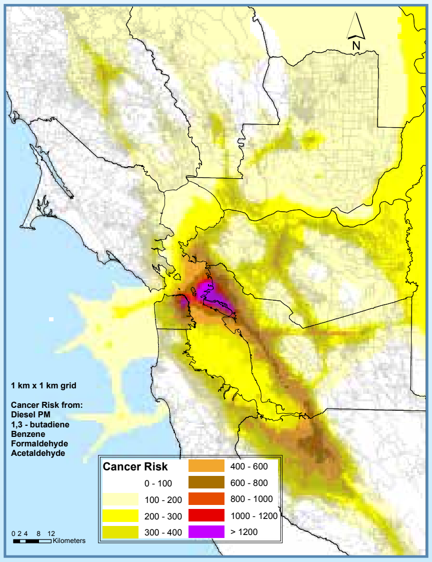
IMPROVING AIR QUALITY & HEALTH IN BAY AREA COMMUNITIES



Community Air Risk Evaluation Program Retrospective & Path Forward (2004 - 2013)

April 2014

HEALTHY NEIGHBORHOODS | EXPOSURE ASSESSMENTS | SCIENTIFIC STUDIES

Collaborations with the Public, Researchers, and Health & Planning Departments

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

IMPROVING AIR QUALITY & HEALTH IN BAY AREA COMMUNITIES

Community Air Risk Evaluation (CARE) Program Retrospective & Path Forward (2004 - 2013)

April 2014

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Authors and Contributors:

Philip Martien, Ph.D.

Virginia Lau

David Fairley, Ph.D.

Reviewers:

Henry Hilken

Jean Roggenkamp

Jack P. Broadbent

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CARE TASK FORCE MEMBERS

Gillian Adams, Association of Bay Area Governments

Guy Bjerke, Western States Petroleum Association

Dennis Bolt, Western States Petroleum Association

Dr. Henry Clark, West County Toxics Coalition

Amy Cohen, Esq., Bay Area Environmental Health Collaborative

Akoni Danielsen, City of San Jose Planning Division

Aleka Eisentraut, East Bay Economic Development Alliance

Joel Ervice, Regional Asthma Management and Prevention

Pam Evans, Alameda County Department of Environmental Health

James D. Fine, Ph.D., Environmental Defense Fund

Eric Fujita, Ph.D., Desert Research Institute

Wendy Goodfriend, Ph.D., San Francisco Bay Conservation and Development Commission

Margaret Gordon, West Oakland Environmental Indicators Project

Richard Grow, U.S. EPA, Region 9

Michael Harris, San Francisco Department of Public Health

Marie Harrison, GreenAction

Kim Hoang, Ph.D., U.S. EPA, Region 9

Jerry Jakubauskas, Port of Oakland

Ellen Johnck, Bay Planning Coalition

Jeff Jones, Port of Oakland

Ronit Ben Abraham-Katz, M.D., Lawrence Livermore National Laboratory; Stanford Univ. Medical Center

Michael Kent, Contra Costa County Department of Health Services

Bruce Kern, East Bay Economic Development Alliance

Thomas Kirchstetter, Ph.D., Lawrence Berkeley National Laboratory

Ken Kloc, Ph.D., Bay Area Environmental Health Collaborative

Matt Lakin, U.S. EPA, Region 9

Anna Lee, Communities for a Better Environment

Tim Leong, Port of Oakland

Nile Malloy, Communities for a Better Environment

Gordon Mar, Bay Area Environmental Health Collaborative

Jane Martin, Dr.PH., Alameda County Public Health Department

Steven Moss, San Francisco Community Power Cooperative

Shankar Prasad, Ph.D., Coalition for Clean Air

Bill Quinn, California Council for Environmental and Economic Balance

Darin Ranelletti, City of Oakland Planning and Zoning Division

Maureen Riordan, City of Redwood City

Tom Rivard, San Francisco Department of Public Health

Eric Roberts, M.D., Ph.D., California Department of Health Services

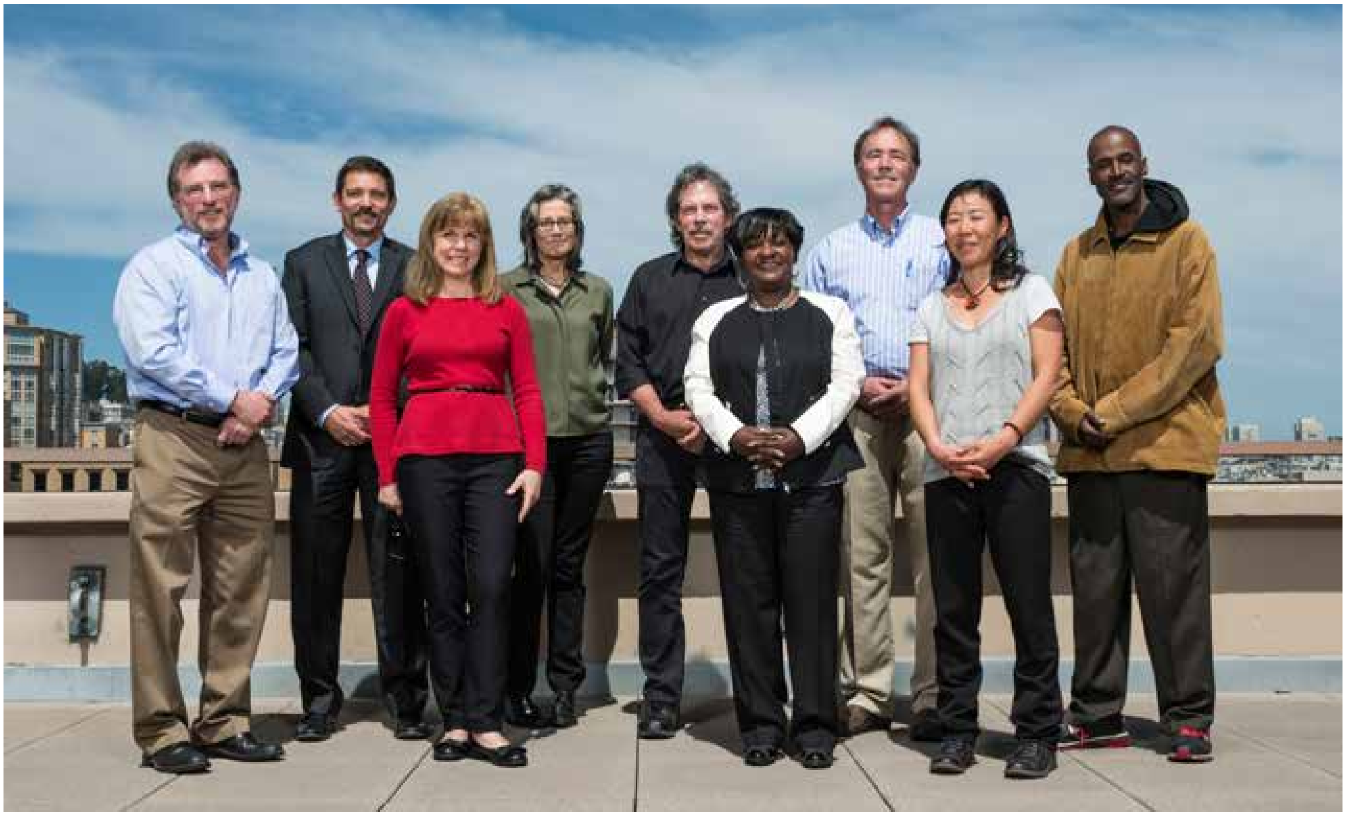
Rosina Roibal, Bay Area Environmental Health Collaborative

Kerrie Romanow, City of San Jose Environmental Services

Maria Luz Torre, Parent Voices – San Francisco Health Authority Governing Board

Johnny White, West County Toxics Coalition

Janet Whittick, California Council for Environmental and Economic Balance



Members of the CARE Task Force, Air District staff, and community members (left to right): Michael Kent, Phil Martien, Pam Evans, Jane Martin, Richard Grow, Marie Harrison, Tom Rivard, Janet Whittick, and Leaotis Martin.

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RESEARCHERS, COLLABORATORS, AND ADVISORS

Rajiv Bhatia, M.D., MPH, San Francisco Department of Public Health

Wendel Brunner, M.D., Ph.D., Contra Costa County Department of Public Health

Dave Campbell, Desert Research Institute

Glen Colwell, Bay Area Air Quality Management District

Timothy Dallman, Ph.D., University of California Berkeley

Yuan Du, Sonoma Technology, Inc.

Lisa Fasano, Bay Area Air Quality Management District

Marty Fenstersheib, M.D., Santa Clara County Department of Health and Human

Robert Harley, Ph.D., University of California Berkeley

David Holstius, University of California Berkeley

Anthony Iton, M.D., JD, MPH, Alameda County Public Health Department

Erin Pollard, Sonoma Technology, Inc.

Laurel Prevetti, City of San Jose Planning Division

Jessica Range, San Francisco Planning Department

Rebekah Ross, City of San Jose Planning Division

Steve Reid, Sonoma Technology, Inc.

Eric Stevenson, Bay Area Air Quality Management District

John Stilley, Sonoma Technology, Inc.

Saffet Tanrikulu, Ph.D., Bay Area Air Quality Management District

EXECUTIVE SUMMARY

In 2004, the Bay Area Air Quality Management District (Air District) initiated the *Community Air Risk Evaluation* (CARE) program to identify areas with high concentrations of air pollution and populations most vulnerable to air pollution's health impacts. Maps of communities impacted by air pollution, generated through the CARE program, are being integrated into many of the Air District's programs. The maps, along with information about pollutants and their sources that lead to the impacts, help prioritize a broad array of actions designed to foster healthy communities via the *Clean Air Communities Initiative*.

This report provides a retrospective of the CARE program since its initiation nearly a decade ago. It reviews accomplishments, challenges, and the road ahead, highlighting the program's scientific basis and collaborative development. This report also describes how the CARE program has guided policy decisions, enhanced Air District programs, and fostered long-term partnerships with local jurisdictions, business and community groups.

CARE Program Goals

Despite tremendous strides in air pollution reduction, some communities in the Bay Area still experience relatively higher pollution levels, and corresponding health effects, compared to their counterparts in other parts of the Bay Area. Air pollution levels of many pollutants are highest in close proximity to pollution sources—such as near freeways, busy roadways, busy distribution centers, and large industrial sources. Communities where these types of sources are concentrated contain areas where air pollution is consistently relatively high and corresponding health impacts are greater. The CARE program represents a critical step toward reducing health disparities linked to air quality. The program has brought together government, communities and business in an effort to understand and address localized areas of elevated air pollution and its adverse health impacts on communities.

One of the main objectives of the CARE Program has been to promote an ongoing dialogue with Air District stakeholders. In order to facilitate this dialogue, the Air District invited a range of representatives from local health and planning departments, research institutions, regulated industry, and community organizations to participate in a *CARE Task Force*.

Policy goals of the CARE Program are to:

Goal 1. Identify areas within the Bay Area where air pollution is most contributing to health impacts and where populations are most vulnerable to air pollution impacts;

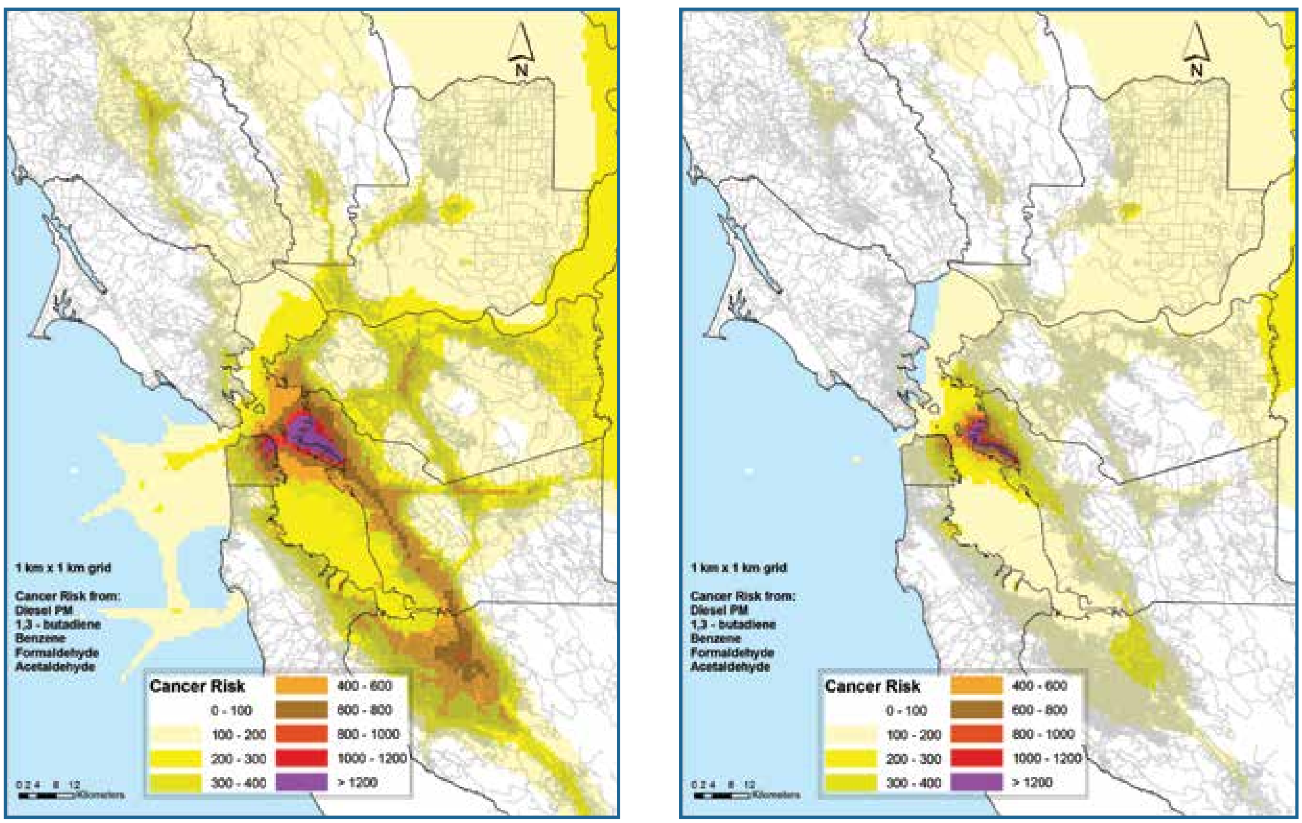
Goal 2. Apply sound science and robust technical analyses to design and focus effective mitigation measures in areas with highest impacts; and

Goal 3. Engage the communities and other stakeholder groups in the program and develop productive relationships with local agencies to craft mitigations that extend beyond what the Air District could do alone.

Scientific Studies and Findings

In 2006, for the first time, the Air District undertook the creation of a regional emissions inventory for toxic air contaminants (TAC) from major sources of emissions in the Bay Area, including nearly 200 toxic gases or particles. Emissions inventories for years 2005 and 2015 were input to a regional air quality model to predict concentrations of key toxic compounds and cancer risk associated with them. Some of the key findings from this work were that particulate matter emitted from diesel engines (diesel PM) contributed more than 85% of the total inventoried cancer risk and that simulated potential cancer risk from TAC is highest near major diesel PM sources (see Figure ES-1). Another key finding is that cancer risk from TAC is dropping: modeled risk values were projected to drop by more than 50% between 2005 and 2015, when emissions inputs accounted for state diesel regulations and other reductions. Measurement-based assessments of cancer risk from air pollution show similar reductions.

Figure ES-1 Potential cancer risk from toxic air contaminants for the Bay Area in year 2005 (left) and 2015 (right)[1]



In 2009, the Air District developed initial maps of areas within the Bay Area with relatively high levels of toxic air pollution and with people who are relatively more vulnerable to the harmful health impacts of air pollution. Cumulative impact areas were identified as those with highest potential cancer risk from TAC exposure (top 50%) for youths and seniors, with nearby areas of high TAC emissions (top 25%), and with areas of low household income (more than 40% of families below 185% of the federal poverty level).[2]

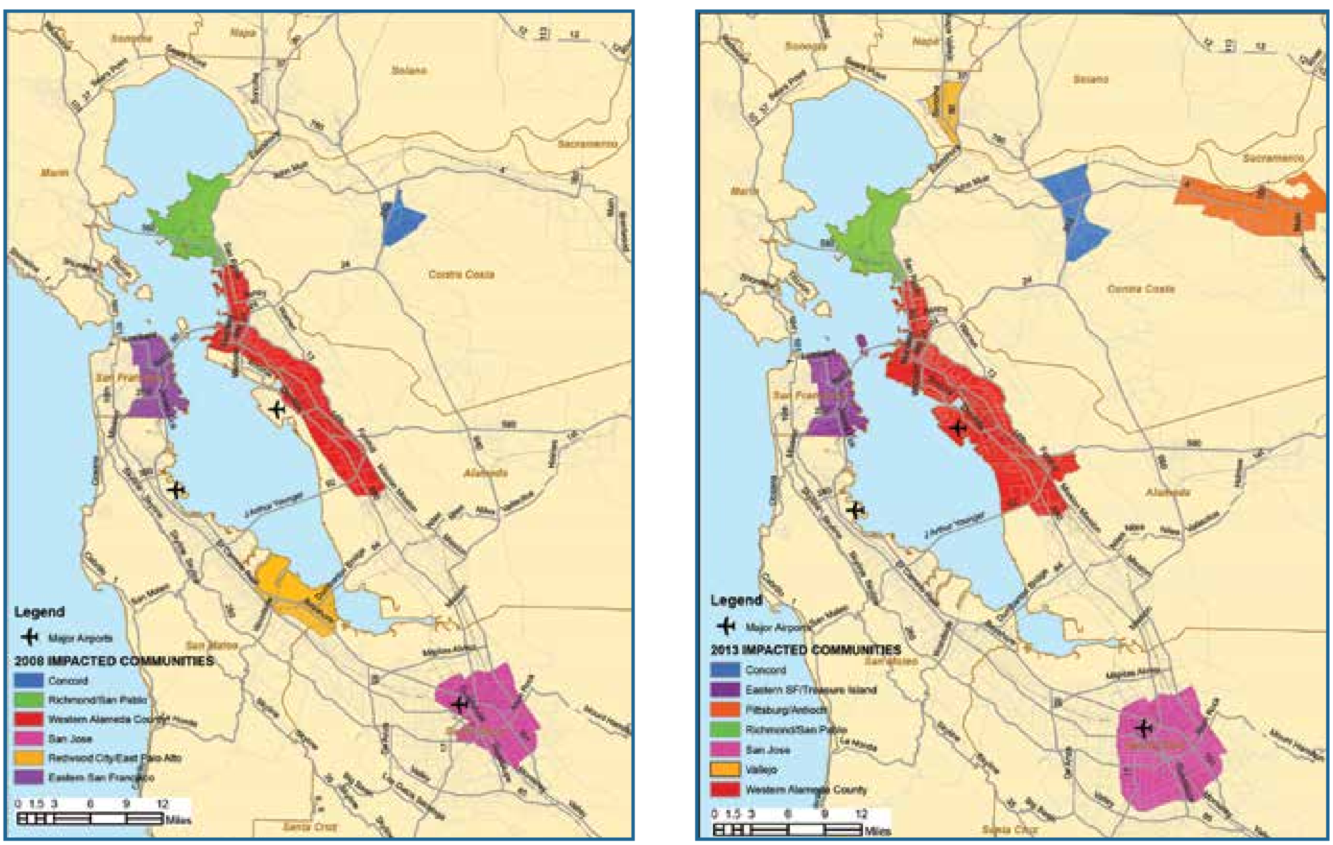
1 Figure ES-1 shows risk levels assuming a 70-year exposure at a constant level of emissions. Units are potential excess cancers per million people exposed.

2 The Association of Bay Area Governments has defined this as measure of poverty.

In 2013, the Air District updated the maps of cumulative impact areas, incorporating more recent data and using new methods. The new method accounted for areas with high cancer risk as before, using the 2015 TAC modeling to estimate cancer risk, instead of 2005 modeling. In addition to cancer risk from TAC, the updated method accounted for increased mortality and illnesses from fine particulate matter ($PM_{2.5}$) and ozone above background levels. Population vulnerability was accounted for in estimating health impacts from air pollution by using a community's existing baseline rates of mortality and illnesses (determined from health records) to determine increases in mortality and illness from air pollution. Socioeconomic data were not used in the updated method. However, once impacted areas were identified, subsequent investigation revealed a clear correlation between areas of impact and socioeconomic factors such as race, income, and education level.

Figure ES-2 shows the 2009 (left) and the 2013 (right) maps of cumulative impact areas. The updated maps, like the initial maps, were developed by considering long-term exposures to air pollution, often with important contributions from local emissions. These maps direct special studies and serve to prioritize Air District activities that mitigate air pollution exposures from local emissions sources, activities such as grant and incentive funding, enforcement efforts, and the adoption of new and amended regulations.

Figure ES-2 Cumulative impact areas as identified in 2009 (left) and as updated in 2013 (right)



Many of the areas in the initial map were also identified in the updated map; however, there are some important differences between the maps. Several areas in the initial maps were expanded and additional areas were identified. These changes do not imply that air pollution in the Bay Area is getting worse. In fact, air pollution levels have been dropping in nearly all Bay Area communities. The addition of some areas and expansion of others is due to the added consideration of new pollutants in the updated method. The area near Redwood City and East Palo Alto appeared on the 2009 map but not on the updated map because TAC levels have dropped since 2009 and $PM_{2.5}$ and ozone are relatively low there.

While these maps help the Air District focus its resources to protect public health in cumulative impact areas, some types of air quality concerns are not fully addressed by them. One concern is for areas throughout the region where there are *episodes* of relatively high air pollution, that is, certain days on which air quality standards are exceeded (ozone in summer, PM in winter). The analysis discussed in Section 2.4 identified Bay Area communities with the greatest health impacts. However there are areas outside cumulative impact areas that are adversely affected on days when air quality measurement sites record exceedances of state and federal standards for air pollution. Figure ES-3 shows areas that exceeded the 24-hour $PM_{2.5}$ standard (red outline) and the 8-hour ozone standard (blue shading) three or more times in the past three years. Some of the areas with episodic exceedances occur outside the CARE communities. Air quality and health are a concern at all locations with exceedances. Historically the Air District has focused most of its resources to bring regional air pollution levels down throughout the Bay Area. Indeed, programs to address regional air pollution continue to be a primary focus of the Air District's resources and activities.

Figure ES-3 Episodic exceedance areas for fine particulate matter and ozone

Some areas that have episodes of high $PM_{2.5}$ (red outline) and high ozone (blue shading) are outside the updated cumulative impact areas (orange shading).

A second concern regards local, source-specific impacts that may not be identified in the cumulative impact maps, which provide more of a "macro-scale" view of the Bay Area. For example, in certain localized neighborhoods wood smoke may build up to unhealthy levels on calm winter nights in areas where air quality is otherwise good. Also, adjacent to a heavily trafficked roadway outside cumulative impact areas, air pollution from cars and trucks can reach unhealthy levels. Various programs at the Air District are in place and being implemented to address these important additional concerns.

In addition to regional studies and analyses, to more accurately assess exposures and health impacts in a neighborhood, the Air District has undertaken many local-scale air quality studies. The goal of local-scale studies has been to develop information and tools to reduce exposures to local sources of air pollution and reduce associated health impacts, especially in impacted communities. Four of these studies—completed by the Air District in partnership with other agencies, community groups, and air quality researchers—assessed air pollution in West Oakland, an area bounded by the Maritime Port of Oakland (the Port), the Union Pacific rail yard, and I-580, I-880, and I-980 freeways. West Oakland is one of the most impacted areas in the Bay Area because of the many sources of diesel PM.

Studies conducted in West Oakland between 2005 and 2010 include the following:

- Diesel Particulate Matter Health Risk Assessment for the West Oakland Community,
- West Oakland Truck Survey,
- Drayage Truck Plume Measurement Study, and
- West Oakland Monitoring Study.

In combination, the West Oakland studies indicate that focused grants-funded diesel reduction projects, new regulatory requirements, and focused enforcement near the Port have been effective. However, the West Oakland Monitoring Study showed that high air pollution concentrations still occur along major roadways in West Oakland and near the Port, especially in areas with high traffic volumes of diesel trucks.
Over the past decade, the Air District also has conducted several local-scale measurement studies to characterize pollutant concentrations and risk near individual industrial facilities. Three such recent studies were conducted at sites near:

- A metal foundry and fabrication plant in West Berkeley,
- An aluminum melting and recycling operation in West Oakland, and
- A Portland cement manufacturer in Cupertino.

Each of these studies was initiated in part to address community concerns; each supplemented modeling studies of facility impacts; and each used measurements of toxic compounds to evaluate health risks. Importantly, these studies provided background information and context for subsequent regulations that were adopted by the Air District. Monitoring at Cupertino informed a rule on Portland cement manufacturing (Regulation 9, Rule 13), adopted in September 2012. Monitoring in West Berkeley and West Oakland provided information considered in a rule on foundry and forging operations (Regulation 12, Rule 13), adopted in May 2013.

For many years, regional agencies in the Bay Area have supported infill development as a key strategy to provide needed housing, reduce motor vehicle use, and reduce air pollutant emissions. Efforts to implement infill strategies took on greater urgency with the adoption of state legislation (SB 375) that requires regions in California to develop land-use and transportation strategies to reduce greenhouse gas emissions from motor vehicles. However, infill often favors locations near transit corridors, which are frequently near busy freeways, ports and rail facilities, and industrial and commercial sources of air pollution. To address this tension, the Air District has collaborated with university researchers, regional agency partners, local governments, and others to develop new modeling approaches, online screening tools, and technical guidance. One such online tool was developed to assist planners and others to identify levels of fine particulate matter and health risk from toxic compounds near state highways in the Bay Area.

Air District Actions to Build Health Communities

One of the main goals of the CARE program has been to help design and focus effective air pollution mitigation measures in areas with highest impacts. The CARE program has made a strong commitment to use information gained through scientific studies to support mitigation actions in impacted communities. To carry out actions to improve air quality and reduce health impacts, the Air District has developed a coordinated strategy that uses many of the Air District's available resources. Areas identified as impacted form the foundation of the Clean Air Communities Initiative, an initiative designed to bring resources from throughout the Air District to protect public health in impacted communities.

Figure ES-4 The Clean Air Communities Initiative integrates consideration of impacted communities into many Air District programs

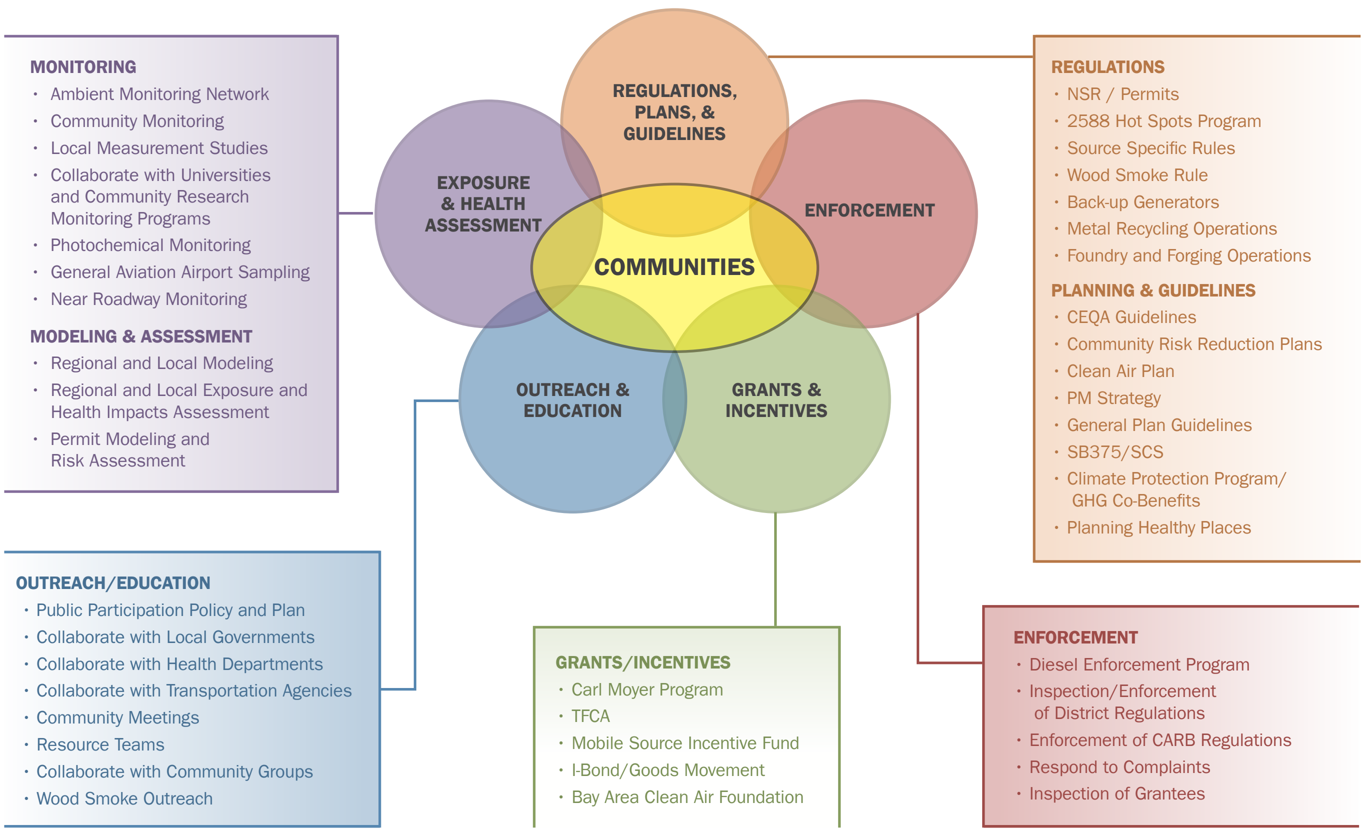
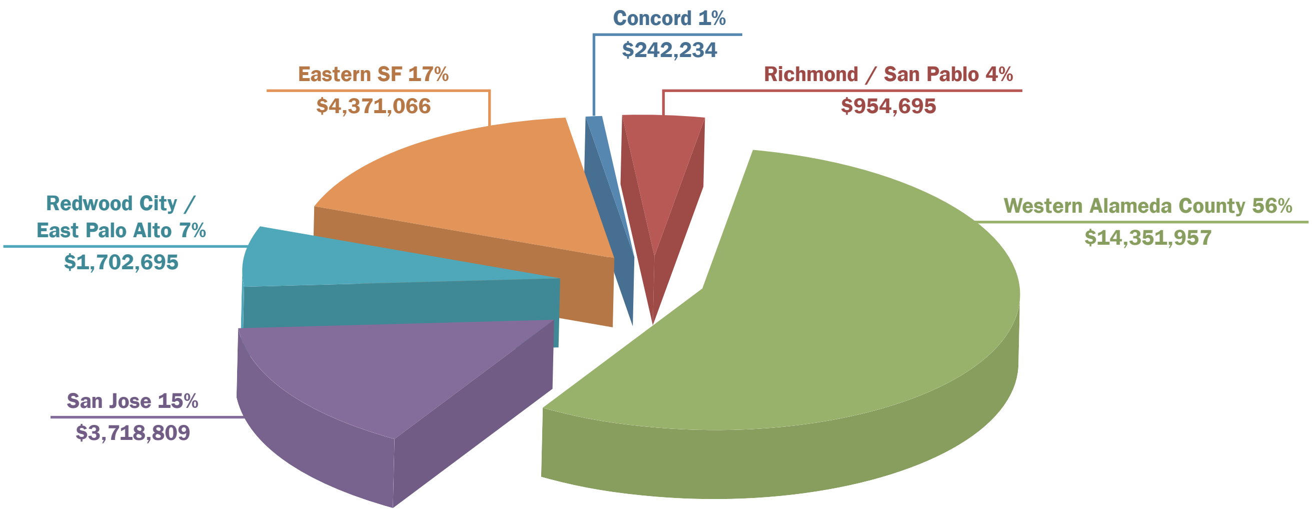


Figure ES-4 illustrates that communities identified through the CARE program are being integrated into the Air District's programs and inform a broad array of actions designed to foster healthy communities:

- **Grants and Incentives.** The Air District's grants and incentive programs coordinate closely with the CARE program to ensure that funding opportunities are prioritized to reduce emissions in impacted communities. The Air District administers many grant programs including the Transportation Fund for Clean Air, Mobile Source Incentive Fund, Carl Moyer Program, Lower Emission School Bus Program, and Goods Movement Program, distributing a total of nearly $50 million in fiscal year 2013. Figure ES-5 shows that in fiscal year 2013 more than $25 million in grant funding was distributed to impacted communities, over 50% of funding awarded.

Figure ES-5 Grant funds allocated to impacted communities in fiscal year 2013

($25.3 MILLION)



- **Regulations.** The Air District has recently developed new regulations targeting pollutants and sources of concern in impacted areas. The Air District recently adopted amendments to the New Source Review and Title V permitting programs that incorporate updated, more health-protective state methods for estimating health effects from air toxics. In May 2013, the Air District adopted two rules to reduce fugitive emissions of particulate matter and odor from foundries, forges, metal recycling and metal shredding operations, many of which are located in impacted communities. The Air District is currently considering additional new regulations to address other sources of concern in impacted areas.
- **Compliance and Enforcement.** The Air District developed a Memorandum of Understanding (MOU) agreement with CARB, whereby the Air District has authority to enforce CARB's diesel regulations for diesel mobile sources in the Bay Area. The program, part of the Mobile Source Compliance Plan, is designed to reduce diesel PM in CARE impacted areas and focuses specifically on drayage trucks at the Port of Oakland. From September 2009 and through 2103, Air District staff performed more than 11,000 inspections on drayage trucks, commercial idling, transportation refrigeration units, off-road construction equipment, locomotives, and ocean-going vessels, spurring compliance with state regulations on diesel equipment.
- **Planning.** Taking on the challenge of supporting infill and minimizing exposure to air pollution, the Air District is collaborating with jurisdictions and regional agencies on land use and transportation planning. In 2010, the Air District published California Environmental Quality Act (CEQA) Guidelines for evaluating local air pollution exposures in environmental review processes. The CEQA Guidelines contain recommendations for estimating and analyzing potential air quality impacts

from sources of toxic air contaminants and fine particulate matter, including stationary sources, freeways, and high volume roadways. The guidelines outline strategies, such as careful building siting and design, to reduce potential health risks in projects. In 2013, in collaboration with its partner regional planning agencies, the Air District developed a local air pollutant analysis for *Plan Bay Area,* a long-range integrated transportation and land-use/housing strategy. Local governments may use *Plan Bay Area's* local pollutant analysis for certain CEQA streamlining purposes.

- **Community Risk Reduction Plans** represent an innovative approach to health-risk reduction as an integral part of the planning process. Pilot plans are under development for the cities of San Francisco and San Jose. These plans coordinate actions and expertise of the Air District with the land-use authority of local jurisdictions. They define policy and programmatic actions that will be undertaken to reduce exposure to air pollution for future and existing residents and to reduce exposure disparities for residents. For example, the San Francisco Plan includes a number of source and exposure reduction strategies, such as installation of air filtering devices for new residential development.
- **Outreach and Education.** The Air District outreach program serves as a liaison between technical staff and the diverse communities in the Bay Area region. The program organizes and facilitates meetings to provide opportunities for local residents to share and receive information about pending regulations, clean air plans and strategies, or other air quality issues of interest to a particular community. The outreach program collaborates with clean air partners throughout the region and develops and maintains the Spare the Air Programs, the Air District's websites, and publications. The outreach program helps organize and facilitate meetings of the CARE Task Force and has worked closely with its members on a variety of regulatory and informational meetings.
- **Monitoring.** The Air District conducts special-purpose, local-scale monitoring, often to address community concerns. As noted above, such monitoring has included sites near industrial facilities, ports, and freeways. In 2014, near-roadway monitoring sites will be established near Bay Area freeways with high traffic levels adjacent to high-density residential areas. The Air District is partnering with UC Berkeley researchers to investigate the feasibility of using low-cost air pollution sensors to create a dense monitoring network in western Alameda County.

Air District Firsts

The past decade of CARE program activities introduced several new approaches and capabilities for understanding and mitigating air pollution problems. This report highlights many such activities. For the first time, the Air District:

1. Assembled a *Task Force* to discuss issues related to air pollution and health within Bay Areas communities;
2. Developed a *regional toxics emissions inventory* and conducted *regional toxics modeling* to predict concentrations of toxic air contaminants;
3. *Identified and mapped communities* with the greatest health impacts: areas with relatively high concentrations of air pollution and vulnerable populations;

4. Partnered with community members and others to conduct a *truck traffic survey* to characterize truck activity in West Oakland;

5. Conducted a *saturation monitoring* study, using a dense network of air monitors to characterize local variations in air pollution in the West Oakland community and near the Port of Oakland;

6. Developed *tools and guidance* to support help characterize air pollution sources from Bay Area freeways, local streets, and stationary sources to support health infill development; and

7. Developed the concept of a *Community Risk Reduction Plan* and technical methods to support it.

Key Accomplishments

Key accomplishments for the CARE program include the following:

1. Developed productive working relations with CARE Task Force members;

2. Integrated maps of impacted communities into many Air District programs and policies;

3. Outfitted a mobile sampling van that has been used in several studies, including the West Oakland Monitoring Study, a drayage truck emissions study, and a near-freeway air monitoring study;

4. Supported may users of screening tools and modeling guidance and facilitated the analysis of air pollution impacts in environmental review documents;

5. Completed the modeling and technical analysis to support the San Francisco Community Risk Reduction Plan pilot project; and

6. Provided on-line reports, documents, journal articles, and conference presentations documenting the CARE program work, including a session at the 2013 Annual Meeting of the Air & Waste Management Association dedicated to the Air District's efforts to characterize and mitigate exposures to local air pollution sources.

Key Findings

Some of the key findings of the CARE program are listed below:

1. Diesel particulate matter is a significant contributor to cancer risk from toxic air contaminants;

2. Particulate matter of all types is linked to poor health outcomes and mortality;

3. In an updated method for identifying cumulative impact areas, socioeconomic information was not used. However, there is a clear correlation between the areas of impact and socioeconomic factors such as income, race, and education levels.

4. Regulatory programs to reduce emissions, especially those at state and regional levels, are resulting in significant health benefits; and

5. Infill development can safely proceed in areas identified as impacted areas, if locations adjacent to heavily trafficked roadways and other localized air pollution sources are avoided or if effective mitigation measures are put in place.

Lessons Learned

Some of the lessons learned to date from the CARE program are summarized below:

1. Collaboration with stakeholders, researchers, and local health and planning department staff extends what the Air District can accomplish alone;
2. Studies that assess the effectiveness of mitigation measures provide valuable assurance that the mitigations are on track;
3. Maps of air pollution levels and risk from multiple sources are especially valuable planning tools. More planning tools, improved datasets, and new mitigation measures are needed for identifying and reducing potential impacts from air pollution;
4. Cumulative impact maps, are useful for prioritizing certain kinds of actions and mitigation measures, particularly efforts aimed at reducing exposures from local air pollution sources, actions such as those identified in the Clean Air Communities Initiative; and
5. Maps of areas with episodes of high particulate matter and ozone complement the cumulative impact maps. Maps of exceedance areas support and focus many long-standing efforts to reduce regional air pollution levels, such as Clean Air Plan policies and programs.

Next Steps

In the near term, Air District staff will build on past successes of the CARE program to:

1. Continue to integrate CARE principles into all Air District functions;
2. Continue to engage governmental agencies, business, and community members to build cooperative relations and strengthen the program;
3. Continue to reduce emissions and risk in impacted areas, implementing the Clean Air Communities Initiative to build healthy communities;
4. Continue to address regional air pollution through the Clean Air Plan and its programs and policies to reduce the frequency, intensity, and extent of high air pollution episodes; and,
5. Prioritize the development of improved datasets, tools, and guidance to support healthy infill development and to reduce existing exposures to air pollution from roadways and other localized sources.

Looking further ahead, Air District staff will:

6. Conduct studies to assess the effectiveness of mitigation measures, such as tightening building envelopes, indoor air filtration, and vegetation walls, for reducing air pollution exposures near local sources of air pollution;

7. Continue programs to identify and mitigate air pollution exposures, within and outside cumulative impact areas, including near-roadway and wood smoke exposures;
8. Investigate the use of networks of low-cost, low-power sensors to characterize air pollution levels in communities;
9. Develop improved exposure assessments during times people are at work, at school, or commuting, including time spent indoors, and investigate policies and programs to reduce those exposures; and
10. Incorporate issues related to climate change in assessing areas of cumulative health impacts in Bay Area communities.

1. INTRODUCTION

The Bay Area Air Quality Management District (Air District), the regional agency responsible for air pollution control in the nine-county San Francisco Bay Area (Bay Area, see Figure 1.1), is committed to protecting and improving air quality and public health for all Bay Area residents. Actions by the Air District, along with efforts of state and federal partner agencies, have resulted in significant air quality improvements throughout the Bay Area, as indicated by trends in air pollution measurements at regional air monitoring locations.[3] The number of days per year with one or more locations exceeding the current national ozone standard (75 parts per billion) has dropped from 45 in 1987 to four in 2012. The number of winter days over the current national 24-hour standard for fine particulate matter (35 micrograms per cubic meter) dropped from 22 in 1999-2000 to 11 in 2011-2012. Cancer risk estimated from ambient measurements in 2012 dropped to 22% of the value estimated in 1990. These improvements have led to better health and longer lives for Bay Area residents.[4]

Figure 1.1 The Air District's Jurisdiction

The Air District's jurisdiction includes Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, and Santa Clara counties and parts of Sonoma and Solano counties

However, despite regional air quality improvements, more work needs to be done. This is especially true in certain communities where air pollution levels are higher than in others and where health disparities exist. The Air District seeks to identify these areas to determine where additional efforts are needed and to help focus limited Air District resources where improved air quality will produce the greatest benefits. Of key concern is the health of residents who live near local air emissions sources, such as busy roadways or industrial activity, as well as the health of vulnerable populations, often low-income and minority neighborhoods.

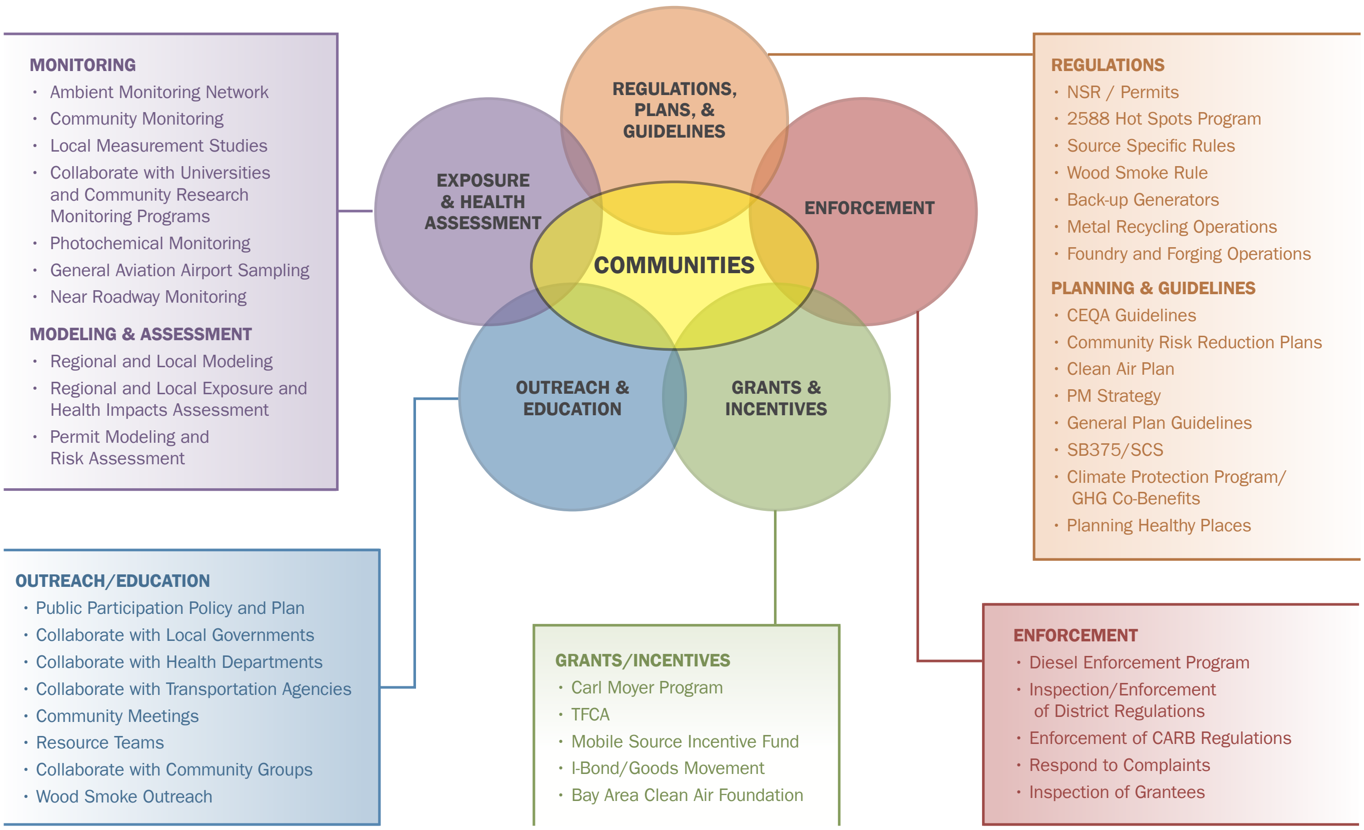
In 2004, the Air District embarked on the Community Air Risk Evaluation (CARE) program to identify the areas with high concentrations of air pollution and populations most vulnerable to those burdens. Once identified, these "impacted" areas would form the foundation of the Clean Air Communities Initiative (CACI), an initiative designed to bring resources from throughout the Air District to protect public health in impacted communities. Figure 1.2 shows how communities identified through the CARE program are being integrated into the Air District's programs and inform a broad array of actions designed to foster healthy communities.

3 Bay Area Air Quality Management District. 2010. Bay Area 2010 Clean Air Plan. Volume II. Adopted September 15, 2010

4 Bay Area Air Quality Management District. 2012. Understanding Particulate Matter: Protecting Public Health in the San Francisco Bay Area. Available at: http://www.baaqmd.gov/Divisions/Planning-and-Research/Plans/PM-Planning.aspx

This document describes the CARE program: its scientific basis, collaborative development, and ongoing findings. This report also describes how the CARE program has guided policy decisions, enhanced Air District programs, and fostered long-term partnerships with local jurisdictions and community groups.

Figure 1.2 The Clean Air Communities Initiative integrates consideration of impacted communities into many Air District programs



- **Section 1** provides a historical perspective on various air pollutants and their health impacts in the Bay Area. It describes the CARE program's goals, programmatic approach, and Task Force of stakeholders and advisors.
- **Section 2** summarizes the CARE program's regional-scale studies that have led to the identification of impacted areas.
- **Section 3** summarizes the CARE program's local-scale measurement and modeling studies whose objectives were guided by the regional-scale studies of Section 2 but tailored to characterize specific communities and specific sources.
- **Section 4** describes the ways in which the CARE program and its scientific studies have guided the Air District's actions to reduce air pollution and build healthy communities.
- Finally, **Section 5** discusses the future of the CARE program.

1.1 TRENDS IN BAY AREA AIR POLLUTION

Historical Approach

The historical approach taken by the Air District, and other regulators, to manage air pollution has generally followed one of two strategies depending on the pollutant type. On the one hand, for *six criteria pollutants*—ozone, carbon monoxide, sulfur dioxide, nitrogen oxides, lead, and particulate matter—state and federal regulators have set standards above which ambient pollution exposures are deemed unsafe. Criteria pollutant concentrations are regulated based on comparisons between standards and measurements collected at central monitoring sites, which are intentionally sited away from busy roads and other pollution sources.

On the other hand, a markedly different approach has been taken to manage *toxic air contaminants* (TAC)—pollutants identified by the California Environmental Protection Agency (Cal/EPA) as potentially hazardous to human health. For TAC pollutants, no ambient standards have been set. TAC pollutants are typically regulated through operating or permitting requirements and via controls on individual sources. In the Bay Area, some TAC are also monitored at central sites, but their combined impacts and ambient concentrations are not regulated, as ambient TAC standards have not been set.

The historical approach for regulating criteria pollutants and TAC has produced many successes. Actions by the Air District, along with efforts of state and federal partner agencies, have resulted in significant air quality improvements throughout the Bay Area, as indicated by air pollution trends at regional air monitoring locations for criteria pollutants and several important TAC pollutants.[5]

Emerging Approaches

Even as success is being achieved with current air quality management approaches, regulators are realizing that alternate approaches are also needed. Air pollution is not uniformly distributed throughout the Bay Area—it varies by community and neighborhood. Unfortunately, some neighborhoods are burdened with more air pollution sources and higher potential air pollution exposures relative to others. Neither criteria pollutants nor TAC have been routinely monitored near pollution sources, where some of the worst exposures can occur. Regulatory approaches are now emerging that consider near-source exposures, multiple sources, and their cumulative impacts.

Trends in Criteria Air Pollutant Concentrations

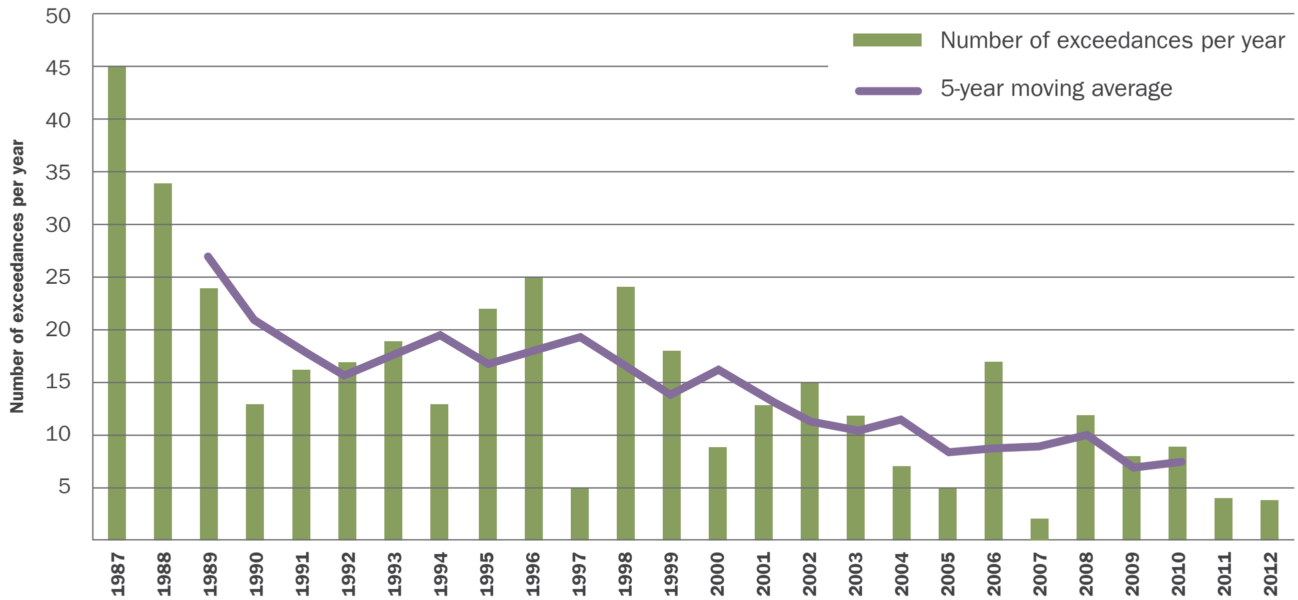
Measurements from the Air District's network of ambient air quality monitors have shown a dramatic decline in pollutant concentrations throughout the Bay Area over time. Ambient air concentrations for the six criteria pollutants have all declined over the past four decades.[6] The Bay Area is currently in attainment for national and state ambient air quality standards for lead, carbon monoxide, sulfur dioxide, and nitrogen dioxide. The Bay Area is not currently in attainment of all standards for ozone and fine particulate matter.

5 Bay Area Air Quality Management District. 2010. Bay Area 2010 Clean Air Plan. Volume II.

6 Bay Area Air Quality Management District. 2010. Bay Area 2010 Clean Air Plan.

Ozone is a regional pollutant that is not directly emitted, but is formed in the atmosphere through complex chemical reactions in the presence of sunlight between reactive organic gases (ROG) and nitrogen oxides (NO_x). Efforts to reduce ozone are focused on reducing emissions of ROG and NOx throughout the region. Since the 1980s, ROG emissions have declined by about 75% and NOx emissions by 50%. The number of days exceeding the ozone standard based on measurements collected from the Air District's monitoring network shows an overall downward trend (see Figure 1.3). Continued efforts by the Air District and the California Air Resources Board (CARB) to reduce emissions from a wide range of sources are expected to result in further reductions in ozone concentrations.

Figure 1.3 Number of days per year with at least one monitoring location exceeding the current 8-hour ozone national air quality standard (75 ppb)



The second compound for which the Bay Area exceeds standards is particulate matter (PM). PM is a mixture of suspended particles and liquid droplets (aerosols) in air. PM is directly emitted (primary PM) and also formed in the atmosphere through chemical reactions among air pollutants (secondary PM). Regulatory standards for PM consider the size of particles, an important factor because particle size strongly influences how particles are dispersed in air and how readily they are inhaled and absorbed by the human body. Standards have been set for particles less than 10 micrometers (10^{-6} meters or μm) in diameter (PM_{10}) and for particles less than 2.5 μm in diameter (fine PM or $PM_{2.5}$). Recent research[7, 8, 9] in both US and international studies has begun to examine the potential health effects of even smaller particles, ultrafine particles (UFP), which are less than 0.1 μm in diameter. These health studies suggest that new standards may be necessary to assess and regulate UFP.

7 Vinzents, P.S., P. Møller, M. Sørensen, L.E. Knudsen, O. Hertel, F. P. Jensen, B. Schibye, and S. Loft. 2005. Personal Exposure to Ultrafine Particles and Oxidative DNA Damage. Environ Health Perspect. 113(11): 1485–1490. doi: 10.1289/ehp.7562

8 Schulz, H., V. Harder, A. Ibald-Mulli, A. Khandoga, W. Koenig, F. Krombach, R. Radykewicz, A. Stampfl, Ba. Thorand, and A. Peters. 2005. Cardiovascular Effects of Fine and Ultrafine Particles. Journal of Aerosol Medicine. 18(1): 1-22. doi:10.1089/jam.2005.18.1.

9 Oberdörster, Günter, A. Elder, J. Finkelstein, M. Frampton, P. Hopke, A. Peters, K. Prather, E. Wichmann, and M. Utell. 2010. Assessment of Ambient UFP Health Effects: Linking sources to exposure and responses in extrapulmonary organs. EPA Grant EPA. Online at epa.gov/ncer/publications/epa_center_reports/rochester_pm_assessment_of_ambient_ufp_he.pdf

Numerous health studies have indicated that, in comparison to other regulated air pollutants in the Bay Area, fine PM exposure likely causes the most harm to public health today. Scientific evidence has shown that both long-term and short-term exposure to fine PM contributes to respiratory problems and potentially to early death. US EPA and CARB have both conducted studies that support a causal relationship between chronic exposure to fine PM (as measured by annual average concentrations) and premature mortality in adult US populations.[10, 11]

Figure 1.4 Number of winter days over the current national 24-hour $PM_{2.5}$ standard (35 µg/m³), November 15–February 15

The Bay Area has seen a significant reduction in PM concentrations over the past decades. Although the region remains out of attainment for certain PM standards, measurements at central monitoring sites in recent years show that the area is coming close to meeting all PM standards. Figure 1.4 shows an overall downward trend in the number of days that Bay Area $PM_{2.5}$ levels exceeded the 35 µg/m³ standard for each winter from 1999-2000 through 2011-2012. This overall downward trend reflects the reduction in PM emissions in response to CARB and Air District control measures. The sawtooth pattern in the number of exceedances is primarily due to year-to-year variation in meteorology, rather than short-term changes in emissions.

Toxic Air Contaminant Trends

The Air District and the state also track and regulate TAC, though in different ways than for criteria pollutants. Although ambient air standards have not been not set for TAC, tracking them is nonetheless important in assessing public health impacts in the Bay Area. Air toxics can cause or contribute to a wide range of short-term and long-term health effects including eye and throat irritation, neurological damage, hormone disruption, development defects, and cancer.

10 US EPA. 2006. Expanded Expert Judgment Assessment of the Concentration-Response Relationship between $PM_{2.5}$ Exposure and Mortality. Prepared by Industrial Economics, Inc. for the US EPA. Research Triangle Park, NC. Dated August 25, 2006.

11 CARB. 2008. Methodology for Estimating Premature Deaths Associated with Long-Term Exposure to Fine Airborne Particulate Matter in California. Staff Report. Dated October 24, 2008.

CARB regulates TAC through a variety of strategies including vehicle emission standards and air toxic control measures (ATCMs).[12] The Air District enforces select ATCMs, but also directly regulates air toxics. The Air District's Regulation 2, Rule 5, New Source Review of Toxic Air Contaminants[13] sets emissions limits for each individual toxic compound based on its potential to cause harmful health effects.

The Air District measures gaseous organic TAC, such as benzene and 1,3-butadiene, at twenty monitoring sites located throughout the Bay Area; CARB makes similar measurements at another five Bay Area sites. The Air District samples air for toxic metals, such as arsenic and mercury, at three sites; CARB samples toxic metals at five sites. This network of TAC measurement stations[14] constitutes one of the largest such networks in the nation. A subset of these sites, shown in Figure 1.5, was used for analysis of trends in TAC.

Figure 1.5 Air District measurement sites used for assessing levels of toxic air contaminants

The type and magnitude of health effects caused by poor air quality can vary substantially by pollutant. Similarly, health risk indicators take different forms depending on the type of pollutant. These risk indicators are used to compare the potential health effects of varying toxic air contaminants, and to track progress in reducing the adverse health impacts of these contaminants.

Cancer risk is generally expressed as the estimated chance that a person will develop cancer if exposed over some length of time (for example, a 70-year lifetime) to some specified concentration of pollutant. Air pollution and health officials often base policies and programs on achieving a certain level of incremental cancer risk; for example, a threshold may be set at a level of 100 per million. Non-cancer hazards are generally expressed using a hazard quotient, another indicator. The hazard quotient is the ratio of a TAC concentration divided by its reference concentration, or safe exposure level. If the hazard quotient for a TAC exceeds one, or if the sum of hazard quotients for multiple contaminants exceeds one, TAC concentrations may pose non-cancer health risks.

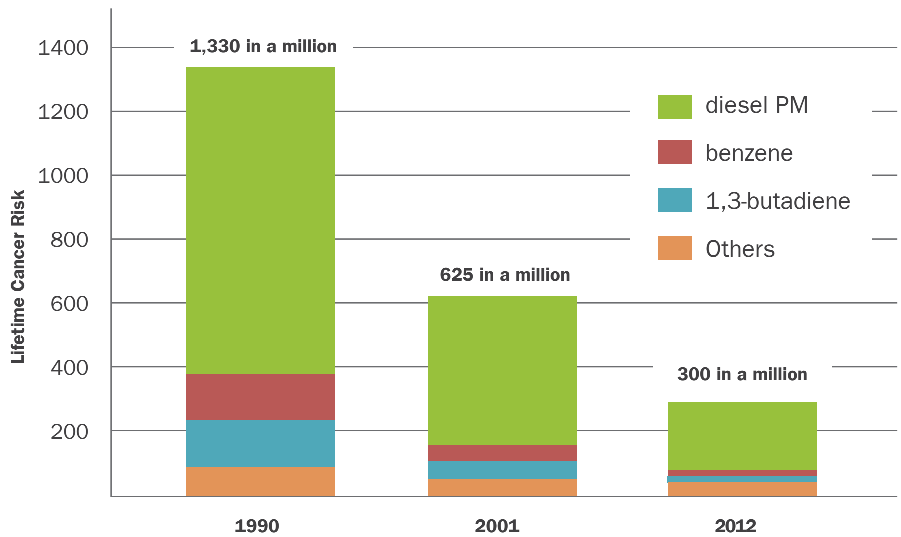
12 Air Toxic Control Measures described online at www.arb.ca.gov/toxics/atcm/atcm.htm

13 Described online at www.baaqmd.gov/Divisions/Planning-and-Research/Rules-and-Regulations.aspx

14 Bay Area Air Quality Management District. 2012 Air Monitoring Network Plan. July 1, 2013.
Online at www.baaqmd.gov/Divisions/Technical-Services/Ambient-Air-Monitoring/AAMN-Plan.aspx

Air District staff has estimated incremental cancer risk due to measured TAC in the Bay Area. According to the most recent analysis (2012), the average regional cancer risk was about 300 per million. That is, for every million residents exposed for 70 years to current levels of TAC, 300 would be expected to develop cancer as a result of the exposure. Figure 1.6 shows a fourfold reduction in cancer risk due to air toxics over time: from 1,300 per million in 1990 to 300 per million in 2012.[15] It also shows the relative contribution of certain specific air toxics to cancer risk. According to the analysis, over 70% of the cancer risk related to air pollution in the Bay Area is due to diesel PM, and 90% of the total risk is due to three compounds: diesel PM, benzene, and 1,3-butadiene. All three of these compounds are emitted via fuel combustion.

Figure 1.6 Estimated Bay Area lifetime cancer risk from toxic air contaminants, based on air pollution measurements[16]



1.2 GOALS OF THE CARE PROGRAM

Despite tremendous strides in air pollution reduction, some communities in the Bay Area experience higher pollution levels, and more adverse health effects, compared to their counterparts in other parts of the region. According to a report by the Bay Area Regional Health Inequities Initiative (BARHII),[17] where a person lives determines his or her health outcomes: West Oakland residents are expected to live an average of 10 years less than people in the Berkeley Hills; Bayview/Hunters Point residents are expected to live 14 years less than those living in Russian Hill; and in Contra Costa County, those in Bay Point can expect to live an average of 11 years less than residents in Orinda.

15 These estimates do not include an Age Sensitivity Factor adjustment, which was recently recommended by the Office of Environmental Health Hazard Assessment (OEHHA) to account for increased susceptibilities of infants and children. Including the ASF, with the same exposure assumptions, would increase the estimates by about a factor of 1.7.

16 The estimated cancer risk assumes a lifetime of exposure to the pollutant at the current concentration levels of the indicated year. Diesel PM is estimated from elemental carbon measurements.

17 Bay Area Regional Health Inequities Initiative, 2008. "Health Inequalities in the Bay Area". Online at www.barhii.org/press/download/barhii_report08.pdf

The underlying causes of such disparities are complex. No single governmental organization at the local, regional, state or national level can resolve the wide-ranging factors that contribute to these disparities in health outcomes. Inequities in air quality are a factor but are only a part of the problem. Ultimately, substantive improvements in health outcomes will require informed strategies, long-term planning, and concerted collaborations among government, communities, and business.

In 2004, the Air District launched the CARE program, a critical step toward reducing and eliminating health disparities linked to air quality. The program brought together government, communities and business in an effort to understand and address localized areas of elevated air pollution and adverse health impacts. While improvements in air quality are occurring throughout the Bay Area, levels of air pollution and their impacts vary from location to location. Air pollution levels of many pollutants are highest in close proximity to pollution sources—such as near freeways, busy roadways, busy distribution centers, and large industrial sources. Communities where these types of sources are concentrated often have areas within them where air pollution is relatively high and corresponding health impacts are greater.

CARE Program Goals

Building on historical approaches to evaluating criteria pollutants and TAC, the CARE program has begun exploring complementary approaches to assessing health impacts from air pollution. For criteria pollutants, the CARE program has sought to understand near-source concentrations and exposures, especially for fine particulate matter. For TAC, the CARE program has sought to understand and map cumulative, regional concentrations, combining the effects of sources throughout the region.

The primary goals of the CARE Program are to:

Goal 1. Identify areas within the Bay Area where air pollution is most contributing to health impacts, and where populations are most vulnerable to air pollution impacts;

Goal 2. Apply sound science and robust technical analyses to address community concerns regarding greater air pollution and health impacts, including low-income and minority communities;

Goal 3. Evaluate health risks from multiple sources of air pollution—that is, evaluate cumulative impacts of sources in combination;

Goal 4. Evaluate health risks from near-source exposures;

Goal 5. Help design and focus effective mitigation measures in areas with highest impacts;

Goal 6. Engage the public and stakeholder groups in the program; seek input and inform the public of progress and findings;

Goal 7. Enhance working relationships with public health and planning departments in Bay Area cities and counties to build healthy communities;

Goal 8. Track progress in reducing air pollution and improving health in communities; and

Goal 9. Prioritize Air District resources to achieve the greatest health benefits.

Measuring Success

The Air District has gauged the success of the CARE program by measuring progress relative to program objectives. While there remain opportunities for future refinement and development, the program has made meaningful progress toward its objectives. Throughout this document, project descriptions make reference to program goals and present examples of where outcomes have been successful and also where additional work is needed.

1.3 PROGRAM APPROACH

CARE Program Design

The Air District designed the CARE program to

- *conduct studies* and
- *build relationships* in order to
- more effectively *reduce health risks* in the Bay Area's most impacted areas.

The Air District set out to achieve the goals listed in Section 1.2 by conducting scientific studies and by building relationships. The scientific studies provided information to identify priority pollutants and emission sources to mitigate and priority areas where mitigations should be implemented. Partnering with community groups, agencies, business, and researchers not only helped the Air District conduct the studies, but also helped to craft and implement reduction measures.

Throughout the CARE program, the Air District maintained a strong commitment to taking early action in using information gained through studies to support mitigations in impacted communities.

Pollutants Considered

Initially, the CARE program and its analyses included only TAC. The decision to focus on TAC was supported by two factors. First, community members engaged in air pollution issues expressed concerns mostly related to toxic pollutants. Second, analyses of impacts from TAC have historically been facility-specific, local-scale analyses that seemed well matched to the goal of assessing community-level exposures. However, prior to the CARE program, the cumulative impacts of TAC and regional patterns of TAC concentrations had not been examined at the same level of detail as criteria pollutants.

Since 2010, the focus of the CARE program has broadened to consider other pollutants in addition to TAC. Specifically, many recent CARE analyses have included $PM_{2.5}$. The decision to include $PM_{2.5}$ in CARE analyses was motivated primarily by many health studies that have shown the significant health impacts of $PM_{2.5}$. An added concern was that concentrations of $PM_{2.5}$ are elevated in close proximity to busy roadways, present in many Bay Area communities. A turning point in the decision to consider $PM_{2.5}$ in the CARE program came in February 2009, when four Public Health officials presented to the Air District's Advisory Council and spoke in support of considering fine PM, in addition to TAC.[18]

18 Dr. Anthony Iton from Alameda County, Dr. Wendel Brunner from Contra Costa County, Dr. Rajiv Bhatia from San Francisco City & County, and Dr. Marty Fenstersheib from Santa Clara County presented to the Advisory Council on air quality and public health.

$PM_{2.5}$ and TAC have been the focus of recent local-scale analyses. In recent regional analyses, ozone has also been considered. The Air District's most recent method for identifying impacted communities, described in Section 2.4, includes health impacts from ozone, $PM_{2.5}$, and TAC. This is consistent with the multi-pollutant approach detailed in the Air District's 2010 Clean Air Plan, which recognized these pollutants as posing the greatest health burdens in the Bay Area.

In the future, as ongoing research provides additional information on the health impacts from exposures to near-roadway air pollutants and other local air pollution sources, the list of pollutants considered may grow. Section 5.4 discusses pollutants of emerging concern, including ultrafine particles (UFP) and nitrogen dioxide (NO_2). These air pollutants are of potential concern for near-source exposures in impacted communities and elsewhere.

CARE Program Analysis Methods

Many of the CARE program analyses have been implemented in three phases:

- **Phase I:** develop an emissions inventory, assessing the amount of toxic air contaminants or criteria pollutants emitted by sources in the region;
- **Phase II:** conduct modeling and measurement studies to estimate ambient concentrations; and
- **Phase III:** estimate health impacts, based on exposures to ambient concentrations of pollutants.

For example, in phase I, the Air District developed a gridded emissions inventory of TAC for the entire Bay Area. In phase II, the Air District used regional TAC modeling based on the gridded inventory to map concentrations of TAC concentrations from many sources. In phase III, the Air District estimated regional exposures and cancer risk from TAC, based on the regional modeling. Maps of impacted communities were initially developed based on TAC risks and regional socio-demographic patterns. (See Section 2.3.)

CARE Program Partners

For many of the CARE program analyses, the Air District partnered with community organizations, local jurisdictions, agencies, and research organizations to conduct studies and to develop mitigation measures. For example, in West Oakland, the Air District partnered with CARB to conduct a health risk assessment of diesel particulate matter (diesel PM); with the community group the West Oakland Environmental Indicators Project (WOIEP) to conduct a truck traffic survey; with the Desert Research Institute (DRI) for a community-scale measurement study; and with UC Berkeley for a truck plume measurement study to measure emission factors. (See Section 3.)

The scientific studies were aided and informed by an ongoing dialogue about the program with a CARE Task Force of stakeholders, described in Section 1.4. The Task Force also provided a venue to build partnerships with communities, with planners and health professionals, and with business to help craft the mitigations.

Health Risk Reduction Actions

Actions to reduce exposures to air pollution and to reduce associated health impacts in the Bay Area's most burdened communities have been a priority during all phases of the CARE program. Actions to reduce air pollution and health impacts have spanned the range of Air District functions: regulations, enforcement, policy development, grant-making, partnerships and education. Among these actions were the following:

- Amendments to the Air District's Regulation 2, Rule 5—New Source Review for Toxics Air Contaminants;
- Updates to the Air District's California Environmental Quality Act (CEQA) Guidelines. Among the guideline updates were recommendations to promote adequate health protection from new and existing sources of air pollution;
- Revisions to Air District grant programs, which have directed millions of dollars in grant funds to reduce diesel PM emissions in impacted communities;
- Development of a Memorandum of Understanding with CARB to allow Air District enforcement staff to conduct hundreds of inspections on diesel trucks to ensure compliance with state regulations; and
- Development of planning tools. For example, the Air District has worked with local Bay Area health departments and planning agencies to develop an innovative and promising health-risk reduction strategy called a *Community Risk Reduction Plan*. Though still under development, these plans coordinate actions and air quality screening tools of the Air District with actions and the land-use authority of local jurisdictions to avoid and mitigate local sources of air pollution early in the planning process.

Health-risk reduction actions and strategies are discussed in greater detail in Section 4 of this report.

1.4 CARE TASK FORCE

Role of Task Force

One of the main objectives of the CARE Program has been to promote an ongoing dialogue among Air District stakeholders. In order to facilitate this dialogue, the Air District invited representatives from local health and planning departments, research institutions, regulated industry, and community organizations to participate in a Task Force.

The Air District regularly convened Task Force meetings to review, discuss, and provide input on technical studies, mitigation strategies, and other key program elements.[19] For example, the Task Force was convened when various milestones on studies were reached or when new risk reduction strategies were proposed and developed, such as amendments to regulations or Risk Reduction Plans. The Task Force served a critical role in bringing varied viewpoints, expertise, and considerations to the process.

19 Agendas and presentations from Task Force and Cumulative Impacts Work Group meetings are available at: http://www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/TF-Meetings.aspx

Joel Ervice, Associate Director, Regional Asthma Management and Prevention (RAMP)

"While data themselves seem neutral at face value, how they're selected, interpreted, and used are primarily political processes that reflect the values of those involved. As such, it was very valuable to have broad representation within the Task Force in order to make the data methodologies stronger."

Local government staff provided feedback on the viability of proposed risk reduction strategies. Health professionals shared their working knowledge of community health concerns and inequities. Some Task Force members lived or worked in the CARE Communities and brought real world perspective on problems facing their communities. The Task Force also served as a forum to hear presentations and discuss current research in the field of air quality assessments.

Figure 1.7 At a CARE Task Force Meeting, Task Force members discuss tools used to estimate health risk

Cumulative Impacts Work Group

In 2009, the Air District established a limited-term Cumulative Impacts Work Group, comprised of some Task Force members and additional representatives from the community, business, government, and non-profit organizations. The Work Group focused on reducing cumulative impacts from stationary sources through changes to existing Air District guidance and regulations. The Work Group reviewed proposed changes to the Air District's Regulation 2, Rule 5: New Source Review for Toxics Air Contaminants and updates to the CEQA Guidelines to promote adequate health protection from new and existing sources of air pollution. With the successful adoption of amendments to Regulation 2, Rule 5 in January 2010 and updated Significance Thresholds for CEQA in June 2010, members of the Work Group joined the Task Force where they continued to advise and provide guidance on CARE activities.

CARE Task Force Involvement

Task Force members represented a wide range of viewpoints, but all shared a common interest in reducing the health risk from air pollution in local Bay Area communities. The wide range of perspectives, backgrounds, and affiliations of Task Force members helped the CARE program in many ways.

- Community members on the Task Force brought Air District staff to their communities to hear about issues and to witness problems first hand.
  - The Air District held meetings in impacted communities. These meetings were most effective when members of the CARE Task Force who lived or worked in the community participated.
  - Task Force member Margaret Gordon, from the West Oakland Environmental Indicators Project, organized a bus tour to allow Air District staff and others to see firsthand the impact trucks were having on her neighborhood.

Margaret Gordon, Co-founder and Co-Director, West Oakland Environmental Indicators Project

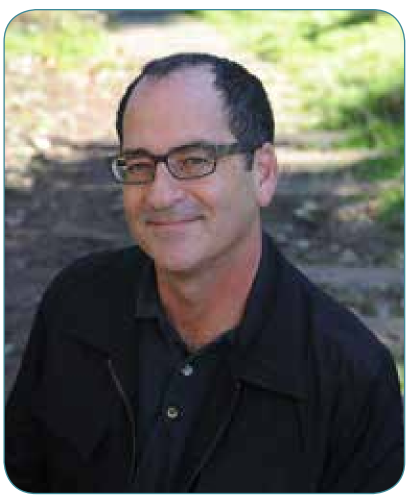
"The CARE Task Force has given the impacted communities a place to meet as equal partners with the Air District staff."

- Community members on the Task Force described their view of a successful outcome, which often involved being included in the process as active participants in scientific studies and mitigation designs.
- Community members on the Task Force helped organize and conduct community studies. For example, the Air District partnered with community members to design and conduct a truck traffic survey in West Oakland.
- Task Force members helped conduct studies and design and implement actions to reduce health risks, beyond what the Air District could do alone.
  - Task Force member Kerrie Romanow, City of San Jose Environmental Services, introduced the idea of a long-range planning approach to reducing risks in a city or community. This idea evolved into the Community Risk Reduction Plans (CRRP), described in Section 4.6.
  - Task Force member Tom Rivard, San Francisco Public Health Department, working with the Air District and with the San Francisco Planning Department, helped craft a technical and planning approach for developing a CRRP for San Francisco.

Tom Rivard, Air Quality, Noise and Radiation Program Manager
San Francisco Department of Pubic Health
(currently at San Francisco State University)

"Not everyone was as concerned with local planning issues as San Francisco; however, I believe that planning and affordable housing are pivotal issues for the CARE Task Force."

- Members of the Task Force helped the Air District evaluate proposed studies and actions from different perspectives. In discussions of whether to have stricter regulations on air pollution emissions in areas identified as impacted, business representatives argued against such an approach because it complicated existing regulations and created an un-level playing field. Community participants often favored this approach, arguing that *any* additional emissions in impacted areas should be considered significant.
- Task Force members provided useful feedback on how to present technical information to a broad audience. Comments received during Task Force meetings and on draft reports helped Air District staff clarify presentations and make reports more accessible.



Steven Moss, Founder and Executive Director
San Francisco Community Power

"Reach out to advocates that currently may not be engaged with air quality… If information is presented in the right way, they could be drawn in."

Feedback from Task Force Members

For the development of this report, Task Force members were invited to share their feedback regarding their experience on the Task Force. Task Force members expressed appreciation for the Air District's initiative in addressing the issue of disparate air quality impacts. They were impressed by the amount of technical resources dedicated to the program, and by the program's integration of science with a multi-disciplinary approach. Members commended the Air District for its transparency in how data were collected and analyzed.

Members commented on the usefulness of the program findings. Member Tom Rivard indicated, "Information from the CARE program helps people and groups develop strategies for improving air pollution problems in their neighborhoods." Member Michael Kent stated that the CARE maps were helpful in conveying health information to the cities in Contra Costa County and in applying for grants.

Members felt that one of the greatest strengths of the Task Force was its diverse membership, and stated that through their participation they gained an appreciation for the views and interests of other stakeholders. They indicated that the input provided to the Air District from diverse representation on the Task Force improved CARE program products, such as the updated methodology for identifying impacted areas, described in Section 2.4.

Janet Whittick, Policy & Communications Director, California Council for Environmental and Economic Balance (CCEEB)

"The CARE Task Force tackled many difficult issues and members often walked away knowing more about the issues and understanding the other side a little bit better."

Although Task Force members appreciated the work of the CARE program, many expressed a strong interest in moving even more quickly beyond the scientific studies toward actions to reduce air pollution. Members challenged the Air District to do more both in areas where the Air District has clear authority—such as permitting industrial facilities and developing regulations—and in areas where others have authority—such as land-use decisions.

Anna Lee, Staff Researcher/Scientist
Communities for a Better Environment (currently with the Alameda County Health Department)

"Can the CARE program do more to enhance enforcement and regulatory efforts? The Air District should take information from the program to the next level."

Task Force member Michael Kent suggested, “Discussion needs to shift from identifying most impacted communities to reducing pollution beyond what has already been done (grants, education, etc.) into areas of permitting, developing regulations, and land-use planning.”

Task Force member Jane Martin, Alameda County Department of Public Health, recommended increasing the amount of communication and collaboration with local land-use authorities, and cited an example of recent discussions on crematoriums in the county.

Some Task Force members suggested that the CARE program start to address issues related to climate change. Task Force member Margaret Gordon: “There are missing elements that the Air District hasn’t introduced regarding climate change, or climate justice... Environmental justice organizations must begin to have support for adaptation which requires actions from many decision-makers in federal, state, tribal, and local governments.”

In addition, Task Force members had constructive criticism for how to make the Task Force itself function more efficiently and be more useful to the Air District. Some improvements have already been implemented, while others will be considered in future community engagement processes. For example, members recommended: making meeting materials available further in advance of meetings; providing language translation of meeting materials; tightening meeting facilitations to move through discussions more efficiently; providing clear goals for each meeting; and being more explicit about what input from members would be most useful.

Overall, members were appreciative of the Air District’s efforts and for the opportunity to participate in a regional, multi-disciplinary Task Force. They look forward to seeing the Air District continuing to utilize CARE program findings in its policy-making.

Dr. Henry Clark, Executive Director
West County Toxics Coalition

“Serving on the CARE Task Force was an honor. The Air District’s efforts to identify hot spots or disproportionately impacted communities should help…identify the major polluting sources and help develop measures to reduce the negative impacts.”

2. REGIONAL-SCALE AIR POLLUTION ASSESSMENTS

The overarching goals of the Air District's CARE program are to identify areas where health impacts of air pollution are greatest and to help focus Air District resources to reduce or mitigate exposure to air pollution in those areas. This section describes the Air District's work to identify areas with higher exposure to air pollution and higher health impacts—specifically, to map regional variations in air pollution and related health impacts.

In the Bay Area, as in other parts of the state and country, communities with the worst air pollution tend to be those that can least bear the burden. Often these are communities with low-income and minority populations, having fewer resources and limited access to health care. Other health stressors, such as noise, crime, and poor access to healthy food, compound the problem. Research has shown that communities with multiple stressors are more susceptible to adverse health impacts from air pollution. To understand where air pollution's health impacts are greatest, the Air District has been investigating not only where pollution levels are relatively high, but also where populations are most vulnerable to air pollution.

This section discusses

- regional inventories of air pollution emissions;
- regional air pollution modeling; and
- regional mapping of air pollution levels and population vulnerabilities.

Regional air pollution maps describe variations in air pollution from one part of the Bay Area to another at a level of detail that reveals changes from city to city, and perhaps across a city, but not from block to block or from street to street. A regional or "macro-scale" analysis is helpful for developing an overview of air pollution levels and associated health impacts. Regional analyses and regional maps can help set agency priories at a high level and can help determine where finer-scale analyses might be warranted.

The CARE program's initial efforts to map areas most impacted by air pollution focused on toxic air contaminants (TAC).[20] These efforts produced several first-time results for the Bay Area: the first regional TAC emissions inventory from all major emissions sources; the first regional modeling to estimate TAC concentrations throughout the Bay Area; and the first regional maps of areas most impacted by air pollution.

Section 2.1 describes how regional toxic emissions were estimated for year 2000, 2005, and 2015.

Section 2.2 describes modeling conducted to develop regional maps of TAC concentrations and cancer risk and to estimate changes between 2005 and 2015.

20 Section 1 discusses the reasons for the initial focus on TAC.

Section 2.3 describes the Air District's initial TAC-based identification of impacted areas. This initial work used population demographics (age and family income) to identify population vulnerabilities.

Section 2.4 describes the CARE program's more recent assessment of impacted areas. The updated method includes more pollutants (ozone and $PM_{2.5}$ in addition to TAC) to identify impacts, and uses health records instead of socioeconomic factors to identify vulnerable populations.[21]

Section 2.5 provides a discussion of how regional maps of impacted areas are used by the Air District. This section also discusses applications for which these maps are not appropriate. Caveats, uncertainties, and future work related to regional maps of air pollution's health impacts are also outlined in Section 2.5.

2.1 EMISSIONS INVENTORY OF TOXIC AIR CONTAMINANTS

Objectives

In 2006, for the first time, the Air District undertook the creation of an emissions inventory for TAC from all major sources of emissions in the Bay Area, including nearly 200 toxic gases and particles. The initial TAC inventory estimated annual emission levels for the year 2000. Building on the experience and findings of the initial TAC inventory, the Air District later updated emissions to year 2005 and developed future year TAC emissions inventories for 2015 and 2020. The future year inventories helped to chart changes in TAC emissions resulting from projected growth as well as anticipated emission reductions resulting from regulations and other air quality programs. The Air District's objectives for developing the TAC emissions inventories were to:

- Identify TAC pollutants, emission source categories, and emission source areas that contribute most to health impacts;
- Track TAC emission trends over time;
- Help identify impacted areas;
- Help prioritize where additional study and emissions reductions would be most warranted; and
- Provide inputs for regional TAC modeling, which further supported the objectives above.

Methods

Methods for calculating TAC emissions are outlined below. The discussion focuses on year 2005 and year 2015, which were used for modeling. More detailed descriptions of TAC inventory development methods are available.[22, 23, 24]

21 This work was recently presented at a session of the 2013 Annual Meeting of the Air & Waste Management Association on the Air District's efforts to characterize and mitigate exposures to local air pollution sources.

22 Sonoma Technology, Inc. 2006. Preparation of Emission Inventories of Toxic Air Contaminants for the Bay Area. Dated August 9, 2006.

23 Sonoma Technology, Inc. 2008. Final Documentation of the Preparation of Year-2005 Emission Inventories of Toxic Air Contaminants for the San Francisco Bay Area. Dated February 15, 2008.

24 Sonoma Technology, Inc. 2010. Draft Documentation of the Preparation of Future-Year Emissions Inventories of Toxic Air Contaminants for the San Francisco Bay Area. Dated April 23, 2010. References 21-23 are online at http://www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

Emissions sources

- In developing emissions estimates for TAC, the Air District started with existing and available information sources focusing on three major source categories:
  - *Permitted sources*—facilities that are required to obtain operating permits from the Air District, including large industrial sources such as refineries, power plants, and chemical manufacturers, as well as smaller sources such as dry cleaners, back-up generators, and gas stations. The Air District compiles estimates of TAC emissions from these permitted sources on an annual basis.
  - *On-road mobile sources*—vehicles that travel on roads and highways such as cars, trucks, and buses. For emissions from on-road mobile sources, the Air District used traffic activity information from the Metropolitan Transportation Commission (MTC) and year-specific emissions factors (pollutant emissions per vehicle-mile travelled) from CARB's emissions factors (EMFAC) model.[25]
  - Distributed *area sources*—which include off-road mobile sources such as ships, rail, construction equipment and other broadly distributed sources, such as wood burning, paint and solvents, and consumer products. The Air District compiles estimates of criteria pollutant emissions from areas sources tri-annually and applies *growth and control factors* to estimate area source emissions for intermediate years.

Future Emissions Projections

- For future years 2015 and 2020, growth-and-control factors specific to source categories were applied to year 2005 emissions. Where control measures had been developed specifically for TAC emissions, these were applied.
  - The phase-out schedule for eliminating the use of perchloroethylene (PERC) was used to develop TAC emission estimates from dry cleaners in future years;
  - At the time of the TAC emissions development, important on-road and off-road diesel regulations had been approved by CARB but the anticipated emission reductions had not yet been included in CARB's emissions modeling programs. The Air District accounted for reductions in diesel PM from these regulations:
    - Drayage Truck Regulation,
    - On-Road Heavy Duty Diesel Vehicle In-Use Regulation,
    - Cargo Handling Equipment Regulation,
    - In-Use Off-Road Diesel Regulation,
    - Shore Power Regulation, and
    - Fuel Sulfur Regulation for Ocean-Going Vessels.

25 EMFAC2007 was the most recent version at the time.

Emissions Gridding

- Emissions were allocated into a grid of cells for use in TAC modeling, one kilometer (km) by one km.

Toxic Emissions

- Available methods for estimating emissions from on-road mobile and area sources produced emissions of criteria pollutants, rather than TAC. To estimate TAC emissions from these sources, speciation profiles were applied to all sub-categories of on-road mobile and areas sources. (The speciation profiles supplied the necessary conversion factors relating TAC emissions to total organic gases (TOG) and PM emissions.)
- To rank the relative importance of the many toxic compounds emitted in terms of their potential health impacts, emissions of each toxic compound were weighted by the Office of Environmental Health Hazard Assessment's (OEHHA's) *toxicity values*.[26]
- To compare health impacts by pollutant and by source category, toxicity-weighted emissions were summed by
  - potential cancer risk,
  - chronic non-cancer hazard quotient, and
  - acute non-cancer hazard quotient.

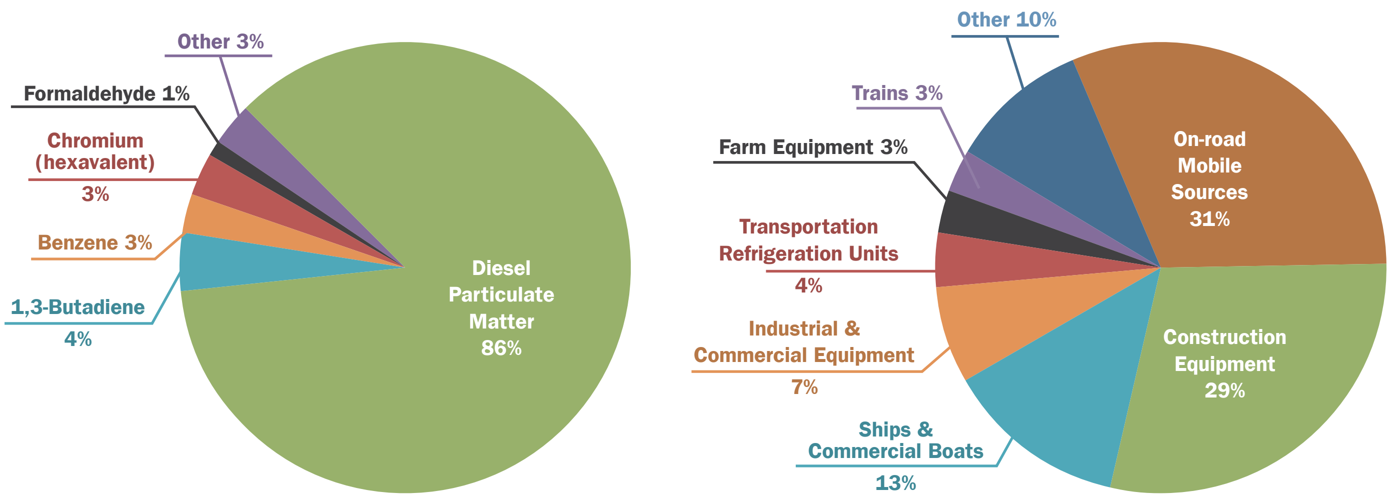
Key Findings

- One of the most important findings from the development and analysis of the Bay Area TAC emissions inventory was that diesel PM was identified as the top contributor to cancer risk-weighted emissions in the Bay Area. Diesel PM contributed more than 85% of the total carcinogenic potential of emissions (Figure 2.1).
- Carcinogenic compounds from gasoline-powered cars and light duty trucks were also identified as significant contributors: 1,3-butadiene contributed 4% of the cancer risk-weighted emissions, and benzene contributed 3%.
- Collectively, five compounds—diesel PM, 1,3-butadiene, benzene, formaldehyde, and acetaldehyde—were found to be responsible for more than 90% of the cancer risk attributed to emissions. All of these compounds are associated with emissions from internal combustion engines.
- The most important sources of cancer risk-weighted emissions were combustion-related sources of diesel PM (Figure 2.1), including on-road mobile sources (31%), construction equipment (29%), and ships and harbor craft (13%).[27]

26 A compound's toxicity value accounts for its relative potency, or potential to cause adverse health impacts, and allows for comparison to other compounds. For example, a pound of diesel particles emitted has a greater potential to cause health impacts than does a pound of emitted benzene gas, so diesel particles have a greater toxicity value. The toxicity values used were developed from cancer unit risk factors and from non-cancer, chronic and acute, reference concentrations adopted by the Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA). See on-line documentation of Hot Spots Guidelines at www.oehha.ca.gov/air/hot_spots/index.html.

27 Subsequent evaluations concluded that several important sources of off-road diesel emissions, including emissions from construction equipment were significantly overestimated. TAC modeling described in Section 2.2 reduced emissions from off-road diesel equipment by a factor of two. Recent updates to CARB's methodology for construction equipment also concluded that OFFROAD2007 significantly over-estimated emissions. See online documentation at www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles. However, the basic conclusion that diesel PM is the top contributor to risk-weighted TAC emissions is unchanged.

Figure 2.1 Cancer-risk-weighted emissions (in 2005) by pollutant (left) and by source category (right)



- Acrolein, formaldehyde, and other aldehydes were found to be significant contributors to non-cancer health impacts derived from toxicity-weighted emissions. However, the measurement method used for estimating acrolein emissions has been called into question and CARB has not yet established a new method.[28]

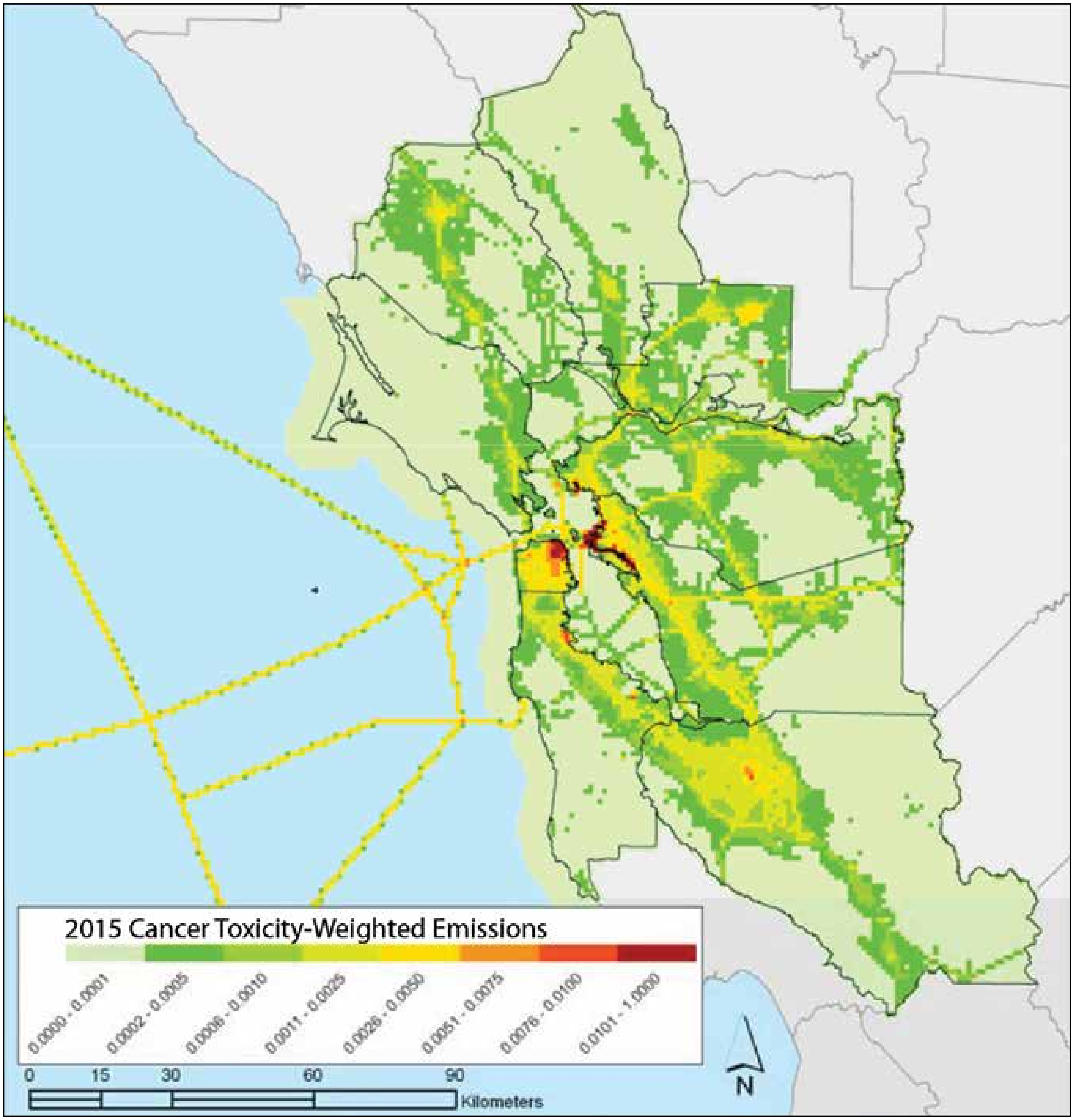
- On-road mobile sources and aircraft are the two most important source categories for non-cancer risks, comprising over 50% of all chronic toxicity-weighted emissions and almost 80% of acute toxicity-weighted emissions.

- Maps of cancer-toxicity-weighted emissions (Figure 2.2) show that cancer risk-weighted emissions are highest in the core Bay Area, near freeways, seaports, and airports. These maps underscore the importance of on-road and off-road mobile sources, particularly sources of diesel PM, to potential health impacts from TAC.

- A 75% reduction in diesel PM was predicted between 2005 and 2015 when the inventory accounted for CARB's diesel regulations.

28 California Air Toxics Emissions Factors (CATEF) database. On-line at www.arb.ca.gov/ei/catef/catef.htm

Figure 2.2 Projected Bay Area cancer risk-weighted emissions for in 2015[29]



29 In pounds per day, with each pollutant multiplied by its respective unit cancer risk factor.

2.2 MODELING TOXIC AIR CONTAMINANTS: 2005 AND 2015

Objectives

Developing a TAC emissions inventory was an important first step in understanding where potential impacts from toxic air contaminants are greatest in the Bay Area. However, to understand how the TAC emissions become dispersed regionally and how they chemically react in the atmosphere to produce ambient concentrations, it was necessary to conduct regional air quality modeling. In 2008, the Air District undertook regional TAC modeling for the top compounds of the risk-weighted TAC emissions.

The objectives in conducting regional TAC modeling were to:

- Map TAC annual average concentrations for important constituents of the TAC emissions inventory and estimate associated risk levels;
- Predict changes in risk from these TAC constituents between years 2005 and 2015, given projected changes in emissions;
- Help identify impacted areas; and
- Help prioritize where additional study and emissions reductions would be most warranted.

Methods

The Air District applied the grid-based model CAMx[30] (Comprehensive Air Quality Model with Extensions) to simulate chemical interactions and three-dimensional dispersion patterns on a regional scale for the entire Bay Area using one by one kilometer grid cells. Inputs needed for applying CAMx were: TAC emissions; meteorological inputs such as winds; and TAC concentrations at the inflow boundaries of the modeling region. Methods for developing modeling inputs, for applying CAMx, and for evaluating regional modeling results are outlined below. More detailed descriptions of Bay Area TAC modeling methods and results are available from other sources.[31, 32, 33, 34 35]

- Annual-average daily TAC emissions estimated for years 2005 and 2015 were used for modeling. Since emissions vary with the time of day (for example, rush-hour versus nighttime traffic levels), source-specific diurnal profiles (emission factors per hour) were applied to annual-average daily TAC emissions estimates to develop modeling emissions inputs.

30 Environ International Corporation, 2006. User's Guide to the Comprehensive Air Quality Model with Extentions (CAMx) version 4.30. Online at www.camx.com/home.aspx.

31 Environ International Corporation, 2008. Final Report. Demonstration Toxics Modeling for the Bay Area Using CAMx. Dated February 14, 2008.

32 Emery, C., et al. 2008. Modeling Chemically Reactive Air Toxics in the San Francisco Bay Area using CAMx. 7th Annual CMAS Conference, Chapel Hill, NC. October 6-8, 2008.

33 Bay Area Air Quality Management District, 2009. Toxics Modeling to Support the Community Air Risk Evaluation (CARE) Program. June 2009.

34 Bay Area Air Quality Management District, 2011. 2015 Toxics Modeling to Support the Community Air Risk Evaluation (CARE) Program. January 2011. References 31 and 32 are online at http://www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling/Toxics-Modeling.aspx

35 Martien, P., et al., 2011. Regional Air Toxics Modeling in California's San Francisco Bay Area. Presented at the American Geophysical Union Annual Fall Meeting, 2011. Online at www.baaqmd.gov/Divisions/Planning-and-Research/Research-and-Modeling/Publications/Posters.aspx

- An adjustment was made to off-road diesel emissions to account for an over-estimation in CARB's OFFROAD2007 model.[36]
- Meteorological fields for winter and summer periods in 2000 were generated using the MM5 mesoscale meteorological model.[37]
- Boundary concentrations for most pollutants were set to zero. For diesel PM, inflow boundaries from the surface to 500 meters were set to match values approximated from surface observations; above 500 meters, the boundary conditions were set to zero.
- Modeling inputs were supplied to the CAMx model to predict concentrations of toxic air contaminants. Some toxic compounds, such as diesel PM, were treated as inert compounds. Other contaminants, such as benzene, 1,3-butadiene, and acrolein, undergo photochemical reactions in the atmosphere; for these pollutants, the reactive tracer chemical of CAMx was used.
- Annual-average concentrations of TAC pollutants were estimated as a weighted average of summer and winter period average concentrations.
- Air quality model performance was evaluated by comparing modeling results with observed TAC.[38] Modeled seasonal averages of gaseous TAC concentrations near measurement sites were compared to observed seasonal (July and December) averages over years 2004–2006. Simulated diesel PM was compared to observed seasonal averages of elemental carbon (EC) as a surrogate for diesel PM for 2005–2006.
- To estimate potential cancer risks from predicted TAC concentrations, concentrations were multiplied by their corresponding cancer risk factors. Total cancer risk, assuming a 70-year exposure to the annual-average concentration, was estimated by combining cancer-risk weighted concentrations of five species: diesel PM, 1,3-butadiene, benzene, formaldehyde, and acetaldehyde. Together, these five species accounted for more than 95% of the modeled risk-weighted emissions.

Key Findings

- Diesel PM was the largest contributor to modeled cancer risk from air pollution.
- Modeled cancer risks from TAC in 2005 were highest near sources of diesel PM: near core urban areas, along major roadways and freeways, and near maritime shipping terminals. Peak modeled risks were found to be located east of San Francisco, near West Oakland and the Maritime Port of Oakland (Figure 2.3, left).
- These findings are similar to those reported by the South Coast Air District,[39] which also found modeled cancer risks to be highest near ports and other sources of diesel PM.

36 TAC modeling reduced emissions from off-road diesel equipment by a factor of two. Recent updates to CARB's methodology for construction equipment also concluded that the OFFROAD2007 significantly over-estimate emissions. See online documentation at www.arb.ca.gov/msei/categories.htm#offroad_motor_vehicles

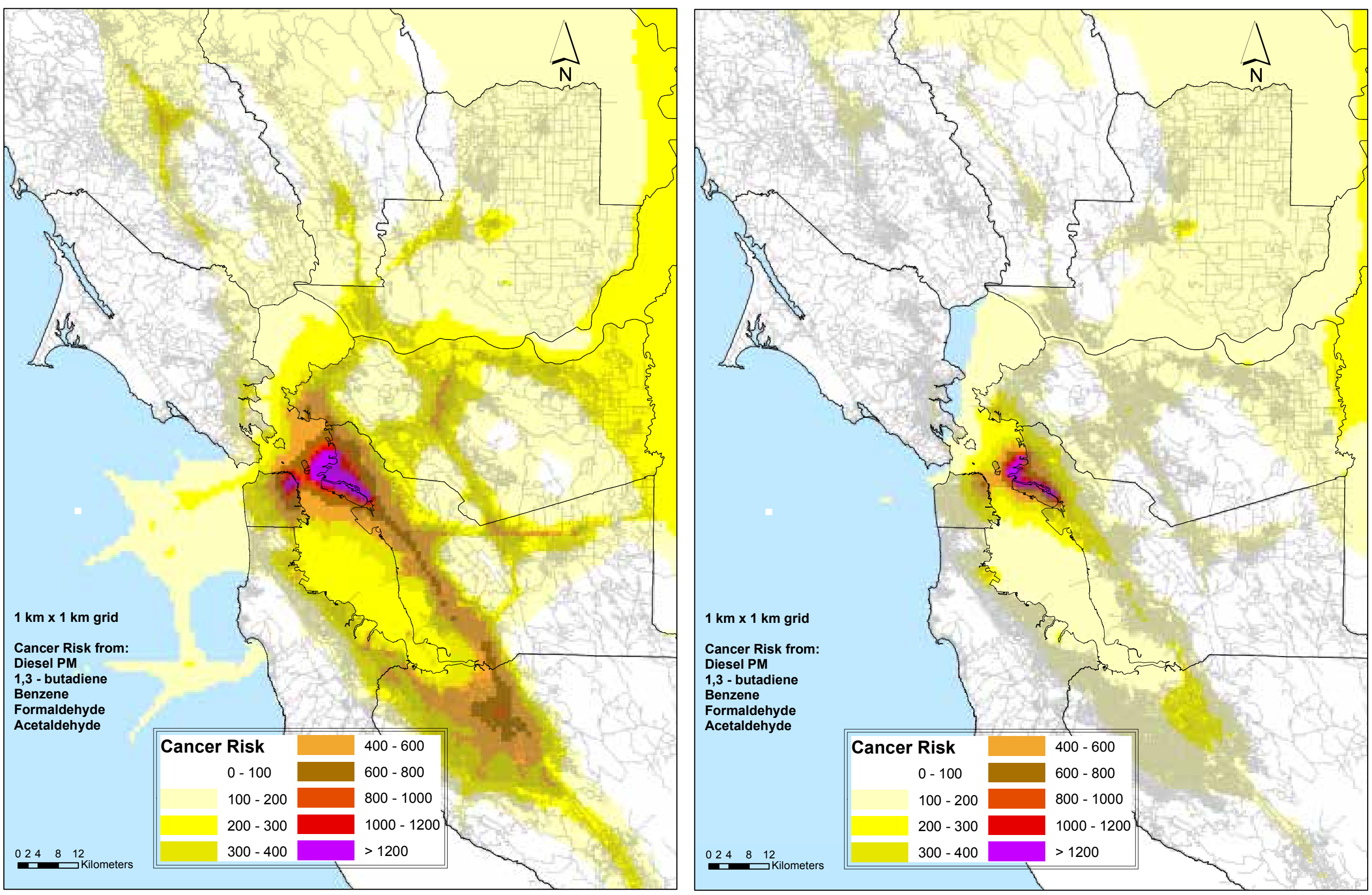
37 Grell, G.A., Dudhia, J., Stauffer, D.R., 1994. A Description of the Fifth Generation Penn State/NCAR Mesoscale Model (MM5). NCAR Technical Note, NCAR/TN-398+STR.

38 Measurements collected at Air District monitoring sites, shown in Figure 1.5, were used to assess TAC levels. Elemental carbon measurements were used to estimate diesel PM.

39 South Coast Air Quality Management District. 2008. Multiple Air Toxics Exposure Study (MATES-III) in the South Coast Air Basin. Final Report.

- The locations of areas with highest potential cancer risk in 2015 (Figure 2.3, right) are similar to those in 2005 (Figure 2.3, left).
- Risks are projected to decline by more than 50% in most areas between 2005 and 2015, mostly due to significant reductions in diesel PM.
- Modeled TAC levels were consistent with reported observations for most gaseous compounds, with the exception of acrolein. Reported levels of acrolein were much larger than modeled levels, but there is a high degree of uncertainty associated with the measurements.
- Modeled diesel PM and measured elemental carbon (EC) were close at most sites. At some rural sites, measured EC was higher than simulated diesel PM; at these sites winter wood smoke may have contributed to an excess of EC.

Figure 2.3 Potential cancer risk from toxic air contaminants for the Bay Area in year 2005 (left) and 2015 (right)[40]



40 Risk values assume a 70-year constant exposure. Units are excess cancers per million people exposed.

2.3 IDENTIFYING IMPACTED COMMUNITIES—VERSION 1

Objectives

In 2009, for the first time, the Air District identified and mapped areas within the Bay Area with relatively high levels of toxic air pollution and with people who are relatively more vulnerable to the harmful health impacts of air pollution. Regions where relatively high levels of pollution overlapped with more sensitive populations were used as a basis for identifying impacted communities. The Air District's objectives in identifying and mapping impacted areas were to:

- Identify areas with highest potential for exposure to TAC and with vulnerable populations; and
- Develop maps to help direct Air District resources to:
    - Prioritize grant and incentive funding,
    - Focus enforcement activities,
    - Develop regulations targeting pollutants and sources of concern in impacted areas,
    - Inform planning activities that mitigate air pollution exposures,
    - Direct outreach efforts, and
    - Direct special studies.

Methods

The version-1 method for determining impacted communities identified Bay Area locations that had high pollution levels, as indicated by concentrations and emissions of carcinogenic TAC, and vulnerable populations, as indicated by high percentages of youth and senior populations and low-income families, based on population statistics from the 2000 US Census. The primary criterion of impact was exposure of youth and seniors in areas with elevated potential cancer risk from TAC. Potential cancer risk from TAC was assessed using the 2005 regional TAC modeling and cancer risk factors established by Cal/EPA, as described in Section 2.2. Areas with highest exposure for vulnerable populations were estimated using the top 50% of modeled potential cancer risk from TAC exposure for youths and seniors (under 18 and over 64).

Because a primary objective for creating the map was to focus Air District resources in reducing emissions, another important criterion was high TAC emissions adjacent to areas of high exposure. Emissions were derived from the 2005 TAC inventory described in Section 2.1, with each TAC compound scaled by its unit cancer risk factor. Areas with high exposure were selected as candidate areas of impact in the version-1 method when there were also nearby areas having TAC emissions in the top 25%.

One additional factor used to identify impacted areas was household income. Areas with high exposures of youth and seniors and high emissions were identified as impacted when at least 40% of families in nearby areas were classified as low-income (below 185% of the federal poverty level, a threshold used by the Association of Bay Area Governments).

Boundaries for impacted areas were constructed along major roads, highways, shorelines, or county boundaries that encompass nearby high exposure areas, high emission areas, and low income areas (as defined above).

More detailed descriptions of methods applied to produce the first set of maps are available.[41]

First Maps of Impacted Areas

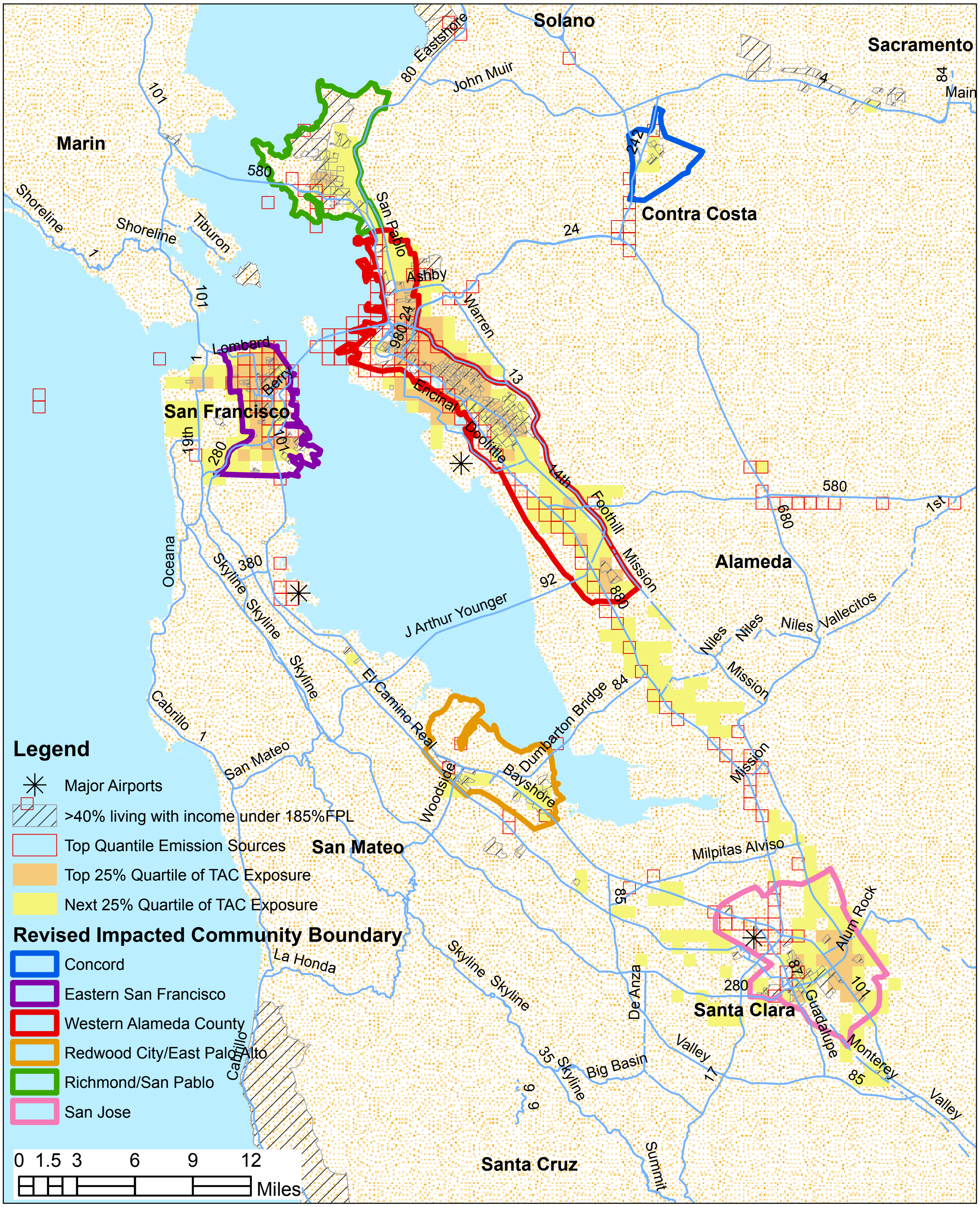
The version-1 method identified six areas as impacted communities[42] (colored polygons in Figure 2.4). Areas identified included portions of, and tracts near:

1. Western Contra Costa County and the Cities of Richmond and San Pablo;
2. Western Alameda County along the Interstate-880 corridor and of the Cities of Berkeley, Oakland, San Leandro, and Hayward;
3. The City of San Jose;
4. Eastern San Mateo County and the Cities of Redwood City and East Palo Alto;
5. The eastern side of the City and County of San Francisco; and
6. The City of Concord.

41 Bay Area Air Quality Management District. 2009. Applied Method for Developing Polygon Boundaries for CARE Impacted Communities. Technical Memorandum. Dated December 2009. Online at: http://www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

42 An electronic file that can be used with geographical information systems software provides the polygon boundaries of the CARE impacted communities is available online at ftp://ftp.baaqmd.gov/pub/CARE/Impacted_communities_boundaries/.

Figure 2.4 Boundaries of impacted communities based on exposure of vulnerable populations in Bay Area counties in 2005 to toxic air contaminants (orange and yellow squares), emissions (red outlined squares), and poverty level (gray hashing)



2.4 IDENTIFYING IMPACTED COMMUNITIES—VERSION 2

Objectives

Since 2009, when the Air District developed the initial maps of impacted areas, additional data, methods, and tools have become available. In 2014, the Air District updated the maps of impacted areas, incorporating new data and methods. The fundamental goal remained the same: to identify and map areas within the Bay Area with relatively high levels of air pollution and with residents who are relatively more vulnerable to the harmful health impacts of air pollution. The Air District's specific objectives in updating maps of impacted areas were to:

- Identify vulnerable populations by directly estimating health impacts of air pollution;
- Consider additional pollutants. Specifically, identify areas with highest heath impacts from exposure to fine PM and ozone, in addition to cancer risk from TAC;
- Consider existing rates of air-pollution related diseases in estimating heath impacts; and
- Develop maps to prioritize and focus activities that mitigate air pollution exposures and direct special studies, as before.

Methods

In addition to using more recent data, the version-2 method is different from version 1 in two important respects. First, health impacts from fine PM and ozone were also considered, in addition to cancer risk from TAC. Second, the version-2 method used existing health records, rather than socioeconomic measures (such as income and age), as indicators of population vulnerabilities.

Key components of the version-2 method are shown schematically in Figure 2.5. Potential cancer risk from TAC (top sequence of steps in Figure 2.5) was considered in version 1 and is also considered in version 2. Health impacts from fine PM and ozone (bottom sequence) included increased mortality rates and increased costs from emergency room visits and hospitalizations for many respiratory and cardiovascular diseases aggravated by air pollution.[43] These impacts were estimated using the BenMAP model[44] from US EPA. BenMAP uses published health studies to predict an increase in health impacts with increments in pollutant concentrations using two key sets of inputs:

- Air pollution levels above background, and
- Health records, including baseline rates of mortality, ER visits, and hospital admissions within a community.

Baseline rates of mortality, ER visits, and hospital admissions are used in BenMAP because areas with higher existing health impacts are generally more susceptible to adverse effects from air pollution, even if the higher baseline rates of health problems are not linked to air pollution. For example, for two areas with the same $PM_{2.5}$ and ozone levels, this approach would predict a higher increase in asthma hospitalizations from air pollution in the area with higher baseline asthma hospitalization rates, regardless of underlying causes of the baseline rates.

43 Diseases included asthma, pneumonia, COPD, other respiratory diseases, heart attack, and other cardiovascular diseases.

44 See documentation online at www.epa.gov/air/benmap/

Finally, potential cancer risk was combined with health impacts from fine PM and ozone to form a single metric, the *pollution-vulnerability index* (Figure 2.5). PVI represents the combined effects of

- cancer risk from TAC,
- mortality rates from $PM_{2.5}$ and ozone above background, and
- health costs from ER visits and hospitalizations from $PM_{2.5}$ and ozone levels above background.

The effects listed above were ranked, highest to lowest, and the sums of ranks within a zip code area formed the PVI.

Baseline rates[45] of mortality, ER visits, and hospital admissions used as input were determined from death records and health records from recent years.[46] Since the health records were available by zip code, the analysis of impacted areas for version 2 was based on zip code areas.

Air pollution levels in the Bay Area used as input were mapped to zip code areas. As before, the version-2 method accounted for areas with relatively high cancer risk from air pollution, but reflected more current conditions by using regional modeling for TAC levels in 2015 to estimate cancer risk, instead of 2005 modeling. Figure 2.6 (a) shows potential cancer risk from TAC for year 2015. Annual average $PM_{2.5}$ above background levels, shown in Figure 2.6 (b), was estimated using regional air quality modeling and observations from Bay Area measurement sites. Mean 8-hour ozone above background levels, shown in Figure 2.6(c), was interpolated from observations at Bay Area measurement sites only.[47] Figure 2.6 shows that cancer risk values are highest in the urban core of the Bay Area, where most TAC emissions occur. PM concentrations are also high near these same high emission areas, but since some PM is formed in the atmosphere from other pollutants, it also tends to be high downwind from the highest emission sources. Ozone concentrations are highest downwind of the highest emissions, since nearly all ozone is formed from other pollutants.

Figure 2.7 shows PVI values in zip code areas throughout the Bay Area. A low value of the PVI corresponds to lower health impacts; a high value corresponds to higher health impacts. By considering existing rates of mortality and illnesses when determining health impacts from fine PM and ozone, in addition to the levels of these pollutants, *population vulnerability* was accounted for in the PVI. The highest PVI values occur where TAC and PM concentrations are high and where health records indicate higher rates of illness associated with air pollutants.

In the version-2 method, boundaries were drawn to encompass areas within the top 15% of the PVI. These boundaries were selected to follow major roads, highways, shorelines, or county boundaries. Socioeconomic data were not used to identify impacted areas. However, once impacted areas were identified, population demographics within them were examined, including race, income, and education level.[48] More detailed descriptions of methods applied to produce version-2 maps are available.[49]

45 Baseline rates were age-adjusted, meaning that age differences between one community and another were not a factor in determining vulnerability. Alternatives to applying age-adjustments will be explored in future work.

46 Death records were obtained for years 2008-2010. Emergency room visits and hospital records for illnesses aggravated by air pollution were obtained for years 2009-2011.

47 Since ozone modeling was only available for a few time periods and since ozone concentrations change more gradually from one location to another than $PM_{2.5}$ concentrations, using measurements only was found to produce more realistic results for predicting mean 8-hour ozone levels than using a combination of modeling and measurements.

48 Population totals for major ethnic groups were obtained from the 2010 Census. Data on income and education were obtained from the American Community Survey for 2006-2010.

49 Martien, P. et al., Identifying Areas Impacted by Air Pollution in the San Francisco Bay Area, Version 2. March 2014. Bay Area Air Quality Management District Technical Memorandum. Online at www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

Figure 2.5 Schematic representation of the version-2 method

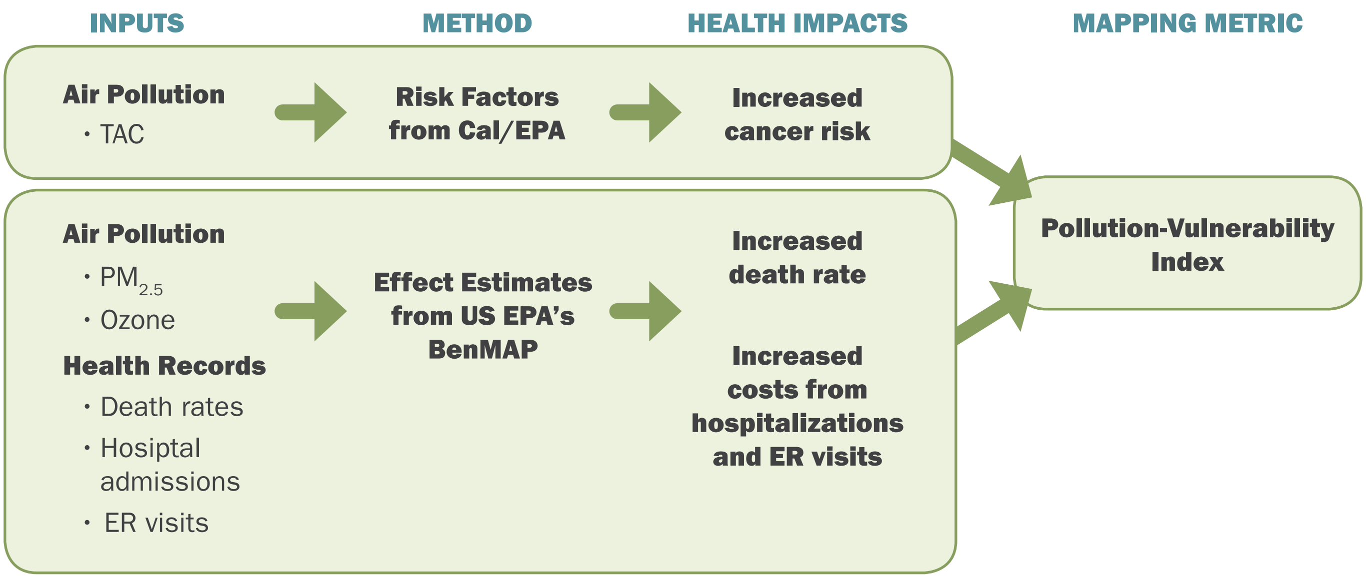


Figure 2.6 Cancer risk and air pollution levels mapped to zip code areas: (a) cancer risk from air toxics, (b) annual $PM_{2.5}$, and (c) mean 8-hour ozone above background

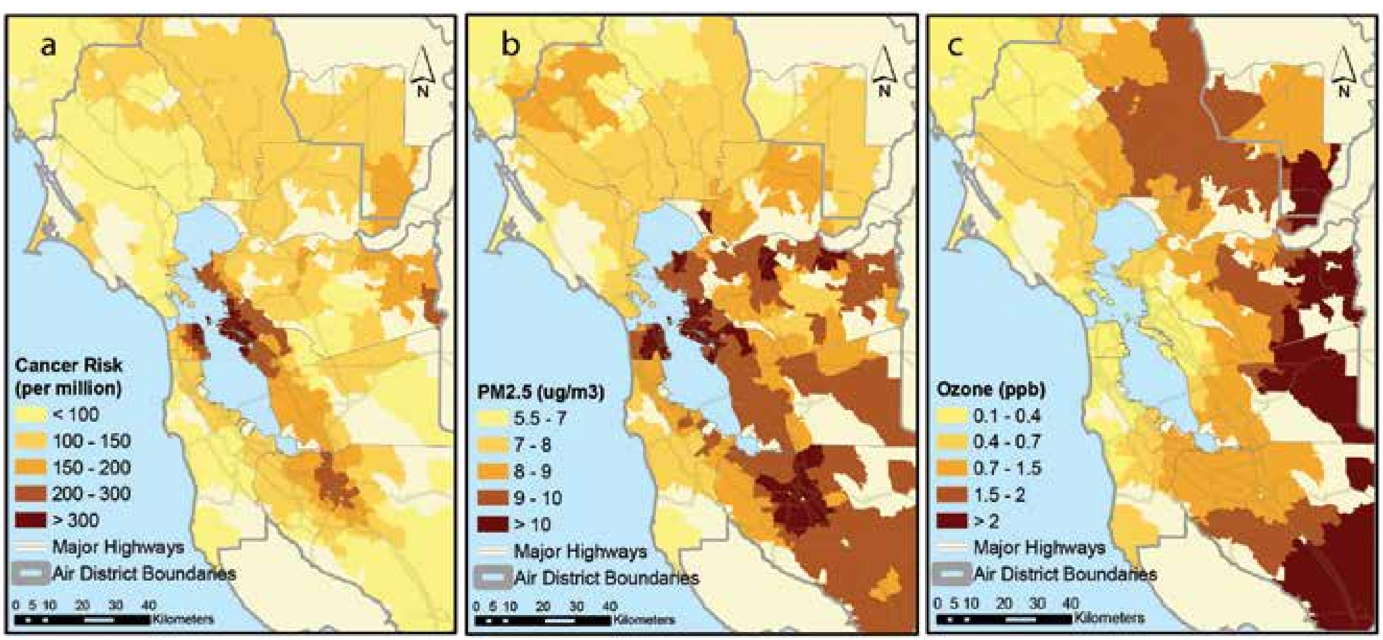
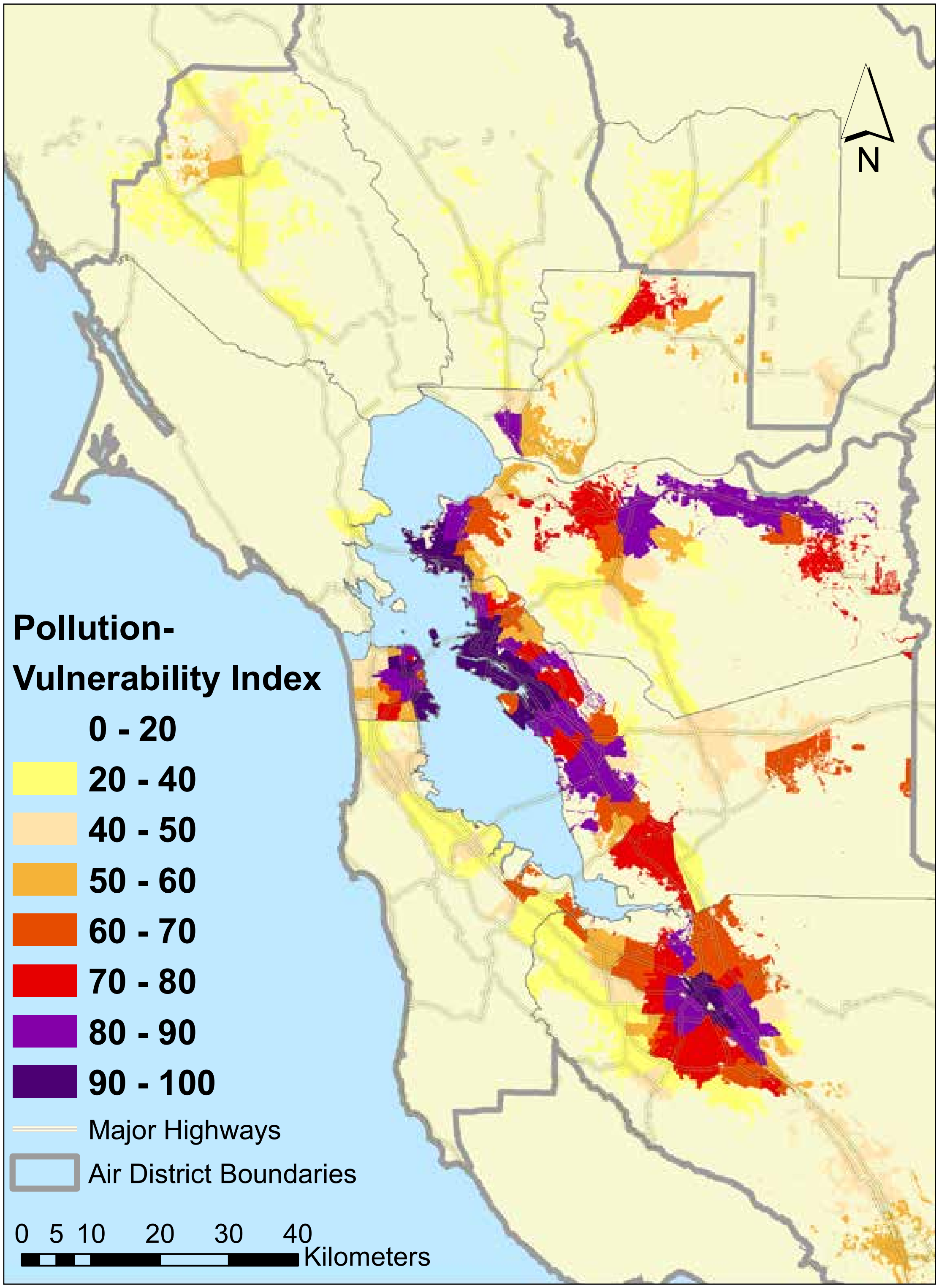


Figure 2.7 The pollution-vulnerability index uses information on air pollution levels and health outcomes for each zip code area[50]



50 Only populated portions of each zip code area are shown.

Updated Maps of Impacted Areas

The version-2 method identified seven areas as impacted communities[51] (blue polygons in Figure 2.8). Areas identified included portions of and tracts near:

1. Western Contra Costa county and the Cities of Richmond and San Pablo;
2. Western Alameda County along the Interstate-880 corridor and the Cities of Berkeley, Alameda, Oakland, and Hayward;
3. The City of San Jose; and
4. The eastern side of the City and County of San Francisco;
5. The City of Concord;
6. The City of Vallejo;
7. The Cities of Pittsburg and Antioch;

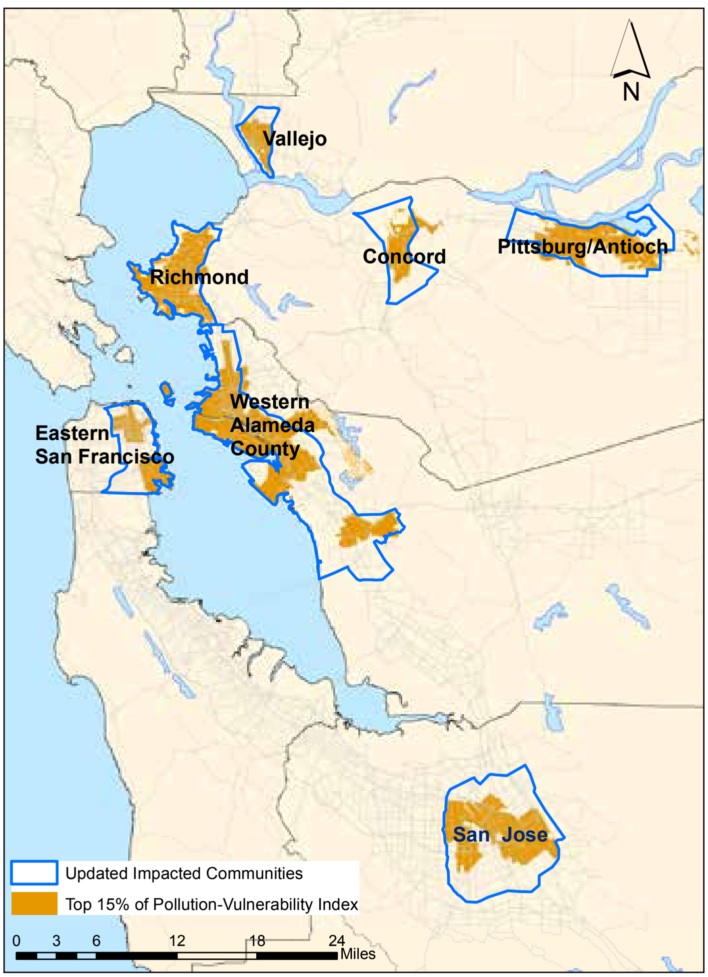


Figure 2.8 shows the top 15% of the PVI, where combined health impacts are predicted to be greatest. These are Bay Area communities with the highest cancer risk, mortality rates, and health costs from air pollution.

Figure 2.8
Updated impacted areas (blue lines) based on areas with high pollution-vulnerability index (PVI)

Orange areas show the top 15% of PVI

51 An electronic file that can be used with geographical information systems software provides the polygon boundaries of the CARE impacted communities is available online at ftp://ftp.baaqmd.gov/pub/CARE/Impacted_communities_boundaries/.

Key Findings

In the version-2 method, socioeconomic information was not used in determining the PVI or to identify impacted areas. However, there is a clear correlation between PVI and socioeconomic factors such as income, race, and education levels. Figure 2.9 shows average annual household income and population race/ethnicity percentages versus values of PVI. In Figure 2.9, the bottom 20% of PVI contains the least impacted areas while the top 20% contains the most impacted areas. Figure 2.9 shows:

- Average annual household income is more than $40,000 greater in the lowest PVI areas than the highest PVI areas.
- Areas with the lowest PVI are more than 70 percent white, while areas with the highest PVI are nearly 70 percent non-white. The percentage of Hispanics in the highest index areas is double that in the lowest index areas. The percentage of blacks is more than five times higher in the highest index areas than the lowest index areas.

Additional analysis (not shown) found that on average, residents in areas with the lowest PVI have a year and a half more education than residents in the highest PVI areas. Further, on average, residents in areas with the lowest PVI live three years longer than residents in the highest PVI areas.

Figure 2.9 Household income (left) in US dollars and race/ethnicity (right) in percent for ranges of the pollution-vulnerability index

Comparing Version-1 and Version-2 Maps of Impacted Areas

Version-1 and version-2 impacted areas (compare Figure 2.10 left to right) share many similarities, but there are some important differences:

- The Redwood City/East Palo Alto area is not included in the version-2 map. This area was included in the version-1 map because of relatively high cancer risk, which is lower in the version-2 analysis due to significant reductions in emissions of diesel PM in 2015 compared to 2005. Fine PM levels in this community are generally similar to those in most other Bay Area communities and ozone values are lower.
- Two communities, Vallejo and Pittsburg/Antioch, have been added in the version-2 method. The addition of these two communities was mostly determined by the relatively high levels of fine PM in these areas and was also influenced by health records there.
- Several impacted areas were expanded:
  - the eastern San Francisco area now includes Treasure Island;
  - the San Jose area was expanded to the west;
  - the western Alameda County area was expanded to the bay coast and now includes the City of Alameda; and
  - the Concord area was expanded to the north.

The addition of two communities and the expansion of others in the updated map does not imply that air pollution in the Bay Area is getting worse. In fact, air pollution levels have been dropping in nearly all Bay Area communities. The addition and expansion of areas is due to the added consideration of new pollutants, primarily $PM_{2.5}$, in the version-2 method. Adding $PM_{2.5}$ has identified new areas disproportionately affected by fine particulate matter.

Comparing Version-2 Maps to Recent Screening Methods

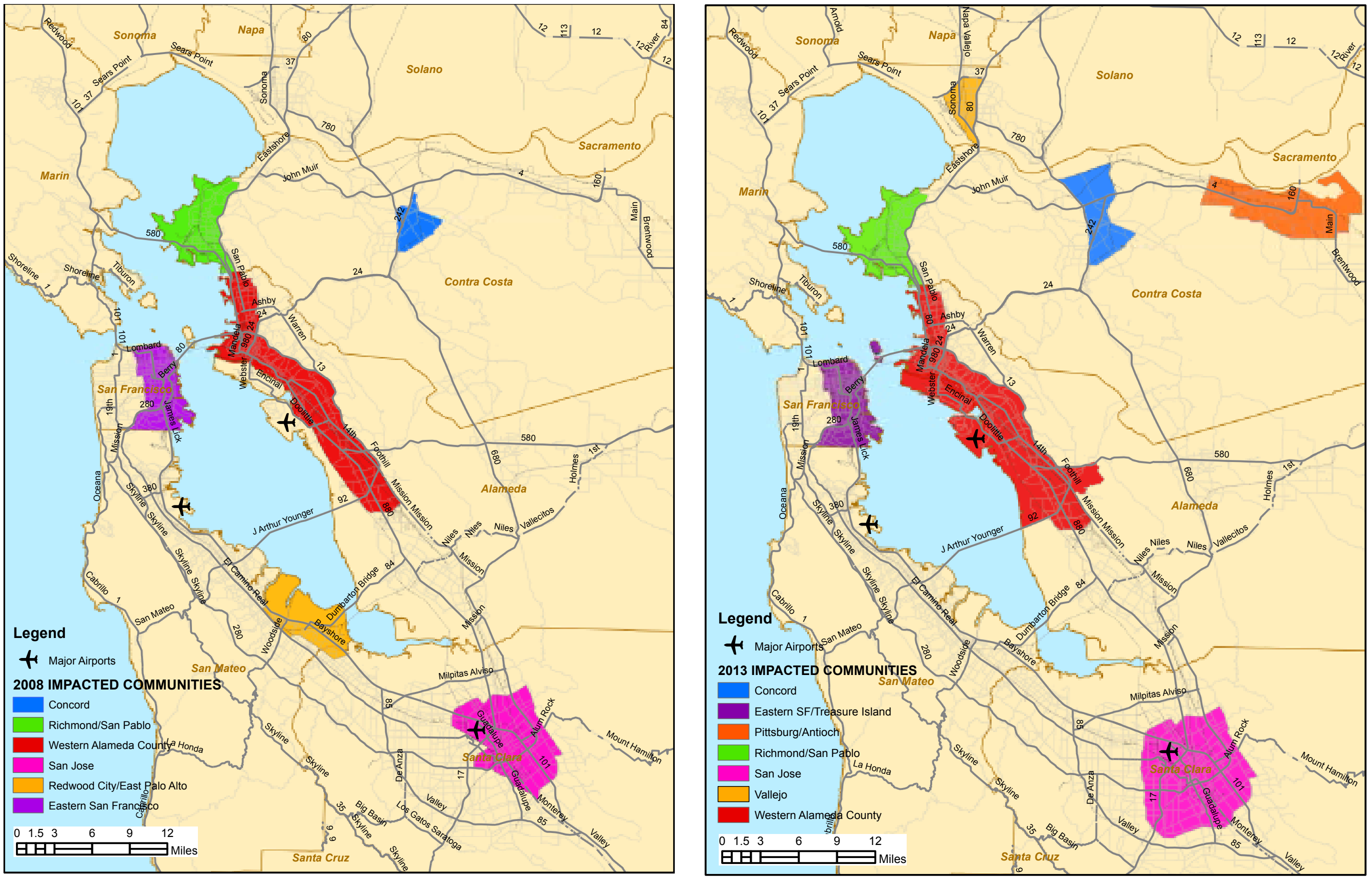
At the state level, Cal/EPA's OEHHA has developed a screening tool, CalEnviroScreen,[52] for identifying areas within California that are likely to experience health impacts from environmental pollutants, including air pollution. CalEnviroScreen follows an approach to identifying impacts advanced by developers of an earlier screening tool, the Environmental Justice Screening Method (EJSM).[53,54] Unlike the Air District's version-2 method, CalEnviroScreen and EJSM do not attempt to directly estimate health impacts from pollution. Rather, these screening tools use likely surrogates of impact, including: pollution levels; proximity to sources; socioeconomic and demographic factors; and health records. Screening based on these indicators can help to identify areas where residents may be particularly affected by environmental pollution. In spite of significant differences in their approaches, the areas within the Bay Area identified by these methods are nearly the same as those identified by the Air District's version-2 method.

52 California Communities Environmental Health Screening Tool, Version 1 (CalEnviroScreen 1.0); California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, April, 2013. Online: www.oehha.ca.gov/ej/pdf/042313CalEnviroScreen1.pdf

53 Sadd, J.L., Pastor, M., Morello-Frosch, R., Scoggins, J., Jesdale, B., 2011. Playing It Safe: Assessing Cumulative Impact and Social Vulnerability through an Environmental Justice Screening Method in the South Coast Air Basin. *Int. J. Environ. Res. Public Health*, 8(5), 1441-1459; doi:10.3390/ijerph8051441

54 Morello-Frosch, R., M. Pastor, J.L. Sadd. 2012. Environmental Justice Screening Method. (EJSM) and Community Participation. Presented at the June 6, 2012, CARE Task Force Meeting. Online: www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/TF-Meetings.aspx

Figure 2.10 Impacted areas identified by the initial version-1 method (left) and by the updated version-2 method (right)



2.5 APPLICATIONS FOR MAPS OF IMPACTED AREAS AND OTHER AREAS OF CONSIDERATION

Impacted Area Maps

The updated maps, like the initial maps of impacted areas, provide a “macro-scale” identification of impacted communities. This means that communities identified in the maps share characteristics that suggest greater health impacts from air pollutants relative to other areas in the region. These regional maps will be used to help prioritize and focus the Air District’s activities and resources. In these areas the Air District will continue to

- Prioritize grant funding for projects that reduce emissions;
- Focus enforcement activities;
- Develop new and revised regulations that consider source categories contributing to local impacts;
- Provide assistance in developing Community Risk Reduction Plans;
- Focus outreach and community education and engagement programs; and
- Conduct special studies to measure and model local air pollution impacts.

While the maps of impacted areas help form the foundation of the Clean Air Communities Initiative (CACI), a program which brings resources from throughout the Air District to protect public health in impacted communities, they do not identify all areas with air quality concerns in the Bay Area. Additional types of concerns may not be fully addressed by the impacted areas maps.

Additional Conisderations

One additional concern is for areas throughout the region where there are *episodes* of relatively high air pollution, that is, certain days on which air quality standards are exceeded (ozone in summer, PM in winter). These areas may not experience the same chronic health impacts associated with the areas identified by version 2, but public health in such areas is adversely affected on days when air quality measurement sites record exceedances of state and federal standards for air pollution. A second additional concern is for local, source-specific impacts that are not identified in the maps of macro-scale impacts. For example, in certain neighborhoods, wood smoke may build up to unhealthy levels on calm winter nights. Various programs at the Air District are in place and being implemented to address these important additional concerns.

Episodic Exceedance Sites

While pollution levels are declining in nearly all parts of the Bay Area, the Air District's measurement sites still sometimes record episodes of air pollution at levels above state and federal standards. These episodes may occur within areas identified as having the greatest health impacts (i.e., CARE communities) but also occur outside these areas. Locations outside the impacted areas with air pollution exceedances may not suffer the same level of impacts as those inside because of the episodic nature of the high air pollution or because of the type of pollutants. However, air quality and health are a concern at all locations with exceedances. Historically the Air District has focused most of its resources to bring regional air pollution levels down throughout the region. Indeed, programs to address regional air pollution continue to be a primary focus of the Air District's resources and activities.

Figure 2.11 shows measurement locations (blue shading) where 8-hour ozone levels exceeded the federal standard (75 ppb) three or more times in the last three years (2011-2013). Livermore, San Ramon, and Bethel Island sites sometimes exceed the ozone standard, but are not within the areas identified as having the highest health impacts (orange shading), because PM and TAC levels at these sites are not high relative to other areas. However, the Air District recognizes the importance of continuing programs to reduce ozone and its associated health impacts in these areas. Importantly, precursor emissions that lead to high ozone in places like Livermore can be traced to upwind areas like San Francisco and Oakland. Emissions reductions in these upwind areas have reduced ozone impacts in Livermore and will continue to do so. (See the discussion of ozone trends in Section 1.1.)

Figure 2.11 also shows locations (red outline) where 24-hour $PM_{2.5}$ levels exceeded the federal standard (35 mg/m^3) in the last three winters (2010-2012). San Rafael was not identified as being within an impacted area, despite experiencing episodes of high PM, because average PM levels remained relatively low. In areas such as San Rafael, San Ramon, and Livermore, it is also true that health records indicate lower rates of health impacts related to air pollution compared to areas identified as impacted.

Maps of exceedance sites will continue to direct Air District actions to:

- Develop and implement plans and programs to reduce episodes of peak pollution;
- Focus outreach and community education and engagement programs;
- Inform Spare-the-Air alerts; and
- Conduct special studies to measure and model regional air pollution impacts.

Figure 2.11 Episodic exceedance sites for ozone and fine particulate matter

Some areas that have episodes of high air pollution (blue shading, red outlines) are outside the updated areas identified as having greatest health impacts (orange shading)

Source-Specific Impact Areas

Regional maps of impacted areas do not fully inform all air pollution management activities. Regional patterns can become more nuanced and variable at the local level. While regional maps guide many of the Air District's actions and directions, for some applications, local assessments—at the level of communities and even city blocks—can provide better representations of air pollution levels, exposures, and health impacts. For example, not all neighborhoods in impacted communities necessarily face greater health threats. There is a greater density of relatively unhealthy neighborhoods in the impacted communities; but there are also neighborhoods within impacted communities that are just as healthy as other parts of the Bay Area, or healthier.

Conversely, neighborhoods outside areas identified as impacted can have important source-specific, localized impacts. The density of sources may not be sufficient to identify impacts in a macro-scale regional analysis, but localized exposure may still be important. For example, regional mapping may not reveal source-specific, local impacts in the following situations:

- Near freeways or busy roads. Residents may face local air pollution health impacts if they are close to freeways or busy roadways.
- Near wood burning. Residents in neighborhoods where there is a high level of wood burning in wood stoves and fireplaces can experience unhealthy levels of fine particulate matter.
- A local industrial source. Residents near a specific industrial source may be exposed to relatively high levels of air pollution.

In general, at a specific location or site, additional analyses are required to determine actual risks or hazards, whether the location is within or outside an impacted area. In recognition of the importance of localized sources, the Air District advises local staff evaluating new development projects not to rely on impacted areas maps to assess exposures. Rather, they should use local-scale analyses to determine if new residents would be exposed to a significant level of air pollution.

Local air pollution impacts, and Air District responses, are explored in greater detail in Section 3, *Local-scale Air Pollution Monitoring and Assessments*. In future work, the Air District will continue to make improvements to regional maps of air pollution's health impacts. Discussion of next steps for identifying impacted areas is presented in Section 5, *Key Findings, Lessons Learned, and Next Steps*.

3. LOCAL-SCALE AIR POLLUTON MONITORING AND ASSESSMENTS

The regional studies and analyses of Section 2 can guide policy decisions and can help focus resource allocations. However, for many applications we need more detailed, fine-grained information. Because air pollution from individual sources disperses quickly, local activities and near-by emissions sources can strongly influence local pollutant exposures even if they have only a minor influence on regional exposures. To more accurately assess exposures and health impacts in a neighborhood, or near a specific location, local-scale studies and analyses are needed. For example, many studies have found that air pollution from busy freeways has serious health implications for residents within a few hundred feet of the freeway. Beyond the first few hundred feet, air pollution levels and health impacts drop sharply. Pollutants drop to near background levels by about 1,000 feet from the edge of road for most roadways.

Local-scale air quality studies collect various types of information to make neighborhood or site-specific impact assessments. Typical components of a local-scale study include information to determine and track emission levels and pollutant concentrations. Examples of such considerations include the following:

- Activity levels and types of equipment or industries may be surveyed at specific locations.
- Emission levels from specific air pollution sources may be measured.
- Air pollution concentrations and concentration gradients may be monitored at varying distances from pollution sources within a community;
- Dispersion modeling may be conducted to determine near-source pollution concentrations and gradients.
- Risk levels or health impacts may be estimated based on measured or modeled air pollution concentrations.

The overarching goal of local-scale air quality studies undertaken through the CARE program has been to develop information and tools to reduce exposures to local sources of air pollution and reduce associated health impacts, especially in impacted communities.

Local-scale studies have been designed to support reductions in health impacts from air pollution following two distinct approaches:

1. Efforts to *reduce air pollution emissions* and
2. Efforts, through urban planning processes, that avoid bringing people near pollution sources or that design sites and buildings to *reduce exposures*.

The first approach falls under the jurisdiction of the Air District or under the jurisdiction of the Air District's state and federal partners. The second approach requires coordination and partnering with local staff and developers at the regional and city/county level.

Another goal of local-scale air quality studies is to track progress in reducing health impacts. The CARE program's local-scale studies have been designed to inform efforts to reduce health impacts related to air pollution and to track those reductions. Section 3 summarizes the CARE program's local-scale studies, highlighting their objectives, methods, and key findings. Many of the studies summarized were the first of their kind for the Air District. Although the Air District has had a long-standing concern for local-scale impacts, these studies represent a renewed and increased level of commitment to addressing multiple sources of air pollutants at the neighborhood scale.

Section 3 also highlights the many collaborations and partnerships that have made these studies possible. These partnerships have greatly extended what the Air District could have achieved working alone. Not only have technical experts contributed to these studies, but community members and organizations also have actively participated in the design and implementation and lent their local knowledge and resources to the studies. Partnerships with and feedback from regional and local planning organizations have also enhanced these studies and their relevance in the planning arena.

Sections 3.1 through 3.4 describe studies that collectively form a case study assessing local-scale air pollution in West Oakland, one of the most impacted areas in the Bay Area. West Oakland is home to approximately 22,000 residents and is bounded by the Maritime Port of Oakland (the Port), the Union Pacific rail yard, and I-580, I-880, and I-980 freeways. The combination of ship, rail, and freeways, and associated local truck activity within this community, contribute high levels of diesel PM emissions. Between 2005 and 2010, four studies were conducted by the Air District in partnership with other agencies, community groups, and air quality researchers to assess health impacts of diesel PM and track the effectiveness of emission-reduction measures:

- Diesel Particulate Matter Health Risk Assessment for the West Oakland Community[55]
- West Oakland Truck Survey[56]
- Drayage Truck Plume Measurement Study[57]
- West Oakland Monitoring Study[58, 59]

Together these studies document the health impacts of diesel PM in West Oakland, local variations in emissions and exposures, and also the significant emission reductions and air quality improvements that have occurred there. Section 3.5 summarizes several local-scale monitoring studies conducted near specific industrial sources in the Bay Area. Often these studies have been conducted in impacted communities, but not in all cases. These studies have been designed to address specific concerns related to the impact of industrial facilities on their surrounding communities, whether the facility is within or outside of an impacted area.

55 California Air Resources Board. 2008. Diesel Particulate Matter Health Risk Assessment for the West Oakland Community. December 5, 2008. Online: www.arb.ca.gov/ch/communities/ra/westoakland/westoakland.htm

56 Bay Area Air Quality Management District. 2009. West Oakland Truck Survey. December 2009. Online: www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

57 Dallmann, T.R., Harley, R.A., and Kirchstetter, T.W. 2011. Effects of Diesel Particle Filter Retrofits and Accelerated Fleet Turnover on Drayage Truck Emissions at the Port of Oakland. Environ. Sci. Technol. 45 (24): 10773-9. doi:10.1021/es202609q

58 Desert Research Institute. 2010. West Oakland Monitoring Study. Prepared by E. M. Fujita and D. E. Campbell. September 9, 2010. Online: www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

59 Fujita, E.M., D.E. Campbell, W. P. Arnott, V. Lau, P.T. Martien. 2013. Spatial Variations of Particulate Matter and Air Toxics in Communities Adjacent to the Port of Oakland. *J Air & Waste Mgmt. Assoc.* In Press. doi:10.1080/10962247.2013.824393

Section 3.6 summarizes a pilot measurement study designed to collect air quality data near freeways. One of the chief concerns of the CARE program has been, and continues to be, the localized impacts of freeways and busy roadways on nearby residents. The purpose of this study was to evaluate levels of air pollution near freeways, as well as to inform future measurement studies and to help evaluate near-roadway modeling results.

Section 3.7 summarizes a set of local-scale modeling studies conducted with the intent of developing screening and assessment tools to inform local Bay Area planning efforts, both for the region and for individual cities. One goal in developing these tools has been to estimate impacts from specific sources—freeways, roads, and permitted facilities—and to create web-based screening tools. A second goal has been to assess impacts from multiple sources within a city and to generate maps that are useful for comprehensive planning.

3.1 WEST OAKLAND HEALTH RISK ASSESSMENT: CASE STUDY

Objectives

In 2006 CARB undertook a multi-year collaborative study with the Air District and the Port of Oakland to conduct a health risk assessment (HRA)[60] to estimate public health risks from exposure to diesel PM emissions in West Oakland in 2005. The study considered diesel exhaust emissions from three sets of sources:

- Maritime Port of Oakland (Port),
- Union Pacific rail yard, and
- Other sources in and around the West Oakland community, including non-Port marine vessels, trucks, and other significant sources of diesel PM.

The emissions from these three sets of sources were analyzed separately to evaluate the impacts of each on residents of West Oakland and the broader Bay Area. The study was part of a statewide investigation of health impacts from diesel PM in support of CARB's diesel regulations.

The main goals of the study were to:

- Investigate potential cancer risk and other health impacts from diesel PM in the West Oakland community from Port operations, locomotives, and other significant sources in and around the community surrounding the Port;
- Provide information to help evaluate the effectiveness of possible mitigation measures; and
- Provide a benchmark of emissions and cancer risk in 2005 from which to gauge future reductions.

60 California Air Resources Board. 2008. Diesel Particulate Matter Health Risk Assessment for the West Oakland Community. December 5, 2008. Online: www.arb.ca.gov/ch/communities/ra/westoakland/westoakland.htm

Methods

- An interagency study team compiled a 2005 baseline emissions inventory[61] of diesel PM emissions from each of the three source sets:
  - Emissions from the Port compiled by Environ International Corporation and reviewed by CARB and the Air District;
  - Emissions from the Union Pacific Rail Yard compiled by Union Pacific and reviewed by CARB;
  - Emissions from other sources in and around West Oakland—such as freeways, construction, and local businesses—compiled by CARB and the Air District.
- CARB and the Air District conducted dispersion modeling to estimate the annual average concentrations of diesel PM in 2005 using U.S. EPA's CALPUFF model.
- The entire study area included the Port, the ocean to the west of the Golden Gate Bridge out to the outer buoys (about 20 miles offshore), the inner bay shipping lanes, and surrounding communities, covering a 100 km by 100 km area (about 3,800 square miles).
- Estimated annual-average diesel PM concentrations were used to estimate potential lifetime cancer risk and other health impacts.[62]

Key Findings

The total diesel PM emissions in 2005 from all three sets of sources were estimated to be about 870 tons.

Once emissions were modeled and risk assessment assumptions were applied, the study concluded that:

- In 2005, the West Oakland community was exposed to diesel PM ambient concentrations that were almost three times higher than the average background diesel PM levels in the Bay Area.
- The estimated lifetime potential cancer risk for residents of West Oakland from exposure to 2005 diesel PM levels was about 1,200 excess cancers per million over a 70 year lifespan. (See Figure 3.1.)
- Port-related activity contributed a cancer risk of nearly 200 per million; the Union Pacific rail yard about 40 per million (Table 3.1).

61 CARB. 2008. West Oakland Health Risk Assessment, Appendix A, Emissions Inventory Summary. Online: http://www.arb.ca.gov/ch/communities/ra/westoakland/documents/appendixa_final.pdf. Additional documentation for each of the three parts of the emissions inventory is available online: http://www.arb.ca.gov/ch/communities/ra/westoakland/westoakland.htm

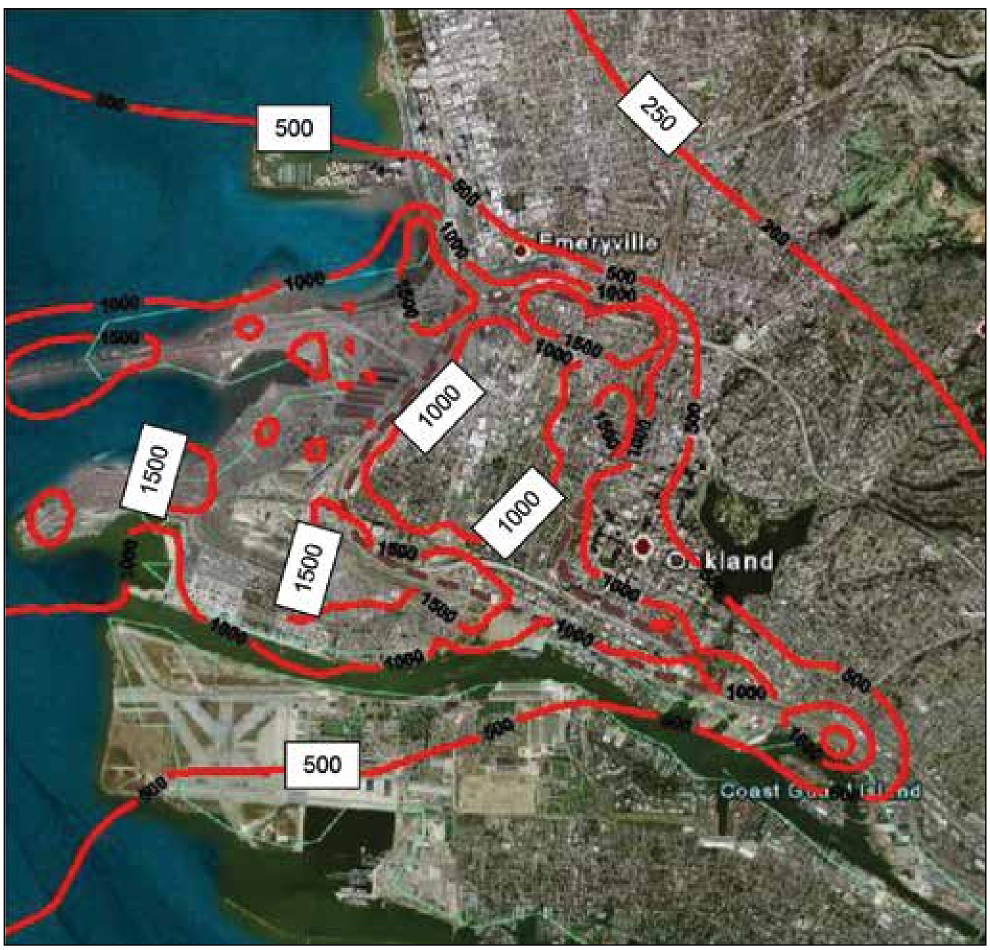
62 Cancer risk was estimated using cancer potency factors established by the Office of Environmental Health Hazard Assessment (OEHHA) to estimate health risks. For cancer health effects, the risk is expressed as the number of chances in a population of a million people who might be expected to develop cancer, if they were to breathe the estimated concentration of pollution over a 70-year lifetime.

Table 3.1 Average potential cancer risk (per million) due to exposure to diesel PM in West Oakland by source areas in year 2005

Source of Diesel Particulate Matter Emissions	Average Potential Cancer Risk Per Million in West Oakland
Port of Oakland	190
Union Pacific Rail Yard	40
Other sources in and around West Oakland	950
Total	**1180**

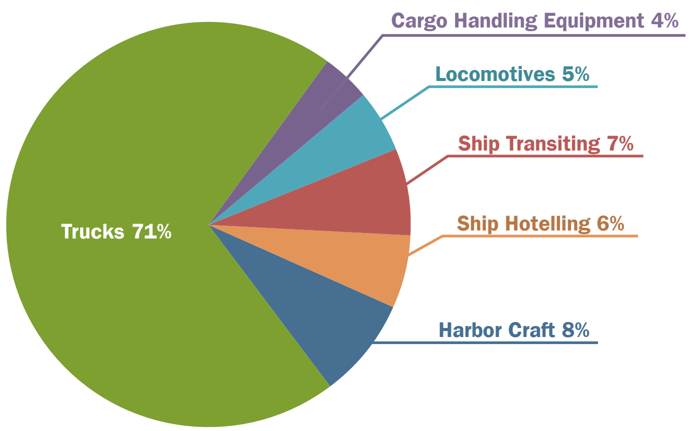
- On-road heavy-duty trucks result in the largest contribution to the overall potential cancer risk levels in the West Oakland community; followed by ships, harbor craft, locomotives, and cargo handling equipment (see Figure 3.2).
- Over three million people in the Bay Area were found to have potential elevated cancer risk of more than 10 chances in a million due to exposure from diesel PM emissions from Port-related activity.

Figure 3.1 West Oakland cancer risk contours (per million) from diesel particulate matter in 2005, based on a health risk assessment



- For the entire study area, the results showed that annually there would be potentially 18 premature deaths, 290 asthma-related attacks, 2,600 days of work loss, and 15,000 minor restricted activity days from Port-related activities.

Figure 3.2 Apportionment of total cancer risk in year 2005 (in percent) by source category from all source areas



- The report recommended more study of truck traffic at the Port and in West Oakland because of uncertainties associated with estimating truck activity and the fraction of trucks in the community that were Port-related. (A follow-on study of truck traffic was later undertaken by the Air District in the West Oakland Truck Survey described in Section 3.2.)
- Overall, results supported CARE findings that people living in the West Oakland community are exposed to unhealthful levels of diesel PM emissions and that a collective effort at the community, local, State, federal, and international levels were needed.

3.2 WEST OAKLAND TRUCK SURVEY: CASE STUDY

In late 2008 and early 2009, the Air District partnered with the community organization, West Oakland Environmental Indicators Project (WOEIP), and consultants Sonoma Technology, Inc., (STI) and Wiltec to design and conduct a truck-traffic survey[63] in West Oakland.

Objectives

The West Oakland health risk assessment (HRA) noted significant uncertainties related to truck traffic in West Oakland, the source determined to pose the greatest health risk. A major goal of the truck-traffic survey was to reduce uncertainties in the HRA related to truck traffic. In support of this goal, the study sought to improve information on the following:

- Volume of medium heavy-duty (MHD) and heavy heavy-duty (HHD) truck traffic on the surface streets and freeways of West Oakland;

63 Bay Area Air Quality Management District. 2009. West Oakland Truck Survey. Dated December 2009. Available for download at: http://www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

- Primary routes of truck travel;
- Locations and duration of truck idling activity;
- Vehicle miles travelled for trucks within the study area;
- Age distribution of trucks in West Oakland; and
- Fraction of trucks travelling through West Oakland whose purpose was related to the Port of Oakland (Port).

Another important goal was to evaluate the effectiveness of information campaigns in establishing truck routes and reducing idling within the West Oakland community. In support of this goal, improved information on truck routes and locations and duration of truck idling were also needed.

Methods

Study participants completed the following tasks to meet the study's objectives:

- Surveyed MHD and HHD trucks on surface streets in West Oakland at nearly 40 locations using manual counts and automated counters.
- Surveyed MHD and HHD trucks on freeways in West Oakland using video footage, manual counts, and exiting automated traffic counters on I-880, I-580, and I-980.
- For surface streets and freeways, the study estimated truck numbers by truck type and number of axles, truck routes, traffic speeds, and the fraction of Port versus non-Port trucks.
- Recorded license plate numbers to develop a truck age distribution.
- Collected observations to determine locations and durations of truck idling.

The HRA assumptions about truck activity were compared to the truck survey results. Where HRA and survey results differed, HRA cancer risks were re-estimated. Rather than re-running HRA models to re-estimate risks, the study scaled the HRA risks by the ratio of activity levels developed from the truck survey to those from the HRA to generate revised risk estimates.

Key Findings

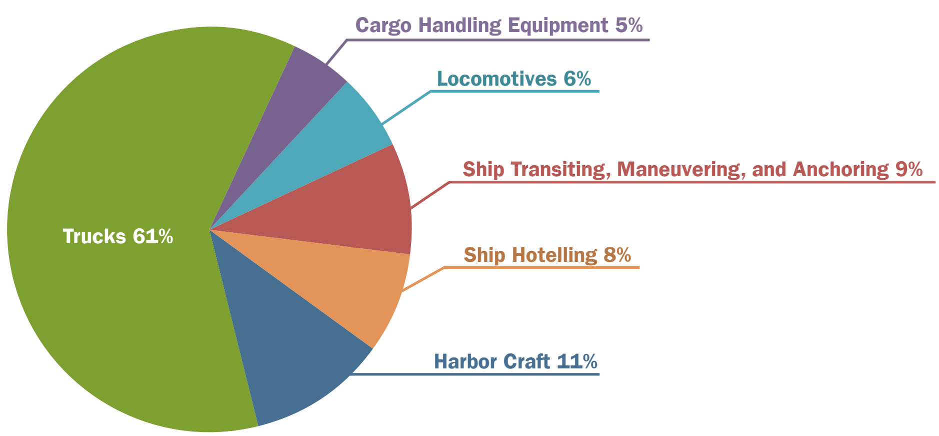
- The survey supported the HRA's findings on the age distribution of West Oakland trucks, their average speed, and their idling activity.
- The survey roughly confirmed truck volumes on freeways, but found
  - fewer trucks traveling along I-980 and I-580 freeways, and
  - more trucks along I-880.
- However, the survey results indicated that there are
  - significantly fewer trucks on surface streets than assumed in the HRA,
  - but a higher percentage of the trucks were Port-related.

- Using truck survey results, the overall cancer risk in West Oakland was adjusted to about 860 per million, down from 1180 per million estimated by the HRA (see Table 3.2).
- The Port's contribution to the population-weighted cancer risk for West Oakland is higher than the 16% attributed in the HRA. With information from the truck survey, the Port contribution to the cancer risk rose to about 29%. This increase was a result of the survey findings that more of the trucks in West Oakland were there in service of the Port-related than was accounted for in the HRA.
- Trucks remain the single highest source of diesel emissions in West Oakland, responsible for 61% of the population-weighted cancer risk (see Figure 3.3).

Table 3.2 Average potential cancer risk (per million) in West Oakland by source areas in year 2005, with revisions based on truck survey

Source of Diesel Particulate Matter Emissions	Average Potential Cancer Risk (per million) in West Oakland—Revised based on truck survey	Average Potential Cancer Risk (per million) in West Oakland—Based on HRA
Port of Oakland	250 (29%)	190 (16%)
Union Pacific Rail Yard	40 (5%)	40 (4%)
Other sources in and around West Oakland	570 (66%)	950 (80%)
Total	**860 (100%)**	**1180 (100%)**

Figure 3.3 Revised based on truck survey: apportionment of total cancer risk in year 2005 (in percent) by source category from all source areas



- The survey findings supported the HRA's conclusions that the residents of West Oakland are exposed to unhealthful levels of diesel PM and that most of the risk is due to trucks (based on 2005 emissions). However, the survey suggests that a larger fraction of risk is due to Port activities than the HRA reported.

- The survey confirmed that older trucks were in service at the Port. As of late 2008, the survey found that 17% of drayage trucks had 1993 or older model engines, and only 6% were 2004 or newer.
- The study suggested that continued collaborative effort from CARB, the Air District, and the Port are needed to reduce diesel PM emissions.
- Outreach by the community to curb idling at local businesses and initiatives by the City of Oakland and the Port to move truck support services and long-term truck parking out of the community are all steps in the right direction.

3.3 DRAYAGE TRUCK PLUME MEASUREMENT STUDY: CASE STUDY

While studies were underway that characterized health impacts from diesel emissions in West Oakland, important mitigations were also underway. Among the mitigations was a statewide regulation on drayage truck emissions adopted by CARB, which was set to take effect in 2010.[64] Rather than relying on fleet turnover to clean up the truck fleet, CARB's drayage truck regulation required retrofitting or replacing trucks. The regulation's retrofit schedule required:

- Starting in 2010, a ban on 1993 and older engine model years which were not suitable for retrofitting,
- Starting in 2010, diesel particle filter (DPF) retrofits or replacements for trucks with 1994-2006 engine model years,
- In stages from 2010 to 2013, retrofits of 2004-06 truck engines, and
- Starting in 2014, all drayage trucks are required to meet the 2007 engine emission standards.

In addition, incentives funds were made available to replace older trucks with 2007 or newer models that met the most stringent exhaust PM emission standards currently in force. The Air District's considerable efforts in West Oakland to fund early compliance or to go beyond regulatory requirements are described in Section 4.1. Through a Memorandum of Understanding with the State, described in Section 4.3, the Air District deployed enforcement staff to ensure compliance with the drayage truck regulation, focused particularly on trucks servicing the Port of Oakland.

Prior to the implementation of the drayage truck regulation, the Air District helped fund a study, designed and conducted by the University of California at Berkeley (UCB) and the Lawrence Berkeley National Laboratory (LBNL), to determine its effectiveness.

The goals of this study were to:

- Measure drayage truck emissions at the Port of Oakland and
- Quantify emission changes due to the retrofit and renewal of the truck fleet in response to California's drayage truck rule.

64 http://www.arb.ca.gov/msprog/onroad/porttruck/porttruck.htm

Methods

Researchers at UCB and LBNL used the Air District's mobile sampling van to measure emissions of Port trucks in West Oakland before and after implementation of the drayage truck rule.

- Researchers parked the Air District's mobile sampling van on the Bay Street overpass above 7th Street in West Oakland and deployed pollutant analyzers in the van to measure emissions.
- Truck exhaust plumes were sampled through a sampling line extended over the edge of the overpass above trucks in the westbound lanes of 7th Street headed into the Port (see Figure 3.4).
- Measurements were collected on selected weekdays during November 2009 and June 2010 before and after the implementation of the regulation.
- Sampling occurred once per second in order to capture pollutant concentrations as trucks passed by.
- Pollutant measurements included CO_2, NO_x, black carbon (BC), and $PM_{2.5}$.
- Concentrations of NO_x, BC, and $PM_{2.5}$ were normalized by CO_2 concentrations, the main carbon-containing compound of diesel exhaust.
- Knowledge of the weight fraction of carbon in diesel fuel allowed for the calculation of emission factors in terms of pollutants emitted per unit of fuel burned.
- Details of the study method were reported in a published journal article.[65]

Figure 3.4 The Air District's mobile sampling van used to measure pollutant concentrations of exhaust plumes from Port trucks in West Oakland

65 Dallmann, T.R.; Harley, R.A.; Kirchstetter, T.W. 2011. Effects of Diesel Particle Filter Retrofits and Accelerated Fleet Turnover on Drayage Truck Emissions at the Port of Oakland. *Environ. Sci. & Tech.* 45, 10773-9. doi: 10.1021/es202609q

Key Findings

The study found substantial reductions in exhaust emissions of black carbon and NO_x from trucks had occurred as a result of implementation of the regulation, which included truck retrofits and accelerated replacements.
For the drayage truck fleet serving the Port, after implementation of the drayage truck regulation:

- Emission factors for BC decreased by about 50%;
- Emission factors for NO_x decreased by about 40%;
- Reductions in BC are linked to both the installation of retrofit devices and replacement of trucks;
- NO_x reductions are linked mainly to replacement of the older trucks; and
- The study documented the expected shift toward newer trucks.

The study suggested that future work should continue to track emissions from the Port truck fleet and examine the possibility of increased emissions of nitrogen dioxide (NO_2) and ultrafine particles from trucks equipped with DPF systems.

3.4 WEST OAKLAND MONITORING STUDY: CASE STUDY

Objectives

The Air District partnered with the Desert Research Institute (DRI) to conduct the West Oakland Monitoring Study (WOMS). WOMS provided supplemental air quality monitoring data to identify potential air pollution hot spots in West Oakland and to evaluate local-scale dispersion modeling of diesel emissions from the Port of Oakland and vicinity.

The goal of WOMS was to characterize TAC concentrations within the Port of Oakland and the adjacent community of West Oakland via a monitoring study designed to answer the following questions:

1. Do gradients in pollutant concentrations exist within West Oakland that can be related to the community's proximity to emissions from the Port of Oakland and associated heavy-duty vehicle traffic?
2. Is the existing air quality monitoring in the area adequate to characterize cumulative exposure within the community?
3. Are mean pollutant concentrations higher in West Oakland than in other urban areas of the Bay Area?
4. Measurements of elemental carbon (EC) are sometimes used as a marker for diesel PM. How much of EC in West Oakland is from diesel PM and how much is from other sources, such as gasoline exhaust or wood burning?
5. Are the concentrations and spatial variations in diesel PM estimated from WOMS consistent with the modeled results from the CARB and Air District health risk assessment described in Section 3.1?

Methods

WOMS was conducted during two seasonal periods of four weeks in summer 2009 (7/30/09-8/27/09) and winter 2009-10 (12/9/09-12/23/09 and 1/6/10-1/20/10). A dense network was formed from monitoring stations placed at various distances upwind and downwind of the Port and I-880 freeway, as shown in Figure 3.5. The monitoring during each season included the following three components:

- *Saturation monitoring* using week-long samples collected at multiple fixed locations (see Figure 3.5):
  - All sites measured selected volatile air toxics, oxides of nitrogen (NO and NO_2), and sulfur dioxide (SO_2) using passive monitors.
  - Certain sites measured $PM_{2.5}$, organic carbon (OC), and EC.
- *Mobile monitoring* of NO, CO, volatile organic compounds (VOC), $PM_{2.5}$, black carbon, and ultrafine particles to characterize the spatial variations in pollutant concentrations and identify local "hot spots" within West Oakland and the Port of Oakland. Sampling occurred, on three weekdays and one weekend day, during summer and winter saturation monitoring.
- *Particulate matter composition and source attribution* using chemical analysis of PM samples and Chemical Mass Balance (CMB) receptor modeling to estimate the source contributions of diesel PM and other combustion sources in the study area.

Ambient concentrations of diesel PM were estimated from the measured EC concentrations using a relationship developed from this and other studies. Using estimates of diesel PM, the study examined whether diesel PM estimated from WOMS monitoring data were consistent with modeled results from the health risk assessment described in Section 3.1. More detailed descriptions of WOMS methods and findings are available in a technical summary[66] and a journal article.[67]

66 Desert Research Institute. 2010. West Oakland Monitoring Study. Prepared by E. M. Fujita and D. E. Campbell. September 9, 2010. Online: www.baaqmd.gov/Divisions/Planning-and-Research/CARE-Program/CARE-Documents.aspx

67 Fujita, E.M., D.E. Campbell, W. P. Arnott, V. Lau, P.T. Martien. 2013. Spatial Variations of Particulate Matter and Air Toxics in Communities Adjacent to the Port of Oakland. *J Air & Waste Mgmt. Assoc.* In Press. doi:10.1080/10962247.2013.824393

Figure 3.5 West Oakland Monitoring Study (WOMS) fixed monitoring sites

Orange circles show locations with passive monitoring; white diamonds show with added PM measurements; and white diamonds with vertical lines show sites with PM measurements with speciation. Blue circles show sites of a concurrent Air District study (see Section 3.5) to sample metals near a recycling facility.

Community Outreach and Participation

The Air District held several meetings with the West Oakland local community to discuss and solicit input on the objectives and scope of the proposed study. The West Oakland monitoring study benefited greatly from the assistance of community participants who contributed ideas for the study and offered their residences and businesses for many of the sampling sites.

Key Findings

The WOMS study taken in combination with other recent studies indicates that focused grants-funded diesel reduction projects, new regulatory requirements, and focused enforcement near the Port of Oakland have been effective. However, the study also showed higher pollutant concentrations along major roadways in West Oakland, especially in areas with high traffic volumes of diesel trucks.

The study provided useful answers to the study questions posed:

1. Sharp gradients in pollutant concentrations were observed:

    - Relatively high concentrations of NO and black carbon occurred near highways and major truck routes and dropped off rapidly away from them. For example, Figure 3.6 shows that summertime concentrations for NO for sites near I-880 were up to five times higher than sites within residential areas of West Oakland at least one city block from major roadways.
    - Mobile sampling showed localized peaks in pollutant concentrations on roadways when trucks were nearby (see Figure 3.7).
    - Compared to NO and black carbon, concentrations of $PM_{2.5}$, CO, and VOC were more uniformly distributed throughout the area.

Figure 3.6 Average NO concentrations collected at West Oakland sites during summer 2009

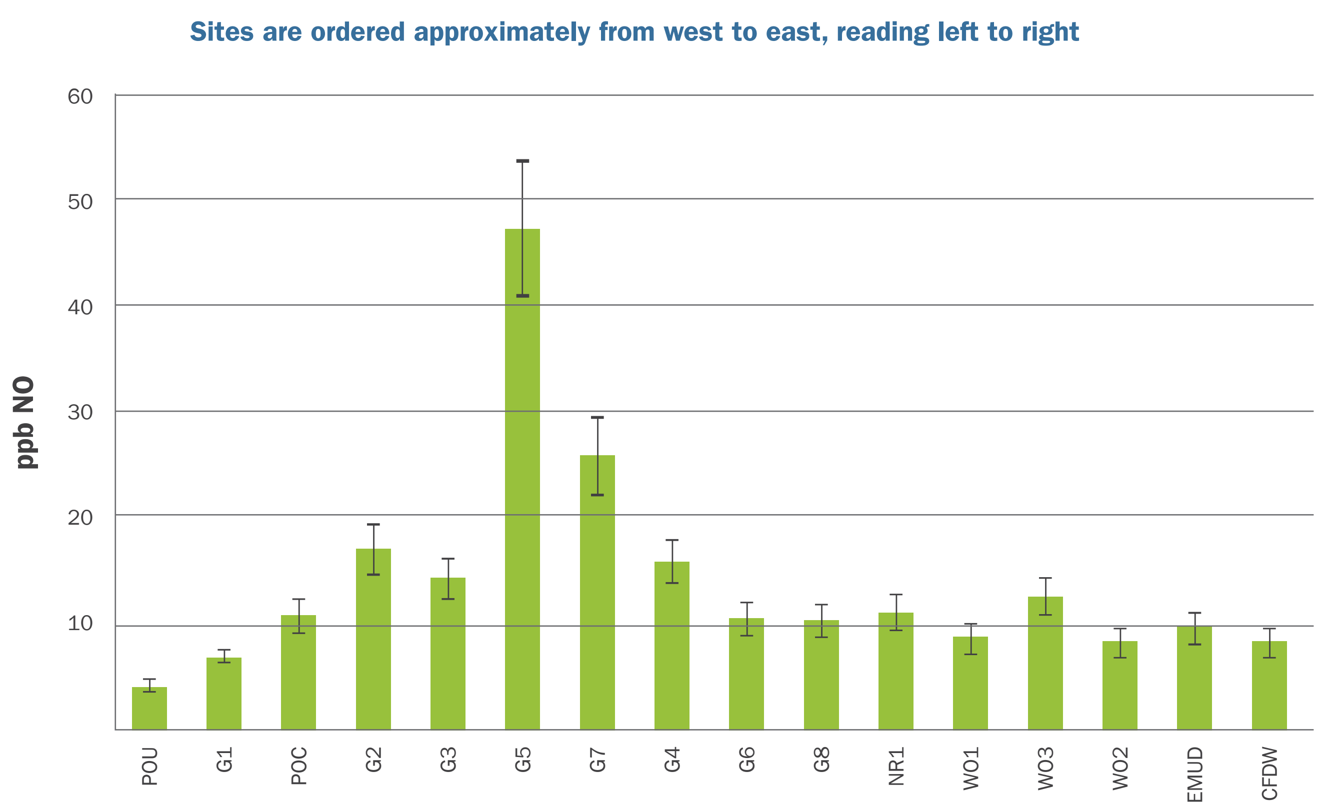
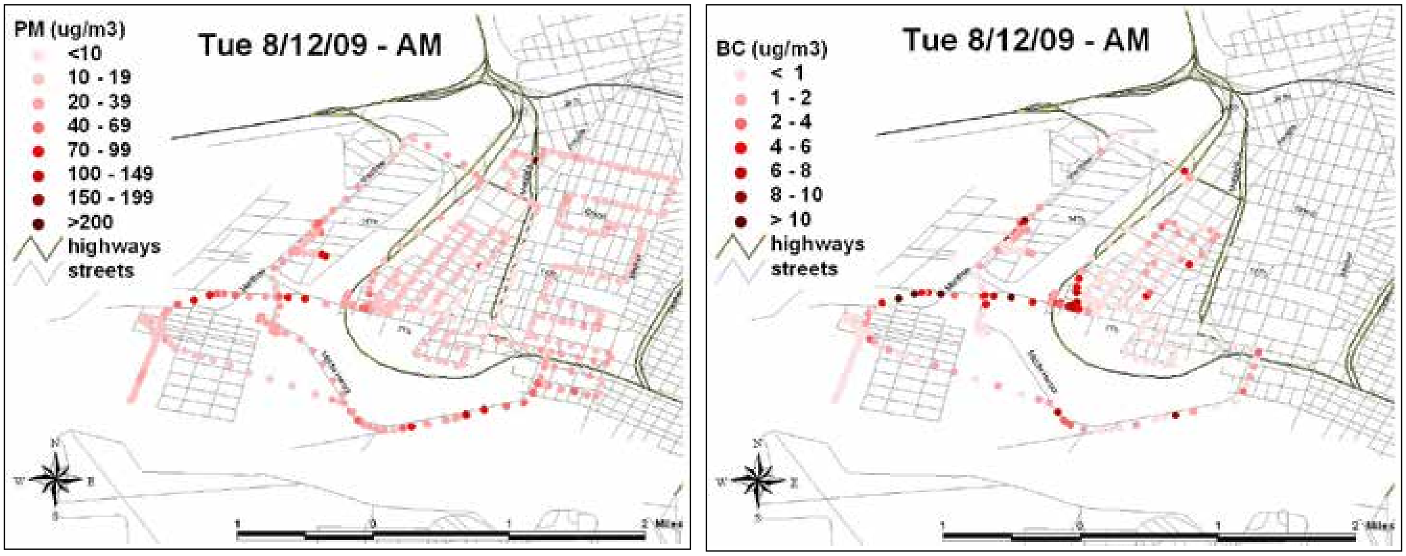


Figure 3.7 Particulate matter and black carbon measurements collected during summertime mobile sampling in West Oakland



2. The central monitoring site at the East Bay Municipal Utility District maintenance yard was found to be representative of the West Oakland community, except for locations within 500-1,000 feet of major roadways.

   - Near-road concentrations of diesel PM may be five times higher along I-880 and other truck routes within the Port of Oakland compared to the central monitoring site.
   - Other TAC compounds and CO may be 2-3 times higher.

3. Concentrations of TAC in West Oakland, away from the Port and freeways, were found to be similar to levels in other urban Bay Area locations. This finding reflects the facts that diesel PM levels dropped in West Oakland during WOMS due to reductions in diesel exhaust from drayage trucks (see Section 3.3) and that concentrations dropped rapidly away from the Port and freeways (see finding 1 above).

   - The concentrations of EC (the primary surrogate for diesel PM) in West Oakland were similar to San Jose, one of the highest Bay Area sites. However the ratio EC to total fine PM was higher in West Oakland than San Jose because diesel vehicle exhaust may account for a greater proportion of fine PM in West Oakland.
   - Levels of other TAC compounds in West Oakland are generally similar to those at other urban Bay Area locations (San Francisco, Fremont, and San Jose).
   - Secondary pollutants, such as aldehydes, were lower in West Oakland than at San Jose and Fremont reflecting greater contributions of atmospheric formation of aldehydes from photooxidation of hydrocarbons in Fremont and San Jose.

4. About 70-80% of EC was found to be from diesel PM in West Oakland; about 90% of EC was from diesel PM within the Port of Oakland.
   - Chemical Mass Balance receptor modeling showed that diesel exhaust accounted for about 80% of the ambient EC in summer and slightly less (68%) in winter (see Figure 3.8).
   - The reduction in the contribution of diesel PM to EC during the winter may have been due to reductions in diesel exhaust from drayage trucks that occurred during WOMS and may have also been due to an increased contribution from wood burning and gasoline vehicles during cold weather.
5. WOMS estimates of average levels of diesel PM levels agreed reasonably well with HRA modeling estimates after two adjustments were made to the modeling.
   - Average levels of diesel PM estimated from WOMS EC measurements were consistently lower than unadjusted modeling estimates from the 2005 HRA by more than a factor of two (see Figure 3.9).
   - However, significant reductions in DPM emissions took effect between 2005, the base year of the HRA, and the 2009-2010 WOMS. Additionally, improved estimates of diesel truck activity on surface streets in West Oakland were available from the 2008 West Oakland Truck Traffic survey.
   - Using adjusted HRA results that account for estimated emissions reductions (40-60% decrease) since 2005 and corrected truck activity, the study found that the average modeled West Oakland diesel PM concentrations would range between about 1.2 and 1.9 μg/m^3 in 2010 as compared to 1.4 μg/m^3 based on the WOMS measurements.

Figure 3.8 Estimates of source contributions to ambient elemental carbon by Chemical Mass Balance during winter 2009-10 in West Oakland

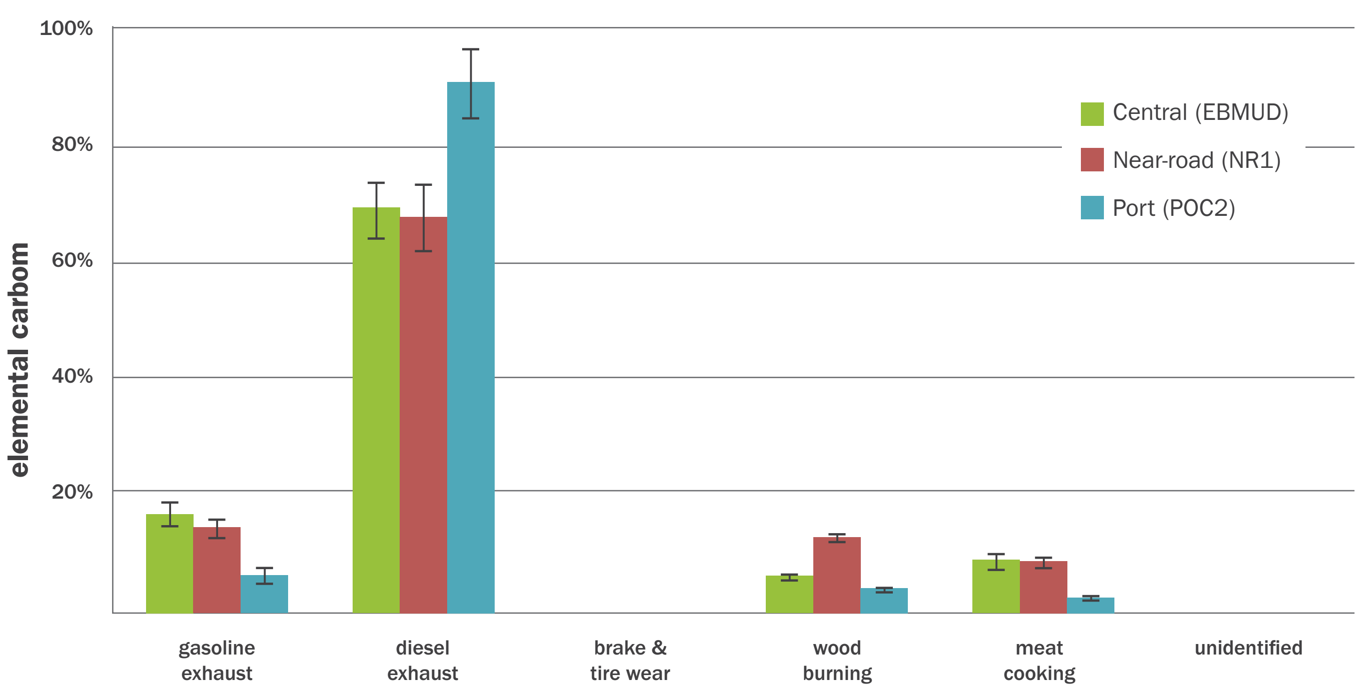
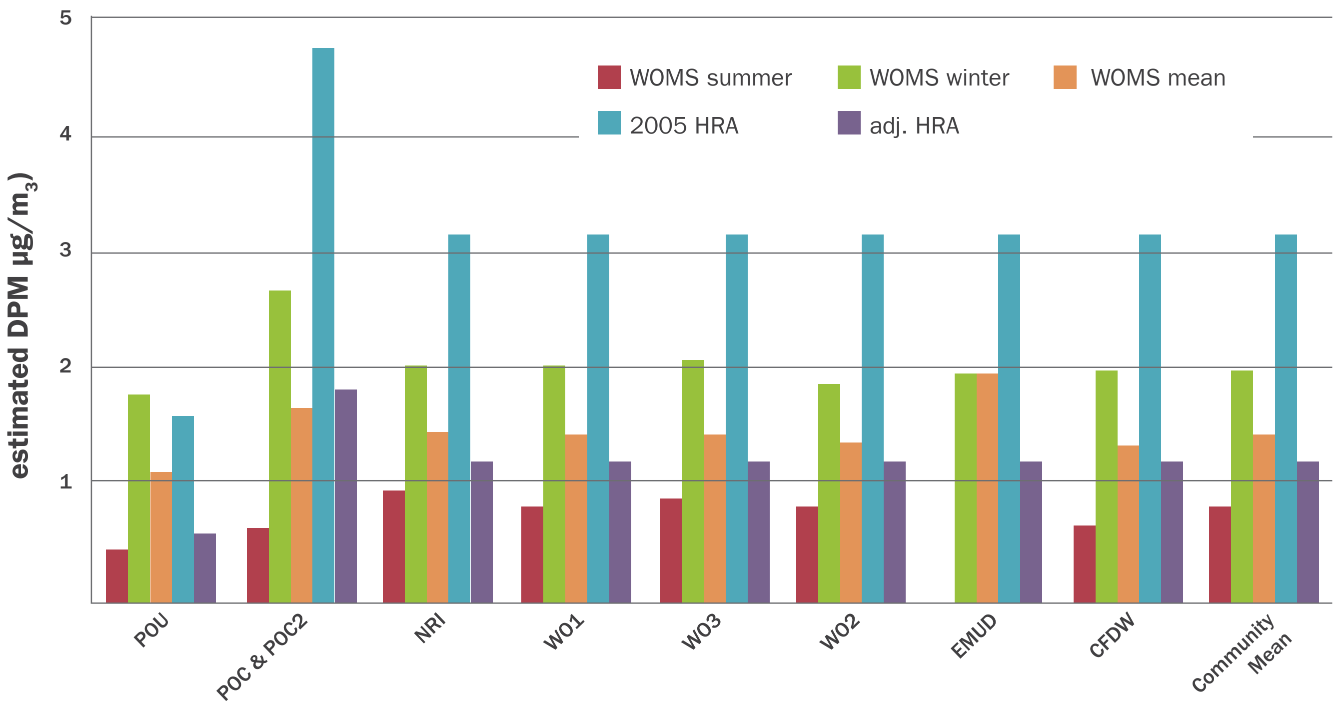


Figure 3.9 Estimated levels of diesel PM in West Oakland from WOMS (seasonal and annual average), from the West Oakland modeling HRA for 2005, and from adjusted HRA estimates



Permanent Resources Added

To support the West Oakland Monitoring Study, the Air District developed permanent sites and resources that continue to be of use for tracking air quality in West Oakland and in the Bay Area:

- A permanent air quality monitoring site in central West Oakland continues to track air pollution levels and trends;
- A meteorological station re-established in West Oakland continues to monitor winds and other parameters; and
- The Air District's mobile sampling van will continue to be used in West Oakland and other communities.

3.5 MEASUREMENT STUDIES NEAR INDUSTRIAL FACILITIES

Over the past decade, the Air District has conducted several local-scale measurement studies to characterize pollutant concentrations and risk near individual industrial facilities. This section describes three such recent studies conducted at sites near:

- A metal foundry and fabrication plant in West Berkeley;
- An aluminum melting and recycling operation in West Oakland; and
- A Portland cement manufacturer in Cupertino.

These studies built on lessons learned from previous studies[68] and were initiated in part to address community concerns. Historically, concerns about air pollution levels near facilities have arisen within areas the Air District identified as relatively burdened by air pollution, such as West Berkeley and West Oakland; however, concerns have also arisen outside impacted areas, such as Cupertino.

These types of local-scale, near-source studies are not new to the Air District but they have become more common in recent years. As regional air pollution continues to improve, the Air District has been able to increase its commitment to evaluating local-scale impacts of pollution sources. Also, as cities shift land-use development patterns, introducing mixed residential uses into historically industrial areas, the need to examine localized impacts from industrial sources has grown.

Local-scale monitoring studies support the goals of the CARE program in important ways by:

- Evaluating risk from air pollution at the local scale;
- Engaging community members and plant managers in discussions about air quality; and
- Helping to identify effective mitigation strategies, where necessary.

These three studies share common threads that are explored in this section. Each of the studies:

- Defined and communicated clear project objectives and scope;
- Evaluated risks based on measured concentrations of toxic air contaminants;
- Conducted community meetings to understand concerns and to report study findings; and
- Improved the collective understanding of the air quality near industrial sources of air pollution.

Each of these three measurement studies supplemented modeling studies of facility impacts. Each evaluated risks using measurements of toxic compounds and following OEHHA methodologies for evaluating cancer and non-cancer health risks.[69]

Importantly, these studies provided background information and context for subsequent regulations that were recently adopted by the Air District. Monitoring at Cupertino provided information that was considered in an Air District rule on nitrogen oxides, particulate matter, and toxic air contaminants from Portland cement manufacturing (Regulation 9, Rule 13), adopted in September 2012, in advance of proposed federal regulation tightening controls for cement plants. Monitoring in Berkeley and West Oakland provided information considered in a rule on foundry and forging operations (Regulation 12, Rule 13), adopted in May 2013, to minimize fugitive emissions of particulate matter and odorous substances from foundries and forges.

68 State of the Air in Bayview/Hunters Point, Results of the Bayview Community Air Monitoring Project (BayCAMP) prepared for: San Francisco Department of the Environment, November 2006. Prepared by: Sierra Research, Inc.

69 The findings of these measurement studies were recently presented at a session of the 2013 Annual Meeting of the Air & Waste Management Association on the Air District's efforts to characterize and mitigate exposures to local air pollution sources.

A METAL FOUNDRY AND FABRICATION PLANT IN WEST BERKELEY (2008-2010)

At the end of 2007, the Air District began air monitoring in West Berkeley about four blocks east of the Pacific Steel Casting (PSC) metal foundry and fabrication plant and about five blocks east of Interstate 80.

Objectives

Major goals of the study were to:

- Measure concentrations of criteria pollutants and toxic air contaminants downwind of PSC and the freeway;
- Compare criteria pollutants to state and federal air quality standards;
- Estimate health risks from toxic air contaminants;
- Compare pollutant concentrations to other locations in the Bay Area and other parts of California; and
- Provide observational data to promote informed discussion of air quality issues among Air District staff, community members, and plant managers.

Methods

The Air District outfitted a trailer with extensive air monitoring capabilities and parked it at the selected site east of PSC. In order to compare data gathered at the trailer with data from rest of the Air District's air monitoring network, sampling methods for the trailer were designed to be equivalent to those used at other sites.

Equipment in the trailer allowed for measurements of the following:

- Gaseous criteria pollutants: ozone, oxides of nitrogen, sulfur dioxide, and carbon monoxide;
- $PM_{2.5}$ (continuous measurements);
- PM_{10} and total suspended particulate matter every 6th day;
- Organic carbon (OC) and elemental carbon (EC);
- Particle ions;
- Selected particle metals by x-ray fluorescence (XRF) every 6^{th} day;
- Selected gaseous air toxics every 6^{th} day; and
- Methane and non-methane hydrocarbons.

Meteorological measurements were available from the Air District's measurement site located at the East Bay Municipal Utility District Sewage Treatment Plant in West Oakland.

For carcinogenic compounds, lifetime cancer risk was estimated by multiplying measured concentrations by OEHHA's unit risk factors. Diesel particulate matter was estimated from EC measurements.

For compounds with acute or chronic, non-cancer health effects, concentrations were compared to OEHHA's reference exposure levels (REL), concentrations below which adverse health effects are unlikely, even for more sensitive individuals. Hazard quotients were calculated as the ratio of a compound's observed concentration to its REL. The Air District also calculated a hazard index, which is the sum of hazard quotients for each compound that affects the same target organ system, such as the respiratory or nervous system. A hazard index below one indicates that health impacts are not expected. Additional details on the methods and findings of this study are available.[70]

Key Findings

Based on monitoring data collected:

- West Berkeley air quality levels were well below all state and federal standards for gaseous criteria pollutants.
- 24-hour $PM_{2.5}$ levels exceeded the 24-hour federal standard on two days in 2008 and on one day in 2009, but did not exceed the 24-hour PM_{10} federal standard; levels were similar to Oakland.
- Annual average $PM_{2.5}$ and PM_{10} levels were below the federal standard, but exceeded the more stringent annual average state standards; levels were similar to Napa.
- In 2008, total cancer risk in West Berkeley from TAC was 371 per million,[71] based on the sum of the cancer risks for each individual compound; this was somewhat greater than the risk at Benicia at that time, similar to the risk at San Francisco, and significantly less than risk at San Jose and at southern California sites North Long Beach and Rubidoux.
- In 2009, cancer risk in West Berkeley was 11% lower than in 2008, primarily because of reduced concentrations of diesel PM and benzene.
- Hazard indices were less than one for West Berkeley, and at a level similar to other Bay Area sites.
- Previously conducted risk assessment modeling of toxic compounds from PSC was found to be within a factor of two to three of the monitoring results, which Air District staff considered reasonable agreement because the modeling did not account for other sources of pollutant emissions, such as the nearby freeway.

In September 2008, the Air District issued a permit to PSC for a project to improve capture of emissions from operations at their plant by reconfiguring ceiling vents and improved ducting to an existing bag house and carbon adsorption unit.

70 www.baaqmd.gov/~/media/Files/Engineering/Air%20Toxics%20Programs/West%20Berkeley%20Air%20Monitoring%202008%20-%202009%20final%2011%2023.ashx?la=en

71 This estimate does not include an Age Sensitivity Factor (ASF) adjustment, which was recently recommended by the Office of Environmental Health Hazard Assessment (OEHHA) to account for increased susceptibilities of infants and children. Including the ASF, with the same exposure assumptions, would increase the estimate by about a factor of 1.7.

AN ALUMINUM MELTING AND RECYCLING OPERATION IN WEST OAKLAND (2009-2010)

Objectives

Concurrent with the West Oakland Monitoring Study (WOMS, Section 3.4), the Air District conducted a parallel year-long air monitoring project near an aluminum melting and recycling facility, Custom Alloy Scrap Sales (CASS), in West Oakland to characterize concentrations of metals near the facility and address concerns of nearby residents. The goals of the study were to:

- Determine PM and metals concentrations near CASS;
- Evaluate potential sources based on types of metals, their relative amounts, and wind direction;
- Estimate health risk from ambient metals after a year of sampling;
- Compare pollutant concentrations to other Bay Area locations, including sites established for WOMS; and
- Bring observational data into a discussion of air quality among Air District staff, community members, and CASS managers.

Methods

The CASS project began concurrently with the summer WOMS deployment in August 2009 and continued for one year until July 2010. One upwind (CUPW) and two downwind (CNDW and CFDW) monitors were deployed around CASS (see Figure 3.5). Both downwind monitors were located at schools. Figure 3.10 shows monitoring equipment on the roof of a high school, at a location which is typically downwind of CASS. A fourth exploratory monitor was placed upwind of CASS at a nearby food manufacturer for four months. The near-downwind CNDW monitor was relocated for one month to the backyard of a home across the street from CASS.

District staff collected:

- 24-hour PM_{10} every 6^{th} day. PM_{10} was collected to capture larger particles that might be associated with a metal recycling operation.
- Selected particle metals by x-ray fluorescence (XRF) every 6^{th} day. Metals such as aluminum, mercury, lead, chromium, manganese, vanadium, nickel, and cadmium were reported.

Meteorological measurements were available from the Air District's nearby measurement site located at the East Bay Municipal Utility District Sewage Treatment Plant in West Oakland.

For carcinogenic compounds, lifetime cancer risk was estimated by multiplying measured concentrations by OEHHA's unit risk factors. For compounds with acute or chronic, non-cancer health effects, concentrations were compared to OEHHA's RELs.

Figure 3.10 View looking west from the Excel High School monitoring site east, and predominantly downwind, of the CASS facility

Equipment included particulate matter samplers.

Key Findings

Synthesizing a year of monitoring data, the Air District found that:

- Metals concentrations were below the inhalation reference exposure levels at all sites.
- Lead concentrations were higher than at other Bay Area monitoring locations but concentrations were a factor of 10 below the new federal three-month average standard of 0.15 µg/m^3. The upwind site had higher lead concentrations than the other sites.
- For each carcinogenic compound, the cancer risk was below one in a million except for cadmium where the cancer risk was nine in a million at the downwind location and approximately six in a million at the upwind location, measurements that are typical of other Bay Area locations.
- Measured concentrations at the near downwind and upwind locations were similar for most of the metals.
- Similar levels of fine particles were observed at all sites; levels were slightly lower at the far downwind site (Excel High School). All measurements collected were below the State and national PM_{10} standards.

Overall, the study results indicated that PM concentrations near the CASS facility in West Oakland were similar to other Bay Area sites. Certain metals such as manganese and lead were higher at some West Oakland sites than at other Bay Area sites, but at concentrations below the reference exposure levels or federal standard.

A notable outcome of this study was that it helped build trust and community confidence. During the course of a series of meetings, dialog among community members, CASS managers, and the Air District became progressively more productive. Working relationships developed and collaborative discussions began, eventually focusing on finding an alternate site for the facility on the Oakland Army Base, portions of which are being redeveloped by the City of Oakland.

A PORTLAND CEMENT MANUFACTURER IN CUPERTINO (2010-2013)

Objectives

Beginning in September 2010 and continuing through late 2013, the Air District conducted monitoring for criteria pollutants and toxic air contaminants near the Lehigh Southwest Cement Plant in Cupertino. Although the plant and associated quarry are tucked in the wooded hills of Cupertino, the facility is the region's highest source of mercury emissions and residents in Cupertino and the surrounding Santa Clara Valley are concerned about levels of mercury and other pollutants generated by the plant.

The goals of the study were to:

- Determine levels of criteria pollutants and toxic air contaminants near the facility;
- Collect accurate measurements of mercury;
- Estimate health risk from measured pollutants, including mercury;
- Compare pollutant concentrations to other locations in the Bay Area and other parts of California; and
- Provide observational data for discussions of air quality among Air District staff, community members, and Lehigh plant managers.

Methods

The sampling site for this study was located at the Monte Vista Park in Cupertino in a residential neighborhood approximately a half mile east of the Lehigh Southwest Cement plant. Compounds measured at Cupertino location included:

- Total atmospheric mercury (TAM, both gaseous and particulate mercury);
- Gaseous criteria pollutants: ozone, oxides of nitrogen, sulfur dioxide, and carbon monoxide;
- $PM_{2.5}$ continuous measurements;
- PM_{10} and total suspended particulate matter every 6^{th} day;
- OC and EC;
- Particle ions;
- Selected particle metals by x-ray fluorescence (XRF) every 6^{th} day;
- Selected gaseous air toxics every 6^{th} day; and
- Methane and non-methane hydrocarbons.

Meteorological measurements were also collected at the Cupertino site.

Cancer risk and non-cancer hazard index were calculated based on measured levels of toxic air contaminants. Additional details on methods and findings of the Cupertino study are available online.[72]

72 www.baaqmd.gov/~/media/Files/Engineering/Air%20Toxics%20Programs/SpecialReports/Summary%20and%20Analysis%20of%20Cupertino%20Air%20Monitoring%20Revised%205%2016%202012%20Final.ashx?la=en

Key Findings

Based on three years of monitoring data at Cupertino:

- Air quality levels for gaseous pollutants were well below all state and federal standards.
- PM levels did not exceeded the 24-hour $PM^{2.5}$ federal standard, nor the 24-hour PM_{10} federal standard; levels were similar to Concord and San Rafael.
- The annual average $PM^{2.5}$ levels were below both the federal and state standards; levels were similar to Santa Rosa and Gilroy.
- Total cancer risk from recent TAC observations was about 238 per million, less than at other Bay Area sites.
- The chronic, non-cancer hazard index for disease related to the nervous system was 1.1. A value over one indicates that health impacts may be possible. Contributing to the hazard index were mercury (0.5), arsenic (0.5), and manganese (0.1).
- Previously conducted risk assessment modeling of toxic compounds from the Lehigh cement plant did not agree well with the monitoring results, likely in part because of the hilly terrain.

Monitoring at Cupertino provided information that was considered in an Air District rule on nitrogen oxides, particulate matter, and TAC from Portland cement manufacturing (Regulation 9, Rule 13), adopted in September 2012, in advance of proposed amendments to federal regulations tightening controls for cement plants. While new federal standards on Portland cement manufacturing have been delayed until 2015, the Air District's actions mean the Lehigh facility is required to reduce emissions two years earlier, in 2013. The new Air District regulation requires stricter limits on mercury emissions and other pollutants from the Lehigh plant and requires continuous emissions monitoring during plant operation.

3.6 NEAR-ROADWAY MEASUREMENTS

An important finding of the CARE program's regional assessments (see Section 2) was that emissions from mobile vehicles are a major contributor to health risk from air pollution in the Bay Area. Exhaust emissions from on-road vehicles will continue to be a major source of air pollution, even as cars and trucks have become cleaner, because of the projected continued increase in the number of motor vehicles in the Bay Area and the continued increase in vehicle miles traveled.

While heavily travelled roadways are projected to remain major emissions sources, more new developments are expected along these same roadways to meet a growing demand for Bay Area housing. Many health studies have shown that residents living in close proximity to major roadways are exposed to unhealthful levels of air pollution. As discussed in more detail in Section 4.4, regional agencies, planning departments, and health departments will need strategies not only for mitigating existing health impacts, but also for minimizing impacts to future residents.

To address a growing recognition of the health impacts of near-roadway air pollution exposures, national and local efforts are underway to assess the health impacts of transportation decisions and near-roadway development. The

US EPA has established requirements for monitoring nitrogen dioxide (NO_2) and other pollutant concentrations near busy roads in urban areas throughout the nation.[73] According to the US EPA, the monitoring data will be used to develop new federal regulations and to support voluntary programs to reduce air pollution along highways.[74]

Modeling tools also provide important information to assess current and future health impacts from near-roadway exposures. The Air District has partnered with others to develop screening tools for assessing air pollutant concentrations and health impacts along roadways. These tools, discussed in Section 3.7, can be used to assess health impacts to existing and future sensitive receptors near the roadways.

In 2011, in support of upcoming federal near-road monitoring requirements and to provide preliminary assessments of modeling tools, the Air District partnered with the Desert Research Institute (DRI) to conduct exploratory air pollution monitoring near Bay Area freeways.

Objectives

The goals of the exploratory near-roadway monitoring were to provide information for various freeway configurations, traffic volumes, and vehicle mixes to:

- Help select suitable monitoring locations for federally required near-road monitoring;
- Provide data to evaluate near-road modeling tools applied to Bay Area freeways.

Methods

Using the Air District's mobile sampling van and a push-cart equipped with air monitoring equipment, DRI and the Air District collected measurements along three major roadways:

- Below grade section of Highway 101 in San Francisco,
- At grade section of Highway 580 in Livermore, and
- Above grade (20 feet above grade) section of Highway 680 in Dublin.

A series of measurements of NO and $PM_{2.5}$ concentrations and ultrafine particle counts were collected at each of these sites over a three-day period (Sunday April 3 - Tuesday April 5, 2011, in Livermore and Dublin and Wednesday April 20 - Friday April 22, 2011, in San Francisco) at various distances, from 0 to 300 meters (about 1,000 feet), upwind and downwind of the freeway.

For each highway section analyzed, one of the monitoring platforms remained stationary at a location approximately 50 meters (about 160 feet) downwind while the other was moved perpendicular to the freeway up to 300 meters on either side. At the San Francisco location the mobile measurements were collected along a circuit that included a pedestrian overpass over Highway 101.

73 US EPA regulations require near-road monitoring to begin in January 2014 for nitrogen dioxide and by 2017 for carbon monoxide and fine particulate matter.

74 US EPA Near-roadway Research. Accessed August 2013. Available online: http://www.epa.gov/nrmrl/appcd/nearroadway/index.html

Key Findings

- The highest concentrations were measured in San Francisco directly downwind of Highway 101, with a rapid drop in concentrations away from the highway (See Figure 3.11). The higher concentrations found in San Francisco were consistent with the higher traffic flows in comparison to the other two locations. Concentrations may have also been elevated at the San Francisco site because of the local terrain; the below-grade segment of roadway may have concentrated pollutants. As expected, lower concentrations were measured upwind of Highway 101. For ultrafine PM, particle counts tend to reach background concentrations at about 250 meters, which was consistent with measurement studies conducted in Southern California.[75]
- Measurements collected near Interstate 580 in Livermore did not show as pronounced a concentration drop with distance from the highway as at San Francisco and concentrations were evenly distributed on both sides of the freeway. At this site, winds often paralleled the freeway and shifted during the day. Vegetation along the north edge of the freeway may have also affected pollutant concentrations.
- Measurements near Interstate 680 in Dublin showed the smallest changes in concentration near the freeway and the lowest pollutant concentrations, even though the traffic flow was higher than at Livermore. The above grade freeway at the Dublin site may have enhanced pollutant dissipation. The variable wind direction at this site may have distorted the roadway air pollution gradients.
- Measured concentrations of $PM_{2.5}$ and ultrafine PM collected from the three sites were compared to concentrations modeled using the Rcaline model (a version of the CALINE3 model described in Section 3.7). The model results matched the San Francisco measurements best, where the roadway pollution gradients were sharpest. The Rcaline model did not perform as well at reproducing the effects of variable winds, vegetation, and above-grade freeways.
- By demonstrating the variability created by winds, different types of roadways, and varying levels of traffic, this exploratory study helped inform site selection for permanent near-road monitoring locations.

Future Work

To provide more information about air pollution levels near busy roads and to meet new federal requirements for near-road monitoring, discussed above, in 2014 the Air District will start collecting pollutant measurement at three locations near major freeways. The new monitoring data will allow the Air District to:

- Assess the health effects from near-roadway exposures;
- Assess factors affecting the variability of near-road air pollutants, such as traffic activity and roadway-design features; and
- Improve modeling tools for near-road air quality and human exposure assessments.

EPA requirements stipulate that the sites are located within 50 meters (about 160 feet) of busy freeways, in high population centers, and in areas with susceptible and vulnerable populations. Measurements of NO_2 are required at all sites while CO and $PM_{2.5}$ measurements are required at only one site.

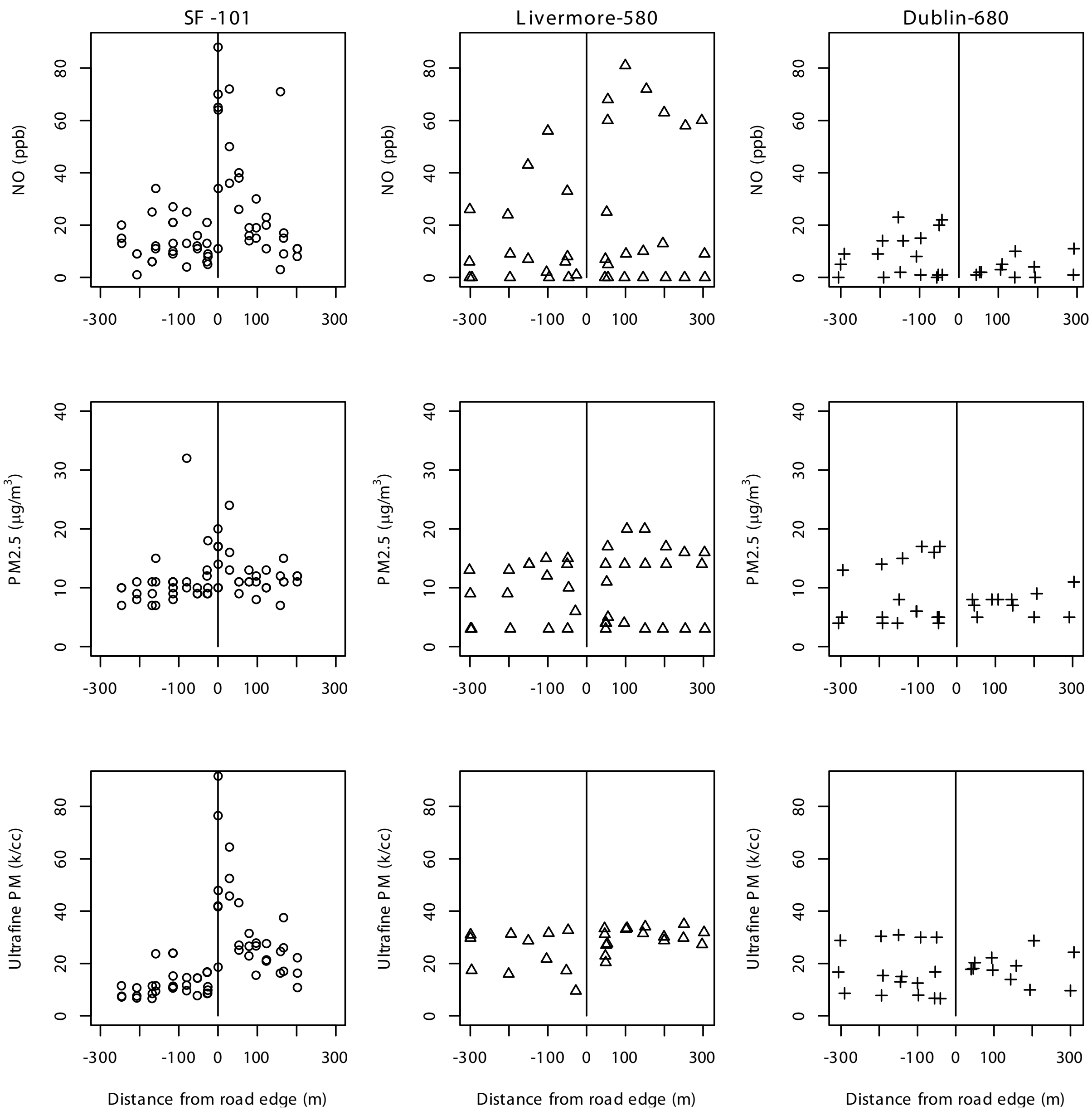
75 Zhu, Y.F., W.C. Hinds, S. Kim, S Shen, C. Sioutas. 2002. Study of ultrafine particles near a major highway with heavy-duty diesel traffic. Atmos. Environ. 36, 4323-4335. doi:10.1016/S1352-2310(02)00354-0

The sites selected by the Air District meet the siting requirements and will collect more pollutant measurements than required. Starting in 2014, the Air District will begin operations at the following sites:

- Near Interstate 80, west of Aquatic Park in Berkeley;
- On the east side of Interstate 880, on the Laney College campus in Oakland; and
- Near the intersection of Interstates 280 and 680 and Highway 101 in San Jose.

The Air District will collect NO_2, CO, and $PM_{2.5}$ measurements at all these sites. Ultrafine particle (UFP) monitoring is not required by EPA but the Air District intends to equip each near-road monitoring site with instrumentation capable of detecting UFPs.

Figure 3.11 Measurements at three sites for three pollutants upwind (negative distances) and downwind (positive distances) of the edge of roadway



3.7 MODELING AND SCREENING TOOLS TO SUPPORT INFILL DEVELOPMENT

For many years, regional agencies in the Bay Area have supported infill development as a key strategy to provide needed housing, reduce motor vehicle use, and reduce air pollutant emissions. Section 4.4 discusses the tension between regional infill development goals and policies and the potential for increasing population exposures to air pollution: by bringing residents to mixed-use communities, infill development can also bring residents closer to pollution sources, such as freeways and busy roads.

To address this tension, Air District staff has collaborated with university researchers, regional agency partners, local governments, and others to develop new modeling tools.[76] Implementation of an effective infill strategy requires a fine-grained analysis of pollutant exposure to protect the health of future residents. Modeling tools exist for project-level analyses of near-roadway air pollution, often applied by consultants and local staff after a project has been planned and designed, but few tools are available for screening and urban planning at the community-scale or city-scale to evaluate and minimize local air quality impacts at the early planning stages of infill developments.

New planning strategies and analyses require new modeling and screening tools. These tools should help planners and others evaluate trade-offs, including potential health impacts. For example, as described in Section 4.4, in 2010, the Air District published CEQA Guidelines to assist local lead agencies in conducting environmental review processes. The CEQA Guidelines contain recommendations for estimating, analyzing, and mitigating potential air quality impacts from the public's exposure to toxic air contaminants and fine particulate matter emitted from stationary sources, freeways, and high volume roadways. These modeling and screening tools can help planners conduct analyses recommended in the updated CEQA Guidelines.

A recent collaborative study by the California Department of Public Health and the Air District has highlighted that infill development, as a strategy to reduce greenhouse gas emissions, can have health benefits. The study found that the added health burden of increased exposure to air pollution was far outweighed by the benefits of exercise if residents in mixed-use developments completed more trips by walking and biking. New tools have been developed and applied to assess whether health benefits outweigh the added risk from traffic and exposure to air pollution.

This section describes the development of:

- New modeling approaches;
- Online screening tools; and
- Technical guidance.

76 An overview these modeling and screening tools was recently presented at a session of the 2013 Annual Meeting of the Air & Waste Management Association on the Air District's efforts to characterize and mitigate exposures to local air pollution sources.

New Modeling Approaches

The Air District has funded and partnered with universities, agencies, and consultants to develop and apply several new modeling approaches and tools, including:

- An efficient model for assessing near-roadway air pollution and health risk;
- A modeling approach to estimate the dispersion of emissions from multiple sources on a city-scale to facilitate community risk reduction plans;
- A modified model to describe air flow around individual buildings; and
- A health impacts model to estimate health co-benefits of walking and bicycling.

Near-roadway Air Pollution and Health Risk

For assessing impacts of near-roadway air pollution, improved tools are needed that encourage and facilitate proactive planning and that track cumulative air pollution impacts as infill development occurs. To develop one such tool, the Air District partnered with researchers at UC Berkeley.[77]

With Air District support, researchers at UC Berkeley's Department of Public Health developed and applied Rcaline,[78] a freely available software package. Rcaline contains the dispersion model CALINE3 but extends its usefulness by removing its restrictions on the number of sources and receptors that can be modeled. Rcaline can input common data sources such as ESRI™ shape files. It automates the process of generating receptors near roadways, uses multiple computer processors to speed processing, and incorporates modern graphical tools to display and export results that can be shared online.

One key benefit of Rcaline is that it allows pollution levels, and associated health risks, to be evaluated for many roadways and many receptors in an automated fashion, thereby facilitating, for example, the development of online roadway screening tools, such as the Highway Screening Analysis Tool discussed below.

City-wide Planning

Proactive planning for designing healthy infill development considers cumulative impacts from local sources for a broad geographical area, such as an entire city. Modeling tools to represent impacts from multiple sources would ideally create maps of localized pollutant concentrations and health risks for the area of interest. Generating such maps at a city-scale requires a massive amount of information gathering and processing. To be practical, such processes require a high degree of automation.

Air District staff, working with the San Francisco Public Health Department and the San Francisco Planning Department, designed and created a modeling system that automates the processes of:

- Generating inputs for dispersion models based on available data sets;
- Configuring model runs;
- Batching runs for individual pollution sources to a cluster computer system; and
- Combining and summing modeling results to a common receptor grid.

77 Holstius, D., E. Seto, P. Martien, V. Lau, A. Fanai, D. Vintze, H. Hilken, S. Reid. 2013. A Near-Roadway Risk Screening Tool for Urban Planners. Presented at the A&WMA 2013 Annual Conference, June 25-28th, 2013, Chicago, IL. Extended Abstract #12914.

78 Holstius, D. 2011. Rcaline: Modeling Traffic-Related Pollution with R and the CALINE3 Dispersion Model. Online: www.davidholstius.com/rcaline

This system was first applied to the City of San Francisco[79] to estimate concentrations of $PM_{2.5}$ and cancer risk from many categories of emissions throughout the City, including:

- On-road mobile sources—cars, trucks, and buses;
- Stationary sources—gas stations, dry cleaners, back-up diesel generators, and industrial sources;
- Ships and harbor craft;
- Transit centers;
- Local commuter rail line; and
- Construction projects.

The dispersion models applied for this initial application were:

- Rcaline model described above and
- The American Meteorological Society/EPA Regulatory Model (AERMOD).

Results from the application of this modeling system were used as part of the technical foundation for a Community Risk Reduction Planning process that is underway for the City of San Francisco (see Section 4.6). The Air District has undertaken similar modeling work for the City of San Jose. Air District staff anticipates that this modeling system could support similar local risk reduction planning efforts in other jurisdictions.

Air Quality Modeling near Buildings

Building and site design, including locating buildings and their air intakes away from the highest concentrations of air pollution, may be important factors in mitigating air pollution exposures for new infill development projects. Key to evaluating the importance of such factors is a detailed evaluation of air and pollutant flows around proposed buildings. Current dispersion models applied for risk assessments do not provide sufficient flow details to make such evaluations. To develop improved tools for investigating this issue, the Air District partnered with UC Berkeley researchers and the San Francisco Department of Public Health.

The City of San Francisco is currently evaluating a proposed housing development located downwind from Interstate-280, travelled by more than 250,000 vehicles per day. The proposed development site is near an opening in the coastal mountains that funnels the sea breeze from the Pacific Ocean and accentuates westerly winds.

The Air District helped fund an investigation of building and site design for the development project using an advanced modeling tool being developed by UC Berkeley.[80] The UC Berkeley team has modified the Weather Research and Forecasting model (WRF) to use an immersed boundary method (IBM)[81,82] that allows for detailed

79 Bay Area Air Quality Management District. 2012. The San Francisco Community Risk Reduction Plan: Technical Support Documentation. December 2012.

80 Wiersema, D.J., K.A. Lundquist, P.T. Martien, T. Rivard, F.K. Chow. 2012. High Resolution Urban Air Quality Modeling with an Immersed Boundary Method in WRF. Poster presented at the American Meteorological Society 20th Symposium on Boundary Layers and Turbulence. July 2012.

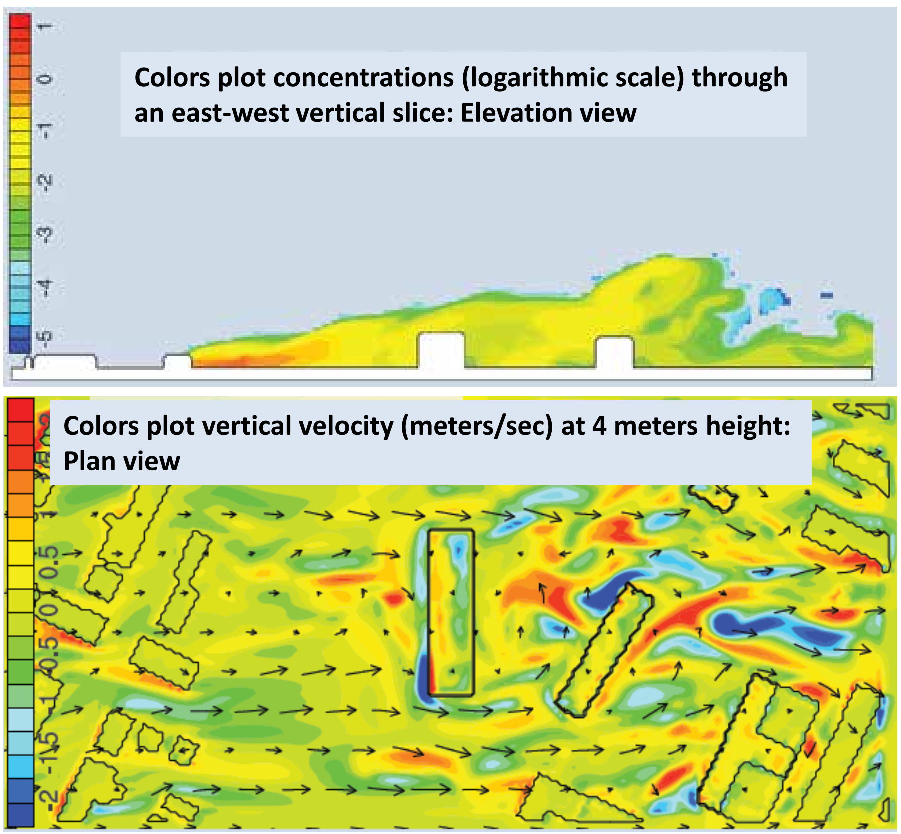
81 Lundquist, K.A., Chow, F.K., J.K. Lundquist. 2010. An immersed boundary method for the Weather Research and Forecasting model. *Mon. Weather Rev.* 138, 796-817. doi: 10.1175/2009MWR2990.1

82 Lundquist, K.A., Chow, F.K., J.K. Lundquist. 2012. An immersed boundary method enabling large-eddy simulations of complex terrain in the WRF model. Model. *Mon. Weather Rev.*, 140, 3936–3955. doi: 10.1175/MWR-D-11-00311.1

representation of urban geometries and wind patterns, representing flow around individual buildings. Preliminary testing shows that IBM-WRF performs well when simulating flow through complex urban terrain.

Figure 3.12 shows detailed wind flow patterns (bottom) and pollutant dispersion results from IBM-WRF. These kinds of detailed dispersion results will be useful to compare to results from simpler, commonly applied, dispersion models to evaluate their similarities and differences for the complex wind patterns found in urban settings. Such results may also prove to be useful for designing buildings, and their site orientations, to optimize air quality around and within the buildings.

Figure 3.12 Results from the IBM-WRF model showing pollutant concentrations (top) and wind flow (bottom) around a proposed affordable housing development



Health Co-benefits of Active Transport

An important consideration in designing healthy infill developments is the health impact of promoting more active forms of transportation, such as walking and bicycling, in urban locations.[83] On the one hand, compared to driving, active transportation increases exercise levels and overall reduces emissions of air pollutants. On the other hand, it exposes those exercising to more traffic hazards and more inhalation of air pollution. To investigate this issue, the Air District partnered with the California Department of Public Health to quantify health benefits of mix-use and transit-oriented development strategies that reduce GHG and other pollutant emissions.

83 Maizlish, N., J. Woodcock, S. Co, B. Ostro, A. Fanai, and D. Fairley. 2013. Health Cobenefits and Transportation-Related Reductions in Greenhouse Gas Emissions in the San Francisco. Bay Area *Am J Public Health*. 103(4): 703–709. doi: 10.2105/AJPH.2012.300939

Study participants gathered information on travel patterns, bicycle and pedestrian injuries, physical activity, fine particulate matter emissions, and GHG emissions in the Bay Area. This information was input to the Integrated Transport and Health Impacts Model (ITHIM) to estimate the health impacts of walking and bicycling short distances instead of travel by car. ITHIM considered the change in disease burden in life years based on changes in physical activity, pollutant emissions, exposure to particulate matter, and traffic injuries.

The study concluded that:

- Increased physical activity associated with walking and bicycling and facilitated by infill development patterns could generate a large net improvement in health in the Bay Area;
- Measures would be needed to minimize pedestrian and bicyclist injuries; and
- Active transportation combined with cleaner vehicle fleets (with reduced carbon emissions) could achieve greenhouse gas reductions sufficient for California to meet legislative mandates.

Online Screening Tools

The Air District has developed a set of online screening tools[84] to assist the public, project sponsors, and local agencies in identifying and assessing the potential health impacts from exposure to air pollutant emissions from high trafficked roadways and permitted stationary sources. These tools can be used for environmental documents, specific plans and general plan updates, and other local planning studies to facilitate future growth in a community that is health protective for existing and new residents. These tools complement CARB's *Air Quality and Land Use Handbook: A Community Health Perspective*[85] and provide more detailed guidance for Bay Area communities.

Highways

The Highway Screening Analysis Tool (HSAT) is an online resource that facilitates early planning assessments of near-roadway risk and hazards from air pollution. Built using Rcaline, described above in this section, HSAT makes risk-screening tables publically available for State highways in the Bay Area. HSAT estimates potential cancer risk, non-cancer hazards, and fine particulate matter concentrations at varying distances on each side of highway links. The results are shown (see Figure 3.13) on Google-Earth™ maps.

Surface streets

For surface streets, Air District staff prepared county-specific screening tables of potential cancer risks, non-cancer hazards, and fine particulate matter concentrations at varying distances from roadways to estimate impacts for varying levels of street traffic. These tables supplement HSAT by providing similar information for generic surface streets with a north-south or east-west orientation for each county.

Permitted sources

Google-Earth™ maps are also available for permitted sources, such as gas stations, back-up diesel generators, and many industrial sources of air pollution. These maps provide locations of individual facilities permitted by the Air District along with screening estimates of maximum potential cancer risks, non-cancer hazards, and fine

84 http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx

85 CARB. 2005. Air Quality and Land Use Handbook: A Community Health Perspective. Online: http://www.arb.ca.gov/ch/landuse.htm

particulate matter concentrations from facility pollutant emissions. These screening maps for stationary sources can be used, for example, to identify stationary sources of air pollution near a proposed development project and to make screening assessments of risk from nearby sources.

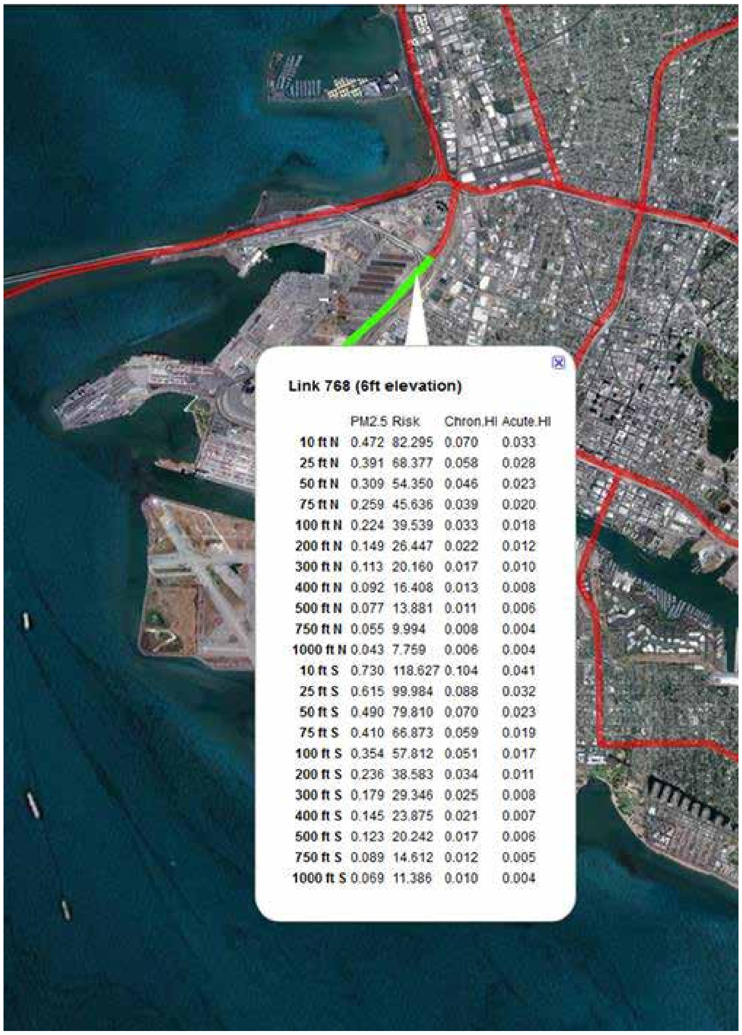


Figure 3.13
Online Highway Screening Analysis Tool

Highlighted highway link shows $PM_{2.5}$ concentrations (µg/m³), cancer risk (per million), chronic and acute hazard index on each side of the highway.

Technical Guidance

The Air District's technical guidance *Recommended Methods for Screening and Modeling Local Risks and Hazards, version 2*,[86] describes the methodologies followed to develop many of the screening tools. In addition, the technical guidance provides a step-by-step description of how to apply the screening methods. Examples of how to use the screening tables are also presented in the Air District's updated CEQA Guidelines document,[87] dated May 2012. The screening tables and documentation can be used together to assist local jurisdictions in identifying air pollution sources in a community and in crafting projects, programs, ordinances, or other measures to reduce residents' long-term exposures to air pollution.

86 http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Tools-and-Methodology.aspx

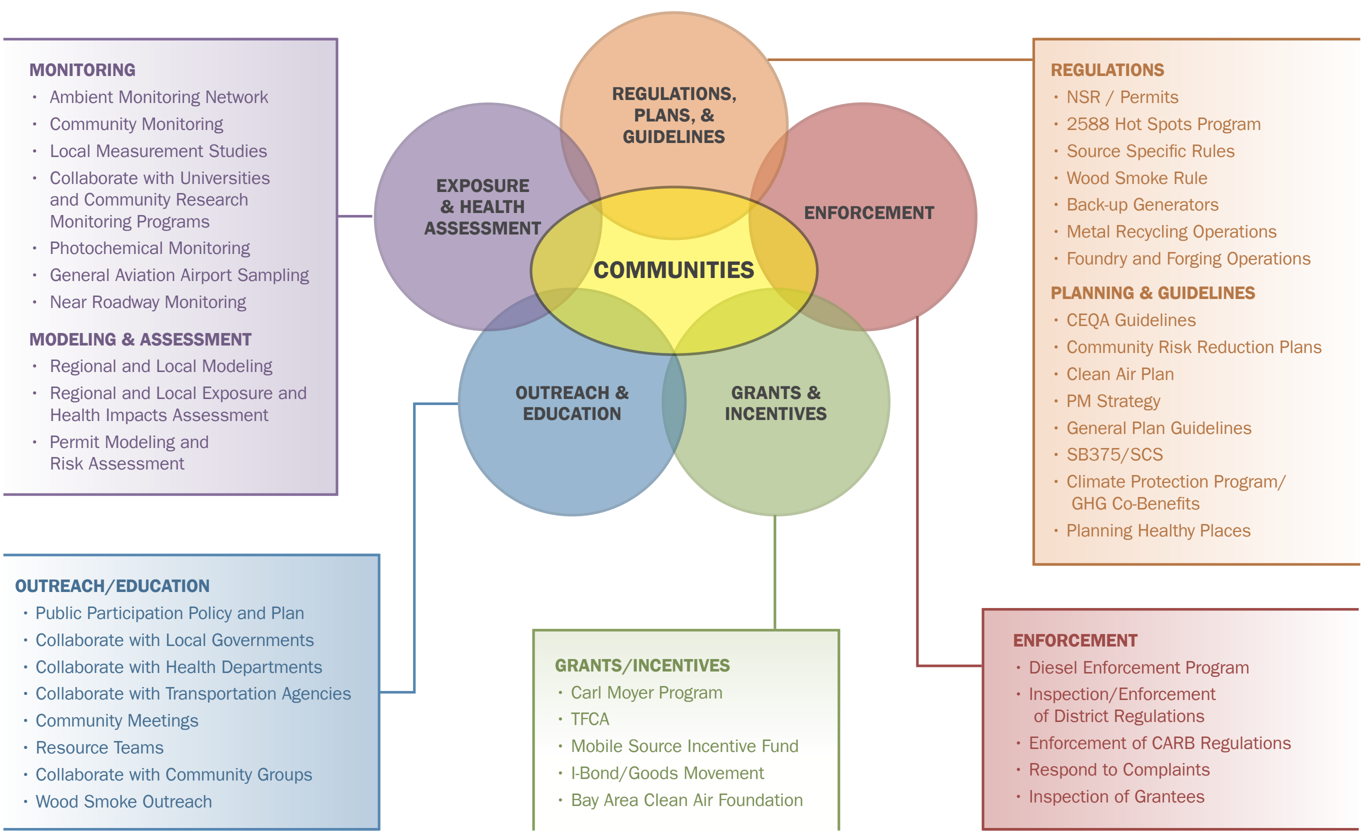
87 http://www.baaqmd.gov/Divisions/Planning-and-Research/CEQA-GUIDELINES/Updated-CEQA-Guidelines.aspx

4. AIR DISTRICT ACTIONS TO SUPPORT HEALTHY COMMUNITIES

One of the main goals of the CARE program has been to help design and focus effective air pollution mitigation measures in areas with highest impacts. The Air District has used information gained through the CARE program's scientific studies to support a range of mitigation actions in impacted communities drawing upon the skills and resources of many Air District programs.

To carry out actions to improve air quality and reduce health impacts, the Air District developed a coordinated, comprehensive strategy that utilizes the agency's available resources. That coordinated strategy has been implemented through the Clean Air Communities Initiative (CACI). CACI is a multi-faceted approach that focuses risk-reduction efforts from many of the Air District's programs in the impacted communities (see Figure 4.1) to improve air quality and health in these communities. The following sections describe the elements of CACI.

Figure 4.1 Clean Air Communities Initiative (CACI)



4.1 GRANTS AND INCENTIVES

The Air District's Strategic Incentives staff works closely with the CARE program to ensure that funding opportunities are prioritized to reduce emissions in the communities identified as impacted. In the Bay Area, mobile sources are the greatest contributor to air pollution and greenhouse gases. The purpose of the grant programs is to expedite reductions in mobile sources emissions through the distribution of incentive funds to purchase lower and zero-emission equipment for public agencies, school districts, and private companies. Air District's grant programs complement and enhance CARB mobile source regulations by supporting *early* compliance or by supporting emission reduction projects that *exceed* CARB requirements. The Air District administers many expansive grant programs including the Transportation Fund for Clean Air, Mobile Source Incentive Fund, Carl Moyer Program, Lower Emission School Bus Program, and Goods Movement Program.[88] Funds for these programs are generated through surcharges on motor vehicle registration, tire fees, bond sales, and smog check fees.

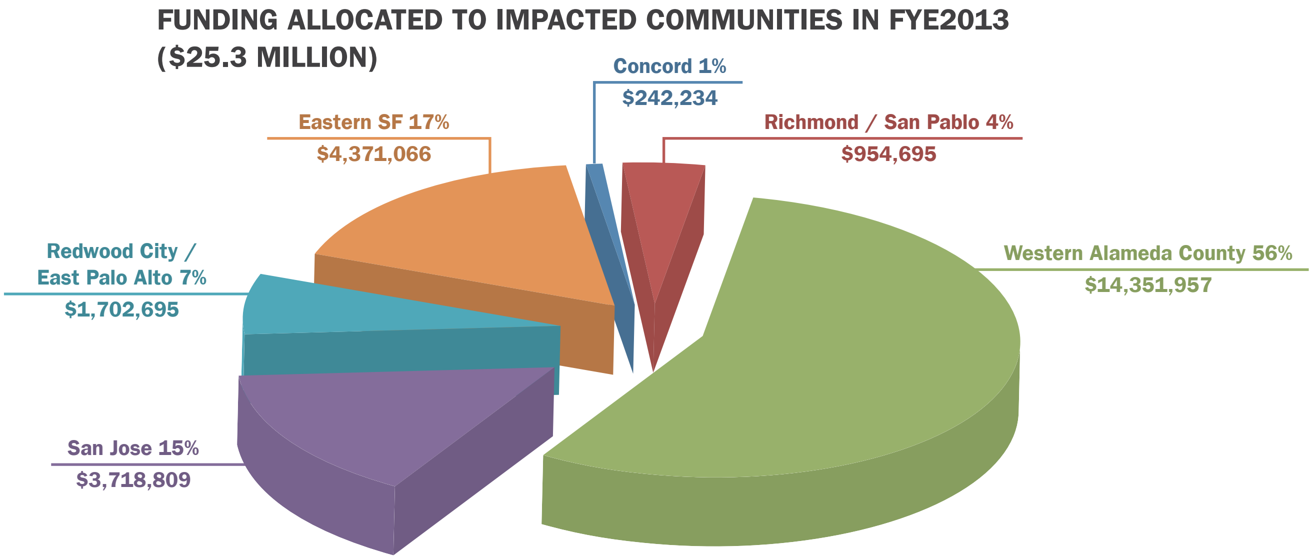
Since 1992, the Air District has awarded over $500 million in grant funds for cost effective emission reduction projects. The Air District oversees up to 1,500 projects per year and administers about $12 million each from the Transportation Fund for Clean Air, Carl Moyer Program, Mobile Source Incentive Fund, over $6 million for the Lower Emission School Bus Program, and over $35 million for the California Goods Movement Bond program. Grants are used to retrofit and replace on-road trucks, construction equipment, older diesel school buses, locomotives, cargo-handling equipment, marine vessels, and to install electric vehicle recharging stations. These grants have been instrumental in reducing air pollution emissions and health risks throughout the Bay Area, particularly along transportation corridors. Additionally, grants are used to reduce vehicle miles traveled (VMT) by funding shuttle, ridesharing, smart growth, and bicycle projects.

In West Oakland, the Air District provided over $25 million to retrofit and replace 1,522 drayage trucks in 2009 and 2010. The Air District also provided $24 million in grants to install shore-side power at 11 berths at the Port of Oakland and an additional $29 million to replace or retrofit an additional 420 port trucks and 380 on-road trucks that operate in Western Alameda County and Eastern San Francisco by 2013. These grant programs have resulted in significant benefits. As discussed in Section 3.3, independent studies conducted by UC Berkeley have demonstrated that the use of this funding in conjunction with the enforcement of regulations for drayage trucks have reduced emissions from that source category by as much as 50% in the West Oakland community. Figure 4.2 shows the distribution of grant funds allocated to each impacted community for fiscal year 2013 (July 1, 2012 to June 30, 2013). More than $25 million was awarded to impacted communities in fiscal year 2013, which represents over 50% of funds awarded that year.

As well as providing funding for the cleanup of vehicles and equipment, Air District grant funds are used to provide outreach on and enforcement of CARB's truck regulations. These efforts include one-to-one assistance for truckers on regulatory requirements and compliance, including multilingual assistance in Hindi, Chinese and Spanish. These efforts also include compliance assurance via truck inspections conducted in concert with CARB and the California Highway Patrol. As a result of these efforts, thousands of truckers were provided with information on regulatory compliance annually by the Air District staff via Internet media, postcards, flyers, one-on-one meetings and outreach events.

88 More detailed description of each program is available at: http://www.baaqmd.gov/Divisions/Strategic-Incentives.aspx

Figure 4.2 Fund Allocation for Impacted Communities in Fiscal Year 2013



4.2 REGULATIONS

The Air District has a long history of adopting and enforcing regulations to reduce emissions of air pollution. Since 1957, when the Air District adopted its first regulation banning open burning at dumps, the Air District has adopted over 120 rules that limit emissions from a wide range of stationary sources, from large industrial facilities such as petroleum refineries and power plants to local commercial enterprises such as gas stations, dry cleaners, and auto body shops. Air District staff continuously review these rules to assure they reflect the most current pollution control technology and processes, meet federal and state requirements, and adequately protect public health. Proposed rules or rule amendments are developed through an extensive public outreach and involvement process, and are ultimately presented to the Board of Directors for consideration and adoption at a public hearing.

The rule development process supports the Air District's CACI program by identifying and developing rules to reduce public exposure to air pollution, especially in impacted areas. Through the rule development process, Air District staff identifies types of sources that may contribute to localized air pollution exposures. This process is open and responsive to community concerns. In some cases, community concerns have helped identify local sources of pollution exposure and that involvement led to new or amended rules.

Most of the Air District's regulations are tailored to reducing air pollution emissions from specific types of stationary sources while others apply more generally to permitting a wide variety of sources. Examples of the former are two regulations adopted in 2013 on metal recycling and shredding operations and on foundry and forging operations (see Figure 4.3). The rule on metal recycling and shredding operations (Regulation 6, Rule 4) requires that facilities develop and implement plans to minimize fugitive PM emissions. The rule on foundries and forges (Regulation 12, Rule 13) requires plans to minimize emissions of PM and odorous compounds. Most of the Bay Area facilities subject to these rules are sited in areas identified as impacted by the CARE program.

Figure 4.3 Foundries and metal melting operations in the Bay Area are subject to new Air District regulations

Another regulation that applies to a specific type of source is the regulation on wood burning devices. One of the Air District's major recent successes, the wood burning rule (Regulation 6, Rule 3) adopted in 2008, prohibits use of wood-burning devices, such as fireplaces and woodstoves, when air quality is forecast to be unhealthy from November through February. The rule has resulted in significant reductions in wintertime $PM_{2.5}$ concentrations. Locally-emitted wood smoke accounts for approximately one-third of $PM_{2.5}$ levels on days when Bay Area PM levels exceed the national 24-hr $PM_{2.5}$ standard. Preliminary analyses suggest that the wood burning rule has reduced ambient wood smoke levels by 50 to 75%. Wood burning devices are located throughout the Bay Area, both within and outside impacted areas. However, elevated PM levels are a main contributor to health impacts in CARE communities, as identified in Section 2.4. By lowering PM levels throughout the region, this rule plays an important role in improving health in impacted areas. Because of the importance of reducing PM levels to improving health outcomes, Air District staff is currently investigating additional PM rules to reduce local impacts of particulate sources, many of which are located in CARE communities.

The Air District is currently considering a new regulation to address impacts from diesel generators. Stand-by, back up diesel generators are used throughout the Bay Area in hospitals, senior housing, high rise buildings, and data centers to provide temporary emergency electricity when utility services are not available. Health risk screening analyses have suggested that these back up diesel generators may contribute significantly to cancer risk, particularly in areas where there are older, higher emitting, engines or where greater numbers of engines are located. As part the development process for this rule, previous risk analyses will be examined in detail, checking emissions estimates during routine tests, to evaluate the effectiveness of additional controls on backup generators.

The Air District is currently developing a source-specific rule on Bay Area petroleum refineries. This proposed rule would establish improved procedures for tracking air emissions from refineries, and enhance fence-line and community air monitoring systems. The improved emissions and air quality information resulting from this rule would better inform Air District staff of additional regulatory measures that may need to be developed for refineries.

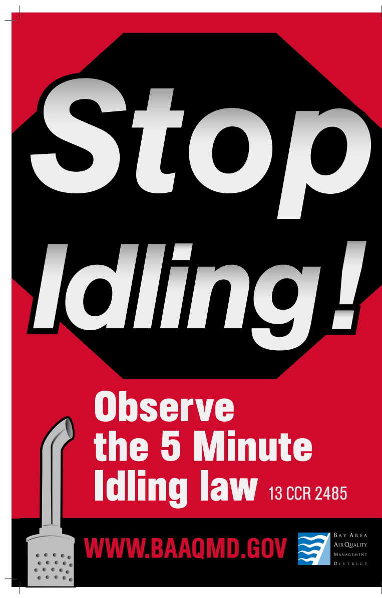
Regulations that specify how stationary sources are permitted can greatly influence permitted emission levels from a wide variety of sources. For example, in 2005, the Air District adopted amendments to the New Source Review and Title V permitting programs (Regulation 2, Rule 2), which are federal permitting requirements established under the Clean Air Act. The principal changes included adding permit requirements for $PM_{2.5}$ and greenhouse gases and a requirement that applicants demonstrate that their projects will not cause or contribute to a violation of the National Ambient Air Quality Standards. These amendments ensure compliance with EPA requirements, but also facilitate reductions of $PM_{2.5}$ and greenhouse gases regionally and improve the accuracy of our emission inventory for these sources.

In 2010, the Air District amended its New Source Review permit requirements for toxic air contaminants (Regulation 2, Rule 5). Those amendments, which were developed with input from the Cumulative Impacts Work Group (see Section 1.4), incorporated OEHHA's age sensitivity factors and updated health-effects values. The Bay Area Air District was the first air district in California to adopt these changes. By incorporating the age sensitivity factors, the Air District increased its estimates of potential cancer risk from sources of carcinogenic TAC emissions by nearly a factor two, resulting in a greater level of health protection. This had far-reaching implications for cancer risks levels calculated for new and modified sources of TAC, effectively cutting allowable emissions of carcinogenic air pollutants nearly in half for all new permits.

By identifying regulations that promote public health, with focus on impacted areas, and by promoting open discussions of community concerns, the Air District will continue to implement regulatory programs to improve the air quality in all Bay Area communities.

4.3 COMPLIANCE AND ENFORCEMENT ACTIONS

Air District Compliance and Enforcement staff ensure that permitted facilities comply with existing regulations and permit conditions and that appropriate enforcement actions are taken when facilities are out of compliance. A well-trained staff of inspectors conducts inspections of air pollution sources, verifies compliance, investigates breakdowns, documents violations, and responds to citizen complaints about air pollution and to accidental releases of air contaminants. In addition, inspectors check recipients of grants to ensure that emission control devices are installed properly (see Section 4.1).



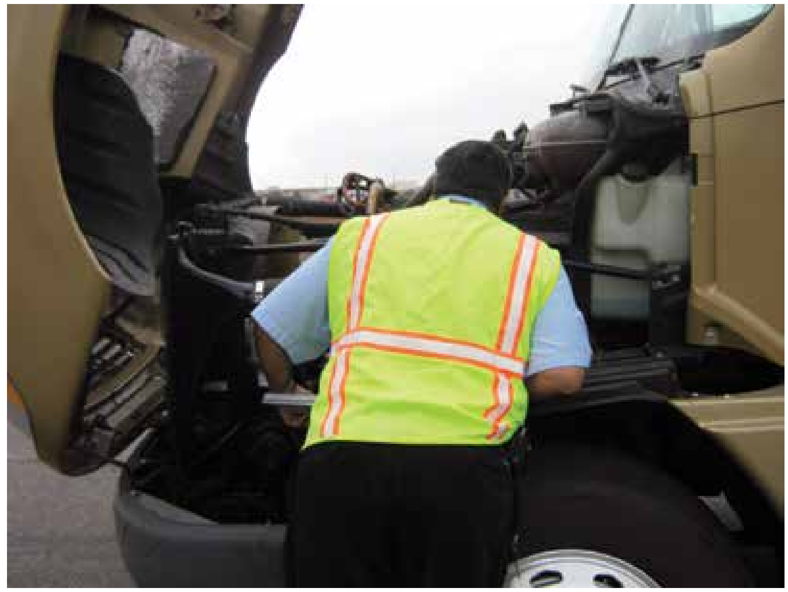
In addition to routine inspections of permitted facilities, Air District staff developed and managed several high profile projects that have been successful in further reducing air pollution throughout the Bay Area. Through a Memorandum of Understanding (MOU) with CARB, the Air District has authority to enforce CARB's diesel mobile source regulations within the Bay Area. The program, called the Mobile Source Compliance Plan, is designed to reduce diesel PM in CARE impacted areas, focused particularly on drayage trucks and other sources at the Port of Oakland.

From September 2009 through 2103, Air District staff performed more than 11,000 inspections on drayage trucks, commercial idling, transportation refrigeration units, off-road construction equipment, locomotives, and ocean-going vessels. Table 4.1 shows the number of inspections by year for various types of inspections of mobile diesel equipment. Since 2010, when the state regulation on drayage trucks became effective, many inspections have been conducted on drayage trucks in support of the regulation (see Figure 4.4). From 2010 through 2013, Air District staff inspected more than 5,000 drayage trucks. More than 2,500 inspections have supported limits on commercial diesel idling. Table 4.1 also lists violations issued by year (bottom row) during inspections for lack of compliance with regulations on mobile diesel equipment. A total of 324 violations have been issued since 2010.

Table 4.1 Since 2009, the Air District's Mobile Source Compliance Plan program has conducted over 11,000 inspections of mobile diesel equipment

	2009 starting in September	2010	2011	2012	2013	Total
Portable Equipment		412	188	174	184	958
Commercial Idling		75	930	922	752	2,679
Off-Road Diesel Equipment			85	519	293	897
Harbor Craft	4					4
Drayage Truck Regulation		1,145	2,436	954	597	5,132
Ocean Going Vessels	24		17		27	68
Transport Refrigeration Units		106	647	259	256	1,268
Onboard Incineration	24		17		27	68
Total Inspections	52	1,738	4,320	2,828	2,136	11,074
Violations	**0**	**42**	**59**	**92**	**131**	**324**

Figure 4.4 From 2010 through 2013, Air District staff inspected more than 5,000 drayage trucks



This major enforcement effort has spurred greater compliance with state regulations on diesel equipment and assured that the maximum emissions reductions and public health benefits are achieved. The effectiveness of the drayage truck regulation (see Section 3.3) in reducing emissions from trucks serving the Port of Oakland was ensured in part through the Air District's enforcement efforts.

The Air District has also been actively enforcing the wood burning rule (Regulation 6, Rule 3) adopted in response to elevated PM concentrations from wood burning during winter time conditions. The regulation, described in Section 4.2, prohibits use of wood-burning devices when air quality is forecast to be unhealthy. Air District inspectors conduct wood smoke investigations in areas with high rates of wood burning, respond to citizen complaints, and issue violation notices.

The Air District's Smoking Vehicle Assistance and Vehicle Buy-Back programs were implemented to decrease the number of vehicles spewing visible tailpipe exhaust on the region's roads and highways. These programs reduce emissions throughout the Bay Area, but are particularly effective in areas with older, high-emitting cars and trucks. Numerous studies[89] have shown that high emitting vehicles are responsible for a large proportion of the total mobile-source emissions even though they represent a small fraction of the total vehicle fleet on a roadway. A recent study[90] found that removing the highest 5% of the emitting vehicles in light duty gas vehicles and heavy duty diesel truck classes would reduce NO_x emissions by 34%, black carbon (an indicator of diesel PM) by 39%, $PM_{2.5}$ by 44%, and ultrafine PM by 31%.

Air District enforcement efforts to ensure compliance with stationary-source regulations have historically been an essential component of the agency's emission-reduction efforts. The Air District will continue these efforts to reduce air pollution exposures and, with the development of the MOU, also continue to devote agency resources to enforcing diesel mobile source regulations, focusing on areas identified as impacted.

89 Park, S., and Rakha, H. 2009. Environmental Impacts of High-Emitting Vehicles. Transportation Research Record: Journal of the Transportation Research Board. Issue 2123: 97-108.

90 Park S.S., Kozawa, K., Fruin, S., Mara, S., Hsu, Y.K., Jakober, C., Winer, A., and Herner, J. 2011. Emission Factors for High-Emitting Vehicles Based on On-Road Measurements of Individual Vehicle Exhaust with a Mobile Measurement Platform. J Air Waste Manag Assoc. 61 (10): 1046-56. October 2011.

4.4 LAND-USE POLICIES AND AGENCY COLLABORATIONS

Land-use planning serves as an important and effective tool to improve air quality and reduce people's exposure to air pollutants. Land-use plans that support mixed-use, high-density, infill development near transit corridors result in fewer vehicle trips and fewer vehicle miles traveled when compared to greenfield development. Mixed-use, infill development near transit provides residents and employees with transportation alternatives to driving, such as transit, walking, and cycling. This reduction in vehicle trips and vehicles miles of travel can substantially reduce air pollutant emissions from cars and trucks, the largest source of air pollution in the Bay Area, thus reducing the public's exposure to toxic air contaminants, particulate matter, and other air pollution from vehicles.

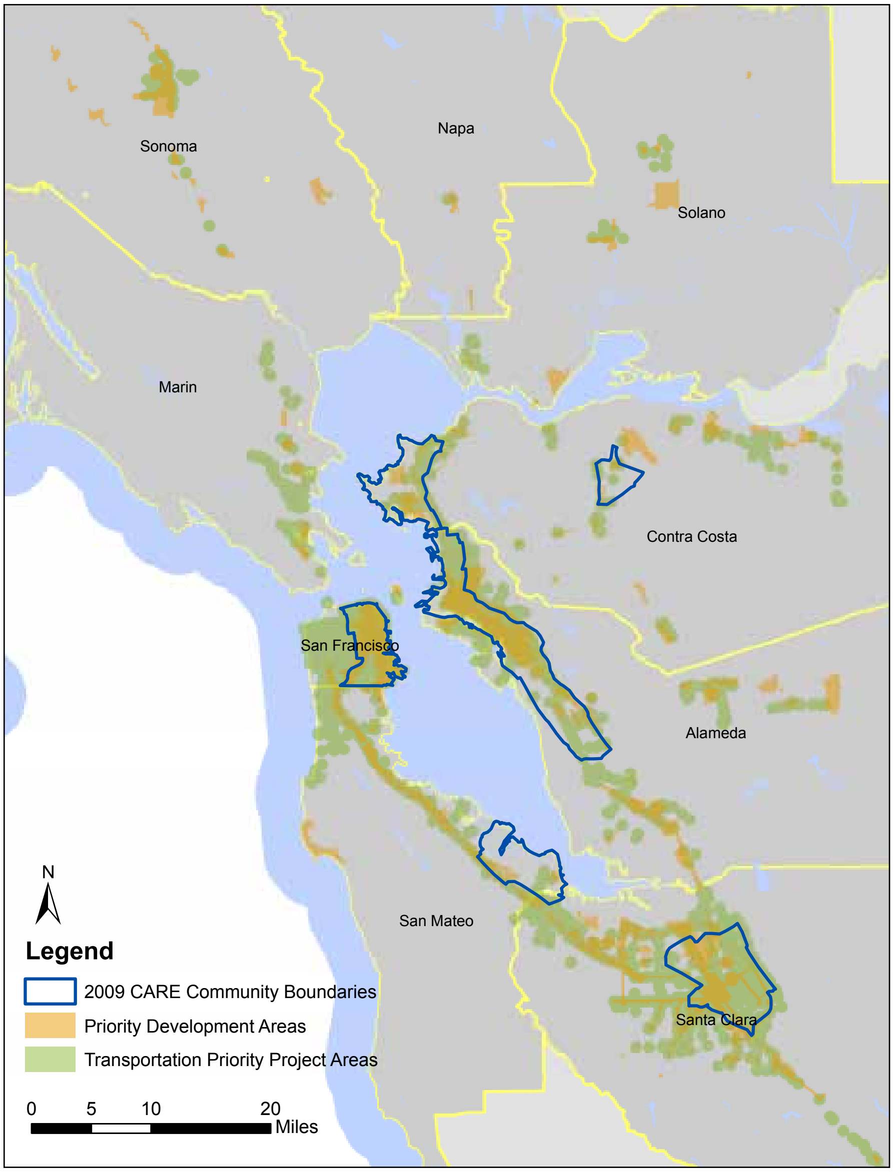
The Air District and its regional agency partners are collaborating on promoting infill development in the region. Pursuant to State legislation (California Senate Bill 375, Steinberg, 2008),[91] the regional agencies recently developed a Sustainable Communities Strategy (SCS) as an element of the regional transportation plan. The SCS must demonstrate how the region can reduce greenhouse gas (GHG) emissions from cars and light trucks sufficient to meet targets set by CARB through integrated long-term transportation investments and land use decisions. The Bay Area SCS, titled *Plan Bay Area*, was developed by the Association of Bay Area Governments (ABAG) and the Metropolitan Transportation Commission (MTC), in collaboration with the Air District and the Bay Conservation and Development Commission (BCDC), and was adopted in July 2013.

Plan Bay Area emphasizes compact, mixed-use, infill development located near transit by focusing future land development in Priority Development Areas (PDAs). PDAs are areas within existing communities that have been identified by city or county governments to accommodate larger shares of future growth. These areas are typically easily accessible to transit, jobs, shopping and other services. PDAs also tend to overlap with Transportation Priority Project (TPP) areas, identified based on criteria in SB 375, which are areas located near frequent transit service.

Many of the locations identified in *Plan Bay Area* as possible infill development opportunities are also located in impacted communities identified through the CARE program. Locations with transit service, built infrastructure, and a range of jobs and services often correspond with older, more densely developed communities. These communities are frequently located near, or include, busy freeways, ports and rail facilities, and industrial and commercial sources of air pollution. Figure 4.5 shows development opportunity areas in *Plan Bay Area* overlaid with CARE impacted communities. While such regional-scale maps suggest a conflict between infill development and air pollution exposure, careful planning often can resolve such conflicts and accommodate infill in healthy locations.

91 http://www.onebayarea.org/pdf/SB375_OneBayArea-Fact_Sheet2.pdf

Figure 4.5 CARE impacted community boundaries (version 1) shown with Priority Development Areas and Transit Priority Project Areas identified in the Sustainable Communities Strategy[92]



As part of *Plan Bay Area*'s environmental review, MTC, with assistance from Air District staff, prepared a local pollutant analysis that focused on potential health risk impacts associated with public exposure to TAC and PM within Transit Priority Project areas. The local pollutant analysis identifies areas in the Transit Priority Project corridors in which residents may be exposed to unhealthy levels of air pollution and encourages mitigation measures to lessen or avoid potential impacts. Mitigation measures include setbacks and buffers; high efficiency filters in heating, ventilation, and air conditioning systems; phased development; and best practices for building design and construction operations. The analysis also identified areas not significantly affected by local air pollution.

92 Infill in Transportation Priority Project Areas can qualify for CEQA streamlining through the SCS.

Local governments may use *Plan Bay Area's* local pollutant analysis for certain CEQA streamlining purposes in future projects. Projects that demonstrate consistency with *Plan Bay Area's* environmental review by implementing the recommended mitigation measures as appropriate may, with certain exemptions, benefit from reduced CEQA costs and a more efficient permitting and entitlement process. This effort lifts a significant CEQA burden for future projects and creates a more predictable and straightforward process for developers.

The fact that Priority Development Areas and Transit Priority Project areas often overlap CARE areas underscores the need for thoughtful planning. The overlap does not necessarily imply conflict: as discussed in Section 2.5, site-specific analysis provides a more accurate picture of potential air quality impacts, whether the location is within or outside an impacted area. Thoughtful urban design and zoning can separate residents and other individuals from air pollution sources such as industrial facilities and busy roadways. Moreover, as discussed in Section 3.7, the health co-benefits of walking and cycling facilitated by infill development patterns could generate a large net improvement in health in the Bay Area. Yet the tension between infill and increased exposure to air pollution does warrant analysis, careful project siting and design and, potentially, mitigation measures.

To address the challenge between supporting infill and minimizing exposure to air pollution, the Air District is collaborating with local jurisdictions and regional agencies on a variety of land-use and transportation-planning initiatives. As noted above, the Air District worked with MTC on the environmental review of *Plan Bay Area* to support infill development in healthy locations. In addition, Air District staff developed technical guidance to assist local planners in making healthy land-use decisions. In 2010, the Air District published CEQA Guidelines to assist local lead agencies in conducting in environmental review processes. The CEQA Guidelines contain recommendations for estimating, analyzing, and mitigating potential air quality impacts from the public's exposure to sources of toxic air contaminants and fine particulate matter, including stationary sources, freeways, and high volume roadways. The CEQA Guidelines outline strategies to reduce potential health risks in projects, such as recommendations for careful building siting and design.

The Air District also developed a suite of tools to assist local planners in analyzing air pollution exposures. The following tools provide estimates of potential concentrations and health hazards from TAC and fine PM:

- A stationary source screening analysis tool that identifies stationary sources using Google Earth and contains conservative estimates of associated health risks;
- Roadway screening analysis tables with county-specific risk estimates by roadway volumes; and
- A highway screening analysis tool with risk estimates for all state highways in the Bay Area.

More discussion of modeling and screening tools available to support infill development is provided in Section 3.7.

In addition to developing tools to support air quality evaluations in infill projects, Air District staff works closely with local planners on analyzing potential health risks and hazards in specific projects and plans. Effective risk and exposure reduction strategies and measures are growing increasingly important as cities look to infill development for future growth. Air District staff is currently developing additional guidance to assist local governments in addressing healthy infill development in local plans and programs. This additional guidance incorporates input from the CARE Task Force, local cities, health departments, and regional agency partners ABAG and MTC. The guidance will lay out steps for identifying air pollution sources, estimating health risks from those sources, and applying risk reduction measures to reduce exposure and emissions of toxic air contaminants and particulate matter. The goal is to identify a range of feasible, effective strategies to minimize local air quality exposures, such as

- Setbacks and site design,
- High efficiency filters in heating, ventilation, and air conditioning systems,
- Sound walls and vegetation,
- Truck routes and idling limits, and
- Clean up of older, dirtier engines and equipment.

4.5 REGIONAL PLANS

Protecting public health and reducing population exposure to particulate matter in local communities are key priorities in the Air District's 2010 Clean Air Plan. The Bay Area 2010 Clean Air Plan[93] was developed in association with the Air District's regional agency partners, MTC, ABAG, and the San Francisco Bay Conservation and Development Commission (BCDC). The Plan includes a review of air quality progress to date in the Bay Area and provides a comprehensive control strategy for achieving California's ozone standards. For the first time, the Air District used a multi-pollutant approach by addressing ozone, particulate matter, air toxics, and GHG emission reductions in a single integrated plan to protect air quality, public health, and the climate. The 2010 Plan included an analysis of the health burden from air pollution in the Bay Area and demonstrated that particulate matter is the air pollutant with the greatest health impact in the Bay Area. The 2010 Plan's multi-pollutant approach to assessing air pollution health impacts parallels the CARE program's updated method for identifying impacted areas (Section 2.4) and supports its findings.

The 2010 Plan's control strategy includes five types of control measures. As in previous air quality plans, the 2010 Plan includes Stationary Sources Control Measures to reduce emissions from refineries, factories and other stationary sources; Mobile Source Measures to promote the use of clean fuels and advanced technology vehicles; and Transportation Control Measures to reduce motor vehicle travel. In addition, to reflect the focus of the 2010 Plan on protecting public health and protecting the climate, the control strategy in the 2010 Plan introduced two new categories of control measures: Land Use and Local Impact Measures, and Energy and Climate Measures. The Land Use and Local Impact Measures are designed to guide local jurisdictions in assessing health impacts and implementing appropriate mitigations to reduce pollution exposures within their community.

The Air District has implemented a number of projects that targeted reductions in fine particulate matter. These included preparation of a PM Summary Report;[94] modeling and technical analyses to better understand PM sources, formation, transport, and health effects; ongoing improvement of the PM emission inventory; development of regulations to reduce PM emissions; and collaboration with local jurisdictions to develop and implement local programs to reduce PM emissions and exposures.

93 Bay Area Air Quality Management District. 2010. Bay Area 2010 Clean Air Plan. Adopted September 15, 2010.

94 Bay Area Air Quality Management District. 2012. Understanding Particulate Matter: Protecting Public Health in the San Francisco Bay Area.

The PM Summary Report summarizes the Air District's efforts to reduce PM to date and lays the groundwork to guide the Air District's future efforts to continue reducing PM in future years. The report describes PM and its impacts on public health, climate change, and ecosystems; describes which PM sources account for the greatest population exposure to PM; provides technical information about how PM is emitted and formed in the Bay Area; describes progress in reducing PM levels in the San Francisco Bay Area in recent years; describes current regulations and programs to reduce PM emissions and concentrations; identifies future technical work needed to improve the Air District's understanding of PM; and explains the importance of continuing the Air District's efforts to reduce PM in order to protect public health and the environment.

The Air District has also developed and implemented a variety of GHG reduction policies and programs. As discussed in Section 4.4, these include collaborating with ABAG and MTC to create a Sustainable Communities Strategy pursuant to Senate Bill 375 to achieve GHG emission reductions by integrating transportation and land use planning. The Air District develops guidance and provides technical assistance to local jurisdictions in developing local climate action plans, identifying and emphasizing the air quality co-benefits of GHG reduction strategies, and maintaining a Bay Area regional-wide GHG emission inventory.

In the Bay Area, nearly 50 local governments have adopted local climate action plans to reduce GHG emissions in their communities. These plans all follow a similar format, including community-wide GHG inventories and projections, emission reduction targets, a wide variety of GHG mitigation measures targeting all major community emission sources. Common mitigation measures include energy efficiency and green building requirements, local production of renewable energy, promotion of walking, biking and public transportation as alternatives to single occupancy-vehicle travel, water conservation and waste reduction. By targeting fossil fuel use, many of the measures in these local plans have the added benefit of reducing air pollution that result from burning fossil fuels. Contra Costa County's climate action plan includes an analysis of the health co-benefits of GHG reduction measures in the plan.

On November 6, 2013, the Air District Board of Directors adopted a climate protection resolution[95] with three elements:

- Setting a regional goal of reducing GHG emissions 80% below 1990 levels by 2050;
- Developing a regional climate protection strategy within the Clean Air Plan Update; and
- Developing a 10-point climate action work program to guide Air District activities in the near-term.

The Work Program includes efforts to enhance the GHG inventory emissions monitoring and regulatory enforcement activities currently underway, evaluate expanded rule-making and policy development to reduce GHG emissions, and assist local governments to further local GHG reduction efforts. The Work Program also calls for the Air District to launch a "Climate Change and Public Health Impacts Initiative," which would consist of collecting and synthesizing information on climate change impacts related to air quality and public health. This effort would involve collaboration with state and local public health professionals and would identify strategies to assist the Bay Area's most vulnerable populations and impacted communities.

95 http://www.baaqmd.gov/The-Air-District/Board-of-Directors/Adopted-Resolutions.aspx

4.6 COMMUNITY RISK REDUCTION PLANS

Local planning decisions can greatly influence public exposure to air pollution. As discussed in Section 4.4, the tension between infill development and increased exposure to air pollution warrants analysis, careful planning, and, in some cases, mitigation measures. Past practice for evaluating risks to new residents in a development project has historically relied on project-by-project analyses. The Air District has pioneered a plan-based approach as a proactive alternative to a project-by-project approach for addressing health impacts from air pollution: the Community Risk Reduction Plan (CRRP).

The CRRP concept promotes a community-level risk assessment and planning process for designing healthy infill development. The CRRP considers cumulative impacts from local sources for a broad geographical area, such as an entire city. One advantage of the CRRP compared to project-by-project assessments is that the CRRP identifies local air-pollution hotspots for the entire city and facilitates consideration of measures to reduce air pollution exposures for existing residents as well as for new residents. Another advantage is that once a plan is in place, jurisdictions may use it to streamline environmental assessment of air pollution impacts from infill projects.

Pilot CRRP projects have begun for the Cities of San Francisco and San Jose. The Air District has partnered with staff in each of these cities, provided financial support, and provided technical expertise and substantial in-kind support by inventorying local emissions sources and by evaluating air pollution concentrations and cancer risks from these local sources.

Objectives

The City and County of San Francisco Public Health and Planning Departments, with technical assistance from the Air District, are currently engaged in a planning process to develop a CRRP. Goals of the San Francisco CRRP include reducing the extent and intensity of existing pollution hotspots and preventing the creation of new pollution hotpots; reducing exposure to air pollution for future and existing residents of pollutant hotspot areas; and reducing the health impacts of pollution citywide and particularly for vulnerable low-income residents.

The San Francisco CRRP defines policy and programmatic actions that will be undertaken over the near-term (by 2014) and medium-term (by 2025) to reduce exposure to air pollution for future and existing residents and to reduce exposure disparities for City residents.[96] The San Jose CRRP, though not yet as far along, shares similar goals of identifying air pollution sources and hotspots and incorporating these into City planning processes.

Identifying Impacts

The CRRPs rely on innovative city-scale modeling[97] of ambient air pollution, as described in Section 3.7. Fine particle concentrations and potential cancer risk from thousands of individual pollution sources were estimated on a 20 meter receptor grid to provide sufficient detail for planning applications. Each CRRP assessment included air pollution emissions from freeways and major city streets, permitted stationary sources, locomotives, and

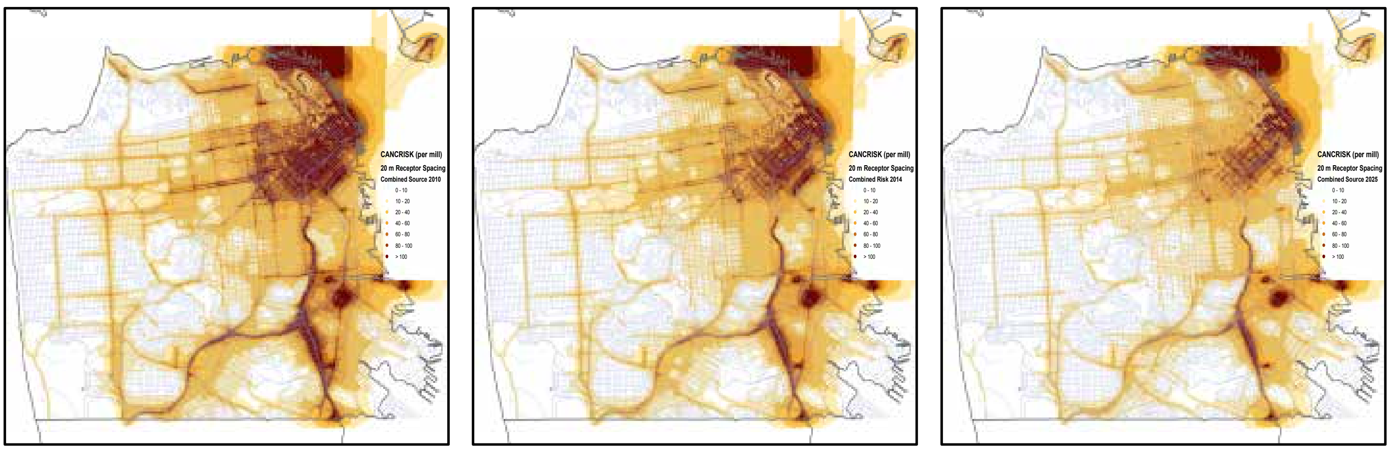
96 Martien, P., V. Lau, H. Hilken, T. Rivard, M. Harris, R. Bhatia, J. Range, and B. Wycko. The San Francisco Community Risk Reduction Plan. Presented at the Air and Waste Management Association (A&WMA) 2013 Annual Conference, June 25-28th, 2013, Chicago, IL. Extended Abstract # 13165.

97 Bay Area Air Quality Management District. 2012. The San Francisco Community Risk Reduction Plan: Technical Support Documentation. December 2012.

construction projects. San Francisco's assessment also included ships and harbor craft; San Jose's assessment also included two airports. Figure 4.6 shows modeling-estimated cancer risk for San Francisco from major emissions sources in the City for multiple planning years.

For its CRRP, San Francisco defined quantitative standards for $PM_{2.5}$ and cancer risk that were determined to be health protective. City staff makes use of these standards to identify areas of the City with existing elevated air pollution health risks in order to target pollution reduction and exposure reduction strategies.

Figure 4.6 Incremental cancer risk estimated from all modeled sources in San Francisco for years 2010 (left), 2014 (middle), and 2025 (right)



Pollutant Reduction Strategies

San Francisco's CRRP goals, including reducing air pollution hotspots, will be implemented through policies, regulations, programs, and cooperation with other agencies. The City of San Francisco has already adopted specific regulations and ordinances that are consistent with the goals and strategies of the CRRP. The Plan outlines exposure reduction measures beyond what is anticipated to occur by 2025 to reduce hotspot areas. New near term actions include amendments to a City ordinance[98] that requires particulate matter filtration for new developments near high-volume roadways, clean construction equipment regulations, investigating additional indoor air quality improvement measures, preferential deployment of clean air transit vehicles in hotspot areas, and other measures. Medium-term actions include policies to reduce stationary-source emissions, for example working with the Air District to provide grant funding and additional regulation for diesel back-up generators; policies to reduce mobile-source emissions within hotspots; development of an air quality improvement fund; and other measures.

Metrics, such as the net land area with cancer risk or $PM_{2.5}$ levels above air quality standards and estimated mortality attributable to $PM_{2.5}$, will be used as indicators for determining the long term success of the CRRP. The CRRP also specifies tracking mechanisms to ensure that planned emission reductions occur.

98 San Francisco Health Code Ordinance, Article 38, is an innovative measure to reduce air pollution exposures in new development projects by requiring air filtration. Online: http://www.sfdph.org/dph/eh/Air/default.asp

The Air District is encouraging cities, especially those with disproportionality impacted communities, to prepare a CRRP. The pilot programs undertaken by San Francisco and San Jose, working with the Air District, have helped develop a roadmap that other cities may follow. For example, the City of Hayward recently completed a CRRP with assistance from planning consultants and the Air District. While the pilot projects have provided examples of how the CRRP process can work, they have also shown that a significant level of up-front effort is required to develop them. Both technical and policy-related aspects of developing CRRPs have required more time and resources than initially envisioned. Developing datasets of emissions sources to conduct the technical evaluations was especially challenging and time consuming. Future work will focus on finding efficient methods for developing such datasets to streamline the CRRP process.

4.7 LOCAL-SCALE MONITORING

As required to meet state and federal requirements, the Air District operates a network of monitoring sites[99] (see Figure 4.7) throughout the Bay Area that provides measurements of outdoor concentrations of criteria gaseous pollutants, TAC, and fine PM concentrations.

Figure 4.7
2012 Air Quality Monitoring Network

The monitoring network is designed to

- Provide data to determine the Bay Area's attainment status for national and state ambient air quality standards;
- Track pollutant trends;
- Provide up-to-date air quality data to the public; and
- Support air pollution research and modeling studies.

Air monitoring data are also used for air quality forecasts, Clean Air Plan modeling, Prevention of Significant Deterioration permit modeling, and environmental review documents.

The Air District's monitoring stations collect real-time hourly and sub-hourly measurements of various air pollutants, depending on the location, including carbon monoxide, hydrogen sulfide, lead,

99 Bay Area Air Quality Management District. 2012. Air Monitoring Network Plan. Online: http://www.baaqmd.gov/~/media/Files/Technical%20Services/2012_Network_Plan.ashx

methane, nitric oxide, nitrogen dioxide, ozone, PM_{10}, $PM_{2.5}$, and ultrafine PM. Some monitoring stations also collect measurements of air toxics, from which cancer risk and non-cancer hazards have been evaluated, as discussed in Section 1.1. Measurements of both criteria and toxic air pollutants are used to track regional air quality trends, as also discussed in Section 1.1.

To meet EPA requirements, monitoring locations are specifically sited following federal guidance so that the data are not influenced by emissions from major sources—such as busy roadways and oil refineries—in order to characterize regional ambient conditions. Because of the requirements to follow EPA siting criteria, measurements may not be well placed for estimating a community's peak exposures.

To support the CARE program's focus on areas where the highest air pollution exposures may occur, the Air District has conducted special-purpose monitoring closer to sources of air pollution emissions. For example, recent and current monitoring projects focused on estimating near-source exposures include the monitoring near the following types of sources:

- Industrial facilities, as described in Section 3.5;
- Freeways: as discussed in Section 3.6, to meet new EPA requirements for near-road monitoring, the Air District has identified three Bay Area sites with high population and high traffic counts within 50 meters (about 160 feet) of busy freeways. These monitors will begin operation in 2014;
- Wood stoves and fireplaces, as discussed in Section 2.5; and
- Airports: since 2012, several monitors have been sited and are testing for lead near general aviation airports where small planes use leaded gasoline fuel.

The Air District also works with certain large regulated industries, such as oil refineries, to install ground level monitors as part of permit conditions for these large facilities. Each refinery collects air monitoring data and provides the data to the Air District to evaluate and to track air quality in communities near these sources.

Looking ahead, the Air District will continue to maintain monitoring programs to track air pollution trends and to determine its regional attainment status with respect to outdoor air quality standards. The Air District also intends to continue and expand its programs to assess near-source exposures in areas identified as impacted and throughout the Bay Area near sources that contribute to higher population exposures.

4.8 PUBLIC PARTICIPATION

The Air District's Communication and Outreach staff serves as a liaison between our technical staff and the diverse communities in the Bay Area region.[100] Air District outreach programs work closely with the CARE program to engage community members and other stakeholders in discussing concerns related to air quality and related local health impacts. The outreach program organizes and facilitates meetings to provide an opportunity for local residents to share and receive information about community air quality studies, pending regulations, clean air plans and strategies, and other air quality issues of interest to a particular

100 http://www.baaqmd.gov/Divisions/Communications-and-Outreach.aspx

community. The Air District's outreach staff has helped organize and facilitate meetings of the CARE Task Force and has worked closely with its members on a variety of regulatory and informational meetings.

For over 20 years, the Air District has worked with community-based Spare the Air resource teams to support local clean air projects (see Figure 4.8). The Air District provides services to team members including assistance with planning and implementation of local projects that improve air quality. Air District outreach staff manages informational programs such as Spare the Air, Winter Spare the Air, and the Spare the Air Employer Program. The Air District communicates Spare the Air information and collaborates with clean air partners throughout the region via websites and multiple publications, including brochures, flyers, and newsletters.

The Air District also works with regional agency partners to promote air quality and climate education with teachers, students and parents through the Spare the Air Youth Program.[101] In addition, the Air District has an active speakers' bureau where, upon request, the latest air quality and health information is presented to local community groups and schools.

The Air District has developed a Public Participation Plan based on surveys and feedback from CARE Task Force Members and other community and business groups. It includes guidelines for actively engaging stakeholders through the regulatory process now and into the future. Included in the Public Participation Plan is a rebuild of the Air District's website in 2014 to facilitate better public access to air quality information.

Figure 4.8 The Air District participates in many events in CARE Communities, such as a recent interagency walk-through in Bayview/Hunters Point in San Francisco

101 http://www.sparetheairyouth.com

5. KEY FINDINGS, LESSONS LEARNED, AND NEXT STEPS

Since the start of the CARE program nearly a decade ago, Air District staff has formed productive working relationships with stakeholder groups, designed and performed informative modeling and monitoring studies, and designed and implemented successful air pollution reduction measures to meet program goals. During this formative period, Air District staff also encountered many challenges. Along the way the Air District experimented with new methods and gained valuable experience implementing them. Many of the new methods worked well from the start, while others highlighted the need for refinement or additional work.

This section presents key findings and some of the lessons from the CARE program to date. It also charts a path forward, looking at both near-term and longer-term objectives. Key findings and lessons learned through the CARE program are presented in Section 5.1. The key findings in Section 5.1 are summarized from regional- and local-scale studies presented in Sections 2 and 3. The lessons learned originate both from the many successes of the past decade and through challenges that arose. These lessons have helped Air District staff draw some general conclusions, which will guide next steps of the program.

The goals presented in Section 1 provided initial direction to the CARE program, guiding studies to identify impacted areas and guiding subsequent actions to focus the Air District's resources in impacted communities. The goals also provided guidance with respect to engaging the public and stakeholder groups in the program and working collaboratively with local government to build healthy communities. These goals will continue to provide guidance to the CARE program in the years ahead.

In implementing program goals in the future, the Air District will embrace several basic principles discussed in Section 5.2, which evolved from lessons of the past. These principles will aid Air District staff in moving from general goals to specific, near-term activities. They identify certain areas where previous work has proved effective and where it has identified needs.

Near-term activities of the CARE program—over the next two to three years—are discussed in Section 5.3. While recognizing the need to remain flexible and open to important issues as they arise, Section 5.3 plots a course of action for the near future and discusses planned next steps for the program.

Beyond the near-term, there are emerging issues on the horizon that have been identified as areas for future research, study and action. These emerging issues are presented in Section 5.4 as longer-term projects that may be undertaken by the Air District in the future.

5.1 KEY FINDINGS AND LESSONS LEARNED

Key findings and lessons learned to date from the CARE program are summarized below:

Key Findings

1. **Diesel PM is a significant contributor to cancer risk from TAC.**
   - Based on regional TAC emissions estimates from 2005, diesel PM contributed more than 85% of the total Bay Area cancer risk from TAC emissions.
2. **Fine PM of all types is linked to poor health outcomes and mortality.**
   - Over the past decade, numerous health studies have linked fine PM to serious health impacts, including respiratory diseases, heart attacks, and premature death.
   - The Air District's 2010 Clean Air Plan and the updated (version 2) assessment of cumulative impact areas found that fine PM was the pollutant that posed the greatest health risk in the Bay Area.
3. **In the version-2 method for identifying cumulative impact areas, socioeconomic information was not used. However, there is a clear correlation between the areas of impact and socioeconomic factors such as income, race, and education levels.**
   - Average annual household income is more than $40,000 greater in the lowest impact areas than the highest impact areas.
   - Areas with the lowest impact are more than 70 percent white, while areas with the highest impact are nearly 70 percent non-white. The percentage of hispanics in the highest impact areas is double that in the lowest impact areas. The percentage of blacks is more than five times higher in the highest impact areas than the lowest impact areas.
4. **Regulatory programs, grant and incentive programs, and enforcement actions, especially those at state and regional levels, are resulting in emission reductions, lower air pollution levels, and significant health benefits.**
   - Measurements collected at central monitoring sites show large region-wide reductions in elemental carbon levels, a surrogate for diesel PM, and large reductions in cancer risk from air pollution.
   - The port truck plume study, conducted by UC Berkeley and funded by the Air District, demonstrated emission reductions from the statewide drayage truck rule.
5. **Infill development can safely proceed in areas identified as impacted areas, if areas adjacent to heavily trafficked roadways and other localized air pollution sources are avoided or if effective mitigation measures are put in place.**
   - From regional-scale modeling assessments one might infer that impacted areas have uniformly high air pollution levels. However, more refined local-scale modeling assessments show reduced pollution levels away from freeways and other local pollution sources. The West Oakland Measurement Study found that even in West Oakland, a community identified as impacted, high concentrations of air pollution were confined to locations near-busy roadways and other specific sources. Localized, near-source exposures to air pollutants appear to pose the greatest health risks even in impacted areas.

Lessons Learned

1. **Collaboration with stakeholders, researchers, and local health and planning department staff extends what the Air District can accomplish alone.**

   In designing and conducting CARE program projects, collaboration among Air District staff, researchers, community members, businesses, and local health and planning staff has consistently produced positive results. There are many examples of good outcomes resulting from consultation and collaborative work:

   - Consultation with members of the CARE Task Force regularly offered perspectives from diverse stakeholders whose input improved project outcomes.
   - The Air District's collaboration with members of the West Oakland community in the West Oakland Truck Survey benefited the study and engaged community members in understanding an important source of local air pollution.
   - Shared information about local conditions and assistance obtaining site access for air quality measurements were key ingredients to the success of local-scale monitoring projects, for example at the Port of Oakland and near the Custom Alloy Scrap Sales aluminum recycling facility. This assistance grew from community meetings as trust developed among community members, facility managers, and Air District staff
   - The collaborative work on the San Francisco Community Risk Reduction Plan combined expertise of the San Francisco Planning Department, the San Francisco Department of Public Health Department, and the Air District.

2. **Studies that assess the effectiveness of mitigation measures provide valuable assurance that the mitigations are on track.**

   Mitigation measures are paramount, but the Air District and the public also seek assurance that measures are effective. Studies that track performance and verify anticipated benefits are extremely valuable.

   - For example, the Air District has modeled anticipated changes in TAC emissions, especially those related to the state's diesel exhaust regulations, to show significant regional reductions in diesel PM and in cancer risk from air pollution.
   - The port truck plume study, conducted by UC Berkeley and funded by the Air District, was particularly helpful because it demonstrated emission reductions from the statewide drayage truck rule.

3. **Assessing relative health impacts from air pollution is a useful way to identify impacted areas.**

   - The Air District's version-2 method for identifying cumulative impact areas considered where health impacts from air pollution were relatively high. Estimating direct impacts on health, rather than relying on surrogates such as socioeconomic factors, was found to be an effective and defensible method for considering population vulnerability.

4. **Cumulative impact maps, are useful for prioritizing certain kinds of actions and mitigation measures, particularly efforts aimed at reducing exposures from local air pollution sources.**

   - Maps of cumulative impact areas help form the foundation of the Clean Air Communities Initiative (CACI), a program which brings resources from throughout the Air District to protect public health in impacted communities.

5. **Maps of areas with episodes of high particulate matter and ozone complement the cumulative impact maps.**
   - Maps of exceedance areas support and focus many long-standing efforts to reduce regional air pollution levels, such as Clean Air Plan policies and programs.
6. **Detailed maps of air pollution levels and risk from multiple sources are especially valuable planning tools.**
   - Detailed maps of air pollution and risk levels from major emissions sources greatly simplify proactive planning processes, at the city level—such as for Community Risk Reduction Plans (CRRPs)—and at the regional level—such as for environmental review of Transportation Priority Project areas.
   - Such maps can be used by Air District staff, local health and planning staff, and others to identify, avoid, and mitigate air pollution risks at a local level.
7. **The Air District's ability to produce detailed maps for large areas is currently limited by the time needed to generate supporting emissions inputs.**
   - One of the lessons learned during the pilot CRRP projects is that developing the input datasets needed to produce detailed assessments over a large region is a significant undertaking.
   - More work is needed to streamline the development of emission inventories to support local-scale assessments over large areas.
8. **Agencies should strive to focus positive actions in impacted areas.**
   - Actions that bring beneficial goods and services and that speed emission reductions to impacted areas are most helpful. Beneficial actions would:
     - Prioritize grant funding;
     - Focus enforcement of existing regulations;
     - Assist with Community Risk Reduction Plans and other local planning efforts;
     - Increase outreach and education; and
     - Identify important sources of air pollution in impacted areas and target new regulation to these source categories.

5.2 GUIDING PRINCIPLES

In moving forward, the CARE program will follow guiding principles that emphasize some program goals and prioritize near-term activities. The program will not be making big changes. Rather, the program will build on past successes and refine current activities, using the principles below to provide direction:

1. **Build on past success.**
   This document highlights many successful studies and actions that will be carried forward. In Section 5.1 in particular, the *Lessons Learned* section discusses programs that worked and will likely be repeated in the future.

2. **Engage governmental agencies, business, and community members.**
   One of the important successes of the CARE program that will be emphasized in the future is engaging stakeholders to strengthen the program. The program will intensify previous efforts to seek input from, provide feedback to, and build relationships and collaborate with interested groups.

3. **Continue to reduce emissions and risk in impacted areas.**
   The CARE program has invested significant efforts to identify impacted areas. One of the main areas of emphasis moving forward will be to reduce emissions and risk in these impacted areas. As described in Section 4, the Air District will continue to implement the Clean Air Communities Initiative to build healthier communities.

4. **Support healthy infill development.**
   A key area of emphasis moving forward will be to support healthy infill development by identifying and minimizing risks to both new and existing residents from local sources of air pollution. A major initiative of the CARE program in the near future will be to develop planning tools, improved datasets, and new mitigation measures to support healthy infill.

5.3 PATH FORWARD: NEXT STEPS

Reflecting the guiding principles listed above, during the next two to three years the CARE program will prioritize developing datasets, tools, and guidance to help communities and planners avoid future air pollution exposures from local sources and to reduce existing exposures. The CARE program will also continue to integrate CARE principles into all Air District functions, including those listed below:

1. **Planning**
   A central focus of the Air District's Planning staff will be on assisting city planning departments with health-protective infill development:
   - Improve datasets for local-scale assessments, especially for permitted sources
   - Develop Community Risk Reduction Plans in other areas, such as Richmond
   - Investigate and quantify health co-benefits of active transportation
   - Develop improved datasets on community health

2. **Grants and Strategic Incentives**
   The Air District will continue to ensure that funding opportunities are prioritized to reduced emissions in communities identified as impacted.

3. **Rule Development**
   - The Air District will evaluate new regulations that address pollutants and source categories that have important health impacts in impacted communities. For example, the Air District is investigating additional particulate matter regulations to reduce near-term impacts of particulate sources, many of which are located in CARE communities. One new regulation under consideration would specifically address impacts from diesel generators. The Air District is currently developing a source-specific regulation on Bay Area petroleum refineries that would establish existing baseline air emissions from each refinery and track the quantity of air emissions from each refinery in the future on an on-going basis.

4. **Local-scale monitoring studies**

Efforts are underway to assess the health impacts of transportation decisions and near-roadway housing development. In January 2014, the Air District will begin monitoring air pollutant concentrations near Bay Area freeways (see Section 3.6). The monitoring data will be used to evaluate the need for new federal regulations and to support local programs to reduce air pollution and health impacts along highways.

In addition, the Air District is partnering with UC Berkeley to investigate the feasibility of using low-cost air pollution sensors to create a dense monitoring network in western Alameda County.[102] Instruments will collect one-minute measurements at more than 20 locations. If successful, such networks would provide important real-time information about air pollution levels close to local sources in between locations where air pollution is regularly monitored.

5. **Modeling studies**

Gaps remain in our understanding of what upwind air pollution sources and source areas are most affecting areas identified as impacted. To improve our understanding of this important issue, the Air District is undertaking a modeling study with UC Berkeley that will conduct source apportionment studies for air pollution in the Bay Area, and map upwind zones of influence for individual impacted communities and specific pollutants.

6. **Outreach**

The Air District's Communication and Outreach staff will continue to serve as a liaison between technical staff and the diverse communities in the Bay Area region.

As the CARE Task Force concludes in 2014, the Community Outreach staff will guide the development of a new forum for community engagement that will serve to provide input to the Air District on a range of issues and programs, including the CARE program and other programs that support the Clean Air Communities Initiative. A major initiative is underway at the Air District to make more technical data available to the public via the web. In the future, more of the CARE program's emissions estimates, monitoring and modeling data, maps, and analysis tools will be made available online.

7. **Compliance & Enforcement**

The Air District's Compliance and Enforcement staff will continue to focus on emissions reductions in impacted areas and reductions to support healthy infill. Staff will continue to devote resources to help enforce the Mobile Source Compliance Plan. In addition, staff is investigating partner agreements with local jurisdictions to improve enforcement of idling regulations.

As in the past, these efforts, which focus primarily on exposures from local emissions sources, will be implemented as part of the Clean Air Communities Initiative. These efforts complement and supplement on-going programs and policies to reduce the frequency, intensity, and extent of high air pollution episodes from pollution sources throughout the region.

102 This study suggests a new approach to observing atmospheric gases over an urban area. More information is available online: http://beacon.berkeley.edu/

5.4 ON THE HORIZON: EMERGING ISSUES

There are several emerging issues that the CARE program has identified as areas for future research. While Air District staff members may not address all of these emerging issues in the next two to three years, we recognize them as important topics to investigate and address. Some of these issues are at the edge of current research. Others involve a significant amount of work such that Air District staff will regularly need to evaluate current priorities and resources.

Pollutants of emerging concern

To date, the CARE program has primarily considered toxic air contaminants and fine particulate matter ($PM_{2.5}$) and their health impacts. Two additional air pollutants are of potential concern for near-source exposures in impacted communities and elsewhere: ultrafine particles (UFP) and nitrogen dioxide (NO_2).

Ultrafine particles (UFPs) are particles with diameters less than 100 nanometers.[103] Regulations do not exist for this size class of ambient air pollution particles, which are far smaller than the regulated PM_{10} and $PM_{2.5}$ particle classes. Although they make up only a small fraction of the mass of particles in the air, by number UFPs are the main constituent of airborne particulate matter. Due to their high counts and ability to deeply penetrate into lungs and even enter cells, UFPs may have important health impacts. Teams of investigators funded by US EPA and others are evaluating the adverse health effects of ultrafine particles.

The Air District has recently begun monitoring counts of UFPs at four Bay Area locations to develop a better understanding of where and when concentrations are high. Regional modeling of UFPs has also begun but poses challenges because of UFPs change rapidly, coagulating onto larger particles shortly after they are emitted.

Much remains to be learned about UFPs. It will be important to continue to track research on health impacts. It may also be necessary to design new and different control strategies since effective mitigation measures for UFPs may be different than those for $PM_{2.5}$.

Recent studies suggest that NO_2 exposures may also play an important role in causing adverse health impacts near busy roadways. Like UFPs, concentrations of NO_2 change rapidly away from sources. Chemical transformations of NO_2 in urban atmospheres complicate local-scale modeling compared to more inert compounds. In fact, the main reason for the new federal requirements for near-roadway monitoring is to better understand the level of NO_2 near heavily trafficked roadways and the importance of near-source NO_2 exposures. Starting in 2014, the Air District will begin monitoring NO_2 at three locations near busy freeways in the Bay Area. Monitoring data from these sites will inform future strategies to mitigate near-source exposures.

103 A nanometer is one billionth, or one thousand-millionth, of a meter. Twenty-five 100 nanometer-sized particles would span one particle with a diameter of 2.5 micrometers, the maximum size for $PM_{2.5}$.

Changing composition of on-road emissions of particles

Significant progress has been made over past decades in reducing exhaust emissions from on-road cars and trucks. However, current forecast models of emissions from on-road vehicles predict that continued increases in the amount of vehicle miles travelled each year may soon begin to erode the PM emission benefits of cleaner engines. In the future, increased PM emissions are forecast from on-road motor vehicles in large part because of break wear, tire wear, and road dust increasing emissions with increased vehicle use and miles travelled.

In the past, these types of vehicle emissions have received much less scrutiny and analysis than exhaust emissions. But as engines become cleaner, non-exhaust emissions become more important. New questions arise: will vehicle travel really continue to increase in the future? How reliable are current emission factors for brake and tire wear and for road dust? How toxic are these sources of PM?

Such questions will need to be addressed to ensure that current progress in reducing health impacts of the near-road environment continue into the future.

Evaluating Mitigation Measures

In the future the Air District will continue programs to identify and mitigate air pollution exposures, within and outside cumulative impact areas, including near-roadway exposures. Future studies to evaluate the effectiveness of these mitigation measures will be needed to assure that current and future residents are not exposed to unhealthy levels of air pollution. Issues to investigate include developing an improved understanding of the effectiveness of mitigation measures, such as tightening building envelopes, indoor air filtration, and vegetation walls, for reducing air pollution exposures near local sources of air pollution.

The Air District has recently partnered with researchers at the Lawrence Berkeley National Laboratory to investigate the effectiveness of measures to reduce indoor air pollution levels in existing housing near busy roadways. This is a multi-agency pilot initiative to deploy, demonstrate, and evaluate approaches to mitigating pollutant exposures in homes that are impacted by traffic-related air pollution. Partner agencies include the Mayor's Office of Housing and the Department of the Environment. The project is focused on mitigation approaches and evaluation protocols. LBNL has provided expertize in basic building and indoor air quality sciences, filtration systems integrated with or separate from central forced air heating, synergistic approaches to mitigating indoor air pollutant exposures while also reducing residential energy use, and the measurement of mitigation strategy effectiveness. If successful, this pilot project could pave the way for longer-term studies of the effectiveness of measures to reduce indoor pollution levels in Bay Area residences.

Climate change

On June 1, 2005, the Air District's Board of Directors adopted a resolution establishing a Climate Protection Program and acknowledging the link between climate protection and programs to reduce air pollution in the Bay Area. The Board of Directors also formed a standing Committee on Climate Protection to provide direction on District climate protection activities.

On November 6, 2013, the Board of Directors adopted a resolution setting a regional goal of reducing GHG emissions 80% below 1990 levels by 2050 and calling for a Work Program that outlines steps the Air District will take toward the goal. One of the elements of the Work Program is a "Climate Change and Public Health Impacts Initiative," which would identify strategies to assist the Bay Area's most vulnerable populations and impacted communities and thereby begin to integrate the Air District's climate protection program with the CARE program. Climate change issues overlap with those of the CARE program in several important ways:

- Bay Area air pollution levels will be affected by changes in climate;
- Direct health impacts, such as higher temperatures at some times and places, may pose important additional stressors for impacted communities;
- There are strategic climate co-benefits of reducing TAC and PM emissions. Specifically, black carbon has been identified as a short-lived climate forcing compound that is a key to mitigating climate change. Efforts to reduce diesel PM, a major focus for improving air quality in impacted areas, also reduce black carbon and have important climate benefits.
- The locations of impacted communities may change if we consider climate change impacts in addition to direct pollution impacts.

In the future, Air District staff will address these issues. Climate change impacts on community health and disparities in impacts among communities should be considered in future climate protection strategies. In addition, potential climate co-benefits should be considered in designing mitigations for reducing exposures to local air pollution sources.

Personal exposures to air pollution

The CARE program has made significant progress in estimating air pollution concentrations at a level of detail that is useful for planning and estimating exposures. However, exposure calculations to date have assumed that people are outside breathing air adjacent to their homes—so called backyard exposure estimates. One important next step will be to account for personal travel and track people's daily activities and changing locations. Considering that people move around during the day may change conclusions about where highest impacts are occurring, which in turn may shift Air District priorities.

Another important next step will be to account for the fact that people spend much of their time indoors and in vehicles, where air pollution levels are different than outdoor, ambient levels. Understanding and accounting for the microenvironments where people spend time may also change conclusions about what exposures most influence health impacts. For example, questions of interest to the CARE program related to personal exposures include the following:

- How significant are on-road, in-vehicle exposures?
- If one considers exposures in indoor environments, how do priorities shift?
- If long commutes result from a lack of affordable housing in the Bay Area, what is the relative importance of exposure from living near freeways versus exposure while commuting?

Addressing these issues requires information about the travel behavior of Bay Area residents and understanding the relationship between indoor and outdoor air quality for different microenvironments.

Developing improved measurement techniques for characterizing air pollution levels near where people live and work could also be an important element for characterizing and tracking personal exposures. For example, low-cost sensor networks, such as those discussed in Section 5.3, may play an important role and will be considered in longer-term future work.

5.5 CONCLUSION

In summary, despite tremendous regional improvements in air quality, some communities in the Bay Area still experience relatively higher pollution levels, and corresponding health effects, compared to other parts of the Bay Area. Air pollution levels of many pollutants are consistently highest in close proximity to pollution sources—such as near freeways, busy roadways, busy distribution centers, and large industrial sources. Communities where these types of sources are concentrated contain areas where air pollution levels are relatively high and corresponding health impacts are greater.

Over the past decade, the Air District has made significant progress in identifying impacted communities within the Bay Area and in developing an agency-wide approach to reducing health disparities linked to air quality through the Clean Air Communities Initiative. The CARE program, through regional and local-scale studies, has helped develop the framework through which many Air District programs address health disparities. The CARE program has been successful bringing together researchers, government, communities, and business to understand and address localized areas of elevated air pollution and its adverse health impacts on communities.

In moving forward, the CARE program will build on past success. Air District actions to focus emission reductions and other activities in impacted areas will continue: in impacted areas the Air District will continue to prioritize grant and incentive funding, focus enforcement activities, develop regulations targeting pollutants and sources of concern, focus outreach efforts, and conduct special studies.

One of the main areas of emphasis in the near future will be continuing work to build healthier Bay Area communities. Improved methods are needed to streamline the development of emission inventories to support local-scale assessments over large areas. Such methods will facilitate the creation of additional maps of air pollution and risk levels, like those developed for the San Francisco and San Jose Community Risk Reduction Plans, to simplify proactive planning for Bay Area cities that addresses air quality issues.

Another area of emphasis will be integrating climate protection activities with CARE program activities. Identifying the health impacts of climate change on Bay Area residents will be an important long-term step. In the short-term, it will important to identify and exploit strategic co-benefits of reducing TAC and PM emissions. For example, efforts to reduce diesel PM, a major focus for improving air quality in impacted areas, also reduce black carbon and have important climate benefits. As the Air District pursues emission reductions, it will be important to coordinate the reductions of climate-forcing pollutants while maximizing the health benefit to the Bay Area's most vulnerable populations.

Historically the Bay Area Air Quality Management District, like other air districts, has focused much of its resources to bring regional concentrations of criteria pollutants levels down throughout the Bay Area. Indeed, programs to address regional air pollution continue to be a primary focus of the Air District's resources and activities. The historical approach for managing TAC has been regulation through through operating or permitting requirements and via controls on individual sources. These management approaches have achieved notable successes.

Yet, even as success is being achieved in reducing air pollution throughout the region with traditional air quality management approaches, regulators are realizing that alternate approaches are also needed. The distribution of air pollutants is not uniform throughout the region, and varies by community and neighborhood. Unfortunately, some neighborhoods are burdened with more air pollution sources and higher air pollution exposures relative to others. Neither criteria pollutants nor TAC have been routinely monitored near pollution sources where some of the worse exposures can occur. Regulatory approaches are now emerging that consider near-source exposures and that consider multiple pollutants, multiple sources and their cumulative impacts.

In addition to tracking regional criteria pollution levels as measured at central monitoring sites, and in addition to tracking TAC pollution levels from individual permitted facilities, the Air District has begun to track the cumulative impacts of exposures to multiple pollutants and multiple sources in the neighborhoods where people live. With the shift toward more consideration of cumulative air pollution exposures, Air District staff is poised to begin evaluating the health status of Bay Area residents and how health status and affects vulnerability to air pollution. This has been a gradual but important shift. It is a shift that will require closer collaboration between the Air District and the region's health departments and health professionals and researchers. By exploring the links between air pollution exposures and community heath status, the CARE program will continue to help focus the Air District's resources to achieve the greatest health benefits.

ACRONYMS & ABBREVIATIONS

$\mu g/m_3$	micrograms per cubic meter
ABAG	Association of Bay Area Governments
AERMOD	American Meteorology Society/US EPA's Regulatory Model Improvement Committee Modeling System Air Dispersion Model
Air District	Bay Area Air Quality Management District
ASF	age sensitivity factor
ATCM	air toxics control measures
BAEHC	Bay Area Environmental Health Collaborative
BARHII	Bay Area Regional Health Inequalities Initiative
BayCAMP	San Francisco's Bayview Community Air Monitoring Project
BC	Black carbon
BCDC	Bay Conservation and Development Commission
BMPs	Best Management Practices
CACI	Clean Air Communities Initiative
CACP	Clean Air and Climate Protection
Cal/EPA	California Environmental Protection Agency
CALINE	California Line Source Dispersion Model
CAMx	Comprehensive Air Quality Model with Extensions
CARB	California Air Resources Board
CARE	Community Air Risk Evaluation
CASS	Custom Alloy Scrap Sales
CCAA	California Clean Air Act
CATEF	California Air Toxics Emissions Factors Database
CEQA	California Environmental Quality Act
CO2	carbon dioxide
CMB	chemical mass balance
CRA	California Resources Agency
CRRP	Community Risk Reduction Plan
DOE	Department of Energy
DPF	diesel particulate filter
DRI	Desert Research Institute
EC	elemental carbon
EJSM	Environmental Justice Screening Method
EMFAC	California Air Resources Board's On-Road Mobile-Source Emission Model Factors
EPA	U.S. Environmental Protection Agency

ER	emergency room
GHG	greenhouse gas
HHD	heavy, heavy duty
HRA	health risk assessment
HSAT	Highway Screening Analysis Tool
IBM	immersed boundary method
ITHIM	integrated transport and health impacts model
km	kilometer
LBNL	Lawrence Berkeley National Laboratory
MATES	Multiple Air Toxics Exposure Study
MHD	medium, heavy duty
MM5	National Center for Atmospheric Research's Mesoscale Meteorological Model
MOU	memorandum of understanding
MTC	Metropolitan Transportation Commission
NO	nitric oxide
NOP	Notice of Preparation
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NSR	New Source Review
OC	organic carbon
OEHHA	Office of Environmental Health Hazard Assessment
PDA	priority development area
PERC	perchloroethylene
Plan	Community Risk Reduction Plan
PM	particulate matter
PM_{10}	particulate matter with an aerodynamic diameter equal to or less than 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter equal to or less than 2.5 microns
Port	Port of Oakland
PSC	Pacific Steel Casting
PVI	pollution-vulnerability index
RELs	reference exposure levels
ROG	reactive organic gases
ROG	reactive organic gas
SB 375	Senate Bill 375 Sustainable Communities Act
SCS	Sustainable Communities Strategy

Continued on next page.

SIP	State Implementation Plan
SO_2	sulfur dioxide
STI	Sonoma Technology, Inc.
TAC	toxic air contaminant
TAM	total atmospheric mercury
TFCA	Transportation Fund for Clean Air
TOG	total organic gases
TPP	transportation priority project
UC	University of California
UCB	University of California Berkeley
UFP	ultrafine particles
VMT	vehicle miles traveled
VOC	volatile organic compound
WOEIP	West Oakland Environmental Indicators Project
WOMS	West Oakland Monitoring Study
WRF	Weather Research and Forecasting Model
XRF	x-ray fluorescence

GLOSSARY

Air Toxic Control Measures (ATCM) – Regulations adopted by the California Air Resources Board to identify and control toxic air contaminant releases from specific sources.

Age Sensitivity Factors (ASF) – OEHHA proposed lifestage weighing factors when estimating cancer risk based on exposures to infants and children to reflect their increased susceptibility to carcinogens in comparison to adults.

Area Sources – The emissions of toxic air contaminants are aggregated from a single or multiple sources within an area for modeling purposes in order to characterize the release of these pollutants from non-stack source. Examples include gas stations, dry cleaners, and water heaters.

California Environmental Quality Act (CEQA) – Statute passed by the California State Assembly that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible.

CalEnviroScreen – Cal/EPA's screening tool for identifying areas in California that are likely to experience health impacts from environmental pollutants.

Chemical Mass Balance – The model is used to determine the average contribution of a specific source category to total particulate fallout at a receptor site based on physical principles of aerosol chemistry.

Criteria Air Pollutants – The federal and/or state government has established ambient air quality standards for these pollutants including ozone, carbon monoxide, sulfur dioxide, PM_{10}, nitrogen oxide, and lead for the protection of public health.

Diesel Particulate Matter (Diesel PM or DPM) – Diesel particulate matter is a component of diesel exhaust (emitted from engines using diesel fuel such as trucks, construction equipment, and standby emergency generators), which are comprised of soot particles with a solid core of elemental carbon and organic compounds attached to the surface.

Emission Factor – The amount of a specific pollutant emitted from a specified polluting source per unit quantity of material handled, processed, or burned.

Greenhouse Gas (GHG) – Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone.

Health Risk Assessment – A decision making tool where health risk are quantified based on a combination of default exposure/activity assumptions of impacted population, pollutant concentration in the vicinity of the population, and OEHHA approved toxicity potency factors by pollutant.

Hot Spot – A location where source emissions may cumulatively expose individuals and population groups to significantly higher health risks of adverse health effects in comparison to the surrounding area.

Impacted Communities – The Air District defines impacted communities, also known as CARE communities, as areas within the Bay Area where health impacts from air pollution have been determined to be greatest. The Air District's latest analysis (version-2) for determining areas with the greatest health impacts considered air pollution levels (fine particles, ozone, and toxic air contaminants) and population vulnerability as determined from health records (mortality rates and diseases affected by air pollution).

Mobile Source – Any motor vehicle that produces air pollution, e.g., cars, trucks, motorcycles (on-road mobile sources) or airplanes, trains and construction equipment (off-road mobile sources).

Ambient Air Quality Standards – Health-based pollutant concentration limits established by EPA (federal) and/or state government (state) that apply to outdoor air.

Nitrogen Oxides (NO_x) – Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; NO_x is a precursor to the criteria air pollutant ozone.

Ozone (O_3) – A pungent, colorless, toxic gas. Ozone is a product of complex photochemical processes, usually in the presence of sunlight. Tropospheric (lower atmosphere) ozone is a criteria air pollutant.

Photochemical Process – The chemical changes brought about by the radiant energy of the sun acting upon various polluting substances. The products are known as photochemical smog.

Pollution-Vulnerability Index (PVI) – A metric used to quantify the combined impacts of cancer risk from TAC, mortality rates from fine particles and ozone levels above background, and health costs for ER visits and hospitalizations for illnesses related to fine particles and ozone levels above background.

Precursor – Air pollutants that change chemically or physically after being emitted into the air to produce other air pollutants. For example, reactive organic gases and nitrogen oxides are precursors to ozone.

Reactive Organic Gases (ROG) – Classes of organic compounds, such as olefins, aromatics and aldehydes, that react rapidly in the atmosphere to form photochemical smog or ozone.

Sensitive Receptors – Members of the population who are particularly sensitive to the effects of air pollutants, such as children, the elderly, and people with respiratory illnesses. Sensitive receptors can also be facilities or land uses, such as schools, hospitals and residential areas, where sensitive receptors live, work, and play.

State Implementation Plan (SIP) – EPA-approved state plans for attaining and maintaining federal air quality standards.

Stationary Source – A fixed, non-mobile source of air pollution, usually found at industrial or commercial facilities. Examples include larger sources such as power plants, refineries, and chemical manufactures and smaller sources such as gas stations, backup generators, and dry cleaners.

Toxic Air Contaminants (TAC) – Air pollutants defined to be toxic by Cal/EPA. TAC are often air contaminants that, upon exposure, ingestion, inhalation, or other assimilation can cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in people or their offspring.

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

IMPROVING AIR QUALITY & HEALTH IN BAY AREA COMMUNITIES

Community Air Risk Evaluation (CARE) Program Retrospective & Path Forward (2004 - 2013)

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