within 650 feet of heavy traffic and heavy truck volume. (Lin, 2000)
- Asthma symptoms increased with proximity to roadways and the risk was greatest within 300 feet. (Venn, 2001)
- Asthma and bronchitis symptoms in children were associated with proximity to high traffic in a San Francisco Bay Area community with good overall regional air quality. (Kim, 2004)
- A San Diego study found increased medical visits in children living within 550 feet of heavy traffic. (English, 1999)

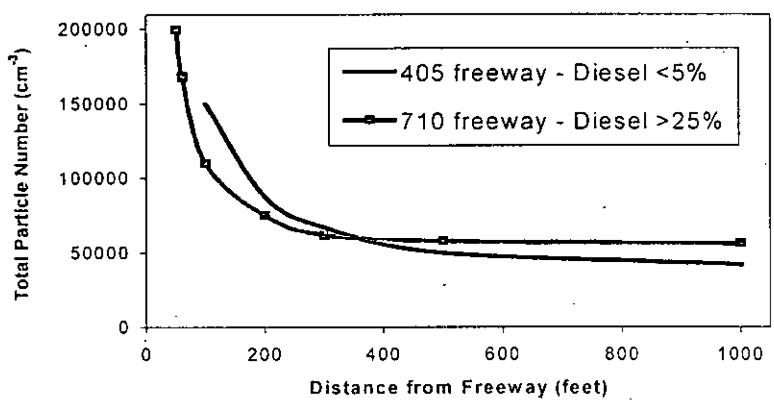
In these and other proximity studies, the distance from the roadway and truck traffic densities were key factors affecting the strength of the association with adverse health effects. In the above health studies, the association of traffic-related emissions with adverse health effects was seen within 1,000 feet and was strongest within 300 feet. This demonstrates that the adverse effects diminished with distance.

In addition to the respiratory health effects in children, proximity to freeways increases potential cancer risk and contributes to total particulate matter exposure. There are three carcinogenic toxic air contaminants that constitute the majority of the known health risk from motor vehicle traffic – diesel particulate matter (diesel PM) from trucks, and benzene and 1,3-butadiene from passenger vehicles. On a typical urban freeway (truck traffic of 10,000-20,000/day), diesel PM represents about 70 percent of the potential cancer risk from the vehicle traffic. Diesel particulate emissions are also of special concern because health studies show an association between particulate matter and premature mortality in those with existing cardiovascular disease.

Distance Related Findings

A southern California study (Zhu, 2002) showed measured concentrations of vehicle-related pollutants, including ultra-fine particles, decreased dramatically within approximately 300 feet of the 710 and 405 freeways. Another study looked at the validity of using distance from a roadway as a measure of exposure

Figure 1-1
Decrease In Concentration of Freeway Diesel PM Emissions With Distance



to traffic related air pollution (Knape, 1999). This study showed that concentrations of traffic related pollutants declined with distance from the road, primarily in the first 500 feet.

These findings are consistent with air quality modeling and risk analyses done by ARB staff that show an estimated range of potential cancer risk that decreases with distance from freeways. The estimated risk varies with the local meteorology, including wind pattern. As an example, at 300 feet downwind from a freeway (Interstate 80) with truck traffic of 10,000 trucks per day, the potential cancer risk was as high as 100 in one million (ARB Roseville Rail Yard Study). The cancer health risk at 300 feet on the upwind side of the freeway was much less. The risk at that distance for other freeways will vary based on local conditions – it may be higher or lower. However, in all these analyses the relative exposure and health risk dropped substantially within the first 300 feet. This phenomenon is illustrated in Figure 1-1.

State law restricts the siting of new schools within 500 feet of a freeway, urban roadways with 100,000 vehicles/day, or rural roadways with 50,000 vehicles with some exceptions.[2] However, no such requirements apply to the siting of residences, day care centers, playgrounds, or medical facilities. The available data show that exposure is greatly reduced at approximately 300 feet. In the traffic-related studies the additional health risk attributable to the proximity effect was strongest within 1,000 feet.

The combination of the children's health studies and the distance related findings suggests that it is important to avoid exposing children to elevated air pollution levels immediately downwind of freeways and high traffic roadways. These studies suggest a substantial benefit to a 500-foot separation.

The impact of traffic emissions is on a gradient that at some point becomes indistinguishable from the regional air pollution problem. As air agencies work to reduce the underlying regional health risk from diesel PM and other pollutants, the impact of proximity will also be reduced. In the meantime, as a preventative measure, we hope to avoid exposing more children and other vulnerable individuals to the highest concentrations of traffic-related emissions.

Recommendation

- Avoid siting new sensitive land uses within 500 feet of a freeway, urban roads with 100,000 vehicles/day, or rural roads with 50,000 vehicles/day.

References

- Brunekreef, B. et al. *"Air pollution from truck traffic and lung function in children living near motorways."* Epidemiology: 1997; 8:298-303
- Lin, S. et al. *"Childhood asthma hospitalization and residential exposure to state route traffic."* Environ Res. 2002;88:73-81
- Venn. et al. *"Living near a main road and the risk of wheezing illness in children."* American Journal of Respiratory and Critical Care Medicine. 2001; Vol.164, pp. 2177-2180
- Kim, J. et al. *"Traffic-related air pollution and respiratory health: East Bay Children's Respiratory Health Study."* American Journal of Respiratory and Critical Care Medicine 2004; Vol. 170. pp. 520-526

[2] Section 17213 of the California Education Code and section 21151.8 of the California Public Resources Code. See also Appendix E for a description of special processes that apply to school siting.

- Zhu, Y et al. *"Study of Ultra-Fine Particles Near A Major Highway With Heavy-Duty Diesel Traffic."* Atmospheric Environment. 2002 ; 36:4323-4335
- Knape, M. *"Traffic related air pollution in city districts near motorways."* The Science of the Total Environment. 1999; 235:339-341
- *Roseville Rail Yard Study.* ARB (October 2004)
- *ARB Diesel Risk Reduction Plan.* (2000)
- Delfino RJ *"Epidemiologic Evidence for Asthma and Exposure to Air Toxics: Linkages Between Occupational, Indoor, and Community Air Pollution Research."* Environmental Health Perspectives. (2002) 110 (supplement 4): 573-589
- English P., Neutra R., Scalf R. Sullivan M. Waller L. Zhu L. *"Examining Associations Between Childhood Asthma and Traffic Flow Using a Geographic Information System."* (1999) Environmental Health Perspectives 107(9): 761-767

Distribution Centers

Distribution centers or warehouses are facilities that serve as a distribution point for the transfer of goods. Such facilities include cold storage warehouses, goods transfer facilities, and inter-modal facilities such as ports. These operations involve trucks, trailers, shipping containers, and other equipment with diesel engines. A distribution center can be comprised of multiple centers or warehouses within an area. The size can range from several to hundreds of acres, involving a number of different transfer operations and long waiting periods. A distribution center can accommodate hundreds of diesel trucks a day that deliver, load, and/or unload goods up to seven days a week. To the extent that these trucks are transporting perishable goods, they are equipped with diesel-powered transport refrigeration units (TRUs) or TRU generator sets.

The activities associated with delivering, storing, and loading freight produces diesel PM emissions. Although TRUs have relatively small diesel-powered engines, in the normal course of business, their emissions can pose a significant health risk to those nearby. In addition to onsite emissions, truck travel in and out of distribution centers contributes to the local pollution impact.

ARB is working to reduce diesel PM emissions through regulations, financial incentives, and enforcement programs. In 2004, ARB adopted two airborne toxic control measures that will reduce diesel PM emissions associated with distribution centers. The first will limit nonessential (or unnecessary) idling of diesel-fueled commercial vehicles, including those entering from other states or countries. This statewide measure, effective in 2005, prohibits idling of a vehicle more than five minutes at any one location.[3] The elimination of unnecessary idling will reduce the localized impacts caused by diesel PM and other air toxics

[3] For further information on the Anti-Idling ATCM, please click on: http://www.arb.ca.gov/toxics/idling/outreach/factsheet.pdf

in diesel vehicle exhaust. This should be a very effective new strategy for reducing diesel PM emissions at distribution centers as well as other locations.

The second measure requires that TRUs operating in California become cleaner over time. The measure establishes in-use performance standards for existing TRU engines that operate in California, including out-of-state TRUs. The requirements are phased-in beginning in 2008, and extend to 2019.[4]

ARB also operates a smoke inspection program for heavy-duty diesel trucks that focuses on reducing truck emissions in California communities. Areas with large numbers of distribution centers are a high priority.

Key Health Findings

Diesel PM has been identified by ARB as a toxic air contaminant and represents 70 percent of the known potential cancer risk from air toxics in California. Diesel PM is an important contributor to particulate matter air pollution. Particulate matter exposure is associated with premature mortality and health effects such as asthma exacerbation and hospitalization due to aggravating heart and lung disease.

Distance Related Findings

Although distribution centers are located throughout the state, they are usually clustered near transportation corridors, and are often located in or near population centers. Diesel PM emissions from associated delivery truck traffic and TRUs at these facilities may result in elevated diesel PM concentrations in neighborhoods surrounding those sites. Because ARB regulations will restrict truck idling at distribution centers, the largest continuing onsite diesel PM emission source is the operation of TRUs. Truck travel in and out of distribution centers also contributes to localized exposures, but specific travel patterns and truck volumes would be needed to identify the exact locations of the highest concentrations.

As part of the development of ARB's regulation for TRUs, ARB staff performed air quality modeling to estimate exposure and the associated potential cancer risk of onsite TRUs for a typical distribution center. For an individual person, cancer risk estimates for air pollution are commonly expressed as a probability of developing cancer from a lifetime (i.e., 70 years) of exposure. These risks were calculated independent of regional risk. For example, the estimated regional cancer risk from air toxics in the Los Angeles region (South Coast Air Basin) is approximately 1,000 additional cancer cases per one million population.

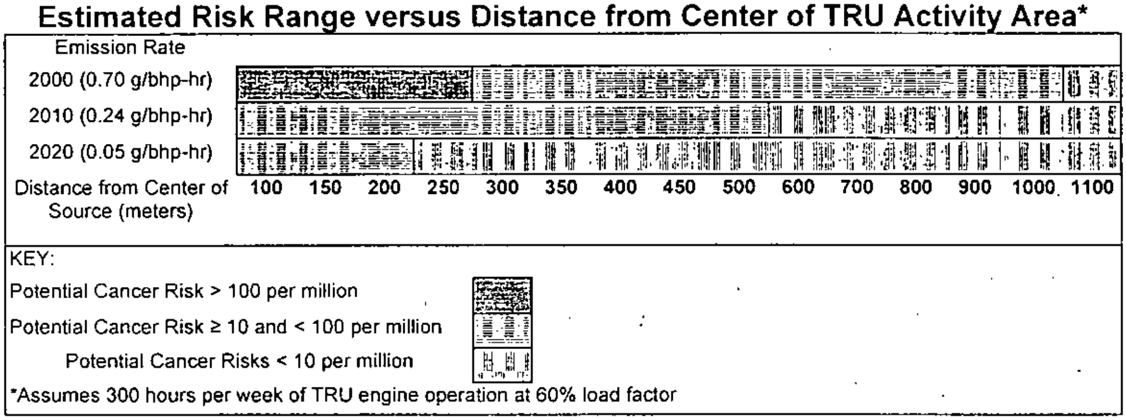
[4] For further information on the Transport Refrigeration Unit ATCM, please click on: http://www.arb.ca.gov/diesel/documents/trufaq.pdf

The diesel PM emissions from a facility are dependent on the size (horsepower), age, and number of engines, emission rates, the number of hours the truck engines and/or TRUs operate, distance, and meteorological conditions at the site. This assessment assumes a total on-site operating time for all TRUs of 300 hours per week. This would be the equivalent of 40 TRU-equipped trucks a day, each loading or unloading on-site for one hour, 12 hours a day and seven days a week.

As shown in Figure 1-2 below, at this estimated level of activity and assuming a current fleet diesel PM emission rate, the potential cancer risk would be over 100 in a million at 800 feet from the center of the TRU activity. The estimated potential cancer risk would be in the 10 to 100 per million range between 800 to 3,300 feet and fall off to less than 10 per million at approximately 3,600 feet. However with the implementation of ARB's regulation on TRUs, the risk will be significantly reduced.[5] We have not conducted a risk assessment for distribution centers based on truck traffic alone, but on an emissions basis, we would expect similar risks for a facility with truck volumes in the range of 100 per day.

Figure 1-2

Estimated Risk Range versus Distance from Center of TRU Activity Area*



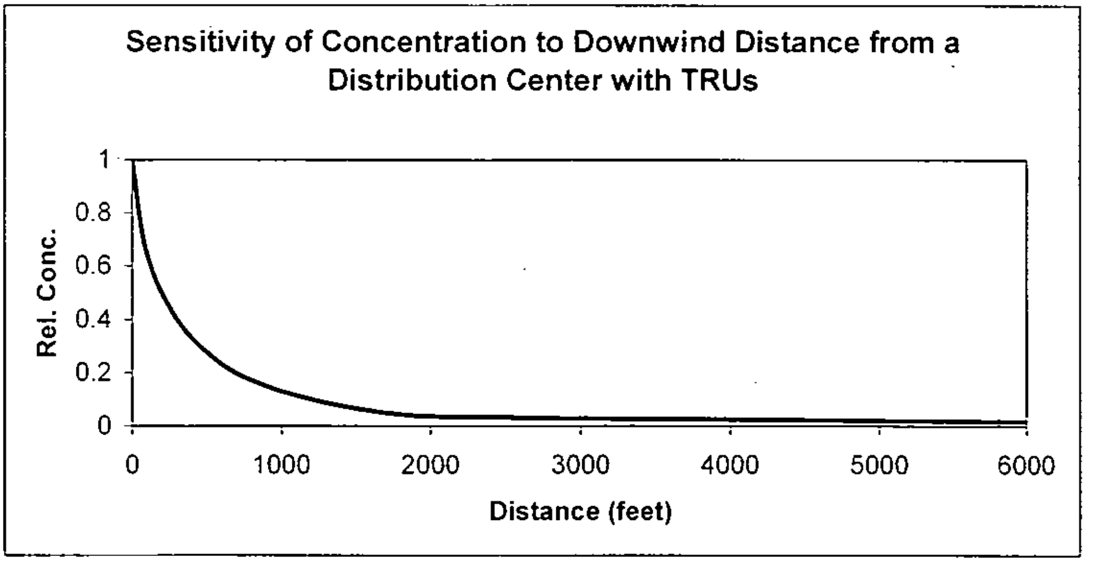
The estimated potential cancer risk level in Figure 1-2 is based on a number of assumptions that may not reflect actual conditions for a specific site. For example, increasing or decreasing the hours of diesel engine operations would change the potential risk levels. Meteorological and other facility specific parameters can also impact the results. Therefore, the results presented here are not directly applicable to any particular facility or operation. Rather, this information is intended to provide an indication as to the potential relative levels of risk that may be observed from operations at distribution centers. As shown in Figure 1-2, the estimated risk levels will decrease over time as lower-emitting diesel engines are used.

---

[5] These risk values assume an exposure duration of 70 years for a nearby resident and uses the methodology specified in the 2003 OEHHA health risk assessment guidelines.

Another air modeling analysis, performed by the South Coast Air Quality Management District (South Coast AQMD), evaluated the impact of diesel PM emissions from distribution center operations in the community of Mira Loma in southern California. Based on dispersion of diesel PM emissions from a large distribution center, Figure 1-3 shows the relative pollution concentrations at varying distances downwind. As Figure 1-3 shows, there is about an 80 percent drop off in concentration at approximately 1,000 feet.

Figure 1-3
Decrease In Relative Concentration of Risk With Distance



Both the ARB and the South Coast AQMD analyses indicate that providing a separation of 1,000 feet would substantially reduce diesel PM concentrations and public exposure downwind of a distribution center. While these analyses do not provide specific risk estimates for distribution centers, they provide an indication of the range of risk and the benefits of providing a separation. ARB recommends a separation of 1,000 feet based on the combination of risk analysis done for TRUs and the decrease in exposure predicted with the South Coast AQMD modeling. However, ARB staff plans to provide further information on distribution centers as we collect more data and implement the TRU control measure.

Taking into account the configuration of distribution centers can also reduce population exposure and risk. For example, locating new sensitive land uses away from the main entry and exit points helps to reduce cancer risk and other health impacts.

Recommendations

- Avoid siting new sensitive land uses within 1,000 feet of a distribution center (that accommodates more than 100 trucks per day, more than 40 trucks with operating TRUs per day, or where TRU unit operations exceed 300 hours per week).

- Take into account the configuration of existing distribution centers and avoid locating residences and other new sensitive land uses near entry and exit points.

References

- *Airborne Toxic Control Measure To Limit Diesel-Fueled Commercial Motor Vehicle Idling.* ARB (August 20, 2004). Rule effectiveness date awaiting submittal of regulation to the Office of Administration Law. http://www.arb.ca.gov/regact/idling/idling.htm

- *Revised Staff Report: Initial Statement of Reasons for Proposed Rulemaking. Airborne Toxic Control Measure for In-Use Diesel-Fueled Transport Refrigeration Units (TRU) and TRU Generator Sets, and Facilities Where TRUs Operate.* ARB (October 28, 2003). http://www.arb.ca.gov/regact/trude03/revisor.doc

- *Health Risk Assessment Guidance for Analyzing Cancer Risks from Mobile Source Diesel Idling Emissions for CEQA Air Quality Analysis.* SCAQMD (August 2003) http://www.aqmd.gov/ceqa/handbook/diesel_analysis.doc

- *"Mira Loma Study: Analysis of the Impact of Diesel Particulate Emissions from Warehouse/Distribution Center Operations"*, PowerPoint presentation. SCAQMD (July 31, 2002)

Rail Yards

Rail yards are a major source of diesel particulate air pollution. They are usually located near inter-modal facilities, which attract heavy truck traffic, and are often sited in mixed industrial and residential areas. ARB, working with the Placer County air district and Union Pacific Railroad, recently completed a study[6] of the Roseville Rail Yard (Yard) in northern California that focused on the health risk from diesel particulate. A comprehensive emissions analysis and air quality modeling were conducted to characterize the estimated potential cancer risk associated with the facility.

---

[6] To review the study, please click on: http://www.arb.ca.gov/diesel/documents/rrstudy.htm

The Yard encompasses about 950 acres on a one-quarter mile wide by four-mile long strip of land that parallels Interstate 80. It is surrounded by commercial, industrial, and residential properties. The Yard is one of the largest service and maintenance rail yards in the West with over 30,000 locomotives visiting annually.

Using data provided by Union Pacific Railroad, the ARB determined the number and type of locomotives visiting the Yard annually and what those locomotives were doing - moving, idling, or undergoing maintenance testing. Union Pacific provided the annual, monthly, daily, and hourly locomotive activity in the yard including locomotive movements; routes for arrival, departure, and through trains; and locomotive service and testing. This information was used to estimate the emissions of particulate matter from the locomotives, which was then used to model the potential impacts on the surrounding community.

The key findings of the study are:

- Diesel PM emissions in 2000 from locomotive operations at the Roseville Yard were estimated at about 25 tons per year.

- Of the total diesel PM in the Yard, moving locomotives accounted for about 50 percent, idling locomotives about 45 percent, and locomotive testing about five percent.

- Air quality modeling predicts potential cancer risks greater than 500 in a million (based on 70 years of exposure) in a 10-40 acre area immediately adjacent to the Yard's maintenance operations.

- The risk assessment also showed elevated cancer risk impacting a larger area covering about a 10 by 10 mile area around the Yard.

The elevated concentrations of diesel PM found in the study contribute to an increased risk of cancer and premature death due to cardiovascular disease, and non-cancer health effects such as asthma and other respiratory illnesses. The magnitude of the risk, the general location, and the size of the impacted area depended on the meteorological data used to characterize conditions at the Yard, the dispersion characteristics, and exposure assumptions. In addition to these variables, the nature of locomotive activity will influence a risk characterization at a particular rail yard. For these reasons, the quantified risk estimates in the Roseville Rail Yard Study cannot be directly applied to other rail yards. However, the study does indicate the health risk due to diesel PM from rail yards needs to be addressed. ARB, in conjunction with the U.S. Environmental Protection Agency (U.S. EPA), and local air districts, is working with the rail industry to identify and implement short term, mid-term and long-term mitigation strategies. ARB also intends to conduct a second rail study in southern California to increase its understanding of rail yard operations and the associated public health impacts.

Key Health Findings

Diesel PM has been identified by ARB as a toxic air contaminant and represents 70 percent of the known potential cancer risk from air toxics in California. Diesel PM is an important contributor to particulate matter air pollution. Particulate matter exposure is associated with premature mortality and health effects such as asthma exacerbation and hospitalization due to aggravating heart and lung disease.

Distance Related Findings

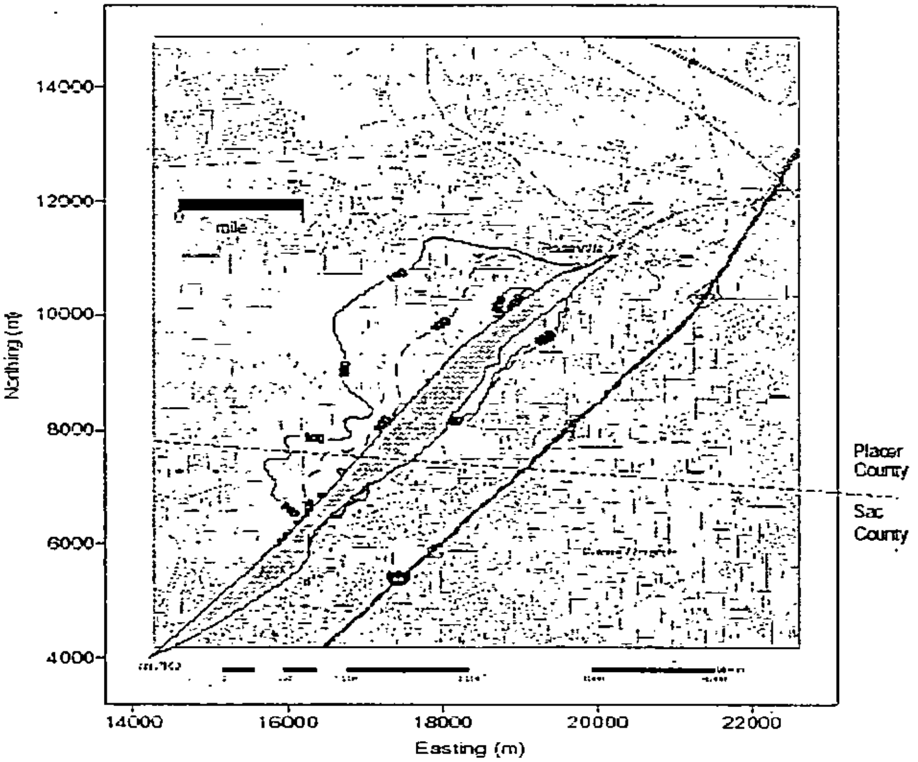
Two sets of meteorological data were used in the Roseville study because of technical limitations in the data. The size of the impact area was highly dependent on the meteorological data set used. The predicted highest impact area ranged from 10 - 40 acres with the two different meteorological data sets. This area, with risks estimated above 500 in a million, is adjacent to an area that includes a maintenance shop (see Figure 1-4). The high concentration of diesel PM emissions is due to the number of locomotives and nature of activities in this area, particularly idling locomotives.

The area of highest impact is within 1,000 feet of the Yard. The next highest impact zone as defined in the report had a predicted risk between 500 and 100 in one million and extends out between a half to one mile in some spots, depending on which meteorological conditions were assumed. The impact areas are irregular in shape making it difficult to generalize about the impact of distance at a particular location. However, the Roseville Rail Yard Study clearly indicates that the localized health risk is high, the impact area is large, and mitigation of the locomotive diesel PM emissions is needed.

For facilities like rail yards and ports, the potential impact area is so large that the real solution is to substantially reduce facility emissions. However, land use planners can avoid encroaching upon existing rail facilities and those scheduled for expansion. We also recommend that while air agencies tackle this problem, land use planners try not to add new sensitive individuals into the highest exposure areas. Finally, we recommend that land use agencies consider the potential health impacts of rail yards in their planning and permitting processes. Additional limitations and mitigation may be feasible to further reduce exposure on a site-specific basis.

Figure 1-4

Estimated Cancer Risk from the Yard
(100 and 500 in a million risk isopleths)



Notes: 100/Million Contours: Solid Line – Roseville Met Data; Dashed Line-McClellan Met Data, Urban Dispersion Coefficients. 80th Percentile Breathing Rate. All Locomotives' Activities (23 TPY), 70-Year Exposure

Recommendation

- Avoid siting new sensitive land uses within 1,000 feet of a major service and maintenance rail yard[7].
- Within one mile of a rail yard, consider possible siting limitations and mitigation approaches.

References

- *Roseville Rail Yard Study.* ARB (2004)

[7] The rail yard risk analysis was conducted for the Union Pacific rail yard in Roseville, California. This rail yard is one of the largest in the state. There are other rail yards in California with comparable levels of activity that should be considered "major" for purposes of this Handbook.

Ports

Air pollution from maritime port activities is a growing concern for regional air quality as well as air quality in nearby communities. The primary air pollutant associated with port operations is directly emitted diesel particulate. Port-related activities also result in emissions that form ozone and secondary particulate in the atmosphere. The emission sources associated with ports include diesel engine-powered ocean-going ships, harbor craft, cargo handling equipment, trucks, and locomotives. The size and concentration of these diesel engines makes ports one of the biggest sources of diesel PM in the state. For that reason, ARB has made it a top priority to reduce diesel PM emissions at the ports, in surrounding communities, and throughout California.

International, national, state, and local government collaboration is critical to reducing port emissions based on both legal and practical considerations. For example, the International Maritime Organization (IMO) and the U.S. EPA establish emission standards for ocean-going vessels and U.S.-flagged harbor craft, respectively. ARB is pursuing further federal actions to tighten these standards. In addition, ARB and local air districts are reducing emissions from ports through a variety of approaches. These include: incentive programs to fund cleaner engines, enhanced enforcement of smoke emissions from ships and trucks, use of dockside electricity instead of diesel engines, cleaner fuels for ships, harbor craft, locomotives, and reduced engine idling. The two ATCMs that limit truck idling and reduce emissions from TRUs (discussed under "Distribution Centers") also apply to ports.

ARB is also developing several other regulations that will reduce port-related emissions. One rule would require ocean-going ships to use a cleaner marine diesel fuel to power auxiliary engines while in California coastal waters and at dock. Ships that frequently visit California ports would also be required to further reduce their emissions. ARB has adopted a rule that would require harbor craft to use the same cleaner diesel fuel used by on-road trucks in California. In 2005, ARB will consider a rule that would require additional controls for in-use harbor craft, such as the use of add-on emission controls and accelerated turnover of older engines.

Key Health Findings

Port activities are a major source of diesel PM. Diesel PM has been identified by ARB as a toxic air contaminant and represents 70 percent of the known potential cancer risk from air toxics in California. Diesel PM is an important contributor to particulate matter air pollution. Particulate matter exposure is associated with premature mortality and health effects such as asthma exacerbation and hospitalization due to aggravating heart and lung disease.

Distance Related Findings

The Ports of Los Angeles and Long Beach provide an example of the emissions impact of port operations. A comprehensive emissions inventory was completed in June 2004. These ports combined are one of the world's largest and busiest seaports. Located in San Pedro Bay, about 20 miles south of downtown Los Angeles, the port complex occupies approximately 16 square miles of land and water. Port activities include five source categories that produce diesel emissions. These are ocean-going vessels, harbor craft, cargo handling equipment, railroad locomotives, and heavy-duty trucks.

The baseline emission inventory provides emission estimates for all major air pollutants. This analysis focuses on diesel PM from in-port activity because these emissions have the most potential health impact on the areas adjacent to the port. Ocean vessels are the largest overall source of diesel PM related to the ports, but these emissions occur primarily outside of the port in coastal waters, making the impact more regional in nature.

The overall in-port emission inventory for diesel particulate for the ports of Los Angeles and Long Beach is estimated to be 550 tons per year. The emissions fall in the following major categories: ocean-going vessels (17%), harbor craft (25%), cargo handling (47%), railroad locomotive (3%), and heavy duty vehicles (8%). In addition to in-port emissions, ship, rail, and trucking activities also contribute to regional emissions and increase emissions in nearby neighborhoods. Off-port emissions associated with related ship, rail, and trucking activities contribute an additional 680 tons per year of diesel particulate at the Port of Los Angeles alone.

To put this in perspective, the diesel PM emissions estimated for the Roseville Yard in ARB's 2004 study are 25 tons per year. The potential cancer risk associated with these emissions is 100 in one million at a distance of one mile, or one half mile, depending on the data set used. This rail yard covers one and a half square miles. The Los Angeles and Long Beach ports have combined diesel PM emissions of 550 tons per year emitted from a facility that covers a much larger area - 16 miles. The ports have about twice the emission density of the rail yard - 34 tons per year per square mile compared to 16 tons per year per square mile. However, while this general comparison is illustrative of the overall size of the complex, a detailed air quality modeling analysis would be needed to assess the potential health impact on specific downwind areas near the ports.

ARB is in the process of evaluating the various port-related emission sources from the standpoint of existing emissions, growth forecasts, new control options, regional air quality impacts, and localized health risk. A number of public processes - both state and local - are underway to address various aspects of these issues. Until more of these analyses are complete, there is little basis for recommending a specific separation between new sensitive land uses and ports.

For example, the type of data we have showing the relationship between air pollutant concentrations and distance from freeways is not yet available.

Also, the complexity of the port facilities makes a site-specific analysis critical. Ports are a concentration of multiple emission sources with differing dispersion and other characteristics. In the case of the Roseville rail yard, we found a high, very localized impact associated with a particular activity, service and maintenance. By contrast, the location, size, and nature of impact areas can be expected to vary substantially for different port activities. For instance, ground level emissions from dockside activities would behave differently from ship stack level emissions.

Nonetheless, on an emissions basis alone, we expect locations downwind of ports to be substantially impacted. For that reason, we recommend that land use agencies track the current assessment efforts, and consider limitations on the siting of new sensitive land uses in areas immediately downwind of ports.

Recommendations

Avoid siting new sensitive land uses immediately downwind of ports in the most heavily impacted zones. Consult local air districts or the ARB on the status of pending analyses of health risks.

References

- *Roseville Rail Yard Study.* ARB (2004)
- Final Draft, "*Port-Wide Baseline Air Emissions Inventory.*" Port of Los Angeles (June 2004)
- Final Draft, "*2002 Baseline Air Emissions Inventory.*" Port of Long Beach (February 2004)

Petroleum Refineries

A petroleum refinery is a complex facility where crude oil is converted into petroleum products (primarily gasoline, diesel fuel, and jet fuel), which are then transported through a system of pipelines and storage tanks for final distribution by delivery truck to fueling facilities throughout the state. In California, most crude oil is delivered either by ship from Alaska or foreign sources, or is delivered via pipeline from oil production fields within the state. The crude oil then undergoes many complex chemical and physical reactions, which include distillation, catalytic cracking, reforming, and finishing. These refining processes have the potential to emit air contaminants, and are subject to extensive emission controls by district regulations.

As a result of these regulations covering the production, marketing, and use of gasoline and other oil by-products, California has seen significant regional air quality benefits both in terms of cleaner fuels and cleaner operating facilities. In the 1990s, California refineries underwent significant modifications and modernization to produce cleaner fuels in response to changes in state law. Nevertheless, while residual emissions are small when compared to the total emissions controlled from these major sources, refineries are so large that even small amounts of fugitive, uncontrollable emissions and associated odors from the operations, can be significant. This is particularly the case for communities that may be directly downwind of the refinery. Odors can cause health symptoms such as nausea and headache. Also, because of the size, complexity, and vast numbers of refinery processes onsite, the occasional refinery upset or malfunction can potentially result in acute or short-term health effects to exposed individuals.

Key Health Findings

Petroleum refineries are large single sources of emissions. For volatile organic compounds (VOCs), eight of the ten largest stationary sources in California are petroleum refineries. For oxides of nitrogen (NOx), four of the ten largest stationary sources in California are petroleum refineries. Both of these compounds react in the presence of sunlight to form ozone. Ozone impacts lung function by irritating and damaging the respiratory system. Petroleum refineries are also large stationary sources of both particulate matter under 10 microns in size (PM_{10}) and particulate matter under 2.5 microns in size ($PM_{2.5}$). Exposure to particulate matter aggravates a number of respiratory illnesses, including asthma, and is associated with premature mortality in people with existing cardiac and respiratory disease. Both long-term and short-term exposure can have adverse health impacts. Finer particles pose an increased health risk because they can deposit deep in the lung and contain substances that are particularly harmful to human health. NOx are also significant contributors to the secondary formation of $PM_{2.5}$.

Petroleum refineries also emit a variety of toxic air pollutants. These air toxics vary by facility and process operation but may include: acetaldehyde, arsenic, antimony, benzene, beryllium, 1,3-butadiene, cadmium compounds, carbonyl sulfide, carbon disulfide, chlorine, dibenzofurans, diesel particulate matter, formaldehyde, hexane, hydrogen chloride, lead compounds, mercury compounds, nickel compounds, phenol, 2,3,7,8 tetrachlorodibenzo-p-dioxin, toluene, and xylenes (mixed) among others. The potential health effects associated with these air toxics can include cancer, respiratory irritation, and damage to the central nervous system, depending on exposure levels.

Distance Related Findings

Health risk assessments for petroleum refineries have shown risks from toxic air pollutants that have quantifiable health risk values to be around 10 potential cancer cases per million. Routine air monitoring and several air monitoring studies conducted in the San Francisco Bay Area (Crockett) and the South Coast Air Basin (Wilmington) have not identified significant health risks specifically associated with refineries. However, these studies did not measure diesel PM as no accepted method currently exists, and there are many toxic air pollutants that do not have quantifiable health risk values.

In 2002, ARB published a report on the results of the state and local air district air monitoring done near oil refineries. The purpose of this evaluation was to try to determine how refinery-related emissions might impact nearby communities. This inventory of air monitoring activities included 10 ambient air monitoring stations located near refineries in Crockett and four stations near refineries in Wilmington. These monitoring results did not identify significant increased health risks associated with the petroleum refineries. In 2002-2003, ARB conducted additional monitoring studies in communities downwind of refineries in Crockett and Wilmington. These monitoring results also did not indicate significant increased health risks from the petroleum refineries.

Consequently, there are no air quality modeling or air monitoring data that provides a quantifiable basis for recommending a specific separation between refineries and new sensitive land uses. However, in view of the amount and potentially hazardous nature of many of the pollutants released as part of the refinery process, we believe the siting of new sensitive land uses immediately downwind should be avoided. Land use agencies should consult with the local air district when considering how to define an appropriate separation for refineries within their jurisdiction.

Recommendations

- Avoid siting new sensitive land uses immediately downwind of petroleum refineries. Consult with local air districts and other local agencies to determine an appropriate separation.

References

- *Review of Current Ambient Air Monitoring Activities Related to California Bay Area and South Coast Refineries. ARB (March 2002)* http://www.arb.ca.gov/aaqm/qmosqual/special/mldrefinery.pdf
- *Community Air Quality Monitoring: Special Studies – Crockett. ARB (September 2004)* http://www.arb.ca.gov/ch/communities/studies/crockett/crockett.htm
- *Wilmington Study - Air Monitoring Results. ARB (2003)* http://www.arb.ca.gov/ch/communities/studies/wilmington/wilmington.htm

Chrome Plating Operations

Chrome plating operations rely on the use of the toxic metal hexavalent chromium, and have been subject to ARB and local air district control programs for many years. Regulation of chrome plating operations has reduced statewide emissions substantially. However, due to the nature of chrome plating operations and the highly toxic nature of hexavalent chromium, the remaining health risk to nearby residents is a continuing concern.

Chrome plating operations convert hexavalent chromium in solution to a chromium metal layer by electroplating, and are categorized based upon the thickness of the chromium metal layer applied. In "decorative plating", a layer of nickel is first plated over a metal substrate. Following this step, a thin layer of chromium is deposited over the nickel layer to provide a decorative and protective finish, for example, on faucets and automotive wheels. "Hard chrome plating" is a process in which a thicker layer of chromium metal is deposited directly on metal substrates such as engine parts, industrial machinery, and tools to provide greater protection against corrosion and wear.

Hexavalent chromium is emitted into the air when an electric current is applied to the plating bath. Emissions are dependent upon the amount of electroplating done per year and the control requirements. A unit of production referred to as an ampere-hour represents the amount of electroplating produced. Small facilities have an annual production rate of 100,000 – 500,000 ampere-hours, while medium-size facilities may have a production rate of 500,000 to about 3 million ampere-hours. The remaining larger facilities have a range of production rates that can be as high as 80 million ampere-hours.

The control requirements, which reduce emissions from the plating tanks, vary according to the size and type of the operation. Facilities either install add-on pollution control equipment, such as filters and scrubbers, or in-tank controls, such as fume suppressants and polyballs. With this combination of controls, the overall hexavalent chromium emissions have been reduced by over 90 percent. Larger facilities typically have better controls that can achieve efficiencies greater than 99 percent. However, even with stringent controls, the lack of maintenance and good housekeeping practices can lead to problems. And, since the material itself is inherently dangerous, any lapse in compliance poses a significant risk to nearby residents.

A 2002 ARB study in the San Diego community of Barrio Logan measured unexpectedly high concentrations of hexavalent chromium near chrome platers. The facilities were located in a mixed-use area with residences nearby. The study found that fugitive dust laden with hexavalent chromium was an important source of emissions that likely contributed to the elevated cancer risk. Largely as a result of this study, ARB is in the process of updating the current requirements to further reduce the emissions from these facilities.

In December 2004, the ARB adopted an ATCM to reduce emissions of hexavalent chromium and nickel from thermal spraying operations through the installation of best available control technology. The ATCM requires all existing facilities to comply with its requirements by January 1, 2006. New and modified thermal spraying operations must comply upon initial startup. An existing thermal spraying facility may be exempt from the minimum control efficiency requirements of the ATCM if it is located at least 1,640 feet from the nearest sensitive receptor and emits no more than 0.5 pound per year of hexavalent chromium.[8]

Key Health Findings

Hexavalent chromium is one of the most toxic air pollutants regulated by the State of California. Hexavalent chromium is a carcinogen and has been identified in worker health studies as causing lung cancer. Exposure to even very low levels of hexavalent chromium should be avoided.

The California Office of Environmental Health Hazard Assessment has found that: 1) many epidemiological studies show a strong association between hexavalent chromium exposure in the work place and respiratory cancer; and 2) all short-term assays reported show that hexavalent chromium compounds can cause damage to human DNA.

Hexavalent chromium when inhaled over a period of many years can cause a variety of non-cancer health effects. These health effects include damage to the nose, blood disorders, lung disease, and kidney damage. The non-cancer health impacts occur with exposures considerably higher than exposures causing significant cancer risks. It is less likely that the public would be exposed to hexavalent chromium at levels high enough to cause these non-cancer health effects. Non-cancer health effects, unlike cancer health effects, have a threshold or exposure level below which non-cancer health effects would not be expected.

Distance Related Findings

ARB's 2002 Barrio Logan Study measured concentrations of hexavalent chromium in the air near two chrome plating facilities. The study was conducted from December 2001 to May 2002. There were two chrome platers on the street - one decorative and one hard plater. The purpose of the study was to better understand the near source impact of hexavalent chromium emissions. Air monitors were placed at residences next to the platers and at varying distances down the street. The monitors were moved periodically to look at the spatial distribution of the impact. Source testing and facility inspections identified one of the facilities as the likely source.

The first two weeks of monitoring results showed unexpectedly high levels of hexavalent chromium at a number of the monitoring sites. The high concentrations were intermittent. The concentrations ranged from 1 to 22 ng/m3 compared to the statewide average of 0.1 ng/m3. If these levels were to continue for 70 years, the potential cancer risk would be 150 in one million. The highest value was found at an air monitor behind a house adjacent to one of the

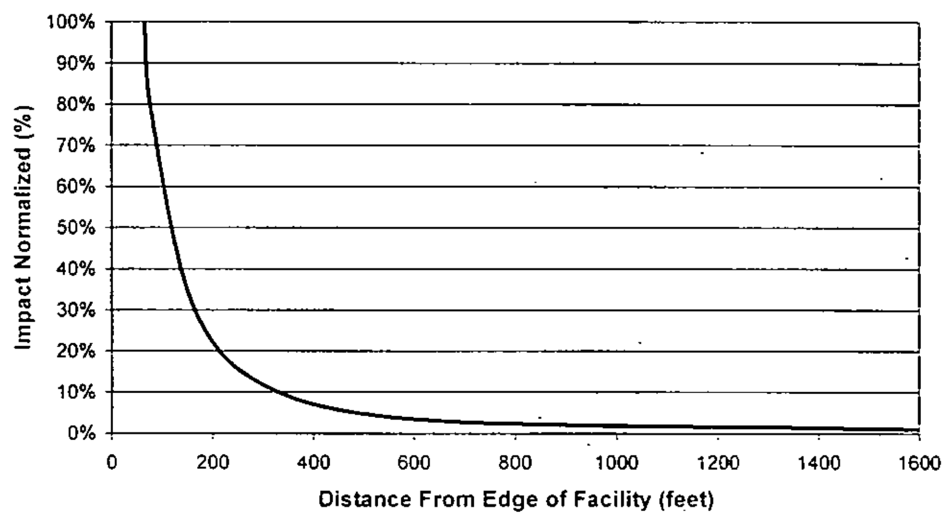
[8] For further information on the ATCM, please refer to: http://www.arb.ca.gov/regact/thermspr/thermalspr.htm

plating facilities–approximately 30 feet from the back entrance. Lower, but significant concentrations were found at an ambient air monitor 250 feet away.

The monitoring covered a period when the facility was not operating its plating tank. During this period, one of the highest concentrations was measured at an adjacent house. It appears that chromium-laden dust was responsible for high concentrations at this location since there was no plating activity at the time. Dust samples from the facility were tested and found to contain high levels of hexavalent chromium. On the day the highest concentration was measured at the house next door, a monitor 350 feet away from the plater's entrance showed very little impact. Similar proximity effects are shown in ARB modeling studies.

Figure 1-5 shows how the relative health risk varies as a function of distance from a chrome plater. This analysis is based on a medium-sized chrome plater with an annual production rate of 3 million ampere-hours. As shown in Figure 1- 5, the potential health risk drops off rapidly, with over 90 percent reduction in risk within 300 feet. This modeling was done in 2003 as part of a review of ARB's current air toxic control measure for chrome platers and is based on data from a recent ARB survey of chrome platers in California. The emission

Figure 1-5
Risk vs. Distance From Chrome Plater
(Based on plating tank emissions)



rates are only for plating operations. Because there are insufficient data available to directly quantify the impacts, the analysis does not include fugitive emissions, which the Barrio Logan analysis indicated could be significant.

Both the ARB Barrio Logan monitoring results and ARB's 2003 modeling analysis suggests that the localized emissions impact of a chrome plater diminishes significantly at 300 feet. However, in developing our recommendation, we also considered the following factors:

- some chrome platers will have higher volumes of plating activity,
- potential dust impacts were not modeled,
- we have only one monitoring study looking at the impact of distance, and,
- hexavalent chromium is one of the most potent toxic air contaminants ARB has identified.

Given these limitations in the analysis, we recommend a separation of 1,000 feet as a precautionary measure. For large chrome platers, site specific information should be obtained from the local air district.

Recommendation

- Avoid siting new sensitive land uses within 1,000 feet of a chrome plater.

References

- *Ambient Air Monitoring for Hexavalent Chromium and Metals in Barrio Logan: May 2001 through May 2002.* ARB, Monitoring and Laboratory Division (October 14, 2003)
- *Draft Barrio Logan Report.* ARB, Planning and Technical Support Division (November 2004)
- *Proposed Amendments to the Hexavalent Chromium Control Measure for Decorative and Hard Chrome Plating and Chromic Acid Anodizing Facilities.* ARB (April 1998)
- Murchison, Linda; Suer, Carolyn; Cook, Jeff. *"Neighborhood Scale Monitoring in Barrio Logan,"* (AWMA Annual Conference Proceedings, June 2003)

Dry Cleaners Using Perchloroethylene (Perc Dry Cleaners)

Perchloroethylene (perc) is the solvent most commonly used by the dry cleaning industry to clean clothes or other materials. The ARB and other public health agencies have identified perc as a potential cancer-causing compound. Perc persists in the atmosphere long enough to contribute to both regional air pollution and localized exposures. Perc dry cleaners are the major source of perc emissions in California.

Since 1990, the statewide concentrations and health risk from exposure to perc has dropped over 70 percent. This is due to a number of regulatory requirements on perc dry cleaners and other sources, including degreasing operations, brake cleaners, and adhesives. ARB adopted an Airborne Toxic Control Measure (ATCM) for Perc Emissions from Dry Cleaning Operations in 1993. ARB has also prohibited the use of perc in aerosol adhesives and automotive brake cleaners.

Perc dry cleaners statewide are required to comply with ARB and local air district regulations to reduce emissions. However, even with these controls, some emissions continue to occur. Air quality studies indicate that there is still the potential for significant risks even near well-controlled dry cleaners. The South Coast AQMD has adopted a rule requiring that all new dry cleaners use alternatives to perc and that existing dry cleaners phase out the use of perc by December 2020. Over time, transition to non-toxic alternatives should occur. However, while perc continues to be used, a preventative approach should be taken to siting of new sensitive land uses.

Key Health Findings

Inhalation of perc may result in both cancer and non-cancer health effects. An assessment by California's Office of Environmental Health Hazard Assessment (OEHHA) concluded that perc is a potential human carcinogen and can cause non-cancer health effects. In addition to the potential cancer risk, the effects of long-term exposure include dizziness, impaired judgment and perception, and damage to the liver and kidneys. Workers have shown signs of liver toxicity following chronic exposure to perc, as well as kidney dysfunction and neurological effects. Non-cancer health effects occur with higher exposure levels than those associated with significant cancer risks. The public is more likely to be exposed to perchloroethylene at levels causing significant cancer risks than to levels causing non-cancer health effects. Non-cancer health effects, unlike cancer health effects, have a threshold or exposure level below which non-cancer health effects would not be expected. The ARB formally identified perc as a toxic air contaminant in October 1991.

One study has determined that inhalation of perc is the predominant route of exposure to infants living in apartments co-located in the same building with a business operating perc dry cleaning equipment. Results of air sampling within co-residential buildings indicate that dry cleaners can cause a wide range of exposures depending on the type and maintenance of the equipment. For example, a well-maintained state-of-the-art system may have risks in the range of 10 in one million, whereas a badly maintained machine with major leaks can have potential cancer risks of thousands in one million.

The California Air Pollution Control Officers Association (CAPCOA) is developing Industry-wide Risk Assessment Guidelines for Perchloroethylene Dry Cleaners which, when published, will provide detailed information on public health risk from exposure to emissions from this source.

Distance Related Findings

Risk created by perc dry cleaning is dependent on the amount of perc emissions, the type of dry cleaning equipment, proximity to the source, and how the emissions are released and dispersed (e.g., type of ventilation system, stack parameters, and local meteorology). Dry cleaners are often located near residential areas, and near shopping centers, schools, day-care centers, and restaurants.

The vast majority of dry cleaners in California have one dry cleaning machine per facility. The South Coast AQMD estimates that an average well-controlled dry cleaner uses about 30 to 160 gallons of cleaning solvent per year, with an average of about 100 gallons. Based on these estimates, the South Coast AQMD estimates a potential cancer risk between 25 to 140 in one million at residential locations 75 feet or less from the dry cleaner, with an average of about 80 in one million. The estimate could be as high as 270 in one million for older machines.

CAPCOA's draft industry-wide risk assessment of perc dry cleaning operations indicates that the potential cancer risk for many dry cleaners may be in excess of potential cancer risk levels adopted by the local air districts. The draft document also indicates that, in general, the public's exposure can be reduced by at least 75 percent, by providing a separation distance of about 300 feet from the operation. This assessment is based on a single machine with perc use of about 100 gallons per year. At these distances, the potential cancer risk would be less than 10 potential cases per million for most scenarios.

The risk would be proportionately higher for large, industrial size, dry cleaners. These facilities typically have two or more machines and use 200 gallons or more per year of perc. Therefore, separation distances need to be greater for large dry cleaners. At a distance of 500 feet, the remaining risk for a large plant can be reduced by over 85 percent.

In California, a small number of dry cleaners that are co-located (sharing a common wall, floor, or ceiling) with a residence have the potential to expose the inhabitants of the residence to high levels of perc. However, while special requirements have been imposed on these existing facilities, the potential for exposure still exists. Avoiding these siting situations in the future is an important preventative measure.

Local air districts are a source of information regarding specific dry cleaning operations—particularly for large industrial operations with multiple machines. The 300 foot separation recommended below reflects the most common situation – a dry cleaner with only one machine. While we recommend 500 feet when there are two or more machines, site specific information should be obtained from the local air district for some very large industrial operations. Factors that can impact the risk include the number and type of machines, controls used, source configuration, building dimensions, terrain, and meteorological data.

Recommendation

- Avoid siting new sensitive land uses within 300 feet of any dry cleaning operation. For operations with two or more machines provide 500 feet. For operations with 3 or more machines, consult with the local air district.

- Do not site new sensitive land uses in the same building with perc dry cleaning operations.

References

- *Proposed Amended Rule 1421 – Control of Perchloroethylene Emissions from Dry Cleaning Systems,* Final Staff Report. South Coast AQMD. (October 2002)
- *Air Toxic Control Measure for Emissions of Perchloroethylene from Dry Cleaning Operations.* ARB (1994) (http://www.arb.ca.gov/toxics/atcm/percatcm.htm)
- *"An Assessment of Tetrachloroethylene in Human Breast Milk"*, Judith Schreiber, New York State Department of Health – Bureau of Toxic Substance Assessment, Journal of Exposure Analysis and Environmental Epidemiology, Vol.2, Suppl.2, pp. 15-26, 1992.
- Draft *Air Toxics "Hot Spots" Program Perchloroethylene Dry Cleaner Industry-wide Risk Assessment Guidelines.* (CAPCOA (November 2002)
- *Final Environmental Assessment for Proposed Amended Rule 1421 – Control of Perchloroethylene Emissions from Dry Cleaning Systems.* South Coast AQMD. (October 18, 2002)

Gasoline Dispensing Facilities

Refueling at gasoline dispensing facilities releases benzene into the air. Benzene is a potent carcinogen and is one of the highest risk air pollutants regulated by ARB. Motor vehicles and motor vehicle-related activity account for over 90 percent of benzene emissions in California. While gasoline-dispensing facilities account for a small part of total benzene emissions, near source exposures for large facilities can be significant.

Since 1990, benzene in the air has been reduced by over 75 percent statewide, primarily due to the implementation of emissions controls on motor vehicle vapor recovery equipment at gas stations, and a reduction in benzene levels in gasoline. However, benzene levels are still significant. In urban areas, average benzene exposure is equivalent to about 50 in one million.

Gasoline dispensing facilities tend to be located in areas close to residential and shopping areas. Benzene emissions from the largest gas stations may result in near source health risk beyond the regional background and district health risk thresholds. The emergence of very high gasoline throughput at large retail or wholesale outlets makes this a concern as these types of outlets are projected to account for an increasing market share in the next few years.

Key Health Findings

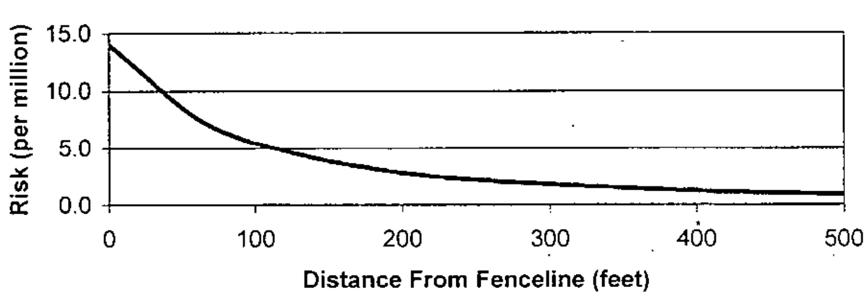
Benzene is a human carcinogen identified by ARB as a toxic air contaminant. Benzene also can cause non-cancer health effects above a certain level of exposure. Brief inhalation exposure to high concentrations can cause central nervous system depression. Acute effects include central nervous system symptoms of nausea, tremors, drowsiness, dizziness, headache, intoxication, and unconsciousness. It is unlikely that the public would be exposed to levels of benzene from gasoline dispensing facilities high enough to cause these non-cancer health effects.

Distance Related Findings

A well-maintained vapor recovery system can decrease emissions of benzene by more than 90% compared with an uncontrolled facility. Almost all facilities have emission control systems. Air quality modeling of the health risks from gasoline dispensing facilities indicate that the impact from the facilities decreases rapidly as the distance from the facility increases.

Statistics reported in the ARB's staff reports on Enhanced Vapor Recovery released in 2000 and 2002, indicated that almost 96 percent of the gasoline dispensing facilities had a throughput less than 2.4 million gallons per year. The remaining four percent, or approximately 450 facilities, had throughputs exceeding 2.4 million gallons per year. For these stations, the average gasoline throughput was 3.6 million gallons per year.

Figure 1-6
Gasoline Dispensing Facility Health Risk
for 3,600,000 gal/yr throughput



As shown in Figure 1-6, the risk levels for a gasoline dispensing facility with a throughput of 3.6 million gallons per year is about 10 in one million at a distance of 50 feet from the fenceline. However, as the throughput increases, the potential risk increases.

As mentioned above, air pollution levels in the immediate vicinity of large gasoline dispensing facilities may be higher than the surrounding area (although tailpipe emissions from motor vehicles dominates the health impacts). Very large gasoline dispensing facilities located at large wholesale and discount centers may dispense nine million gallons of gasoline per year or more. At nine million gallons, the potential risk could be around 25 in one million at 50 feet, dropping to about five in one million at 300 feet. Some facilities have throughputs as high as 19 million gallons.

<u>Recommendation</u>

- Avoid siting new sensitive land uses within 300 feet of a large gasoline dispensing facility (defined as a facility with a throughput of 3.6 million gallons per year or greater). A 50 foot separation is recommended for typical gas dispensing facilities.

<u>References</u>

- *Gasoline Service Station Industry-wide Risk Assessment Guidelines.* California Air Pollution Control Officers Association (December 1997 and revised November 1, 2001)
- *Staff Report on Enhanced Vapor Recovery.* ARB (February 4, 2000)
- *The California Almanac of Emissions and Air Quality.* ARB (2004)
- *Staff Report on Enhanced Vapor Recovery Technology Review.* ARB (October 2002)

Other Facility Types that Emit Air Pollutants of Concern

In addition to source specific recommendations, Table 1-3 includes a list of other industrial sources that could pose a significant health risk to nearby sensitive individuals depending on a number of factors. These factors include the amount of pollutant emitted and its toxicity, the distance to nearby individuals, and the type of emission controls in place. Since these types of facilities are subject to air permits from local air districts, facility specific information should be obtained where there are questions about siting a sensitive land use close to an industrial facility.

Potential Sources of Odor and Dust Complaints

Odors and dust from commercial activities are the most common sources of air pollution complaints and concerns from the public. Land use planning and permitting processes should consider the potential impacts of odor and dust on surrounding land uses, and provide for adequate separation between odor and dust sources. As with other types of air pollution, a number of factors need to be considered when determining an adequate distance or mitigation to avoid odor or

Table 1-3 – Examples of Other Facility Types That Emit[1] Air Pollutants of Concern

Categories	Facility Type	Air Pollutants of Concern
Commercial		
	Autobody Shops	Metals, Solvents
	Furniture Repair	Solvents[2], Methylene Chloride
	Film Processing Services	Solvents, Perchloroethylene
	Distribution Centers	Diesel Particulate Matter
	Printing Shops	Solvents
	Diesel Engines	Diesel Particulate Matter
Industrial		
	Construction	Particulate Matter, Asbestos
	Manufacturers	Solvents, Metals
	Metal Platers, Welders, Metal Spray (flame spray) Operations	Hexavalent Chromium, Nickel, Metals
	Chemical Producers	Solvents, Metals
	Furniture Manufacturers	Solvents
	Shipbuilding and Repair	Hexavalent chromium and other metals, Solvents
	Rock Quarries and Cement Manufacturers	Particulate Matter, Asbestos
	Hazardous Waste Incinerators	Dioxin, Solvents, Metals
	Power Plants	Benzene, Formaldehyde, Particulate Matter
	Research and Development Facilities	Solvents, Metals, etc.
Public		
	Landfills	Benzene, Vinyl Chloride, Diesel Particulate Matter
	Waste Water Treatment Plants	Hydrogen Sulfide
	Medical Waste Incinerators	Dioxin, Benzene, PAH, PCBs, 1,3-Butadiene
	Recycling, Garbage Transfer Stations	Diesel Particulate Matter
	Municipal Incinerators	Dioxin, Benzene, PAH, PCBs, 1,3-Butadiene
Transportation		
	Truck Stops	Diesel Particulate Matter
Agricultural Operations		
	Farming Operations	Diesel Particulate Matter, VOCs, NOx, PM10, CO, SOx, Pesticides
	Livestock and Dairy Operations	Ammonia, VOCs, PM10

[1]Not all facilities will emit pollutants of concern due to process changes or chemical substitution. Consult the local air district regarding specific facilities.
[2]Some solvents may emit toxic air pollutants, but not all solvents are toxic air contaminants.

dust complaints in a specific situation. Local air districts should be consulted for advice when these siting situations arise.

Table 1-4 lists some of the most common sources of odor complaints received by local air districts. Complaints about odors are the responsibility of local air districts and are covered under state law. The types of facilities that can cause odor complaints are varied and can range from small commercial facilities to large industrial facilities, and may include waste disposal and recycling operations. Odors can cause health symptoms such as nausea and headache. Facilities with odors may also be sources of toxic air pollutants (See Table 1-3). Some common sources of odors emitted by facilities are sulfur compounds, organic solvents, and the decomposition/digestion of biological materials. Because of the subjective nature of an individual's sensitivity to a particular type of odor, there is no specific rule for assigning appropriate separations from odor sources. Under the right meteorological conditions, some odors may still be offensive several miles from the source.

Table 1-4
Sources of Odor Complaints

- Sewage Treatment Plants
- Landfills
- Recycling Facilities
- Waste Transfer Stations
- Petroleum Refineries
- Biomass Operations
- Autobody Shops
- Coating Operations
- Fiberglass Manufacturing
- Foundries
- Rendering Plants
- Livestock Operations

Sources of dust are also common sources of air pollution-related complaints. Operations that can result in dust problems are rock crushing, gravel production, stone quarrying, and mining operations. A common source of complaints is the dust and noise associated with blasting that may be part of these operations. Besides the health impacts of dust as particulate matter, thick dust also impairs visibility, aesthetic values, and can soil homes and automobiles. Local air districts typically have rules for regulating dust sources in their jurisdictions, but dust sources can still be a concern. Therefore, separation of these facilities from residential and other new sensitive land uses should be considered.

In some areas of California, asbestos occurs naturally in stone deposits. Asbestos is a potent carcinogenic substance when inhaled. Asbestos-containing dust may be a public health concern in areas where asbestos-containing rock is mined, crushed, processed, or used. Situations where asbestos-containing gravel has been used in road paving materials are also a source of asbestos exposure to the general public. Planners are advised to consult with local air pollution agencies in areas where asbestos-containing gravel or stone products are produced or used.

2. Handbook Development

ARB and local air districts share responsibility for improving statewide air quality. As a result of California's air pollution control programs, air quality has improved and health risk has been reduced statewide. However, state and federal air quality standards are still exceeded in many areas of California and the statewide health risk posed by toxic air contaminants (air toxics) remains too high. Also, some communities experience higher pollution exposures than others - making localized impacts, as well regional or statewide impacts, an important consideration. It is for this reason that this Handbook has been produced - to promote better, more informed decision-making by local land use agencies that will improve air quality and public health in their communities.

Land use policies and practices, including planning, zoning, and siting activities, can play a critical role in air quality and public health at the local level. For instance, even with the best available control technology, some projects that are sited very close to homes, schools, and other public places can result in elevated air pollution exposures. The reverse is also true – siting a new school or home too close to an existing source of air pollution can pose a public health risk. The ARB recommendations in section 1 address this issue.

> *This Handbook is an informational document that we hope will strengthen the relationship between air quality and land use agencies. It highlights the need for land use agencies to address the potential for new projects to result in localized health risk or contribute to cumulative impacts where air pollution sources are concentrated.*

Avoiding these incompatible land uses is a key to reducing localized air pollution exposures that can result in adverse health impacts, especially to sensitive individuals.

Individual siting decisions that result in incompatible land uses are often the result of locating "sensitive" land uses next to polluting sources. These decisions can be of even greater concern when existing air pollution exposures in a community are considered. In general terms, this is often referred to as the issue of "cumulative impacts." ARB is working with local air districts to better define these situations and to make information about existing air pollution levels (e.g., from local businesses, motor vehicles, and other areawide sources) more readily available to land use agencies.

In December 2001, the ARB adopted "Policies and Actions for Environmental Justice" (Policies). These Policies were developed in coordination with a group of stakeholders, representing local government agencies, community interest groups, environmental justice organizations, academia, and business (Environmental Justice Stakeholders Group).

The Policies included a commitment to work with land use planners, transportation agencies, and local air districts to develop ways to identify, consider, and reduce cumulative air pollution emissions, exposure, and health risks associated with land use planning and decision-making. Developed under the auspices of the ARB's Environmental Justice Stakeholders Group, this Handbook is a first step in meeting that commitment.

ARB has produced this Handbook to help achieve several objectives:

- Provide recommendations on situations to avoid when siting new residences, schools, day care centers, playgrounds, and medical-related facilities (sensitive sites or sensitive land uses);

- Identify approaches that land use agencies can use to prevent or reduce potential air pollution impacts associated with general plan policies, new land use development, siting, and permitting decisions;

- Improve and facilitate access to air quality data and evaluation tools for use in the land use decision-making process;

- Encourage stronger collaboration between land use agencies and local air districts to reduce community exposure to source-specific and cumulative air pollution impacts; and

- Emphasize community outreach approaches that promote active public involvement in the air quality/land use decision-making process.

This Handbook builds upon California's 2003 General Plan Guidelines. These Guidelines, developed by the Governor's Office of Planning and Research (OPR), explain the land use planning process and applicable legal requirements. This Handbook also builds upon a 1997 ARB report, "The Land Use-Air Quality Linkage" ("Linkage Report").[9] The Linkage Report was an outgrowth of the California Clean Air Act which, among other things, called upon local air districts to focus particular attention on reducing emissions from sources that indirectly cause air pollution by attracting vehicle trips. Such indirect sources include, but are not limited to, shopping centers, schools and universities, employment centers, warehousing, airport hubs, medical offices, and sports arenas. The Linkage Report summarizes data as of 1997 on the relationships between land use, transportation, and air quality, and highlights strategies that can help to reduce the use of single occupancy automobile use. Such strategies

[9] To access this report, please refer to ARB's website or click on: http://www.arb.ca.gov/ch/programs/link97.pdf

complement ARB regulatory programs that continue to reduce motor vehicle emissions.

In this Handbook, we identify types of air quality-related information that we recommend land use agencies consider in the land use decision-making processes such as the development of regional, general, and community plans; zoning ordinances; environmental reviews; project siting; and permit issuance. The Handbook provides recommendations on the siting of new sensitive land uses based on current analyses. It also contains information on approaches and methodologies for evaluating new projects from an air pollution perspective.

The Handbook looks at air quality issues associated with emissions from industrial, commercial, and mobile sources of air pollution. Mobile sources continue to be the largest overall contributors to the state's air pollution problems, representing the greatest air pollution health risk to most Californians. Based on current health risk information for air toxics, the most serious pollutants on a statewide basis are diesel PM, benzene, and 1,3-butadiene, all of which are primarily emitted by motor vehicles. From a state perspective, ARB continues to pursue new strategies to further reduce motor vehicle-related emissions in order to meet air quality standards and reduce air toxics risk.

While mobile sources are the largest overall contributors to the state's air pollution problems, industrial and commercial sources can also pose a health risk, particularly to people near the source. For this reason, the issue of incompatible land uses is an important focus of this document.

Handbook Audience

Even though the primary users of the Handbook will likely be agencies responsible for air quality and land use planning, we hope the ideas and technical issues presented in this Handbook will also be useful for:

- public and community organizations and community residents;
- federal, state and regional agencies that fund, review, regulate, oversee, or otherwise influence environmental policies and programs affected by land use policies; and
- private developers.

3. Key Community Focused Issues Land Use Agencies Should Consider

Two key air quality issues that land use agencies should consider in their planning, zoning, and permitting processes are:

1) **Incompatible Land Uses.** Localized air pollution impacts from incompatible land use can occur when polluting sources, such as a heavily trafficked roadway, warehousing facilities, or industrial or commercial facilities, are located near a land use where sensitive individuals are found such as a school, hospital, or homes.

2) **Cumulative Impacts.** Cumulative air pollution impacts can occur from a concentration of multiple sources that individually comply with air pollution control requirements or fall below risk thresholds, but in the aggregate may pose a public health risk to exposed individuals. These sources can be heavy or light-industrial operations, commercial facilities such as autobody shops, large gas dispensing facilities, dry cleaners, and chrome platers, and freeways or other nearby busy transportation corridors.

Incompatible Land Uses

Land use policies and practices can worsen air pollution exposure and adversely affect public health by mixing incompatible land uses. Examples include locating new sensitive land uses, such as housing or schools, next to small metal plating facilities that use a highly toxic form of chromium, or very near large industrial facilities or freeways. Based on recent monitoring and health-based studies, we now know that air quality impacts from incompatible land uses can contribute to increased risk of illness, missed work and school, a lower quality of life, and higher costs for public health and pollution control.[10]

Avoiding incompatible land uses can be a challenge in the context of mixed-use industrial and residential zoning. For a variety of reasons, government agencies and housing advocates have encouraged the proximity of affordable housing to employment centers, shopping areas, and transportation corridors, partially as a means to reduce vehicle trips and their associated emissions. Generally speaking, typical distances in mixed-use communities between businesses and industries and other land uses such as homes and schools, should be adequate to avoid health risks. However, generalizations do not always hold as we addressed in section 1 of this Handbook.

In terms of siting air pollution sources, the proposed location of a project is a major factor in determining whether it will result in localized air quality impacts. Often, the problem can be avoided by providing an adequate distance or setback

[10] For more information, the reader should refer to ARB's website on community health: http://www.arb.ca.gov/ch/ch.htm

between a source of emissions and nearby sensitive land uses. Sometimes, suggesting project design changes or mitigation measures in the project review phase can also reduce or avoid potential impacts. This underscores the importance of addressing potential incompatible land uses as early as possible in the project review process, ideally in the general plan itself.

Cumulative Air Pollution Impacts

The broad concept of cumulative air pollution impacts reflects the combination of regional air pollution levels and any localized impacts. Many factors contribute to air pollution levels experienced in any location. These include urban background air pollution, historic land use patterns, the prevalence of freeways and other transportation corridors, the concentration of industrial and commercial businesses, and local meteorology and terrain.

When considering the potential air quality impacts of polluting sources on individuals, project location and the concentration of emissions from air pollution sources need to be considered in the land use decision-making process. In section 4, the Handbook offers a series of questions that helps land use agencies determine if a project should undergo a more careful analysis. This holds true regardless of whether the project being sited is a polluting source or a sensitive land use project.

Large industrial areas are not the only land uses that may result in public health concerns in mixed-use communities. Cumulative air pollution impacts can also occur if land uses do not adequately provide setbacks or otherwise protect sensitive individuals from potential air pollution impacts associated with nearby light industrial sources. This can occur with activities such as truck idling and traffic congestion, or from indirect sources such as warehousing facilities that are located in a community or neighborhood.

In October 2004, Cal/EPA published its Environmental Justice Action Plan. In February 2005, the Cal/EPA Interagency Working Group approved a working definition of "cumulative impacts" for purposes of initially guiding the pilot projects that are being conducted pursuant to that plan. Cal/EPA is now in the process of developing a Cumulative Impacts Assessment Guidance document. Cal/EPA will revisit the working definition of "cumulative impacts" as the Agency develops that guidance. The following is the working definition:

> *"Cumulative impacts means exposures, public health or environmental effects from the combined emissions and discharges, in a geographic area, including environmental pollution from all sources, whether single or multi-media, routinely, accidentally, or otherwise released. Impacts will take into account sensitive populations and socio-economic factors, where applicable, and to the extent data are available."*

4. Mechanisms for Integrating Localized Air Quality Concerns Into Land Use Processes

Land use agencies should use each of their existing planning, zoning, and permitting authorities to address the potential health risk associated with new projects. Land use-specific mechanisms can go a long way toward addressing both localized and cumulative impacts from new air pollution sources that are not otherwise addressed by environmental regulations. Likewise, close collaboration and communication between land use agencies and local air districts in both the planning and project approval stages can further reduce these impacts. Local agency partnerships can also result in early identification of potential impacts from proposed activities that might otherwise escape environmental review. When this happens, pollution problems can be prevented or reduced before projects are approved, when it is less complex and expensive to mitigate.

The land use entitlement process requires a series of planning decisions. At the highest level, the General Plan sets the policies and direction for the jurisdiction, and includes a number of mandatory elements dealing with issues such as housing, circulation, and health hazards. Zoning is the primary tool for implementing land use policies. Specific or community plans created in conjunction with a specific project also perform many of the same functions as a zoning ordinance. Zoning can be modified by means of variances and conditional use permits. The latter are frequently used to insure compatibility between otherwise conflicting land uses. Finally, new development usually requires the approval of a parcel or tract map before grading and building permits can be issued. These parcel or tract maps must be consistent with the applicable General Plan, zoning and other standards.

Land use agencies can use their planning authority to separate industrial and residential land uses, or to require mitigation where separation is not feasible. By separating incompatible land uses, land use agencies can prevent or reduce both localized and cumulative air pollution impacts without denying what might otherwise be a desirable project.[11] For instance:

- a dry cleaner could open a storefront operation in a community with actual cleaning operations performed at a remote location away from residential areas;
- gas dispensing facilities with lower fuel throughput could be sited in mixed-use areas;
- enhanced building ventilation or filtering systems in schools or senior care centers can reduce ambient air from nearby busy arterials; or
- landscaping and regular watering can be used to reduce fugitive dust at a building construction site near a school yard.

---

[11] It should be noted that such actions should also be considered as part of the General Plan or Plan element process.

The following general and specific land use approaches can help to reduce potential adverse air pollution impacts that projects may have on public health.

General Plans

The primary purpose of planning, and the source of government authority to engage in planning, is to protect public health, safety, and welfare. In its most basic sense, a local government General Plan expresses the community's development goals and embodies public policy relative to the distribution of future land uses, forming the basis for most land use decisions. Therefore, the most effective mechanism for dealing with the central land use concept of compatibility and its relationship to cumulative air pollution impacts is the General Plan. Well before projects are proposed within a jurisdiction, the General Plan sets the stage for where projects can be sited, and their compatibility with comprehensive community goals, objectives, and policies.

In 2003, OPR revised its General Plan Guidelines, highlighting the importance of incorporating sustainable development and environmental justice policies in the planning process. The OPR General Plan Guidelines provides an effective and long-term approach to reduce cumulative air pollution impacts at the earliest planning stages. In light of these important additions to the Guidelines, land use agencies should consider updating their General Plans or Plan elements to address these revisions.

The General Plan and related Plan elements can be used to avoid incompatible land uses by incorporating air quality considerations into these documents. For instance, a General Plan safety element with an air quality component could be used to incorporate policies or objectives that are intended to protect the public from the potential for facility breakdowns that may result in a dangerous release of air toxics. Likewise, an air quality component to the transportation circulation element of the General Plan could include policies or standards to prevent or reduce local exposure to diesel exhaust from trucks and other vehicles. For instance, the transportation circulation element could encourage the construction of alternative routes away from residential areas for heavy-duty diesel trucks. By considering the relationship between air quality and transportation, the circulation element could also include air quality policies to prevent or reduce trips and travel, and thus vehicle emissions. Policies in the land use element of the General Plan could identify areas appropriate for future industrial, commercial, and residential uses. Such policies could also introduce design and distance parameters that reduce emissions, exposure, and risk from industrial and some commercial land uses (e.g., dry cleaners) that are in close proximity to residential areas or schools.

Land use agencies should also consider updating or creating an air quality element in the jurisdiction's General Plan. In the air quality element, local decision-makers could develop long-term, effective plans and policies to address air quality issues, including cumulative impacts. The air quality element can also provide a general reference guide that informs local land use planners about regional and community level air quality, regulatory air pollution control requirements and guidelines, and references emissions and pollution source data bases and assessment and modeling tools. As is further described in Appendix C of the Handbook, new assessment tools that ARB is developing can be included into the air quality element by reference. For instance, ARB's statewide risk maps could be referenced in the air quality element as a resource that could be consulted by developers or land use agencies

Zoning

The purpose of "zoning" is to separate different land uses. Zoning ordinances establish development controls to ensure that private development takes place within a given area in a manner in which:

- All uses are compatible (e.g., an industrial plant is not permitted in a residential area);
- Common development standards are used (e.g., all homes in a given area are set back the same minimum distance from the street); and,
- Each development does not unreasonably impose a burden upon its neighbors (e.g., parking is required on site so as not to create neighborhood parking problems).

To do this, use districts called "zones" are established and standards are developed for these zones. The four basic zones are residential, commercial, industrial and institutional.

Land use agencies may wish to consider how zoning ordinances, particularly those for mixed-use areas, can be used to avoid exacerbating poor land use practices of the past or contributing to localized and cumulative air pollution impacts in the community.

Sometimes, especially in mixed-use zones, there is a potential for certain categories of existing businesses or industrial operations to result in cumulative air pollution impacts to new development projects. For example:

- An assisted living project is proposed for a mixed-use zone adjacent to an existing chrome plating facility, or several dry cleaners;
- Multiple industrial sources regulated by a local air district are located directly upwind of a new apartment complex;
- A new housing development is sited in a mixed-use zone that is downwind or adjacent to a distribution center that attracts diesel-fueled delivery trucks and TRUs; or
- A new housing development or sensitive land use is sited without adequate setbacks from an existing major transportation corridor or rail yard.

As part of the public process for making zoning changes, local land use agencies could work with community planning groups, local businesses, and community residents to determine how best to address existing incompatible land uses.

Land Use Permitting Processes

- **Questions to Consider When Reviewing New Projects**

Very often, just knowing what questions to ask can yield critical information about the potential air pollution impacts of proposed projects – both from the perspective of a specific project as well as in the nature of existing air pollution sources in the same impact area. Available land use information can reveal the proximity of air pollution sources to sensitive individuals, the potential for incompatible land uses, and the location and nature of nearby air pollution sources. Air quality data, available from the ARB and local air districts, can provide information about the types and amounts of air pollution emitted in an area, regional air quality concentrations, and health risk estimates for specific sources.

General Plans and zoning maps are an excellent starting point in reviewing project proposals for their potential air pollution impacts. These documents contain information about existing or proposed land uses for a specific location as well as the surrounding area. Often, just looking at a map of the proposed location for a facility and its surrounding area will help to identify a potential adjacent incompatible land use.

The following pages are a "pull-out" list of questions to consider along with cross-references to pertinent information in the Handbook. These questions are intended to assist land use agencies in evaluating potential air quality-related concerns associated with new project proposals.

The first group of questions contains project-related queries designed to help identify the potential for localized project impacts, particularly associated with incompatible land uses. The second group of questions focuses on the issue of potential cumulative impacts by including questions about existing emissions and air quality in the community, and community feedback. Depending on the answers to these questions, a land use agency may decide a more detailed review of the proposal is warranted.

The California Department of Education has already developed a detailed process for school siting which is outlined in Appendix E. However, school districts may also find this section helpful when evaluating the most appropriate site for new schools in their area. At a minimum, using these questions may encourage school districts to engage throughout their siting process with land use agencies and local air districts. The combined expertise of these entities can be useful in devising relevant design standards and mitigation measures that can reduce exposure to cumulative emissions, exposure, and health risk to students and school workers.

As indicated throughout the Handbook, we strongly encourage land use agencies to consult early and often with local air districts. Local air districts have the expertise, many of the analytical tools, and a working knowledge of the sources they regulate. It is also critical to fully involve the public and businesses that could be affected by the siting decision. The questions provided in the chart below do not imply any particular action should be taken by land use agencies. Rather the questions are intended to improve the assessment process and facilitate informed decision-making.

- **Project-Related Questions**

This section includes project-related questions that, in conjunction with the questions in the next section, can be used to tailor the project evaluation. These questions are designed to help identify the potential for incompatible land uses from localized project impacts.

Questions to Consider When Reviewing New Projects

Project-Related Questions	Cross-Reference to Relevant Handbook Sections
1. Is the proposed project: ▲ A business or commercial license renewal ▲ A new or modified commercial project ▲ A new or modified industrial project ▲ A new or modified public facility project ▲ A new or modified transportation project ▲ A housing or other development in which sensitive individuals may live or play	See Appendix A for typical land use classifications and associated project categories that could emit air pollutants.
2. Does the proposed project: ▲ Conform to the zoning designation? ▲ Require a variance to the zoning designation? ▲ Include plans to expand operations over the life of the business such that additional emissions may increase the pollution burden in the community (e.g., from additional truck operations, new industrial operations or process lines, increased hours of operation, build-out to the property line, etc.)?	See Appendix F for a general explanation of land use processes. In addition, Section 3 contains a discussion of how land use planning, zoning, and permitting practices can result in incompatible land uses or cumulative air pollution impacts.
3. Has the local air district provided comments or information to assist in the analysis?	See Section 5 and Appendix C for a description of air quality-related tools that the ARB and local air districts use to provide information on potential air pollution impacts.
4. Have public meetings been scheduled with the affected community to solicit their involvement in the decision-making process for the proposed project?	See Section 7 for a discussion of public participation, information and outreach tools.
5. If the proposed project will be subject to local air district regulations: ▲ Has the project received a permit from the local air district? ▲ Would it comply with applicable local air district requirements? ▲ Is the local air district contemplating new regulations that would reduce emissions from the source over time? ▲ Will potential emissions from the project	See Appendix C for a description of local air district programs.

Project-Related Questions	Cross-Reference to Relevant Handbook Sections
trigger the local air district's new source review for criteria pollutants or air toxics emissions? ▲ Is the local air district expected to ask the proposed project to perform a risk assessment? ▲ Is there sufficient new information or public concern to call for a more thorough environmental analysis of the proposed project? ▲ Are there plans to expand operations over time? ▲ Are there land-use based air quality significance thresholds or design standards that could be applied to this project in addition to applicable air district requirements?	
6. If the proposed project will release air pollution emissions, either directly or indirectly, but is not regulated by the local air district: ▲ Is the local air district informed of the project? ▲ Does the local air district believe that there could be potential air pollution impacts associated with this project category because of the proximity of the project to sensitive individuals? ▲ If the project is one in which individuals live or play (e.g., a home, playground, convalescent home, etc.), does the local air district believe that the project's proximity to nearby sources could pose potential air pollution impacts? ▲ Are there indirect emissions that could be associated with the project (e.g., truck traffic or idling, transport refrigeration unit operations, stationary diesel engine operations, etc.) that will be in close proximity to sensitive individuals? ▲ Will the proposed project increase or serve as a magnet for diesel traffic? ▲ Are there land-use based air quality significance thresholds or design standards that could be applied to this project in addition to applicable air district requirements? ▲ Is there sufficient new information or public concern to call for a more thorough environmental analysis of the proposed project? ▲ Should the site approval process include identification and mitigation of potential	See Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites).

Project-Related Questions	Cross-Reference to Relevant Handbook Sections
direct or indirect emissions associated with the potential project?	
7. Does the local air district or land use agency have pertinent information on the source, such as: ▲ Available permit and enforcement data, including for the owner or operator of the proposed source that may have other sources in the State. ▲ Proximity of the proposed project to sensitive individuals. ▲ Number of potentially exposed individuals from the proposed project. ▲ Potential for the proposed project to expose sensitive individuals to odor or other air pollution nuisances. ▲ Meteorology or the prevailing wind patterns between the proposed project and the nearest receptor, or between the proposed sensitive receptor project and sources that could pose a localized or cumulative air pollution impact.	See Appendix C for a description of local air district programs. See Appendix B for a listing of useful information that land use agencies should have on hand or have accessible when reviewing proposed projects for potential air pollution impacts. Also, do not hesitate to contact your local air district regarding answers to any of these questions that might not be available at the land use agency. See Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites).
8. Based upon the project application, its location, and the nature of the source, could the proposed project: ▲ Be a polluting source that is located in proximity to, or otherwise upwind, of a location where sensitive individuals live or play? ▲ Attract sensitive individuals and be located in proximity to or otherwise downwind, of a source or multiple sources of pollution, including polluting facilities or transportation-related sources that contribute emissions either directly or indirectly? ▲ Result in health risk to the surrounding community?	See Section 3 for a discussion of what is an incompatible land use and the potential cumulative air pollution impacts. See Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites).
9. If a CEQA categorical exemption is proposed, were the following questions considered: ▲ Is the project site environmentally sensitive as defined by the project's location? (A project that is ordinarily insignificant in its impact on the environment may in a particularly sensitive environment be significant.) ▲ Would the project and successive future projects of the same type in the approximate location potentially result in cumulative impacts? ▲ Are there "unusual circumstances" creating the possibility of significant effects?	See CEQA Guidelines section 15300, and Public Resources Code, section 21084. See Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites). See also Section 5 and Appendix C for a description of air quality-related tools that the ARB and local air districts use to provide information on potential air pollution impacts.

- **Questions Related to Cumulative Impact Assessment**

The following questions can be used to provide the decision-maker with a better understanding of the potential for cumulative air pollution impacts to an affected community. Answers to these questions will help to determine if new projects or activities warrant a more detailed review. It may also help to see potential environmental concerns from the perspective of the affected community. Additionally, responses can provide local decision-makers with information with which to assess the best policy options for addressing neighborhood-scale air pollution concerns.

The questions below can be used to identify whether existing tools and procedures are adequate to address land use-related air pollution issues. This process can also be used to pinpoint project characteristics that may have the greatest impact on community-level emissions, exposure, and risk. Such elements can include: the compliance record of existing sources including those owned or operated by the project proponent; the concentration of emissions from polluting sources within the approximate area of sensitive sites; transportation circulation in proximity to the proposed project; compatibility with the General Plan and General Plan elements; etc.

The local air district can provide useful assistance in the collection and evaluation of air quality-related information for some of the questions and should be consulted early in the process.

Questions Related to Cumulative Impact Assessment

Technical Questions	Cross-Reference to Relevant Handbook Sections
1. Is the community home to industrial facilities?	See Appendix A for typical land use classifications and associated project categories that could emit air pollutants.
2. Do one or more major freeways or high-traffic volume surface streets cut through the community?	See transportation circulation element of your general plan. See also Appendix B for useful information that land use agencies should have on hand or have accessible when reviewing proposed projects for potential air pollution impacts. See Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites).
3. Is the area classified for mixed-use zoning?	See your general plan and zoning ordinances.
4. Is there an available list of air pollution sources in the community?	Contact your local air district.
5. Has a walk-through of the community been conducted to gather the following information:	See Appendix B for a listing of useful information that land use agencies

Technical Questions	Cross-Reference to Relevant Handbook Sections
▲ Corroborate available information on land use activities in the area (e.g., businesses, housing developments, sensitive individuals, etc.)? ▲ Determine the proximity of existing and anticipated future projects to residential areas or sensitive individuals? ▲ Determine the concentration of emission sources (including anticipated future projects) to residential areas or sensitive individuals?	should have on hand or have accessible when reviewing proposed projects for potential air pollution impacts. Also contact your local air district.
6. Has the local air district been contacted to obtain information on sources in the community?	See Section 7 for a discussion of public participation, information and outreach tools.
7. What categories of commercial establishments are currently located in the area and does the local air district have these sources on file as being regulated or permitted?	See Appendix A for typical land use classifications and associated project categories that could emit air pollutants. Also contact your local air district.
8. What categories of indirect sources such as distribution centers or warehouses are currently located in the area?	See Appendix A for typical land use classifications and associated project categories that emit air pollutants.
9. What air quality monitoring data are available?	Contact your local air district.
10. Have any risk assessments been performed on emission sources in the area?	Contact your local air district.
11. Does the land use agency have the capability of applying a GIS spatial mapping tool that can overlay zoning, sub-development information, and other neighborhood characteristics, with air pollution and transportation data?	See Appendix B for a listing of useful information that land use agencies should have on hand or have accessible when reviewing proposed projects for potential air pollution impacts. Also contact your local air district for tools that can be used to supplement available land use agency tools.
12. Based on available information, is it possible to determine if the affected community or neighborhood experiences elevated health risk due to a concentration of air pollution sources in close proximity, and if not, can the necessary information be obtained?	Contact your local air district. Also see Section 1 for recommendations on situations to avoid when siting projects where sensitive individuals would be located (sensitive sites).
13. Does the community have a history of chronic complaints about air quality?	See Section 7 for a discussion of public participation, information and outreach tools. Also contact your local air district.
14. Is the affected community included in the public participation process for the agency's decision?	See Section 7 for a discussion of public participation, information and outreach tools.
15. Have community leaders or groups been contacted about any pre-existing or chronic community air quality concerns?	See Section 7 for a discussion of public participation, information and outreach tools. Also contact your local air district.

- **Mitigation Approaches**

In addition to considering the suitability of the project location, opportunities for mitigation of air pollution impacts should be considered. Sometimes, a land use agency may find that selection of a different project location to avoid a health risk is not feasible. When that happens, land use agencies should consider design improvements or other strategies that would reduce the risk. Such strategies could include performance or design standards, consultation with local air districts and other agencies on appropriate actions that these agencies should, or plan to, undertake, and consultation and outreach in the affected community. Potential mitigation measures should be feasible, cost-effective solutions within the available resources and authority of implementing agencies to enforce.[12]

- **Conditional Use Permits and Performance Standards**

Some types of land uses are only allowed upon approval of a conditional use permit (also called a CUP or special use permit). A conditional use permit does not re-zone the land but specifies conditions under which a particular land use will be permitted. Such land uses could be those with potentially significant environmental impacts. Local zoning ordinances specify the uses for which a conditional use permit is required, the zones they may be allowed in, and public hearing procedures. The conditional use permit imposes special requirements to ensure that the use will not be detrimental to its surroundings.

In the context of land use planning, performance standards are requirements imposed on projects or project categories through conditional use permits to ensure compliance with general plan policies and local ordinances. These standards could apply to such project categories as distribution centers, very large gas dispensing facilities, autobody shops, dry cleaners, and metal platers. Land use agencies may wish to consider adding land use-based performance standards to zoning ordinances in existing mixed-use communities for certain air pollution project categories. Such standards would provide certainty and equitable treatment to all projects of a similar nature, and reserve the more resource intensive conditional or special use permits to projects that require a more detailed analysis. In developing project design or performance standards, land use agencies should consult with the local air district. Early and regular consultation can avoid duplication or inconsistency with local air district control requirements when considering the site-specific design and operation of a project.

---

[12] A land use agency has the authority to condition or deny a project based upon information collected and evaluated through the land use decision-making process. However, any denial would need to be based upon identifiable, generally applicable, articulated standards set forth in the local government's General Plan and zoning codes. One way of averting this is to conduct early and regular outreach to the community and the local air district so that community and environmental concerns can be addressed and accommodated into the project proposal.

Examples of land use-based air quality-specific performance standards include the following:

- Placing a process vent away from the direction of the local playground that is nearby or increasing the stack height so that emissions are dispersed to reduce the emissions impact on surrounding homes or schools.
- Setbacks between the project fence line and the population center.
- Limiting the hours of operation of a facility to avoid excess emissions exposure or foul odors to nearby individuals.
- An ordinance that requires fleet operators to use cleaner vehicles before project approval (if a new business), or when expanding the fleet (if an existing business); and
- Providing alternate routes for truck operations that discourage detours into residential neighborhoods.

Outreach to Other Agencies

When questions arise regarding the air quality impacts of projects, including potential cumulative impacts, land use agencies should consult the local air district. Land use agencies should also consider the following suggestions to avoid creating new incompatible land uses:

- Consult with the local air district to help determine if emissions from a particular project will adversely impact sensitive individuals in the area, if existing or future effective regulations or permit requirements will affect the proposed project or other sources in the vicinity of the proposed project, or if additional inspections should be required.
- Check with ARB for new information and modeling tools that can help evaluate projects seeking to site within your jurisdiction.
- Become familiar with ARB's Land Use-Air Quality Linkage Report to determine whether approaches and evaluation tools contained in the Report can be used to reduce transportation-related impacts on communities.
- Contact and collaborate with other state agencies that play a role in the land use decision-making process, e.g., the State Department of Education, the California Energy Commission, and Caltrans. These agencies have information on mitigation measures and mapping tools that could be useful in addressing local problems.

- **Information Clearinghouse**

  - Land use agencies can refer to the ARB statewide electronic information clearinghouse for information on what measures other jurisdictions are using to address comparable issues or sources.[13]

[13] This information can be accessed from ARB's website by going to: http://www.arb.ca.gov/ch/clearinghouse.htm

The next section addresses available air quality assessment tools that land use agencies can use to evaluate the potential for localized or cumulative impacts in their communities.

5. Available Tools to Evaluate Cumulative Air Pollution Emissions and Risk

Until recently, California has traditionally approached air pollution control from the perspective of assessing whether the pollution was regional, category-specific, or from new or existing sources. This methodology has been generally effective in reducing statewide and regional air pollution impacts and risk levels. However, such an incremental, category-by-category, source-by-source approach may not always address community health impacts from multiple sources - including mobile, industrial, and commercial facilities.

As a result of air toxics and children's health concerns over the past several years, ARB and local air districts have begun to develop new tools to evaluate and inform the public about cumulative air pollution impacts at the community level. One aspect of ARB's programs now underway is to consolidate and make accessible air toxics emissions and monitoring data by region, using modeling tools and other analytical techniques to take a preliminary look at emissions, exposure, and health risk in communities.

ARB has developed multiple tools to assist local air districts perform assessments of cumulative emissions, exposure, and risk on a neighborhood scale. These tools include:

- Regional risk maps that show trends in potential cancer risk from toxic air pollutants in southern and central California between 1990 and 2010. These maps are based on the U.S. EPA's ASPEN model. These maps provide an estimate of background levels of toxic air pollutant risk but are not detailed enough to assess individual neighborhoods or facilities.[14]

- The Community Health Air Pollution Information System (CHAPIS) is a user-friendly, Internet-based system for displaying information on emissions from sources of air pollution in an easy to use mapping format. CHAPIS contains information on air pollution emissions from selected large facilities and small businesses that emit criteria and toxic air pollutants. It also contains information on air pollution emissions from motor vehicles. When released in 2004, CHAPIS did not contain information on every source of air pollution or every air pollutant. However, ARB continues to work with local air districts to include all of the largest air pollution sources and those with the highest documented air pollution risk. Additional facilities will be added to CHAPIS as more data become available.[15]

[14] For further information on these maps, please visit ARB's website at: http://www.arb.ca.gov/toxics/cti/hlthrisk/hlthrisk.htm

[15] For further information on CHAPIS, please click on: http://www.arb.ca.gov/ch/chapis1/chapis1.htm

- The Hot Spots Analysis and Reporting Program (HARP) is a software database package that evaluates emissions from one or more facilities to determine the overall health risk posed by the facility(-ies) on the surrounding community. Proper use of HARP ensures that the risk assessment meets the latest risk assessment guidelines published by the State Office of Environmental Health Hazard Assessment (OEHHA). HARP is designed with air quality professionals in mind and is available from the ARB.

- The Urban Emissions Model (URBEMIS) is a computer program that can be used to estimate emissions associated with land development projects in California such as residential neighborhoods, shopping centers, office buildings, and construction projects. URBEMIS uses emission factors available from the ARB to estimate vehicle emissions associated with new land uses.

Local air districts, and others can use these tools to assess a new project, or plan revision. For example, these tools can be used to:

- Identify if there are multiple sources of air pollution in the community;
- Identify the major sources of air pollution in the area under consideration;
- Identify the background potential cancer risk from toxic air pollution in the area under consideration;
- Estimate the risk from a new facility and how it adds to the overall risk from other nearby facilities; and
- Provide information to decision-makers and key stakeholders on whether there may be significant issues related to cumulative emissions, exposure, and health risk due to a permitting or land use decision.

If an air agency wishes to perform a cumulative air pollution impact analysis using any of these tools, it should consult with the ARB and/or the local air district to obtain information or assistance on the data inputs and procedures necessary to operate the program. In addition, land use agencies could consult with local air districts to determine the availability of land use and air pollution data for entry into an electronic Geographical Information System (GIS) format. GIS is an easier mapping tool than the more sophisticated models described in Appendix C. GIS mapping makes it possible to superimpose land use with air pollution information so that the spatial relationship between air pollution sources, sensitive receptors, and air quality can be visually represented. Appendix C provides a general description of the impact assessment process and micro-scale, or community level modeling tools that are available to evaluate potential cumulative air pollution impacts. Modeling protocols will be accessible on ARB's website as they become available. The ARB will also provide land use agencies and local air districts with statewide regional modeling results and information regarding micro-scale modeling.

6. ARB Programs to Reduce Air Pollution in Communities

ARB's regulatory programs reduce air pollutant emissions through statewide strategies that improve public health in all California communities. ARB's overall program addresses motor vehicles, consumer products, air toxics, air-quality planning, research, education, enforcement, and air monitoring. Community health and environmental justice concerns are a consideration in all these programs. ARB's programs are statewide but recognize that extra efforts may be needed in some communities due to historical mixed land-use patterns, limited participation in public processes in the past, and a greater concentration of air pollution sources in some communities.

ARB's strategies are intended to result in better air quality and reduced health risk to residents throughout California. The ARB's priority is to prevent or reduce the public's exposure to air pollution, including from toxic air contaminants that pose the greatest risk, particularly to infants and children who are more vulnerable to air pollution.

In October 2003, ARB updated its statewide control strategy to reduce emissions from source categories within its regulatory authority. A primary focus of the strategy is to achieve federal and state air quality standards for ozone and particulate matter throughout California, and to reduce health risk from diesel PM. Along with local air districts, ARB will continue to address air toxics emissions from regulated sources (see Table 6-1 for a summary of ARB activities). As indicated earlier, ARB will also provide analytical tools and information to land use agencies and local air districts to help assess and mitigate cumulative air pollution impacts.

The ARB will continue to consider the adoption of or revisions to needed air toxics control measures as part of the state's ongoing air toxics assessment program.[16]

As part of its effort to reduce particulate matter and air toxics emissions from diesel PM, the ARB has developed a Diesel Risk Reduction Program[17] that lays out several strategies in a three-pronged approach to reduce emissions and their associated risk:

- Stringent emission standards for all new diesel-fueled engines;
- Aggressive reductions from in-use engines; and
- Low sulfur fuel that will reduce PM and still provide the quality of diesel fuel needed to control diesel PM.

---

[16] For continuing information and updates on state measures, the reader can refer to ARB's website at http://www.arb.ca.gov/toxics/toxics.htm.

[17] For a comprehensive description of the program, please refer to ARB's website at http://www.arbB.ca.gov/diesel/dieselrrp.htm.

Table 6-1
ARB ACTIONS TO ADDRESS
CUMULATIVE AIR POLLUTION IMPACTS IN COMMUNITIES

Information Collection

- Improve emission inventories, air monitoring data, and analysis tools that can help to identify areas with high cumulative air pollution impacts
- Conduct studies in coordination with OEHHA on the potential for cancer and non-cancer health effects from air pollutants emitted by specific source categories
- Establish web-based clearinghouse for local land use strategies

Emission Reduction Approaches (2004-2006)*

- Through a public process, consider development and/or amendment of regulations and related guidance to reduce emissions, exposure, and health risk at a statewide and local level for the following sources:
  - Diesel PM sources such as stationary diesel engines, transport refrigeration units, portable diesel engines, on-road public fleets, off-road public fleets, heavy-duty diesel truck idling, harbor craft vessels, waste haulers
  - Other air toxics sources, such as formaldehyde in composite wood products, hexavalent chromium for chrome plating and chromic acid anodizing, thermal spraying, and perchloroethylene dry cleaning
- Develop technical information for the following:*
  - Distribution centers
  - Modeling tools such as HARP and CHAPIS
- Adopt rules and pollution prevention initiatives within legal authority to reduce emissions from mobile sources and fuels, and consumer products
- Develop and maintain Air Quality Handbook as a tool for use by land use agencies and local air districts to address cumulative air pollution impacts

Other Approaches

- Establish guidelines for use of statewide incentive funding for high priority mobile source emission reduction projects

*Because ARB will continue to review the need to adopt or revise statewide measures, the information contained in this chart will be updated on an ongoing basis.

A number of ARB's diesel risk reduction strategies have been adopted. These include measures to reduce emissions from refuse haulers, urban buses, transport refrigeration units, stationary and portable diesel engines, and idling trucks and school buses. These sources are all important from a community perspective.[18]

[18] The reader can refer to ARB's website for information on its mobile source-related programs at: http://www.arb.ca.gov/msprog/msprog.htm, as well as regulations adopted and under consideration as part of the Diesel Risk Reduction Program at: http://www.arb.ca.gov/diesel/dieselrrp.htm

The ARB will continue to evaluate the health effects of air pollutants while implementing programs with local air districts to reduce air pollution in all California communities.

Local air districts also have ambitious programs to reduce criteria pollutants and air toxics from regulated sources in their region. Many of these programs also benefit air quality in local communities as well as in the broader region. For more information on what is being done in your area to reduce cumulative air pollution impacts through air pollution control programs, you should contact your local air district.[19]

[19] Local air district contacts can be found on the inside cover to this Handbook.

7. Ways to Enhance Meaningful Public Participation

Community involvement is an important part of the land use process. The public is entitled to the best possible information about the air they breathe and what is being done to prevent or reduce unhealthful air pollution in their communities. In particular, information on how land use decisions can affect air pollution and public health should be made accessible to all communities, including low-income and minority communities.

Effective community participation consistently relies on a two-way flow of information -- from public agencies to community members about opportunities, constraints, and impacts, and from community members back to public officials about needs, priorities, and preferences. The outreach process needed to build understanding and local neighborhood involvement requires data, methodologies, and formats tailored to the needs of the specific community. More importantly, it requires the strong collaboration of local government agencies that review and approve projects and land uses to improve the physical and environmental surroundings of the local community.

Many land use agencies, especially those in major metropolitan areas, are familiar with, and have a long-established public review process. Nevertheless, public outreach can often be improved. Active public involvement requires engaging the public in ways that do not require their previous interest in or knowledge of the land use or air pollution control requirements, and a commitment to taking action where appropriate to address the concerns that are raised.

- **Direct Community Outreach**

In conjunction with local air districts, land use agencies should consider designing an outreach program for community groups, other stakeholders, and local government agency staffs that address the problem of cumulative air pollution impacts, and the public and government role in reducing them. Such a program could consider analytical tools that assist in the preparation and presentation of information in a way that supports sensible decision-making and public involvement. Table 7-1 contains some general outreach approaches that might be considered.

Table 7-1
Public Participation Approaches

- Staff and community leadership awareness training on environmental justice programs and community-based issues
- Surveys to identify the website information needs of interested community-based organizations and other stakeholders
- Information materials on local land use and air district authorities
- Community-based councils to facilitate and invite resident participation in the planning process
- Neighborhood CEQA scoping sessions that allows for community input prior to technical analysis
- Public information materials on siting issues are under review including materials written for the affected community, and in different media that widens accessibility
- Public meetings
- Identify other opportunities to include community-based organizations in the process

To improve outreach, local land use agencies should consider the following activities:

- Hold meetings in communities affected by agency programs, policies, and projects at times and in places that encourage public participation, such as evenings and weekends at centrally located community meeting rooms, libraries, and schools.
- Assess the need for and provide translation services at public meetings.
- Hold community meetings to update residents on the results of any special air monitoring programs conducted in their neighborhood.
- Hold community meetings to discuss and evaluate the various options to address cumulative impacts in their community.
- In coordination with local air districts, make staff available to attend meetings of community organizations and neighborhood groups to listen to and, where appropriate, act upon community concerns.
- Establish a specific contact person for environmental justice issues.
- Increase student and community awareness of local government land use activities and policies through outreach opportunities.
- Make air quality and land use information available to communities in an easily understood and useful format, including fact sheets, mailings, brochures, public service announcements, and web pages, in English and other languages.
- On the local government web-site, dedicate a page or section to what the land use program is doing regarding environmental justice and cumulative environmental impacts, and, as applicable, activities conducted with local air districts such as neighborhood air monitoring studies, pollution prevention, air pollution sources in neighborhoods, and risk reduction.

- Allow, encourage, and promote community access to land use activities, including public meetings, General Plan or Community Plan updates, zoning changes, special studies, CEQA reviews, variances, etc.
- Distribute information in multiple languages, as needed, on how to contact the land use agency or local air district to obtain information and assistance regarding environmental justice programs, including how to participate in public processes.
- Create and distribute a simple, easy-to-read, and understandable public participation handbook, which may be based on the "Public Participation Guidebook" developed by ARB.

- **Other Opportunities for Meaningful Public Outreach**

  - Community-Based Planning Committees

Neighborhood-based or community planning advisory councils could be established to invite and facilitate direct resident participation into the planning process. With the right training and technical assistance, such councils can provide valuable input and a forum for the review of proposed amendments to plans, zone changes, land use permits, and suggestions as to how best to prevent or reduce cumulative air pollution impacts in their community.

  - Regional Partnerships

Consider creating regional coalitions of key growth-related organizations from both the private and public sectors, with corporations, communities, other jurisdictions, and government agencies. Such partnerships could facilitate agreement on common goals and win-win solutions tailored specifically for the region. With this kind of dialogue, shared vision, and collaboration, barriers can be overcome and locally acceptable sustainable solutions implemented. Over the long term, such strategies will help to bring about clean air in communities as well as regionally.

APPENDIX A

LAND USE CLASSIFICATIONS AND ASSOCIATED FACILITY CATEGORIES THAT COULD EMIT AIR POLLUTANTS

(1) Land Use Classifications – by Activity[i]	(2) Facility or Project Examples	(3) Key Pollutants[ii,iii]	(4) Air Pollution Permits[iv]
COMMERCIAL/ LIGHT INDUSTRIAL: SHOPPING, BUSINESS, AND COMMERCIAL			
▲ Primarily retail shops and stores, office, commercial activities, and light industrial or small business	Dry cleaners; drive-through restaurants; gas dispensing facilities; auto body shops; metal plating shops; photographic processing shops; textiles; apparel and furniture upholstery; leather and leather products; appliance repair shops; mechanical assembly cleaning; printing shops	VOCs, air toxics, including diesel PM, NOx, CO, SOx	Limited; Rules for applicable equipment
▲ Goods storage or handling activities, characterized by loading and unloading goods at warehouses, large storage structures, movement of goods, shipping, and trucking.	Warehousing; freight-forwarding centers; drop-off and loading areas; distribution centers	VOCs, air toxics, including diesel PM, NOx, CO, SOx	No[v]
LIGHT INDUSTRIAL: RESEARCH AND DEVELOPMENT			
▲ Medical waste at research hospitals and labs	Incineration; surgical and medical instrument manufacturers, pharmaceutical manufacturing, biotech research facilities	Air toxics, NOx, CO, SOx	Yes
▲ Electronics, electrical apparatus, components, and accessories	Computer manufacturer; integrated circuit board manufacturer; semi-conductor production	Air toxics, VOCs	Yes
▲ College or university lab or research center	Medical waste incinerators; lab chemicals handling, storage and disposal	Air toxics, NOx, CO, SOx, PM10	Yes
▲ Research and development labs	Satellite manufacturer; fiber-optics manufacturer; defense contractors; space research and technology; new vehicle and fuel testing labs	Air toxics, VOCs	Yes
▲ Commercial testing labs	Consumer products; chemical handling, storage and disposal	Air toxics, VOCs	Yes

(1) Land Use Classifications – by Activity[i]	(2) Facility or Project Examples	(3) Key Pollutants[ii,iii]	(4) Air Pollution Permits[iv]
INDUSTRIAL: NON-ENERGY-RELATED			
▲ Assembly plants, manufacturing facilities, industrial machinery	Adhesives; chemical; textiles; apparel and furniture upholstery; clay, glass, and stone products production; asphalt materials; cement manufacturers, wood products; paperboard containers and boxes; metal plating; metal and canned food product fabrication; auto manufacturing; food processing; printing and publishing; drug, vitamins, and pharmaceuticals; dyes; paints; pesticides; photographic chemicals; polish and wax; consumer products; metal and mineral smelters and foundries; fiberboard; floor tile and cover; wood and metal furniture and fixtures; leather and leather products; general industrial and metalworking machinery; musical instruments; office supplies; rubber products and plastics production; saw mills; solvent recycling; shingle and siding; surface coatings	VOCs, air toxics, including diesel PM, NOx, PM, CO, SOx	Yes
INDUSTRIAL: ENERGY AND UTILITIES			
▲ Water and sewer operations	Pumping stations; air vents; treatment	VOCs, air toxics, NOx, CO, SOx, PM10	Yes
▲ Power generation and distribution	Power plant boilers and heaters; portable diesel engines; gas turbine engines	NOx, diesel PM, NOx, CO, SOx, PM10, VOCs	Yes
▲ Refinery operations	Refinery boilers and heaters; coke cracking units; valves and flanges; flares	VOCs, air toxics, including diesel PM, NOx, CO, SOx, PM10	Yes
▲ Oil and gas extraction	Oil recovery systems; uncovered wells	NOx, diesel PM, VOCs, CO, SOx, PM10	Yes
▲ Gasoline storage, transmission, and marketing	Above and below ground storage tanks; floating roof tanks; tank farms; pipelines	VOCs, air toxics, including diesel PM, NOx, CO, SOx, PM10	Yes
▲ Solid and hazardous waste treatment, storage, and disposal activities.	Landfills; methane digester systems; process recycling facility for concrete and asphalt materials	VOCs, air toxics, NOx, CO, SOx, PM10	Yes
CONSTRUCTION (NON-TRANSPORTATION)			
	Building construction; demolition sites	PM (re-entrained road dust), asbestos, diesel PM, NOx, CO, SOx, PM10, VOCs	Limited; state and federal off-road equipment standards

(1) Land Use Classifications – by Activity[i]	(2) Facility or Project Examples	(3) Key Pollutants[ii,iii]	(4) Air Pollution Permits[iv]
DEFENSE			
	Ordnance and explosives demolition; range and testing activities; chemical production; degreasing; surface coatings; vehicle refueling; vehicle and engine operations and maintenance	VOCs, air toxics, including diesel PM, NOx, CO, SOx, PM10	Limited; prescribed burning; equipment and solvent rules
TRANSPORTATION			
▲ Vehicular movement	Residential area circulation systems; parking and idling at parking structures; drive-through establishments; car washes; special events; schools; shopping malls, etc.	VOCs, NOx, PM (re-entrained road dust) air toxics e.g., benzene, diesel PM, formaldehyde, acetaldehyde, 1,3 butadiene, CO, SOx, PM10	No
▲ Road construction and surfacing	Street paving and repair; new highway construction and expansion	VOCs, air toxics, including diesel PM, NOx, CO, SOx, PM10	No
▲ Trains	Railroads; switch yards; maintenance yards		
▲ Marine and port activities	Recreational sailing; commercial marine operations; hotelling operations; loading and un-loading; servicing; shipping operations; port or marina expansion; truck idling	VOCs, NOx, CO, SOx, PM10, air toxics, including diesel PM	Limited; Applicable state and federal MV standards, and possible equipment rules
▲ Aircraft	Takeoff, landing, and taxiing; aircraft maintenance; ground support activities		
▲ Mass transit and school buses	Bus repair and maintenance		
NATURAL RESOURCES			
▲ Farming operations	Agricultural burning; diesel operated engines and heaters; small food processors; pesticide application; agricultural off-road equipment	Diesel PM, VOCs, NOx, PM10, CO, SOx, pesticides	Limited[vi]; Agricultural burning requirements, applicable state and federal mobile source standards; pesticide rules
▲ Livestock and dairy operations	Dairies and feed lots	Ammonia, VOCs, PM10	Yes[vii]
▲ Logging	Off-road equipment e.g., diesel fueled chippers, brush hackers, etc.	Diesel PM, NOx, CO, SOx, PM10, VOCs	Limited; Applicable state/federal mobile source standards
▲ Mining operations	Quarrying or stone cutting; mining; drilling or dredging	PM10, CO, SOx, VOCs, NOx, and asbestos in some geographical areas	Applicable equipment rules and dust controls

(1) Land Use Classifications – by Activity[i]	(2) Facility or Project Examples	(3) Key Pollutants[ii,iii]	(4) Air Pollution Permits[iv]
RESIDENTIAL			
Housing	Housing developments; retirement developments; affordable housing	Fireplace emissions (PM10, NOx, VOCs, CO, air toxics); Water heater combustion (NOx, VOCs, CO)	No[vii]
ACADEMIC AND INSTITUTIONAL			
▲ Schools, including school-related recreational activities	Schools; school yards; vocational training labs/classrooms such as auto repair/painting and aviation mechanics	Air toxics	Yes/No[viii]
▲ Medical waste	Incineration	Air toxics, NOx, CO, PM10	Yes
▲ Clinics, hospitals, convalescent homes		Air toxics	Yes

[i] These classifications were adapted from the American Planning Association's "Land Based Classification Standards." The Standards provide a consistent model for classifying land uses based on their characteristics. The model classifies land uses by refining traditional categories into multiple dimensions, such as activities, functions, building types, site development character, and ownership constraints. Each dimension has its own set of categories and subcategories. These multiple dimensions allow users to have precise control over land-use classifications. For more information, the reader should refer to the Association's website at http://www.planning.org/LBCS/GeneralInfo/.

[ii] This column includes key criteria pollutants and air toxic contaminants that are most typically associated with the identified source categories.

Additional information on specific air toxics that are attributed to facility categories can be found in ARB's Emission Inventory Criteria and Guidelines Report for the Air Toxics Hot Spots Program (May 15, 1997). This information can be viewed at ARB's web site at http://www.arb.ca.gov/ab2588/final96/guide96.pdf.

[iii] Criteria air pollutants are those air pollutants for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set. Criteria pollutants include ozone (formed by the reaction of volatile organic compounds and nitrogen oxides in the presence of sunlight), particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and lead.

Volatile organic compounds (VOCs) combine with nitrogen oxides to form ozone, as well as particulate matter. VOC emissions result primarily from incomplete fuel combustion and the evaporation of chemical solvents and fuels. On-road mobile sources are the largest contributors to statewide VOC emissions. Stationary sources of VOC emissions include processes that use solvents (such as dry-cleaning, degreasing, and coating operations) and petroleum-related processes (such as petroleum refining, gasoline marketing and dispensing, and oil and gas extraction). Areawide VOC sources include consumer products, pesticides, aerosols and paints, asphalt paving and roofing, and other evaporative emissions.

Nitrogen oxides (NOx) are a group of gaseous compounds of nitrogen and oxygen, many of which contribute to the formation of ozone and particulate matter. Most NOx emissions are produced by the combustion of fuels. Mobile sources make up about 80 percent of the total statewide NOx emissions. Mobile sources include on-road vehicles and trucks, aircraft, trains, ships, recreational boats, industrial and construction equipment, farm equipment, off-road recreational vehicles, and other equipment. Stationary sources of NOx include both internal and external combustion processes in industries such as manufacturing, food processing, electric utilities, and petroleum refining. Areawide source, which include residential fuel combustion, waste burning, and fires, contribute only a small portion of the total statewide NOx emissions, but depending on the community, may contribute to a cumulative air pollution impact.

Particulate matter (PM) refers to particles small enough to be breathed into the lungs (under 10 microns in size). It is not a single substance, but a mixture of a number of highly diverse types of particles and liquid droplets. It can be formed directly, primarily as dust from vehicle travel on paved and unpaved roads, agricultural operations, construction and demolition.

Carbon monoxide (CO) is a colorless and odorless gas that is directly emitted as a by-product of combustion. The highest concentrations are generally associated with cold stagnant weather conditions that occur during winter. CO problems tend to be localized.

An Air Toxic Contaminant (air toxic) is defined as an air pollutant that may cause or contribute to an increase in mortality or in serous illness, or which may pose a present or potential hazard to human health. Similar to criteria pollutants, air toxics are emitted from stationary, areawide, and mobile sources. They contribute to elevated regional and localized risks near industrial and commercial facilities and busy roadways. The ten compounds that pose the greatest statewide risk are: acetaldehyde; benzene; 1,3-butadiene; carbon tetrachloride; diesel particulate matter (diesel PM); formaldehyde; hexavalent chromium; methylene chloride; para-dichlorobenzene; and perchloroethylene. The risk from diesel PM is by far the largest, representing about 70 percent of the known statewide cancer risk from outdoor air toxics. The exhaust from diesel-fueled engines is a complex mixture of gases, vapors, and particles, many of which are known human carcinogens. Diesel PM is emitted from both mobile and stationary sources. In California, on-road diesel-fueled vehicles contribute about 26 percent of statewide diesel PM emissions, with an additional 72 percent attributed to other mobile sources such as construction and mining equipment, agricultural equipment, and other equipment. Stationary engines in shipyards, warehouses, heavy equipment repair yards, and oil and gas production operations contribute about two percent of statewide emissions. However, when this number is disaggregated to a sub-regional scale such as neighborhoods, the risk factor can be far greater.

[iii] The level of pollution emitted is a major determinant of the significance of the impact.

[iv] Indicates whether facility activities listed in column 4 are generally subject to local air district permits to operate. This does not include regulated products such as solvents and degreasers that may be used by sources that may not require an operating permit per se, e.g., a gas station or dry cleaner.

[v] Generally speaking, warehousing or distribution centers are not subject to local air district permits. However, depending on the district, motor vehicle fleet rules may apply to trucks or off-road vehicles operated and maintained by the facility operator. Additionally, emergency generators or internal combustion engines operated on the site may require an operating permit.

[vi] Authorized by recent legislation SB700.

[vii] Local air districts do not require permits for woodburning fireplaces inside private homes. However, some local air districts and land use agencies do have rules or ordinances that require new housing developments or home re-sales to install U.S. EPA –certified stoves. Some local air districts also ban residential woodburning during weather inversions that concentrate smoke in residential areas. Likewise, home water heaters are not subject to permits; however, new heaters could be subject to emission limits that are imposed by federal or local agency regulations.

[viii] Technical training schools that conduct activities normally permitted by a local air district could be subject to an air permit.

LAND USE-BASED REFERENCE TOOLS TO EVALUATE NEW PROJECTS FOR POTENTIAL AIR POLLUTION IMPACTS

Land use agencies generally have a variety of tools and approaches at hand, or accessible from local air districts that can be useful in performing an analysis of potential air pollution impacts associated with new projects. These tools and approaches include:

- Base map of the city or county planning area and terrain elevations.
- General Plan designations of land use (existing and proposed).
- Zoning maps.
- Land use maps that identify existing land uses, including the location of facilities that are permitted or otherwise regulated by the local air district. Land use agencies should consult with their local air district for information on regulated facilities.
- Demographic data, e.g., population location and density, distribution of population by income, distribution of population by ethnicity, and distribution of population by age. The use of population data is a normal part of the planning process. However, from an air quality perspective, socioeconomic data is useful to identify potential community health and environmental justice issues.
- Emissions, monitoring, and risk-based maps created by the ARB or local air districts that show air pollution-related health risk by community across the state.
- Location of public facilities that enhance community quality of life, including parks, community centers, and open space.
- Location of industrial and commercial facilities and other land uses that use hazardous materials, or emit air pollutants. These include chemical storage facilities, hazardous waste disposal sites, dry cleaners, large gas dispensing facilities, auto body shops, and metal plating and finishing shops.
- Location of sources or facility types that result in diesel on-road and off-road emissions, e.g., stationary diesel power generators, forklifts, cranes, construction equipment, on-road vehicle idling, and operation of transportation refrigeration units. Distribution centers, marine terminals and ports, rail yards, large industrial facilities, and facilities that handle bulk goods are all examples of complex facilities where these types of emission sources are frequently concentrated.[1] Very large facilities, such as ports, marine terminals, and airports, could be analyzed regardless of proximity to a receptor if they are within the modeling area.
- Location and zoning designations for existing and proposed schools, buildings, or outdoor areas where sensitive individuals may live or play.
- Location and density of existing and proposed residential development.
- Zoning requirements, property setbacks, traffic flow requirements, and idling restrictions for trucks, trains, yard hostlers[2], construction equipment, or school buses.
- Traffic counts (including diesel truck traffic counts), within a community to validate or augment existing regional motor vehicle trip and speed data.

[1] The ARB is currently evaluating the types of facilities that may act as complex point sources and developing methods to identify them.

[2] Yard hostler means a tractor less than 300 horsepower that is used to transfer semi-truck or tractor-trailer containers in and around storage, transfer, or distribution yards or areas and is often equipped with a hydraulic lifting fifth wheel for connection to trailer containers.

ARB AND LOCAL AIR DISTRICT INFORMATION AND TOOLS CONCERNING CUMULATIVE AIR POLLUTION IMPACTS

It is the ARB's policy to support research and data collection activities toward the goal of reducing cumulative air pollution impacts. These efforts include updating and improving the air toxics emissions inventory, performing special air monitoring studies in specific communities, and conducting a more complete assessment of non-cancer health effects associated with air toxics and criteria pollutants.[1] This information is important because it helps us better understand links between air pollution and the health of sensitive individuals -- children, the elderly, and those with pre-existing serious health problems affected by air quality.

ARB is working with CAPCOA and OEHHA to improve air pollutant data and evaluation tools to determine when and where cumulative air pollution impacts may be a problem. The following provides additional information on this effort.

How are emissions assessed?

Detailed information about the sources of air pollution in an area is collected and maintained by local air districts and the ARB in what is called an emission inventory. Emission inventories contain information about the nature of the business, the location, type and amount of air pollution emitted, the air pollution-producing processes, the type of air pollution control equipment, operating hours, and seasonal variations in activity. Local districts collect emission inventory data for most stationary source categories.

Local air districts collect air pollution emission information directly from facilities and businesses that are required to obtain an air pollution operating permit. Local air districts use this information to compile an emission inventory for areas within their jurisdiction. The ARB compiles a statewide emission inventory based on the information collected by the ARB and local air districts. Local air districts provide most of the stationary source emission data, and ARB provides mobile source emissions as well as some areawide emission sources such as consumer products and paints. ARB is also developing map-based tools that will display information on air pollution sources.

Criteria pollutant data have been collected since the early 1970's, and toxic pollutant inventories began to be developed in the mid-1980's.

[1] A criteria pollutant is any air pollutant for which EPA has established a National Ambient Air Quality Standard or for which California has established a State Ambient Air Quality Standard, including: carbon monoxide, lead, nitrogen oxides, ozone, particulates and sulfur oxides. Criteria pollutants are measured in each of California's air basins to determine whether the area meets or does not meet specific federal or state air quality standards. Air toxics or air toxic contaminants are listed pollutants recognized by California or EPA as posing a potential risk to health.

How is the toxic emission inventory developed?

Emissions data for toxic air pollutants is a high priority for communities because of concerns about potential health effects. Most of ARB's air toxics data is collected through the toxic "Hot Spots" program. Local air districts collect emissions data from industrial and commercial facilities. Facilities that exceed health-based thresholds are required to report their air toxics emissions as part of the toxic "Hot Spots" program and update their emissions data every four years. Facilities are required to report their air toxics emissions data if there is an increase that would trigger the reporting threshold of the hotspots program. Air toxics emissions from motor vehicles and consumer products are estimated by the ARB. These estimates are generally regional in nature, reflecting traffic and population.

The ARB also maintains chemical speciation profiles that can be used to estimate toxics emissions when no toxic emissions data is available.

What additional toxic emissions information is needed?

In order to assess cumulative air pollution impacts, updated information from individual facilities is needed. Even for sources where emissions data are available, additional information such as the location of emissions release points is often needed to better model cumulative impacts. In terms of motor vehicles, emissions data are currently based on traffic models that only contain major roads and freeways. Local traffic data are needed so that traffic emissions can be more accurately assigned to specific streets and roads. Local information is also needed for off-road emission sources, such as ships, trains, and construction equipment. In addition, hourly maximum emissions data are needed for assessing acute air pollution impacts.

What work is underway?

ARB is working with CAPCOA to improve toxic emissions data, developing a community health air pollution information system to improve access to emission information, conducting neighborhood assessment studies to better understand toxic emission sources, and conducting surveys of sources of toxic pollutants.

How is air pollution monitored?

While emissions data identify how much air pollution is going into the air, the state's air quality monitoring network measures air pollutant levels in outdoor air. The statewide air monitoring network is primarily designed to measure regional exposure to air pollutants, and consists of more than 250 air monitoring sites.

The air toxics monitoring network consists of approximately 20 permanent sites. These sites are supplemented by special monitoring studies conducted by ARB and local air districts. These sites measure approximately sixty toxic air pollutants. Diesel PM, which is the major driver of urban air toxic risk, is not monitored directly. Ten of the

60 toxic pollutants, not including diesel, account for most of the remaining potential cancer risk in California urban areas.

What additional monitoring has been done?

Recently, additional monitoring has been done to look at air quality at the community level. ARB's community monitoring was conducted in six communities located throughout the state. Most sites were in low-income, minority communities located near major sources of air pollution, such as refineries or freeways. The monitoring took place for a year or more in each community, and included measurements of both criteria and toxic pollutants.

What is being learned from community monitoring?

In some cases, the ARB or local air districts have performed air quality monitoring or modeling studies covering a particular region of the state. When available, these studies can give information about regional air pollution exposures.

The preliminary results of ARB's community monitoring are providing insights into air pollution at the community level. Urban background levels are a major contributor to the overall risk from air toxics in urban areas, and this urban background tends to mask the differences between communities. When localized elevated air pollutant levels were measured, they were usually associated with local ground-level sources of toxic pollutants. The most common source of this type was busy streets and freeways. The impact these ground-level sources had on local air quality decreased rapidly with distance from the source. Pollutant levels usually returned to urban background levels within a few hundred meters of the source.

These results indicate that tools to assess cumulative impacts must be able to account for both localized, near-source impacts, as well as regional background air pollution. The tools that ARB is developing for this purpose are air quality models.

How can air quality modeling be used?

While air monitoring can directly measure cumulative exposure to air pollution, it is limited because all locations cannot be monitored. To address this, air quality modeling provides the capability to estimate exposure when air monitoring is not feasible. Air quality modeling can be refined to assess local exposure, identify locations of potential hot spots, and identify the relative contribution of emission sources to exposure at specific locations. The ARB has used this type of information to develop regional cumulative risk maps that estimate the cumulative cancer air pollution risk for most of California. While these maps only show one air pollution-related health risk, it does provide a useful starting point.

What is needed for community modeling?

Air quality models have been developed to assess near-source impacts, but they have very exacting data requirements. These near-source models estimate the impact of local sources, but do not routinely include the contribution from regional air pollution background. To estimate cumulative air pollution exposure at a neighborhood scale, a modeling approach needs to combine features of both micro-scale and regional models.

In addition, improved methods are needed to assess near-source impacts under light and variable wind conditions, when high local concentrations are more likely to occur. A method for modeling long-term exposure to air pollutants near freeways and other high traffic areas is also needed.

What modeling work has ARB developed?

A key component of ARB's Community Health Program is the Neighborhood Assessment Program (NAP). As described later in this section, the NAP studies are being conducted to better understand pollution impacts at the community level. Through two such studies conducted in Barrio Logan (San Diego) and Wilmington (Los Angeles), ARB is refining community-level modeling methodologies. Regional air toxics modeling is also being performed to better understand regional air pollution background levels.

In a parallel effort, ARB is developing modeling protocols for estimating cumulative emissions, exposure, and risk from air pollution. The protocols will cover modeling approaches and uncertainties, procedures for running the models, the development of statewide risk maps, and methods for estimating health risks. The protocols are subject to an extensive peer review process prior to release.

How are air pollution impacts on community health assessed?

On a statewide basis, ARB's toxic air contaminant program identifies and reduces public exposure to air toxics. The focus of the program has been on reducing potential cancer risk, because monitoring results show potential urban cancer risk levels are too high. ARB has also looked for potential non-cancer risks based on health reference levels provided by OEHHA. On a regional basis, the pollutants measured in ARB's toxic monitoring network are generally below the OEHHA non-cancer reference exposure levels.

As part of its community health program, the ARB is looking at potential cancer and non-cancer risk. This could include chronic or acute health effects. If the assessment work shows elevated exposures on a localized basis, ARB will work with OEHHA to assess the health impacts.

What tools has ARB developed to assess cumulative air pollution impacts?

ARB has developed the following tools and reports to assist land use agencies and local air districts assess and reduce cumulative emissions, exposure, and risk on a neighborhood scale.

Statewide Risk Maps

ARB has produced regional risk maps that show the statewide trends for Southern and Central California in estimated potential cancer risk from air toxics between 1990 and 2010.[2] These maps will supplement U.S. EPA's ASPEN model and are available on the ARB's Internet site. These maps are best used to obtain an estimate of the regional background air pollution health risk and are not detailed enough to estimate the exact risk at a specific location.

ARB also has maps that focus in more detail on smaller areas that fall within the Southern and Central California regions for these same modeled years. The finest visual resolution available in the maps on this web site is two by two kilometers. These maps are not detailed enough to assess individual neighborhoods or facilities.

Community Health Air Pollution Information System (CHAPIS)

CHAPIS is an Internet-based procedure for displaying information on emissions from sources of air pollution in an easy to use mapping format. CHAPIS uses Geographical Information System (GIS) software to deliver interactive maps over the Internet. CHAPIS relies on emission estimates reported to the ARB's emission inventory database - California Emissions Inventory Development and Reporting System, or CEIDARS.

Through CHAPIS, air district staff can quickly and easily identify pollutant sources and emissions within a specified area. CHAPIS contains information on air pollution emissions from selected large facilities and small businesses that emit criteria and toxic air pollutants. It also contains information on air pollution emissions from motor vehicle and areawide emissions. CHAPIS does not contain information on every source of air pollution or every air pollutant. It is a major long-term objective of CHAPIS to include all of the largest air pollution sources and those with the highest documented air pollution risk. CHAPIS will be updated on a periodic basis and additional facilities will be added to CHAPIS as more data becomes available.

CHAPIS is being developed in stages to assure data quality. The initial release of CHAPIS will include facilities emitting 10 or more tons per year of nitrogen oxides, sulfur dioxide, carbon monoxide, PM10, or reactive organic gases; air toxics from refineries and power plants of 50 megawatts or more; and facilities that conducted health risk

[2] ARB maintains state trends and local potential cancer risk maps that show statewide trends in potential inhalable cancer risk from air toxics between 1990 and 2010. This information can be viewed at ARB's web site at http://www.arb.ca.gov/toxics/cti/hlthrisk/hlthrisk.htm)

assessments under the California Air Toxics "Hot Spots" Information and Assessment Program.[3]

CHAPIS can be used to identify the emission contributions from mobile, area, and point sources on that community.

"Hot Spots" Analysis and Reporting Program (HARP)

HARP[4] is a software package available from the ARB and is designed with air quality professionals in mind. It models emissions and release data from one or more facilities to estimate the potential health risk posed by the selected facilities on the neighboring community. HARP uses the latest risk assessment guidelines published by OEHHA.

With HARP, a user can perform the following tasks:

- Create and manage facility databases;
- Perform air dispersion modeling;
- Conduct health risk analyses;
- Output data reports; and
- Output results to GIS mapping software.

HARP can model downwind concentrations of air toxics based on the calculated emissions dispersion at a single facility. HARP also has the capability of assessing the risk from multiple facilities, and for multiple locations of concern near those facilities. While HARP has the capability to assess multiple source impacts, there had been limited application of the multiple facility assessment function in the field at the time of HARP's debut in 2003. HARP can also evaluate multi-pathway, non-inhalation health risk resulting from air pollution exposure, including skin and soil exposure, and ingestion of meat and vegetables contaminated with air toxics, and other toxics that have accumulated in a mother's breast milk.

Neighborhood Assessment Program (NAP)

The NAP[5] has been a key component of ARB's Community Health Program. It includes the development of tools that can be used to perform assessments of cumulative air pollution impacts on a neighborhood scale. The NAP studies have been done to better understand how air pollution affects individuals at the neighborhood level. Thus far, ARB has conducted neighborhood scale assessments in Barrio Logan and Wilmington.

As part of these studies, ARB is collecting data and developing a modeling protocol that can be used to conduct cumulative air pollution impact assessments. Initially these

---

[3] California Health & Safety Code section 44300, et seq.
[4] More detailed information can be found on ARB's website at: http://www.arb.ca.gov/toxics/harp/harp.htm
[5] For more information on the Program, please refer to: http://www.arb.ca.gov/ch/programs/nap/nap.htm

assessments will focus on cumulative inhalation cancer health risk and chronic non-cancer impacts. The major challenge is developing modeling methods that can combine both regional and localized air pollution impacts, and identifying the critical data necessary to support these models. The objective is to develop methods and tools from these studies that can ultimately be applied to other areas of the state. In addition, the ARB plans to use these methods to replace the ASPEN regional risk maps currently posted on the ARB Internet site.

Urban Emissions Model (URBEMIS)

URBEMIS[6] is a computer program that can be used to estimate emissions associated with land development projects in California such as residential neighborhoods, shopping centers, office buildings, and construction projects. URBEMIS uses emission factors available from the ARB to estimate vehicle emissions associated with new land uses. URBEMIS estimates sulfur dioxide emissions from motor vehicles in addition to reactive organic gases, nitrogen oxides, carbon monoxide, and PM10.

Land-Use Air Quality Linkage Report[7]

This report summarizes data currently available on the relationships between land use, transportation and air quality. It also highlights strategies that can help to reduce the use of the private automobile. It also briefly summarizes two ARB-funded research projects. The first project analyzes the travel patterns of residents living in five higher density, mixed use neighborhoods in California, and compares them to travel in more auto-oriented areas. The second study correlates the relationship between travel behavior and community characteristics, such as density, mixed land uses, transit service, and accessibility for pedestrians.

[6] For more information on this model, please refer to ARB's website at http://www.arb.ca.gov/html/soft.htm.
[7] To access this report, please refer to ARB's website or click on: http://www.arb.ca.gov/ch/programs/link97.pdf

APPENDIX D

LAND USE AND AIR QUALITY AGENCY ROLES IN THE LAND USE PROCESS

A wide variety of federal, state, and local government agencies are responsible for regulatory, planning, and siting decisions that can have an impact on air pollution. They include local land use agencies, regional councils of government, school districts, local air districts, ARB, the California Department of Transportation (Caltrans), and the Governor's Office of Planning and Research (OPR) to name a few. This Section will focus on the roles and responsibilities of local and state agencies. The role of school districts will be discussed in Appendix E.

Local Land Use Agencies

Under the State Constitution, land use agencies have the primary authority to plan and control land use.[1] Each of California's incorporated cities and counties are required to adopt a comprehensive, long-term General Plan.[2]

The General Plan's long-term goals are implemented through zoning ordinances. These are local laws adopted by counties and cities that describe for specific areas the kinds of development that will be allowed within their boundaries.

Land use agencies are also the lead for doing environmental assessments under CEQA for new projects that may pose a significant environmental impact, or for new or revised General Plans.

Local Agency Formation Commissions (LAFCOs)

Operating in each of California's 58 counties, LAFCOs are composed of local elected officials and public members who are responsible for coordinating changes in local governmental boundaries, conducting special studies that review ways to reorganize, simplify, and streamline governmental structures, and preparing a sphere of influence for each city and special district within each county. Each Commission's efforts are directed toward seeing that local government services are provided efficiently and economically while agricultural and open-space lands are protected. LAFCO decisions strive to balance the competing needs in California for efficient services, affordable housing, economic opportunity, and conservation of natural resources.

[1] The legal basis for planning and land use regulation is the "police power" of the city or county to protect the public's health, safety and welfare. The California Constitution gives cities and counties the power to make and enforce all local police, sanitary and other ordinances and regulations not in conflict with general laws. State law reference: California Constitution, Article XI §7.
[2] OPR General Plan Guidelines, 2003:
http://www.opr.ca.gov/planning/PDFs/General_Plan_Guidelines_2003.pdf

Councils of Government (COG)

COGs are organizations composed of local counties and cities that serve as a focus for the development of sound regional planning, including plans for transportation, growth management, hazardous waste management, and air quality. They can also function as the metropolitan planning organization for coordinating the region's transportation programs. COGs also prepare regional housing need allocations for updates of General Plan housing elements.

Local Air Districts

Under state law, air pollution control districts or air quality management districts (local air districts) are the local government agencies responsible for improving air quality and are generally the first point of contact for resolving local air pollution issues or complaints. There are 35 local air districts in California[3] that have authority and primary responsibility for regional clean air planning. Local air districts regulate stationary sources of air pollutants within their jurisdiction including but not limited to industrial and commercial facilities, power plants, construction activities, outdoor burning, and other non-mobile sources of air pollution. Some local air districts also regulate public and private motor vehicle fleet operators such as public bus systems, private shuttle and taxi services, and commercial truck depots.

- **Regional Clean Air Plans**

Local air districts are responsible for the development and adoption of clean air plans that protect the public from the harmful effects of air pollution. These plans incorporate strategies that are necessary to attain ambient air quality standards. Also included in these regional air plans are ARB and local district measures to reduce statewide emissions from mobile sources, consumer products, and industrial sources.

- **Facility-Specific Considerations**

Permitting. In addition to the planning function, local air districts adopt and enforce regulations, issue permits, and evaluate the potential environmental impacts of projects.

Pollution is regulated through permits and technology-based rules that limit emissions from operating units within a facility or set standards that vehicle fleet operators must meet. Permits to construct and permits to operate contain very specific requirements and conditions that tell each regulated source what it must do to limit its air pollution in compliance with local air district rules, regulations, and state law. Prior to receiving a permit, new facilities must go through a New Source Review (NSR) process that establishes air pollution control requirements for the facility. Permit conditions are typically contained in the permit to operate and specify requirements that businesses must follow; these may include limits on the amount of pollution that can be emitted, the

---

[3] Contact information for local air districts in California is listed in the front of this Handbook.

type of pollution control equipment that must be installed and maintained, and various record-keeping requirements.

Local air districts also notify the public about new permit applications for major new facilities, or major modifications to existing facilities that seek to locate within 1,000 feet of a school.

Local air districts can also regulate other types of sources to reduce emissions. These include regulations to reduce emissions from the following sources:

- hazardous materials in products used by industry such as paints, solvents, and de-greasers;
- agricultural and residential burning;
- leaking gasoline nozzles at service stations;
- public fleet vehicles such as sanitation trucks and school buses; and
- fugitive or uncontrolled dust at construction sites.

However, while emissions from industrial and commercial sources are typically subject to the permit authority of the local air district, sensitive sites such as a day care center, convalescent home, or playground are not ordinarily subject to an air permit. Local air district permits address the air pollutant emissions of a project but not its location.

Under the state's air toxics program, local air districts regulate air toxic emissions by adopting ARB air toxic control measures, or more stringent district-specific requirements, and by requiring individual facilities to perform a health risk assessment if emissions at the source exceed district-specific health risk thresholds[4], [5] (See the section on ARB programs for a more detailed summary of this program).

One approach by which local air districts regulate air toxics emissions is through the "Hot Spots" program.[6] The risk assessments submitted by the facilities under this

---

[4] Cal/EPA's Office of Environmental Health Hazard Assessment has published "A Guide to Health Risk Assessment" for lay people involved in environmental health issues, including policymakers, businesspeople, members of community groups, and others with an interest in the potential health effects of toxic chemicals. To access this information, please refer to http://www.oehha.ca.gov/pdf/HRSguide2001.pdf

[5] Section 44306 of the California Health & Safety Code defines a health risk assessment as a detailed comprehensive analysis that a polluting facility uses to evaluate and predict the dispersion of hazardous substances in the environment and the potential for exposure of human populations, and to assess and quantify both the individual and population-wide health risks associated with those levels of exposure.

[6] AB-2588 (the Air Toxics "Hot Spots" Information and Assessment Act) requires local air districts to prioritize facilities by high, intermediate, and low priority categories to determine which must perform a health risk assessment. Each district is responsible for establishing the prioritization score threshold at which facilities are required to prepare a health risk assessment. In establishing priorities for each facility, local air districts must consider the potency, toxicity, quantity, and volume of hazardous materials released from the facility, the proximity of the facility to potential receptors, and any other factors that the district determines may indicate that the facility may pose a significant risk. All facilities within the highest category must prepare a health risk assessment. In addition, each district may require facilities in the intermediate and low priority categories to also submit a health risk assessment.

Table D-1
Local Sources of Air Pollution, Responsible Agencies, and Associated Regulatory Programs

Source	Examples	Primary Agency	Applicable Regulations
Large Stationary	Refineries, power plants, chemical facilities, certain manufacturing plants	Local air districts	Operating permit rules Air Toxics "Hot Spots" Law (AB 2588) Local district rules Air Toxic Control Measures (ATCMs)* New Source Review rules Title V permit rules
Small Stationary	Dry cleaners, auto body shops, welders, chrome plating facilities, service stations, certain manufacturing plants	Local air districts	Operating permit conditions, Air Toxics "Hot Spots" Law (AB 2588) Local district rules ATCMs* New Source Review rules
Mobile (non-fleet)	Cars, trucks, buses	ARB	Emission standards Cleaner-burning fuels (e.g., unleaded gasoline, low-sulfur diesel) Inspection and repair programs (e.g., Smog Check)
Mobile Equipment	Construction equipment	ARB, U.S. EPA	ARB rules U.S. EPA rules
Mobile (fleet)	Truck depots, school buses, taxi services	Local air districts, ARB	Local air district rules ARB urban bus fleet rule
Areawide	Paints and consumer products such as hair spray and spray paint	Local air district, ARB	ARB rules Local air district rules

*ARB adopts ATCMs, but local air districts have the responsibility to implement and enforce these measures or more stringent ones.

program are reviewed by OEHHA and approved by the local air district. Risk assessments are available by contacting the local air district.

Enforcement. Local air districts also take enforcement action to ensure compliance with air quality requirements. They enforce air toxic control measures, agricultural and residential burning programs, gasoline vapor control regulations, laws that prohibit air pollution nuisances, visible emission limits, and many other requirements designed to clean the air. Local districts use a variety of enforcement tools to ensure compliance. These include notices of violation, monetary penalties, and abatement orders. Under some circumstances, a permit may be revoked.

- **Environmental Review**

As required by the California Environmental Quality Act (CEQA), local air districts also review and comment on proposed land use plans and development projects that can have a significant effect on the environment or public health.[7]

California Air Resources Board

The ARB is the air pollution control agency at the state level that is responsible for the preparation of air plans required by state and federal law. In this regard, it coordinates the activities of all local air districts to ensure all statutory requirements are met and to reduce air pollution emissions for sources under its jurisdiction.

Motor vehicles are the single largest emissions source category under ARB's jurisdiction as well as the largest overall emissions source statewide. ARB also regulates emissions from other mobile equipment and engines as well as emissions from consumer products such as hair sprays, perfumes, cleaners, and aerosol paints.

Air Toxics Program

Under state law, the ARB has a critical role to play in the identification, prioritization, and control of air toxic emissions. The ARB statewide comprehensive air toxics program was established in the early 1980's. The Toxic Air Contaminant Identification and Control Act of 1983 (AB 1807, Tanner 1983) created California's program to reduce exposure to air toxics.[8] The Air Toxics "Hot Spots" Information and Assessment Act (Hot Spots program) supplements the AB 1807 program, by requiring a statewide air toxics inventory, notification of people exposed to a significant health risk, and facility plans to reduce these risks.

Under AB 1807, the ARB is required to use certain criteria to prioritize the identification and control of air toxics. In selecting substances for review, the ARB must consider criteria relating to emissions, exposure, and health risk, as well as persistence in the atmosphere, and ambient concentrations in the community. AB 1807 also requires the ARB to use available information gathered from the Hot Spots program when prioritizing compounds.

The ARB identifies pollutants as toxic air contaminants and adopts statewide air toxic control measures (ATCMs). Once ARB adopts an ATCM, local air districts must

[7] Section 4 of this Handbook contains more information on the CEQA process.
[8] For a general background on California's air toxics program, the reader should refer to ARB's website at http://www.arb.ca.gov/toxics/tac/appendxb.htm.

implement the measure, or adopt and implement district-specific measures that are at least as stringent as the state standard. Taken in the aggregate, these ARB programs will continue to further reduce emissions, exposure, and health risk statewide.

With regard to the land use decision-making process, ARB, in conjunction with local air districts, plays an advisory role by providing technical information on land use-related air issues.

Other Agencies

Governor's Office of Planning and Research (OPR)

In addition to serving as the Governor's advisor on land use planning, research, and liaison with local government, OPR develops and implements the state's policy on land use planning and coordinates the state's environmental justice programs. OPR updated its General Plan Guidelines in 2003 to highlight the importance of sustainable development and environmental justice policies in the planning process. OPR also advises project proponents and government agencies on CEQA provisions and operates the State Clearinghouse for environmental and federal grant documents.

California Department of Housing and Community Development

The Department of Housing and Community Development (HCD) administers a variety of state laws, programs and policies to preserve and expand housing opportunities, including the development of affordable housing. All local jurisdictions must update their housing elements according to a staggered statutory schedule, and are subject to certification by HCD. In their housing elements, cities and counties are required to include a land inventory which identifies and zones sites for future residential development to accommodate a mix of housing types, and to remove barriers to the development of housing.

An objective of state housing element law is to increase the overall supply and affordability of housing. Other fundamental goals include conserving existing affordable housing, improving the condition of the existing housing stock, removing regulatory barriers to housing production, expanding equal housing opportunities, and addressing the special housing needs of the state's most vulnerable residents (frail elderly, disabled, large families with children, farmworkers, and the homeless).

Transportation Agencies

Transportation agencies can also influence mobile source-related emissions in the land use decision-making process. Local transportation agencies work with land use agencies to develop a transportation (circulation) element for the General Plan. These local government agencies then work with other transportation-related agencies, such as the Congestion Management Agency (CMA), Metropolitan Planning Organization

(MPO), Regional Transportation Planning Agency (RTPA), and Caltrans to develop long and short range transportation plans and projects.

Caltrans is the agency responsible for setting state transportation goals and for state transportation planning, design, construction, operations and maintenance activities. Caltrans is also responsible for delivering California's multibillion-dollar state Transportation Improvement Program, a list of transportation projects that are approved for funding by the California Transportation Commission in a 4-year cycle.

When safety hazards or traffic circulation problems are identified in the existing road system, or when land use changes are proposed such as a new residential subdivision, shopping mall or manufacturing center, Caltrans and/or the local transportation agency ensure the projects meet applicable state, regional, and local goals and objectives.

Caltrans also evaluates transportation-related projects for regional air quality impacts, from the perspective of travel-related emissions as well as road congestion and increases in road capacity (new lanes).

California Energy Commission (CEC)

The CEC is the state's CEQA lead agency for permitting large thermal power plants (50 megawatts or greater). The CEC works closely with local air districts and other federal, state and local agencies to ensure compliance with applicable laws, ordinances, regulations and standards in the permitting, construction, operation and closure of such plants. The CEC uses an open and public review process that provides communities with outreach and multiple opportunities to participate and be heard. In addition to its comprehensive environmental impact and engineering design assessment process, the CEC also conducts an environmental justice evaluation. This evaluation involves an initial demographic screening to determine if a qualifying minority or low-income population exists in the vicinity of the proposed project. If such a population is present, staff considers possible environmental justice impacts including from associated project emissions in its technical assessments.[9]

Department of Pesticides Regulation (DPR)

Pesticides are industrial chemicals produced specifically for their toxicity to a target pest. They must be released into the environment to do their job. Therefore, regulation of pesticides focuses on using toxicity and other information to ensure that when pesticides are used according to their label directions, potential for harm to people and the environment is minimized. DPR imposes strict controls on use, beginning before pesticide products can be sold in California, with an extensive scientific program to ensure they can be used safely. DPR and county enforcement staff tracks the use of pesticides to ensure that pesticides are used properly. DPR collects periodic

---

[9] See California Energy Commission, "Environmental Performance Report," July 2001 at http://www.energy.ca.gov/reports/2001-11-20_700-01-001.PDF

measurements of any remaining amounts of pesticides in water, air, and on fresh produce. If unsafe levels are found, DPR requires changes in how pesticides are used, to reduce the possibility of harm. If this cannot be done - that is, if a pesticide cannot be used safely - use of the pesticide will be banned in California.[10]

Federal Agencies

Federal agencies have permit authority over activities on federal lands and certain resources, which have been the subject of congressional legislation, such as air, water quality, wildlife, and navigable waters. The U.S. Environmental Protection Agency generally oversees implementation of the federal Clean Air Act, and has broad authority for regulating certain activities such as mobile sources, air toxics sources, the disposal of toxic wastes, and the use of pesticides. The responsibility for implementing some federal regulatory programs such as those for air and water quality and toxics is delegated by management to specific state and local agencies. Although federal agencies are not subject to CEQA they must follow their own environmental process established under the National Environmental Policy Act (NEPA).

[10] For more information, the reader is encouraged to visit the Department of Pesticide Regulation web site at www.cdpr.ca.gov/docs/empm/pubs/tacmenu.htm.

SPECIAL PROCESSES THAT APPLY TO SCHOOL SITING

The California Education Code and the California Public Resources Code place primary authority for siting public schools with the local school district, which is the 'lead agency' for purposes of CEQA. The California Education Code requires public school districts to notify the local planning agency about siting a new public school or expanding an existing school. The planning agency then reports back to the school district regarding a project's conformity with the adopted General Plan. However, school districts can overrule local zoning and land use designations for schools if they follow specified procedures. In addition, all school districts must evaluate new school sites using site selection standards established in Section 14010 of Title 5 of the California Code of Regulations. Districts seeking state funding for school site acquisition must also obtain site approval from the California Department of Education.

Before making a final decision on a school site acquisition, a school district must comply with CEQA and evaluate the proposed site acquisition/new school project for air emissions and health risks by preparing and certifying an environmental impact report or negative declaration. Both the California Education Code section 17213 and the California Public Resources Code section 21151.8 require school districts to consult with administering agencies and local air districts when preparing the environmental assessment. Such consultation is required to identify both permitted and non-permitted "facilities" that might significantly affect health at the new site. These facilities include, but are not limited to, freeways and other busy traffic corridors, large agricultural operations, and rail yards that are within one-quarter mile of the proposed school site, and that might emit hazardous air emissions, or handle hazardous or acutely hazardous materials, substances, or waste.

As part of the CEQA process and before approving a school site, the school district must make a finding that either it found none of the facilities or significant air pollution sources, or alternatively, if the school district finds that there are such facilities or sources, it must determine either that they pose no significant health risks, or that corrective actions by another governmental entity would be taken so that there would be no actual or potential endangerment to students or school workers.

In addition, if the proposed school site boundary is within 500 feet of the edge of the closest traffic lane of a freeway or traffic corridor that has specified minimum average daily traffic counts, the school district is required to determine through specified risk assessment and air dispersion modeling that neither short-term nor long term exposure poses significant heath risks to pupils.

State law changes effective January 1, 2004 (SB352, Escutia 2003, amending Education Code section 17213 and Public Resources Code section 21151.8) also provides for cases in which the school district cannot make either of those two findings and cannot find a suitable alternative site. When this occurs, the school district must adopt a statement of over-riding considerations, as part of an environmental impact report, that the project should be approved based on the ultimate balancing of the merits.

Some school districts use a standardized assessment process to determine the environmental impacts of a proposed school site. In the assessment process, school districts can use maps and other available information to evaluate risk, including a local air district's database of permitted source emissions. School districts can also perform field surveys and record searches to identify and calculate emissions from non-permitted sources within one-quarter mile radius of a proposed site. Traffic count data and vehicular emissions data can also be obtained from Caltrans for major roadways and freeways in proximity to the proposed site to model potential emissions impacts to students and school employees. This information is available from the local COG, Caltrans, or local cities and counties for non-state maintained roads.

GENERAL PROCESSES USED BY LAND USE AGENCIES TO ADDRESS AIR POLLUTION IMPACTS

There are several separate but related processes for addressing the air pollution impacts of land use projects. One takes place as part of the planning and zoning function. This consists of preparing and implementing goals and policies contained in county or city General Plans, community or area plans, and specific plans governing land uses such as residential, educational, commercial, industrial, and recreational activities. It also includes recommending locations for thoroughfares, parks and other public improvements.

Land use agencies also have a permitting function that includes performing environmental reviews and mitigation when projects may pose a significant environmental impact. They conduct inspections for zoning permits issued, enforce the zoning regulations and issue violations as necessary, issue zoning certificates of compliance, and check compliance when approving certificates of occupancy.

Planning

- **General Plan**[1]

The General Plan is a local government "blueprint" of existing and future anticipated land uses for long-term future development. It is composed of the goals, policies, and general elements upon which land use decisions are based. Because the General Plan is the foundation for all local planning and development, it is an important tool for implementing policies and programs beneficial to air quality. Local governments may choose to adopt a separate air quality element into their General Plan or to integrate air quality-beneficial objectives, policies, and strategies in other elements of the Plan, such as the land use, circulation, conservation, and community design elements.

More information on General Plan elements is contained in Appendix D.

- **Community Plans**

Community or area plans are terms for plans that focus on a particular region or community within the overall general plan area. It refines the policies of the general plan as they apply to a smaller geographic area and is implemented by ordinances and other discretionary actions, such as zoning.

[1] In October 2003, OPR revised its General Plan Guidelines. An entire chapter is now devoted to a discussion of how sustainable development and environmental justice goals can be incorporated into the land use planning process. For further information, the reader is encouraged to obtain a copy of OPR's General Plan Guidelines, or refer to their website at: http://www.opr.ca.gov/planning/PDFs/General_Plan_Guidelines_2003.pdf

- **Specific Plan**

A specific plan is a hybrid that can combine policies with development regulations or zoning requirements. It is often used to address the development requirements for a single project such as urban infill or a planned community. As a result, its emphasis is on concrete standards and development criteria.

- **Zoning**

Zoning is the public regulation of the use of land. It involves the adoption of ordinances that divide a community into various districts or zones. For instance, zoning ordinances designate what projects and activities can be sited in particular locations. Each zone designates allowable uses of land within that zone, such as residential, commercial, or industrial. Zoning ordinances can address building development standards, e.g., minimum lot size, maximum building height, minimum building setback, parking, signage, density, and other allowable uses.

<u>Land Use Permitting</u>

In addition to the planning and zoning function, land use agencies issue building and business permits, and evaluate the potential environmental impacts of projects. To be approved, projects must be located in a designated zone and comply with applicable ordinances and zoning requirements.

Even if a project is sited properly in a designated zone, a land use agency may require a new source to mitigate potential localized environmental impacts to the surrounding community below what would be required by the local air district. In this case, the land use agency could condition the permit by limiting or prescribing allowable uses including operating hour restrictions, building standards and codes, property setbacks between the business property and the street or other structures, vehicle idling restrictions, or traffic diversion.

Land use agencies also evaluate the environmental impacts of proposed land use projects or activities. If a project or activity falls under CEQA, the land use agency requires an environmental review before issuing a permit to determine if there is the potential for a significant impact, and if so, to mitigate the impact or possibly deny the project.

- **Land Use Permitting Process**

In California, the authority to regulate land use is delegated to city and county governments. The local land use planning agency is the local government administrative body that typically provides information and coordinates the review of development project applications. Conditional Use Permits (CUP) typically fall within a land use agency's discretionary authority and therefore are subject to CEQA. CUPs are intended to provide an opportunity to review the location, design, and manner of development of land uses prior to project approval. A traditional purpose of the CUP is to enable a municipality to control certain uses that could have detrimental environmental effects on the community.

The process for permitting new discretionary projects is quite elaborate, but can be broken down into five fundamental components:

- Project application
- Environmental assessment
- Consultation
- Public comment
- Public hearing and decision

Project Application

The permit process begins when the land use agency receives a project application, with a detailed project description, and support documentation. During this phase, the agency reviews the submitted application for completeness. When the agency deems the application to be complete, the permit process moves into the environmental review phase.

Environmental Assessment

If the project is discretionary and the application is accepted as complete, the project proposal or activity must undergo an environmental clearance process under CEQA and the CEQA Guidelines adopted by the California Resources Agency.[2] The purpose of the CEQA process is to inform decision-makers and the public of the potential significant environmental impacts of a project or activity, to identify measures to minimize or eliminate those impacts to the point they are no longer significant, and to discuss alternatives that will accomplish the project goals and objectives in a less environmentally harmful manner.

What is a "Lead Agency"?

A lead agency is the public agency that has the principal responsibility for carrying out or approving a project that is subject to CEQA. In general, the land use agency is the preferred public agency serving as lead agency because it has jurisdiction over general land uses. The lead agency is responsible for determining the appropriate environmental document, as well as its preparation.

What is a "Responsible Agency"?

A responsible agency is a public agency with discretionary approval authority over a portion of a CEQA project (e.g., projects requiring a permit). As a responsible agency, the agency is available to the lead agency and project proponent for early consultation on a project to apprise them of applicable rules and regulations, potential adverse impacts, alternatives, and mitigation measures, and provide guidance as needed on applicable methodologies or other related issues.

What is a "Commenting Agency"?

A commenting agency is any public agency that comments on a CEQA document, but is neither a lead agency nor a responsible agency. For example, a local air district, as the agency with the responsibility for comprehensive air pollution control, could review and comment on an air quality analysis in a CEQA document for a proposed distribution center, even though the project was not subject to a permit or other pollution control requirements.

[2] Projects and activities that may have a significant adverse impact on the environment are evaluated under CEQA Guidelines set forth in title 14 of the California Code of Regulations, sections 15000 et seq.

To assist the lead agency in determining whether the project or activity may have a significant effect that would require the preparation of an EIR, the land use agency may consider criteria, or thresholds of significance, to assess the potential impacts of the project, including its air quality impacts. The land use agency must consider any credible evidence in addition to the thresholds, however, in determining whether the project or activity may have a significant effect that would trigger the preparation of an EIR.

The screening criteria to determine significance is based on a variety of factors, including local, state, and federal regulations, administrative practices of other public agencies, and commonly accepted professional standards. However, the final determination of significance for individual projects is the responsibility of the lead agency. In the case of land use projects, the lead agency would be the City Council or County Board of Supervisors.

A new land use plan or project can also trigger an environmental assessment under CEQA if, among other things, it will expose sensitive sites such as schools, day care centers, hospitals, retirement homes, convalescence facilities, and residences to substantial pollutant concentrations.[3]

CEQA only applies to "discretionary projects." Discretionary means the public agency must exercise judgment and deliberation when deciding to approve or disapprove a particular project or activity, and may append specific conditions to its approval. Examples of discretionary projects include the issuance of a CUP, re-zoning a property, or widening of a public road. Projects that are not subject to the exercise of agency discretion, and can therefore be approved administratively through the application of set standards are referred to as ministerial projects. CEQA does not apply to ministerial projects.[4] Examples of typical ministerial projects include the issuance of most building permits or a business license.

Once a potential environmental impact associated with a project is identified through an environmental assessment, mitigation must be considered. A land use agency should incorporate mitigation measures that are suggested by the local air district as part of the project review process.

Consultation

Application materials are provided to various departments and agencies that may have an interest in the project (e.g., air pollution, building, police, fire, water agency, Fish and Game, etc.) for consultation and input.

---

[3] Readers interested in learning more about CEQA should contact OPR or visit their website at http://www.opr.ca.gov/.
[4] See California Public Resources Code section 21080(b)(1).

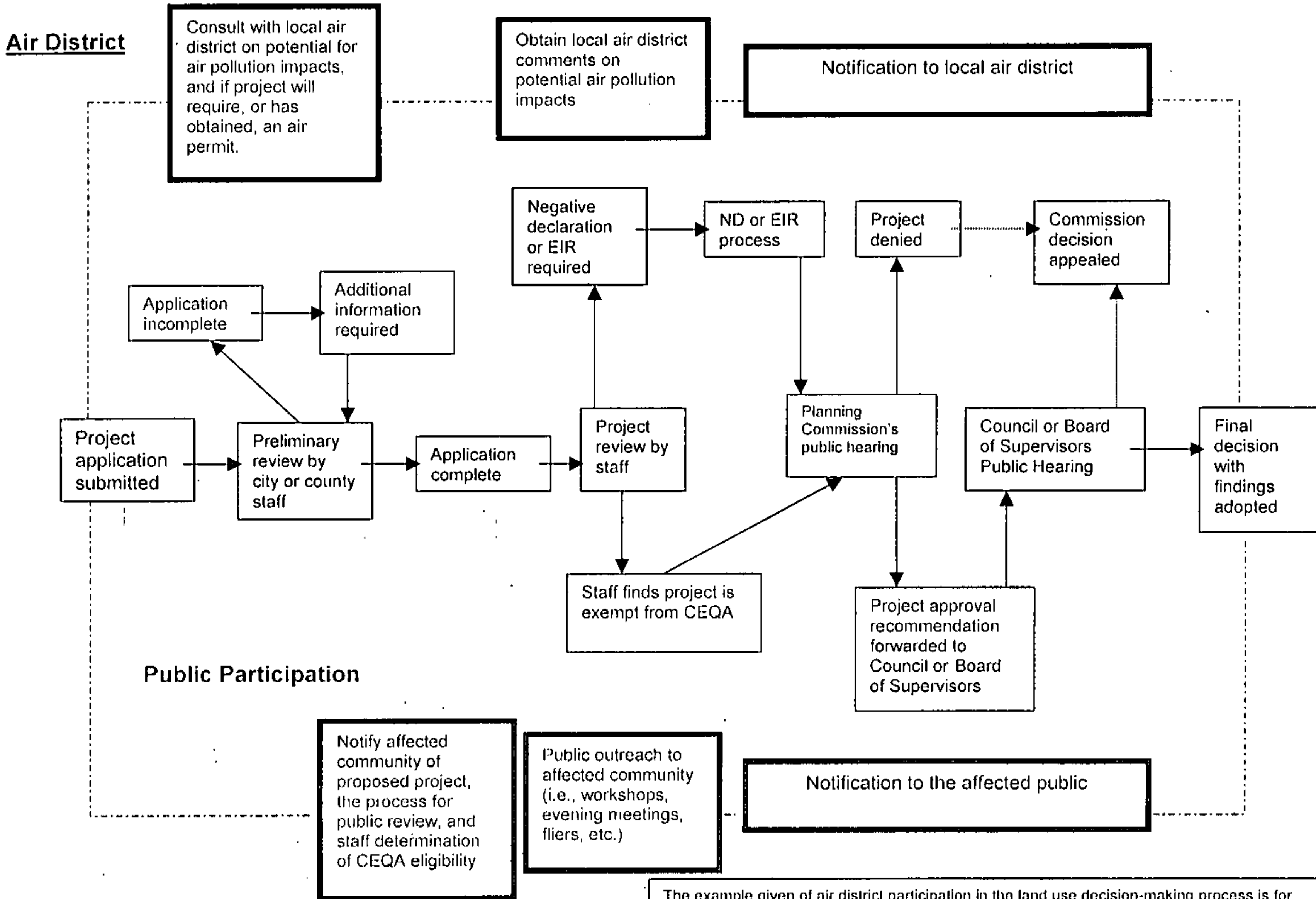
Public Comment

Following the environmental review process, the Planning Commission reviews application along with the staff's report on the project assessment and a public comment period is set and input is solicited.

Public Hearing and Decision

Permit rules vary depending on the particular permit authority in question, but the process generally involves comparing the proposed project with the land use agency standards or policies. The procedure usually leads to a public hearing, which is followed by a written decision by the agency or its designated officer. Typically, a project is approved, denied, or approved subject to specified conditions.

USE PERMIT (DISCRETIONARY ACTION) REVIEW PROCESS*



The example given of air district participation in the land use decision-making process is for illustrative purposes only. In reality, the land use siting process involves the ongoing participation of multiple affected agencies and stakeholders throughout the process.

GLOSSARY OF KEY AIR POLLUTION TERMS

Air Pollution Control Board or Air Quality Management Board: Serves as the governing board for local air districts. It consists of appointed or elected members from the public or private sector. It conducts public hearings to adopt local air pollution regulations.

Air Pollution Control Districts or Air Quality Management Districts (local air district): A county or regional agency with authority to regulate stationary and area sources of air pollution within a given county or region. Governed by a district air pollution control board.

Air Pollution Control Officer (APCO): Head of a local air pollution control or air quality management district.

Air Toxic Control Measures (ATCM): A control measure adopted by the ARB (Health and Safety Code section 39666 et seq.), which reduces emissions of toxic air contaminants.

Ambient Air Quality Standards: An air quality standard defines the maximum amount of a pollutant that can be present in the outdoor air during a specific time period without harming the public's health. Only U.S. EPA and the ARB may establish air quality standards. No other state has this authority. Air quality standards are a measure of clean air. More specifically, an air quality standard establishes the concentration at which a pollutant is known to cause adverse health effects to sensitive groups within the population, such as children and the elderly. Federal standards are referred to as National Ambient Air Quality Standards (NAAQS); state standards are referred to as California ambient air quality standards (CAAQS).

Area-wide Sources: Sources of air pollution that individually emit small amounts of pollution, but together add up to significant quantities of pollution. Examples include consumer products, fireplaces, road dust, and farming operations.

Attainment vs. Nonattainment Area: An attainment area is a geographic area that meets the National Ambient Air Quality Standards for the criteria pollutants and a non-attainment area is a geographic area that doesn't meet the NAAQS for criteria pollutants.

Attainment Plan: Attainment plans lay out measures and strategies to attain one or more air quality standards by a specified date.

California Clean Air Act (CCAA): A California law passed in 1988, which provides the basis for air quality planning and regulation independent of federal regulations. A major element of the Act is the requirement that local air districts in violation of the CAAQS must prepare attainment plans which identify air quality problems, causes, trends, and actions to be taken to attain and maintain California's air quality standards by the earliest practicable date.

California Environmental Quality Act (CEQA): A California law that sets forth a process for public agencies to make informed decisions on discretionary project approvals. The process helps decision-makers determine whether any potential, significant, adverse environmental impacts are associated with a proposed project and to identify alternatives and mitigation measures that will eliminate or reduce such adverse impacts.[1]

California Health and Safety Code: A compilation of California laws, including state air pollution laws, enacted by the Legislature to protect the health and safety of people in California. Government agencies adopt regulations to implement specific provisions of the California Health and Safety Code.

Clean Air Act (CAA): The federal Clean Air Act was adopted by the United States Congress and sets forth standards, procedures, and requirements to be implemented by the U.S. Environmental Protection Agency (U.S. EPA) to protect air quality in the United States.

Councils of Government (COGs): There are 25 COGs in California made up of city and county elected officials. COGs are regional agencies concerned primarily with transportation planning and housing; they do not directly regulate land use.

Criteria Air Pollutant: An air pollutant for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set. Examples include ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM10 and PM2.5. The term "criteria air pollutants" derives from the requirement that the U.S. EPA and ARB must describe the characteristics and potential health and welfare effects of these pollutants. The U.S. EPA and ARB periodically review new scientific data and may propose revisions to the standards as a result.

District Hearing Board: Hears local air district permit appeals and issues variances and abatement orders. The local air district board appoints the members of the hearing board.

Emission Inventory: An estimate of the amount of pollutants emitted into the atmosphere from mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year. .

Environmental Impact Report (EIR): The public document used by a governmental agency to analyze the significant environmental effects of a proposed project, to identify

[1] To track the submittal of CEQA documents to the State Clearinghouse within the Office of Planning and Research, the reader can refer to CEQAnet at http://www.ceqanet.ca.gov.

alternatives, and to disclose possible ways to reduce or avoid the possible negative environmental impacts.

Environmental Justice: California law defines environmental justice as the fair treatment of people of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations; and policies (California Government Code sec.65040.12(c)).

General Plans: A statement of policies developed by local governments, including text and diagrams setting forth objectives, principles, standards, and plan proposals for the future physical development of the city or county.

Hazardous Air Pollutants (HAPs): An air pollutant listed under section 112 (b) of the federal Clean Air Act as particularly hazardous to health. U.S. EPA identifies emission sources of hazardous air pollutants, and emission standards are set accordingly. In California, HAPs are referred to as toxic air contaminants.

Land Use Agency: Local government agency that performs functions associated with the review, approval, and enforcement of general plans and plan elements, zoning, and land use permitting. For purposes of this Handbook, a land use agency is typically a local planning department.

Mobile Source: Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes.

National Ambient Air Quality Standard (NAAQS): A limit on the level of an outdoor air pollutant established by the US EPA pursuant to the Clean Air Act. There are two types of NAAQS. Primary standards set limits to protect public health and secondary standards set limits to protect public welfare.

Negative Declaration (ND): When the lead agency (the agency responsible for preparing the EIR or ND) under CEQA, finds that there is no substantial evidence that a project may have a significant environmental effect, the agency will prepare a "negative declaration" instead of an EIR.

New Source Review (NSR): A federal Clean Air Act requirement that state implementation plans must include a permit review process, which applies to the construction and operation of new or modified stationary sources in nonattainment areas. Two major elements of NSR to reduce emissions are best available control technology requirements and emission offsets.

Office of Planning and Research (OPR): OPR is part of the Governor's office. OPR has a variety of functions related to local land-use planning and environmental programs. It provides General Plan Guidelines for city and county planners, and coordinates the state clearinghouse for Environmental Impact Reports.

Ordinance: A law adopted by a City Council or County Board of Supervisors. Ordinances usually amend, repeal or supplement the municipal code; provide zoning specifications; or appropriate money for specific purposes.

Overriding Considerations: A ruling made by the lead agency in the CEQA process when the lead agency finds the importance of the project to the community outweighs potential adverse environmental impacts.

Public Comment: An opportunity for the general public to comment on regulations and other proposals made by government agencies. You can submit written or oral comments at the public meeting or send your written comments to the agency.

Public Hearing: A public hearing is an opportunity to testify on a proposed action by a governing board at a public meeting. The public and the media are welcome to attend the hearing and listen to, or participate in, the proceedings.

Public Notice: A public notice identifies the person, business, or local government seeking approval of a specific course of action (such as a regulation). It describes the activity for which approval is being sought, and describes the location where the proposed activity or public meeting will take place.

Public Nuisance: A public nuisance, for the purposes of air pollution regulations, is defined as a discharge from any source whatsoever of such quantities of air contaminants or other material which cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health, or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property. (Health and Safety Code section 41700).

Property Setback: In zoning parlance, a setback is the minimum amount of space required between a lot line and a building line.

Risk: For cancer health effects, risk is expressed as an estimate of the increased chances of getting cancer due to facility emissions over a 70-year lifetime. This increase in risk is expressed as chances in a million (e.g.,10 chances in a million).

Sensitive Individuals: Refers to those segments of the population most susceptible to poor air quality (i.e., children, the elderly, and those with pre-existing serious health problems affected by air quality).

Sensitive Sites or Sensitive Land Uses: Land uses where sensitive individuals are most likely to spend time, including schools and schoolyards, parks and playgrounds, day care centers, nursing homes, hospitals, and residential communities.

Setback: An area of land separating one parcel of land from another that acts to soften or mitigate the effects of one land use on the other.

State Implementation Plan (SIP): A plan prepared by state and local agencies and submitted to U.S. EPA describing how each area will attain and maintain national ambient air quality standards. SIPs include the technical information about emission inventories, air quality monitoring, control measures and strategies, and enforcement mechanisms. A SIP is composed of local air quality management plans and state air quality regulations.

Stationary Sources: Non-mobile sources such as power plants, refineries, and manufacturing facilities.

Toxic Air Contaminant (TAC): An air pollutant, identified in regulation by the ARB, which may cause or contribute to an increase in deaths or in serious illness, or which may pose a present or potential hazard to human health. TACs are considered under a different regulatory process (California Health and Safety Code section 39650 et seq.) than pollutants subject to State Ambient Air Quality Standards. Health effects associated with TACs may occur at extremely low levels. It is often difficult to identify safe levels of exposure, which produce no adverse health effects.

Urban Background: The term is used in this Handbook to represent the ubiquitous, elevated, regional air pollution levels observed in large urban areas in California.

Zoning ordinances: City councils and county boards of supervisors adopts zoning ordinances that set forth land use classifications, divides the county or city into land use zones as delineated on the official zoning, maps, and set enforceable standards for future develop