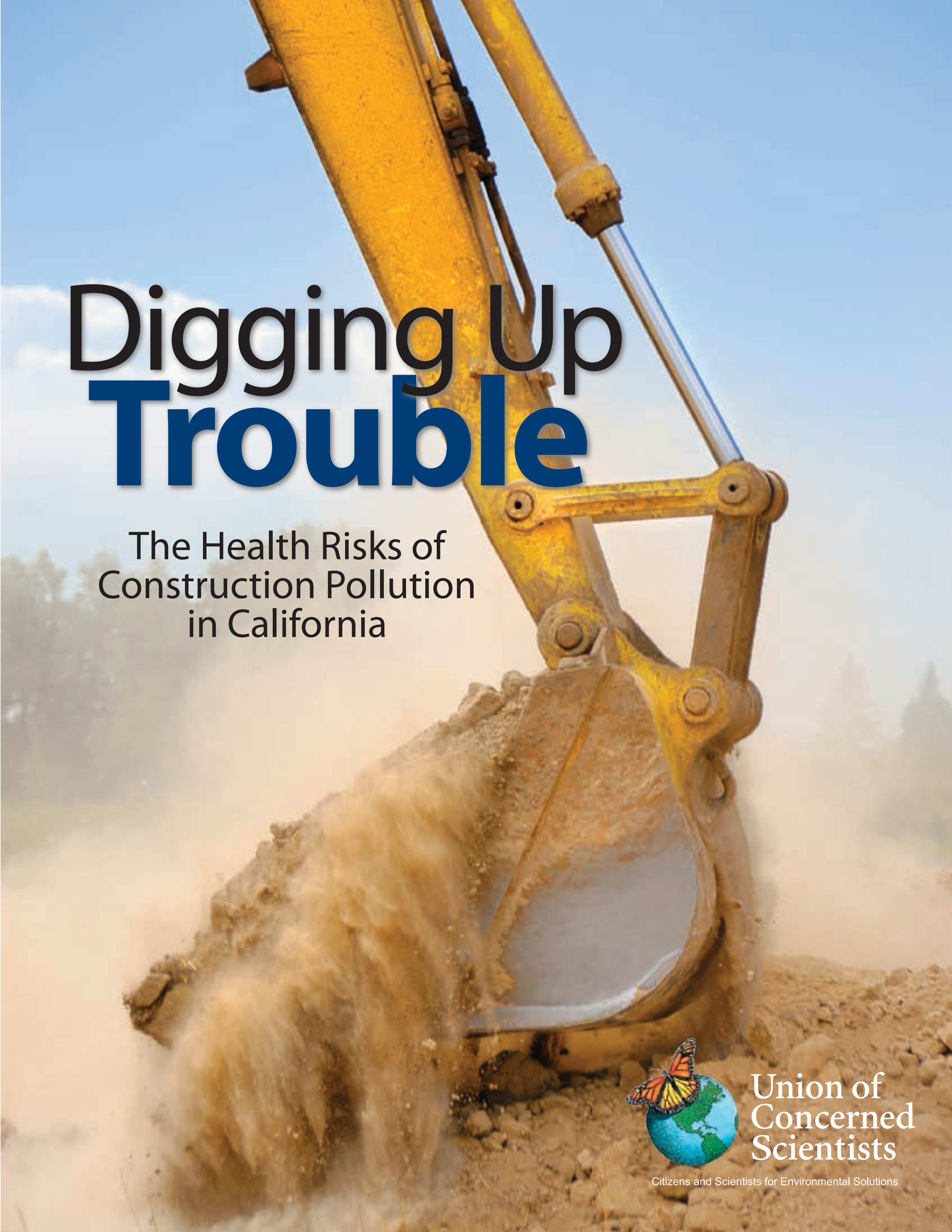


Digging Up Trouble

The Health Risks of Construction Pollution in California

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

Digging Up Trouble

The Health Risks of Construction Pollution in California

DON ANAIR

Union of Concerned Scientists
November 2006

Don Anair is a vehicles engineer in the Union of Concerned Scientists Clean Vehicles Program.

The Union of Concerned Scientists (UCS) is the leading science-based nonprofit working for a healthy environment and a safer world. UCS combines independent scientific research and citizen action to develop innovative, practical solutions and to secure responsible changes in government policy, corporate practices, and consumer choices.

The UCS Clean Vehicles Program develops and promotes strategies to reduce the adverse environmental impact of the U.S. transportation system.

More information about UCS and the Clean Vehicles Program is available on the UCS website at *www.ucsusa.org.*

The full text of this report is available online at *www.ucsusa.org/clean_vehicles* or may be obtained from:

UCS Publications
2 Brattle Square
Cambridge, MA 02238-9105

Or, email *pubs@ucsusa.org* or call (617) 547-5552.

COVER PHOTO: © iStockphoto
DESIGN: David Gerratt/NonprofitDesign.com

Printed on recycled paper

Contents

Figures and Tables

FIGURES

TABLES

Acknowledgments

Support for this work was provided by Foundation M, Steven and Michele Kirsch Foundation, The California Wellness Foundation, The Energy Foundation, and The William and Flora Hewlett Foundation.

The author would like to thank the helpful staff of the California Air Resources Board for its expertise and advice. I am especially grateful to Hien Tran, Kim Heroy-Rogalski, Jeff Wilson, Debbie Futaba, and Lei Zhou.

I would also like to acknowledge Tom Albo at Greeninfo for his data processing and map production, Patrick Otsuji at the California State Water Resources Board for his expertise and help in gathering construction permit information, and Karen Huss and Larry Sherwood at the Sacramento Metropolitan Air Quality Management District for information regarding their construction mitigation program.

Here at the Union of Concerned Scientists, I want to thank Patricia Monahan, Jason Mark, David Friedman, Erin Rogers, Rich Hayes, and Daniel Kalb for their valuable comments and advice at various stages in the preparation of this report. Additional thanks go to Bryan Wadsworth for copyediting and David Gerratt for layout and design.

The opinions expressed in this report do not necessarily reflect the opinions of the foundations that supported the work, or the individuals who reviewed and commented on the report. Both the opinions and information contained herein are the sole responsibility of the author.

Executive Summary

Pollution from diesel construction equipment is taking a toll on the health and economic well-being of California residents. This equipment contributes to particulate and ozone pollution that can cause severe cardiovascular and respiratory illnesses, asthma attacks, acute bronchitis, and even premature death.

This study analyzes air pollution caused by construction equipment and—for the first time—quantifies its effect on California's public health and economy, both across the state and in the five most-affected regions. In addition, we evaluate the risk of exposure to construction activity in specific cities in each of these five regions. Lagging emission standards and very old equipment have made construction equipment one of the largest sources of toxic diesel particulate matter pollution in the state, necessitating an accelerated cleanup program to protect the health of all Californians.

Using established U.S. Environmental Protection Agency (EPA) and California Air Resources Board (CARB) methods to quantify the impact of air pollution, the Union of Concerned Scientists (UCS) estimates that construction equipment emissions statewide are responsible for:

- more than 1,100 premature deaths per year
- more than 1,000 hospital admissions for cardiovascular and respiratory illness
- 2,500 cases of acute bronchitis
- tens of thousands of asthma attacks and other lower respiratory symptoms

This pollution is hurting the state's economy as well. Construction equipment is critical to the building industry (a sector of the economy worth $60 billion per year)[1] and instrumental in maintaining and building our roads and highways (on which California spent eight billion dollars last year). But the pollution from this equipment results in more than nine billion dollars in annual public health costs, including hundreds of thousands of lost work days and school absences.

Construction equipment is used extensively throughout the entire state. More than 270,000 acres of land in California were under construction permit during 2005—an area the size of Los Angeles.[2] In addition, more than 10,000 miles of state roadway were under contract for construction, repairs, or maintenance.[3]

The impact of construction pollution on public health is greatest where equipment and people mix, and 90 percent of the health and economic damage occurs in California's five most populous air basins. The South Coast air basin (which encompasses most of Los Angeles, Orange, Riverside, and San Bernardino counties) ranks first with more than 700 premature deaths and more than 650 hospitalizations for respiratory and cardiovascular illness annually. The San Francisco Bay Area and San Diego follow, with more than 150 and 89 premature deaths, respectively, every year. The San Joaquin Valley and Sacramento Valley (the two largest air basins in

1 As reported to the California Department of Finance by the California Construction Industry Research Board. Available at *http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/FS_Construction.htm*.

2 Total acres based on State Water Resources Control Board data (SWRCB 2005). The city of Los Angeles covers 300,160 acres.

3 Mileage based on ongoing contract data available from the California Department of Transportation (CALTRANS 2005).

TABLE 1 **Health Damage from Construction Pollution (by Air Basin)**

	Total Incidences					
Health Endpoint	**Statewide**	**South Coast**	**San Francisco Bay Area**	**San Diego**	**San Joaquin Valley**	**Sacramento Valley**
Premature Deaths	1,132	731	154	89	49	39
Respiratory Hospitalizations	669	383	56	50	55	30
Cardiovascular Hospitalizations	417	274	61	33	14	12
Asthma and Other Lower Respiratory Symptoms	30,118	20,941	3,406	2,127	1,284	790
Acute Bronchitis	2,494	1,729	284	177	107	66
Lost Work Days	182,940	123,439	25,713	14,014	6,241	4,617
Minor Restricted Activity Days	1,544,952	959,839	168,459	113,280	99,585	50,408
School Absences	331,040	175,339	18,472	24,689	33,282	17,492

NOTE: Values represent the mean annual incidence estimate for 2005.

California's Central Valley) round out the top five with 49 and 39 annual premature deaths, respectively.

Construction activity varies from city to city and, therefore, so does potential exposure to harmful diesel exhaust. Areas with high population density and construction activity are an obvious concern because construction equipment emissions are more likely to be occurring in close proximity to people. Nevertheless, the most densely populated cities are not the only areas with high potential for construction risk; evaluation of active construction projects finds areas outside major population centers also face risks since large-scale construction projects accompany regional population growth.

While incentive programs have begun to clean up some of this equipment, only statewide regulations can achieve the reductions in construction equipment pollution needed to truly protect public health. Cost-effective technology solutions that would help meet this regulatory goal already exist, and more will become available over the next few years. CARB should adopt a regulatory regime that will clean up existing construction equipment by retiring the oldest, most-polluting equipment and using retrofit technology where appropriate.

Chapter 1

Diesel Pollution from Construction Equipment

Highway truck and bus engine manufacturers have had to meet increasingly stringent emission regulations since the late 1980s. Construction and other off-road equipment, however, did not face new particulate matter (PM) emission standards until 1996, with some engines unregulated as late as 2003.[4] In 2004, the U.S. Environmental Protection Agency (EPA) finally forced construction equipment to meet similar standards to highway trucks and buses, requiring 90 percent reductions in nitrogen oxides (NOx) and PM for most engine sizes. These standards will phase in over a seven-year period starting in 2008, reaching full implementation in 2014 (EPA 2004).

Although these standards will significantly reduce pollutants from new engines, the full benefits will not be realized until sometime after 2030, when the long-lasting equipment currently in use today is finally retired. There are technology options available to clean up these existing machines, but neither the EPA nor the state of California currently requires them. As a result, if no additional requirements are put in place, the construction sector will continue emitting high levels of toxic and smog-forming pollution for the next two to three decades.

THE WORST OFFENDERS

The Union of Concerned Scientists (UCS) took a closer look at pollution from California's construction equipment to find out which types of equipment emit the most toxic diesel PM (or "soot") and smog-forming NOx. Most people think of trucks and buses when they think of diesel pollution, but as it turns out, the equipment repairing the road near your home or operating at a construction site near your office may be many times more polluting. Diesel construction equipment ranges from backhoes and bulldozers to paving equipment and cranes; we have identified the worst offenders.

Out of 18 categories of construction equipment identified in the 2005 California Air Resources Board (CARB) emission inventory, the five highest-polluting categories are responsible for 65 percent of PM and 60 percent of NOx emissions. In descending order, they are excavators, tractors/loaders/backhoes, crawler tractors (commonly called bulldozers), rubber-tired loaders, and skid-steer loaders (CARB 2006c).

We compared PM and NOx emissions from these types of equipment with the number of miles a new heavy-duty tractor-trailer truck (or "big rig") would have to travel to emit the same amount of pollution. The emissions of a model year 2007 big rig were estimated based on a truck traveling 55 miles per hour and operating on recently available ultra-low-sulfur diesel fuel. Hourly construction equipment emissions were calculated from equipment population estimates and CARB's 2005 emission inventory.

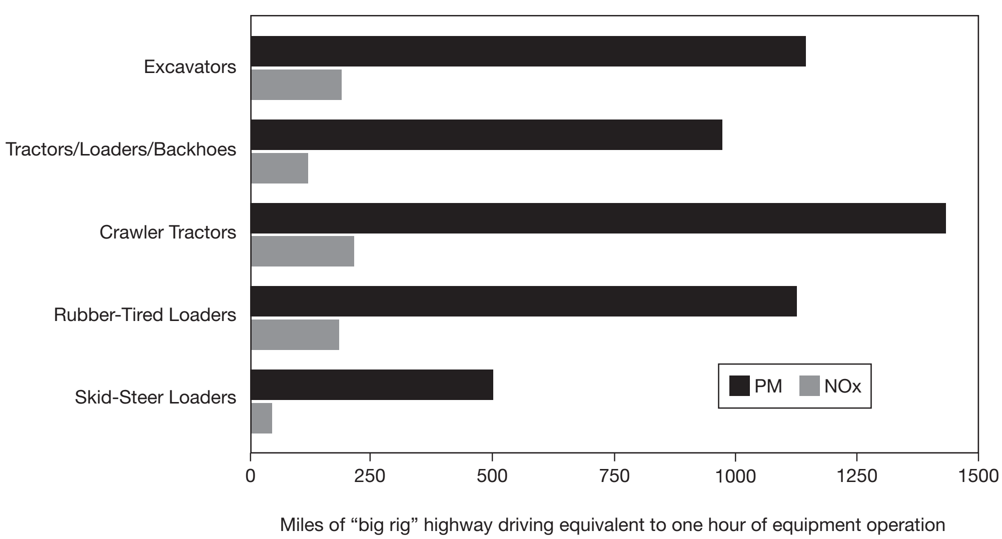
4 Tier 1 EPA nonroad engine standards did not include PM limits for engines of 50 to 175 horsepower.

TABLE 2 **Emissions by Type of Construction Equipment**

	Percent of Total PM from Construction Equipment	Percent of Total NOx from Construction Equipment	Useful Life (in years)
Excavators	17%	18%	17
Tractors/Loaders/Backhoes	16%	12%	18
Crawler Tractors (Tracked Bulldozers)	13%	13%	29
Rubber-Tired Loaders	12%	12%	21
Skid-Steer Loaders	7%	4%	13
Off-Highway Trucks	5%	9%	17
Rough-Terrain Forklifts	5%	3%	16
Graders	5%	5%	23
Off-Highway Tractors	4%	5%	31
Rollers	3%	3%	20
Trenchers	3%	2%	28
Scrapers	3%	4%	26
Cranes	3%	4%	19
Rubber-Tired Dozers	2%	2%	32
Pavers	2%	1%	26
Bore/Drill Rigs	1%	1%	10
Other Construction Equipment	0.4%	1%	16
Paving Equipment	0.3%	0.2%	24
Surfacing Equipment	0.04%	0.1%	22

NOTE: Useful life is defined as the age at which half of the equipment of a given model year has been retired.
SOURCE: Based on 2005 CARB construction emission inventory (updated as of September 2006).

FIGURE 1 **Construction Equipment Emissions Compared with a New "Big Rig"**



Excavators

There are an estimated 19,000 excavators in California, ranging in size from about 50 to 750 horsepower. The annual PM pollution from excavators accounts for 17 percent of all PM from construction equipment. On average, an excavator operating for one hour emits as much PM as a new big rig traveling 1,100 miles, while NOx emissions are equivalent to driving a big rig about 200 miles. The useful life of this equipment is 17 years.[5]

Tractors/loaders/backhoes

These versatile pieces of equipment are commonly used on construction sites and road repair projects. More than 30,000 backhoes are operated in California every year, emitting 16 percent of all PM from construction equipment. The PM produced by the average backhoe in one hour is equivalent to driving a big rig nearly 1,000 miles, while the NOx emissions are equivalent to driving more than 100 miles. The useful life of this equipment is 18 years.

Crawler tractors (bulldozers)

These tracked vehicles are used primarily for earthmoving operations. More than 16,000 bulldozers operate in California and emit 13 percent of all PM from construction equipment. The average bulldozer operating for one hour emits the same amount of PM as a new big rig driving 1,400 miles. The NOx emissions from an hour of operation are equivalent to driving a big rig 200 miles. The useful life of a crawler tractor is an impressive 29 years.

5 Useful life is defined as the age at which half of the equipment of a certain model year has been retired. The useful life, equipment populations, emissions, and other equipment specifics described in this section are based on CARB's updated off-road emission inventory model as of September 2006 (CARB 2006c).

Rubber-tired loaders

These heavy-duty vehicles, commonly used to load trucks, represent the fourth largest source of diesel emissions from construction equipment; the estimated 19,000 rubber-tired loaders in California account for 12 percent of all construction pollution. The average loader operating for one hour emits PM equivalent to driving a new big rig 1,100 miles and NOx emissions equivalent to driving 200 miles. The useful life of rubber-tired loaders is 21 years.

Skid-steer loaders

More than 29,000 of these relatively small pieces of equipment operate in California on all types of construction projects, and account for seven percent of all PM from construction equipment. Even though the average skid-steer loader delivers less than 50 horsepower (a fraction of that provided by a big rig),[6] its PM emissions from one hour of operation are equivalent to driving a new big rig 500 miles. The useful life of a skid-steer loader is 13 years.

6 A new big rig's engine can range anywhere from 300 to 600 horsepower.

Chapter 2

Health and Economic Damage from Construction Equipment

Emissions from construction equipment and other diesel vehicles are harmful to our health and well-being. The damage comes in the form of premature death, increased hospital admissions for respiratory and cardiovascular diseases, asthma attacks, and lost productivity through school absences and missed work days. Following established statistical methods, UCS has quantified the cost of diesel emissions from construction equipment in California.

The impact of several pollutants that comprise diesel exhaust must be taken into account:

- **Particulate matter (PM).** Also known as soot, these small particles (25 times smaller than the width of a human hair) are released directly from the tailpipe or formed indirectly from emissions of NOx and sulfur oxides (SOx). PM can penetrate deeply into the lungs, causing or aggravating a variety of respiratory and cardiovascular illnesses and even leading in some cases to premature death (Pope 2002, Krewski 2000, Samet 2000).
- **Smog-forming pollutants.** NOx and hydrocarbons react in the presence of sunlight to form ozone (smog), which can damage the respiratory tract, reduce lung function, exacerbate asthma, aggravate chronic lung diseases, and also cause premature death (White 1994, Koren 1995, Thurston 2001, Bell 2005). As much as 10 to 20 percent of all summertime hospital visits and admissions for respiratory illness are associated with ozone, and more than 90 percent of Californians live in areas that do not comply with federal ozone standards (Thurston 1992, 1994).
- **Air toxics.** The state of California has classified diesel exhaust and more than 40 compounds in diesel exhaust as toxic air contaminants.[7] Exposure to these chemicals can cause cancer, damage to fetuses, and other serious health and reproductive problems. CARB has estimated that diesel exhaust is responsible for 70 percent of the state's risk of cancer from airborne toxics (CARB 1998).

ESTIMATING HEALTH EFFECTS OF CONSTRUCTION POLLUTION

This analysis uses methods established by CARB and the EPA to quantify health and economic damage from diesel pollution. In March 2006, CARB released a study detailing the regional health and economic damage caused by California's goods movement system (CARB 2006a). A number of adverse health effects, or endpoints, strongly linked to diesel pollution were quantified along with an estimate of the economic costs associated with these endpoints.

7 According to the California Health and Safety Code, a toxic air contaminant is "an air pollutant which may cause or contribute to an increase in mortality or in serious illness, or which may pose a present or potential hazard to human health."

How Diesel Exhaust Damages Lungs

As PM from diesel exhaust travels through the air and is inhaled, the largest particles settle in the nose, throat, and lungs. The finest particles are able to evade the body's natural defenses (such as sneezing and coughing) and travel deep into the lungs. Once there, these particles can cause inflammation and scarring of air passageways and lung tissue, resulting in reduced oxygen flow to the rest of the body. Symptoms can range from coughing and shortness of breath to severe and fatal asthma attacks.

When inhaled, ozone—a key ingredient of smog—can also damage lungs by chemically burning delicate tissue and causing scarring. Recent evidence suggests that exposure to ozone can cause asthma in otherwise healthy children (McConnell 2002). On days with high ozone levels, health officials recommend reducing outdoor activities to lower exposure to this dangerous pollutant.

Using emission data specific to diesel construction equipment in California, we used the same methodology to quantify the damage from construction equipment pollution. Because our ability to quantify the public health impact of diesel pollution is limited, the health endpoints quantified in this analysis do not represent all of the potential damage associated with diesel pollution and are therefore conservative estimates.

Economic damage associated with construction equipment pollution is estimated by assigning each health endpoint an economic value. Economic valuations for each health endpoint are based on the cost of treating an illness, lost productivity or wages, or the value society is willing to pay to lower the risk of certain outcomes.

For further discussion of the methodology used to estimate the health and economic impact of construction pollution, please refer to the appendix.

Our analysis found that the economic and health damage caused by construction equipment pollution in California is staggering. More than 1,000 premature deaths per year can be attributed to these emissions, along with more than 1,000 hospitalizations for cardiovascular and respiratory illness, and more than 30,000 asthma attacks and other respiratory symptoms. Hundreds of thousands of lost work days and school absences equate to more than $60 million in annual economic losses. In addition, Californians collectively experience millions of days each year when air pollution restricts their activities. Overall, construction equipment pollution costs the state more than nine billion dollars every year.

TABLE 3 **Health and Economic Damage from Construction Pollution (Statewide)**

Health Endpoint	Pollutants	Total Incidences	Costs (in thousands of 2005 dollars)
Premature Deaths ($7.9 million/incidence)	PM and ozone	**1,132** (328–1930)	**8,944,256** (2,588,161–15,249,672)
Respiratory Hospitalizations ($34,000/incidence)	PM and ozone	**669** (398–933)	**22,758** (13,530–31,735)
Cardiovascular Hospitalizations ($41,000/incidence)	PM only	**417** (263–646)	**17,082** (10,795–26,491)
Asthma and Other Lower Respiratory Symptoms ($19/incidence)	PM only	**30,118** (11,686–48,110)	**572** (222–914)
Acute Bronchitis ($422/incidence)	PM only	**2,494** (-609–5,408)	**1,053** (-257–2,282)
Lost Work Days ($180/incidence)	PM only	**182,940** (155,031–210,810)	**32,929** (27,906–37,946)
Minor Restricted Activity Days ($60/incidence)	PM and ozone	**1,544,952** (988,809–2,150,641)	**92,697** (59,329–129,038)
School Absences ($88/incidence)	Ozone only	**331,040** (134,632–531,374)	**29,131** (11,848–46,761)
Total Cost			**9,140,480** (2,711,532–15,524,840)

DEFINITIONS:

Premature deaths: Premature deaths due to exposure to PM and ozone, including cardiopulmonary and lung cancer mortality.

Respiratory hospitalizations: Hospital admissions for respiratory illnesses (such as emphysema or chronic bronchitis) as a result of exposure to both PM and ozone.

Cardiovascular hospitalizations: Hospital admissions for cardiovascular illnesses (such as heart attacks or hypertension) as a result of exposure to PM.

Lower respiratory symptoms: Asthma attacks and other symptoms such as wheezing, coughing, and shortness of breath.

Acute bronchitis: Symptoms can include coughing, chest discomfort, and slight fever and can last several days.

Lost work days: Days of work missed due to symptoms resulting from exposure to PM or to take care of an individual with such symptoms.

Minor restricted activity days: Days in which high ozone and PM levels require less strenuous activities but do not result in a lost work day or school absence.

School absences: Days of school missed due to symptoms resulting from exposure to ozone.

NOTE: Mean estimates are shown in bold; ranges shown in parentheses represent the 95 percent confidence interval (i.e., there is a 95 percent chance that the actual value falls between the two values shown).

Chapter 3
Construction Pollution Impact by Region

The majority of the damage caused by construction equipment pollution occurs in areas where large numbers of people are exposed. Five of California's 15 air basins, home to more than 85 percent of the state's population, suffer more than 90 percent of the total health and economic damage from construction pollution. In each of these five air basins, which are the focus of this chapter, concerns exist in both urban and suburban areas.

Air basins are largely defined by physical features, such as mountain ranges, and meteorological conditions, such as air flow patterns, that restrict the movement of air pollution to another air basin. Air quality in a given air basin is influenced by the emission sources within it, and to a lesser degree by pollution entering from another air basin. Transport of air pollution from neighboring air basins is an ongoing area of research and, for the purposes of this analysis, construction equipment emissions are assumed to remain in the air basin in which they were generated.

WHERE PEOPLE AND CONSTRUCTION MIX

UCS also evaluated the likelihood of exposure to construction activity in specific cities within the five most-affected air basins. While construction equipment contributes to overall PM and ozone concentrations in each air basin, people who live or work near construction equipment may be at a higher risk of exposure to these dangerous pollutants.[8] Using 2000 census data and 2005 construction permit data from the California State Water Resources Control Board (SWRCB), we have identified those cities that have a higher risk of exposure to construction activity. The results show that areas where construction activity and people mix are spread throughout each region, in both urban and suburban cities and towns.

The SWRCB requires permits for construction projects that disturb more than one acre of land through clearing, grading, or excavation. We used permits from the SWRCB database for our analysis because such land disturbance generally involves the use of diesel earthmoving construction equipment. By excluding local building permits, we attempted to eliminate small projects such as single-family home construction and remodeling work that may not require the use of diesel equipment. The permits selected for this analysis were either active or issued between January 1, 2005, and December 31, 2005 (SWRCB 2005).

We then created maps using geographic information system (GIS) software to display "Construction Risk Zones" related to construction activity in each of the five studied air basins. Construction Risk Zones represent the risk of exposure to construction pollution in a given city, based on its mixture of construction activity and population density. To determine the relative risk potential for each city, we multiplied the total acreage under construction permit during 2005

8 Northeast States for Coordinated Air Use Management showed increased concentrations of diesel PM near construction sites (NESCAUM 2003). Other studies have shown an elevated risk of cancer near diesel pollution sources; these studies include a health risk assessment at a California rail yard (CARB 2005).

by population density from the 2000 census. A city's risk potential is presented in relation to other cities within the air basin, ranging from a relatively high risk to a relatively low risk.

The resulting Construction Risk Zones are based on the best information available, but it is important to note that this is not a measure of actual exposure to emissions and is only one measure of the likelihood that people and construction equipment will be in proximity to one another. Actual exposure levels depend on the amount of emissions produced by specific equipment, the types of equipment on a construction site and the length of time they operate, wind patterns and atmospheric conditions, and proximity to the emission source. These details are not available from the SWRCB permit database.

Also, because we have measured construction activity in terms of acreage, a multi-story project and a single-story project are treated equally. In addition, the construction permit data used to evaluate Construction Risk Zones does not include California Department of Transportation (Caltrans) highway projects—a major source of construction activity in the state.[9] In spite of these limitations, our Construction Risk Zone evaluation captures a majority of the largest construction sites in the state.

Please see the appendix for further discussion of the SWRCB permit data.

9 For perspective, Caltrans contracts were worth eight billion dollars in 2005 (CALTRANS 2005) while building and construction contracts were valued at $65 billion according to the California Department of Finance (CDF 2005).

SOUTH COAST

Comprising most of Los Angeles, San Bernardino, Riverside, and Orange counties, this air basin experiences the greatest degree of health and economic damage in the state from construction equipment emissions. For 2005, this includes estimates of:

- more than 700 premature deaths
- 650 hospitalizations for respiratory and cardiovascular disease
- more than 1,700 cases of acute bronchitis
- nearly 21,000 incidences of asthma attack and other lower respiratory symptoms
- 300,000 days of lost work and school absences
- close to one million days of restricted activity

This loss of life and productivity cost South Coast residents an estimated $5.9 billion.

Within the air basin, 127 cities and towns had active construction permits during 2005 accounting for more than 70,000 acres of land under construction. Areas designated as high-risk are spread throughout the region, with cities in all four counties falling in the top 10 percent of Construction Risk Zones. San Bernardino and Riverside counties each have four such cities while Los Angeles has three and Orange two. The presence of less population-dense cities such as Murrieta and Temecula in this group reflects the fact that large developments of 50 acres or more are common in these cities.

TABLE 4 **South Coast Construction Pollution Damage**

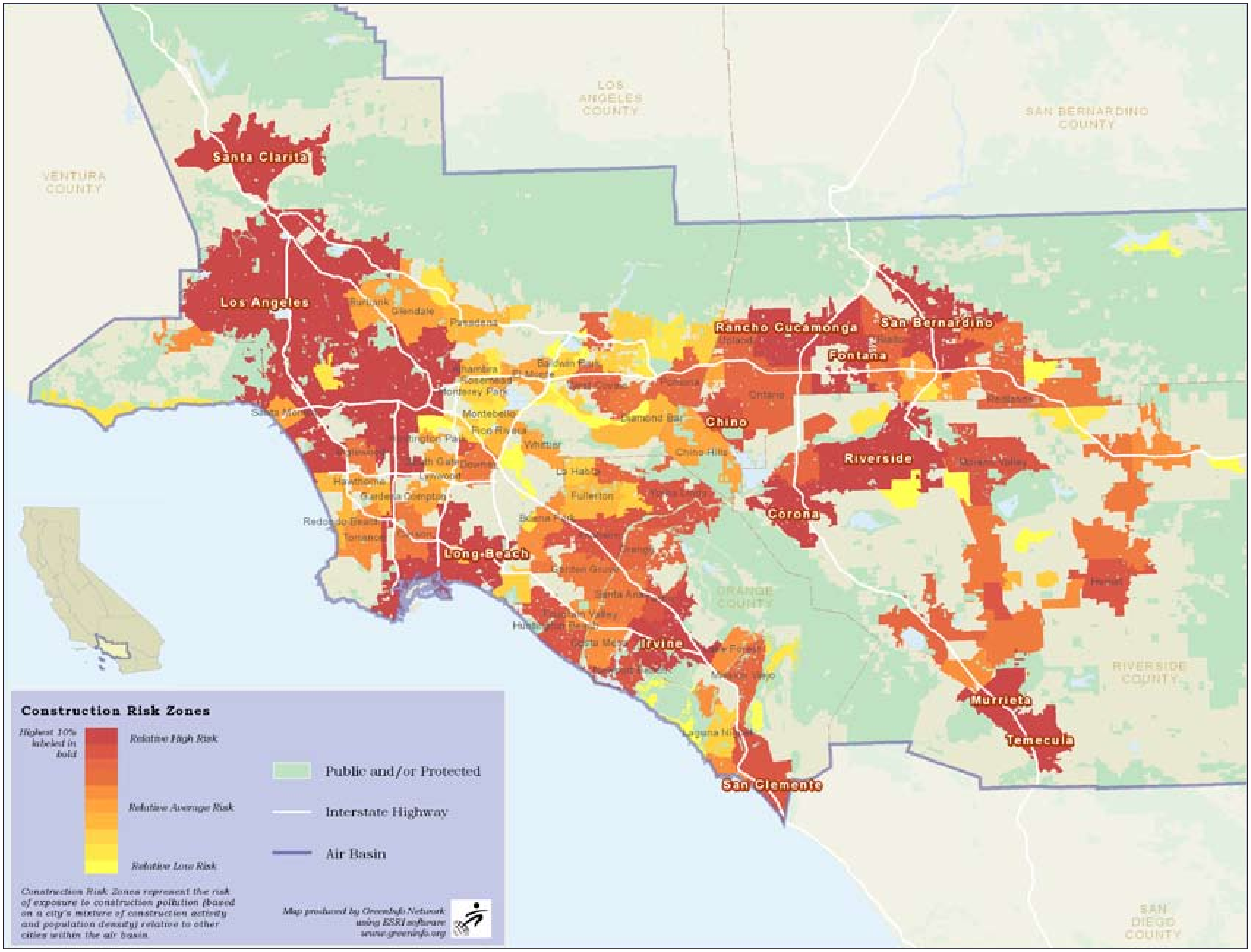
Health Endpoint	Mean Annual Incidences	Annual Costs (in thousands of 2005 dollars)
Premature Deaths	731	**5,776,261**
Respiratory Hospitalizations	383	**13,019**
Cardiovascular Hospitalizations	274	**11,248**
Asthma and Other Lower Respiratory Symptoms	20,941	**398**
Acute Bronchitis	1,729	**730**
Lost Work Days	123,439	**22,219**
Minor Restricted Activity Days	959,839	**57,590**
School Absences	175,339	**15,430**
Total Annual Cost		**5,896,894**

TABLE 5 **Top 10 Percent of South Coast Construction Risk Zones**

City	County
Long Beach	Los Angeles
Los Angeles	Los Angeles
Santa Clarita	Los Angeles
Irvine	Orange
San Clemente	Orange
Corona	Riverside
Murrieta	Riverside
Riverside	Riverside
Temecula	Riverside
Chino	San Bernardino
Fontana	San Bernardino
Rancho Cucamonga	San Bernardino
San Bernardino	San Bernardino

NOTE: Cities are listed in alphabetical order by county.

FIGURE 2 **Construction Pollution Risk in the South Coast Air Basin**



SAN FRANCISCO BAY AREA

This air basin comprises nine counties and is second only to the South Coast air basin in health and economic damage from construction equipment emissions. For 2005, this includes estimates of:

- more than 150 premature deaths
- 100 hospitalizations for respiratory and cardiovascular disease
- more than 280 cases of acute bronchitis
- 3,000 incidences of asthma attack and other lower respiratory symptoms
- 44,000 days of lost work and school absences
- well over 100,000 days of restricted activity

This loss of life and productivity cost Bay Area residents an estimated $1.2 billion.

Within the air basin, 80 cities and towns had active construction permits during 2005 accounting for more than 17,500 acres of land under construction. As in the South Coast, areas designated as high-risk are spread throughout the region. San Francisco and San Jose, both densely populated cities, fall in the top 10 percent of Construction Risk Zones along with less population-dense cities in Contra Costa, Alameda, and Solano counties (where large amounts of acreage are under construction).

It should be noted that the replacement of the Bay Bridge's eastern span, a multi-year, multi-billion-dollar project involving large amounts of construction equipment, is not captured in this evaluation.

TABLE 6 **San Francisco Bay Area Construction Pollution Damage**

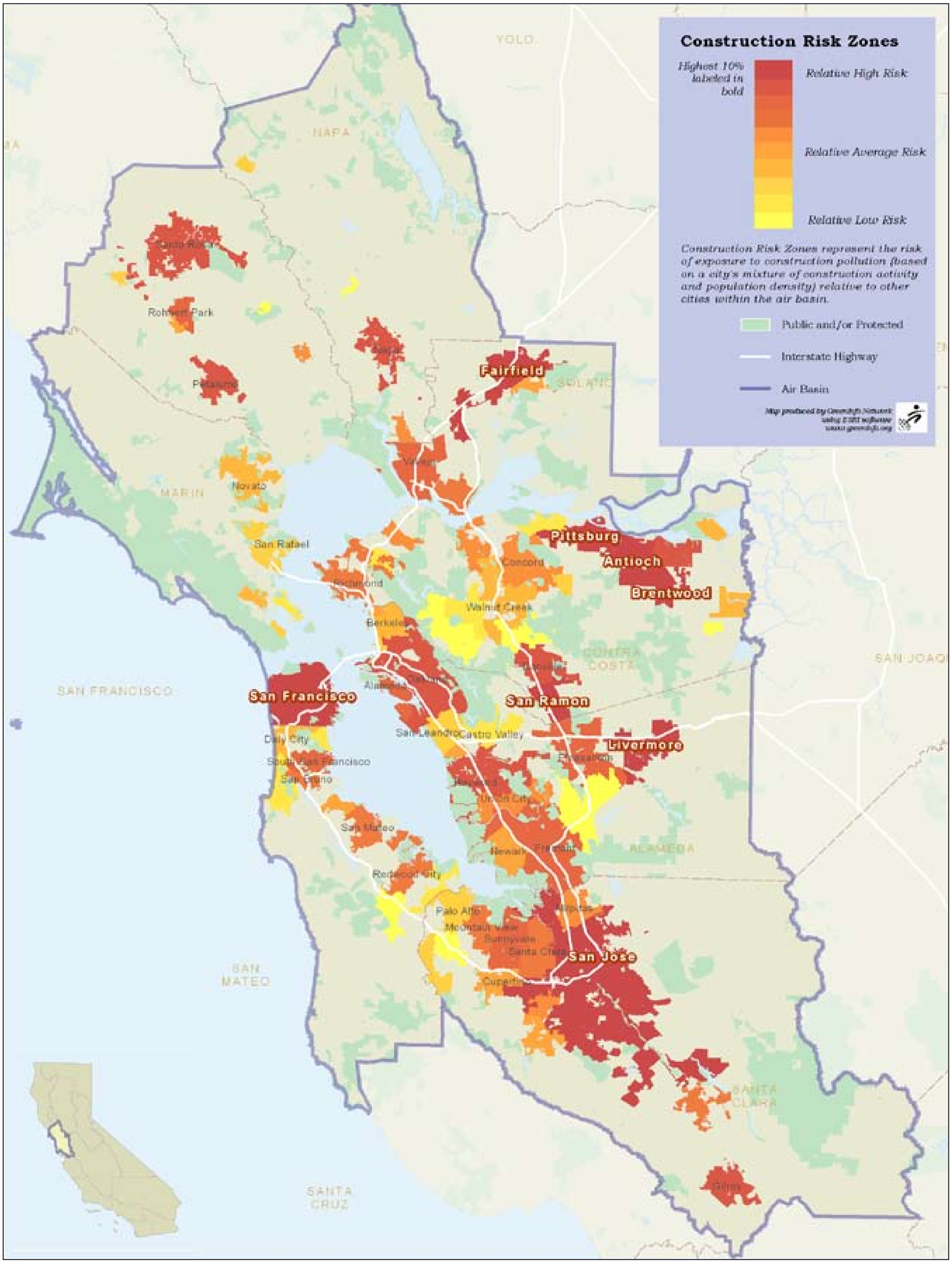
Health Endpoint	Mean Annual Incidences	Annual Costs (in thousands of 2005 dollars)
Premature Deaths	154	**1,215,948**
Respiratory Hospitalizations	56	**1,914**
Cardiovascular Hospitalizations	61	**2,482**
Asthma and Other Lower Respiratory Symptoms	3,406	**65**
Acute Bronchitis	284	**120**
Lost Work Days	25,713	**4,628**
Minor Restricted Activity Days	168,459	**10,108**
School Absences	18,472	**1,626**
Total Annual Cost		**1,236,890**

TABLE 7 **Top 10 Percent of San Francisco Bay Area Construction Risk Zones**

City	County
Livermore	Alameda
Antioch	Contra Costa
Brentwood	Contra Costa
Pittsburg	Contra Costa
San Ramon	Contra Costa
San Francisco	San Francisco
San Jose	Santa Clara
Fairfield	Solano

NOTE: Cities are listed in alphabetical order by county.

FIGURE 3 **Construction Pollution Risk in the San Francisco Bay Area Air Basin**



SAN DIEGO

This air basin ranks third behind the South Coast and San Francisco Bay Area for damage from construction equipment pollution. For 2005, this includes estimates of:

- nearly 90 premature deaths
- more than 80 hospitalizations for respiratory and cardiovascular disease
- more than 170 cases of acute bronchitis
- more than 2,000 incidences of asthma attack and other lower respiratory symptoms
- 38,500 days of lost work and school absences
- more than 100,000 days of restricted activity

This loss of life and productivity cost San Diego residents an estimated $718 million.

Within the air basin, 25 cities and towns had active construction permits during 2005 accounting for more than 22,500 acres of land under construction. San Diego is by far the most populated and largest city in the air basin falling in the top 10 percent of Construction Risk Zones; others include Chula Vista and Oceanside, which both have a population density similar to San Diego and more than 1,000 acres under construction permit in 2005.

TABLE 8 **San Diego Construction Pollution Damage**

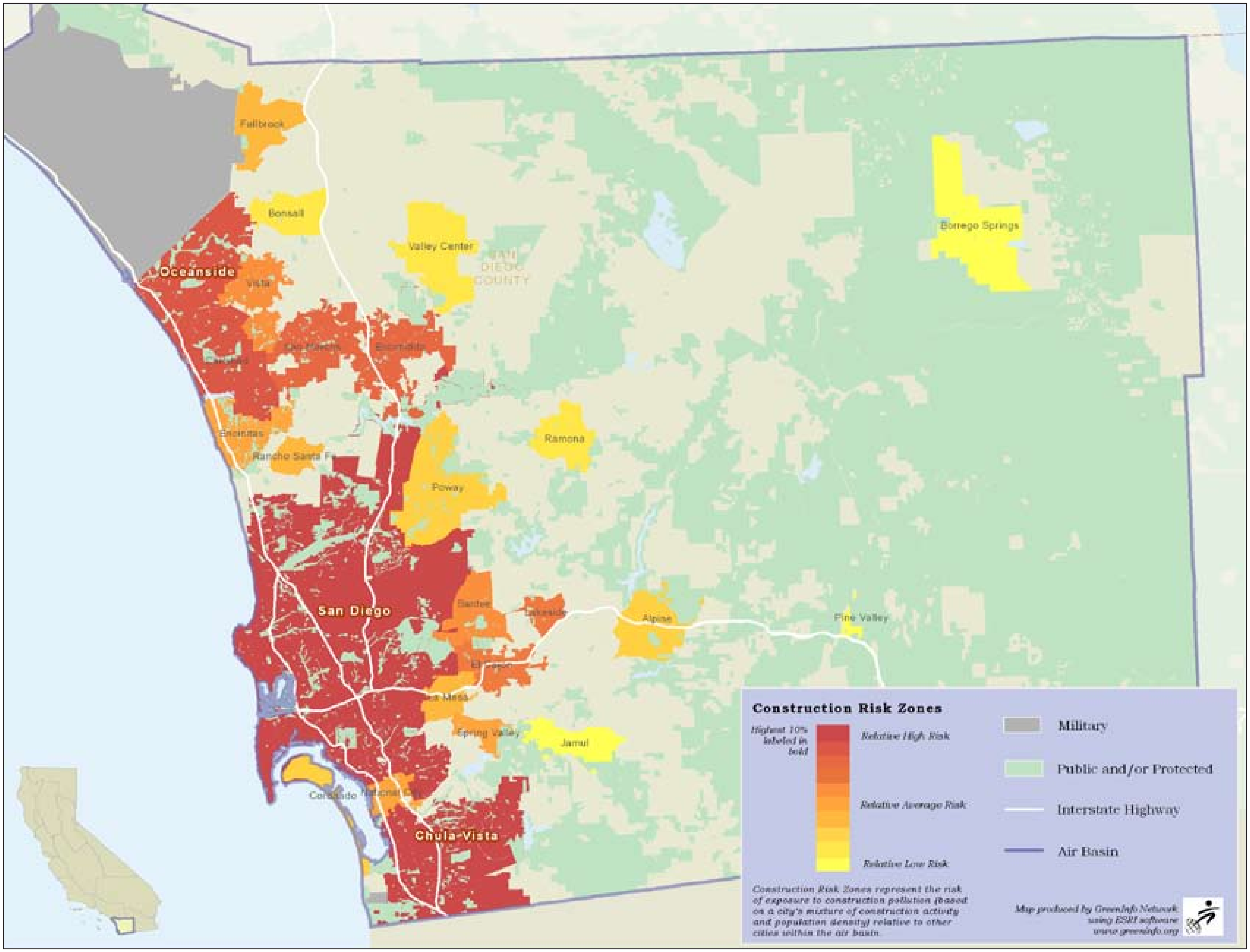
Health Endpoint	Mean Annual Incidences	Annual Costs (in thousands of 2005 dollars)
Premature Deaths	89	**703,222**
Respiratory Hospitalizations	50	**1,703**
Cardiovascular Hospitalizations	33	**1,357**
Asthma and Other Lower Respiratory Symptoms	2,127	**40**
Acute Bronchitis	177	**75**
Lost Work Days	14,014	**2,523**
Minor Restricted Activity Days	113,280	**6,797**
School Absences	24,689	**2,173**
Total Annual Cost		**717,890**

TABLE 9 **Top 10 Percent of San Diego Construction Risk Zones**

City	County
Chula Vista	San Diego
Oceanside	San Diego
San Diego	San Diego

NOTE: Cities are listed in alphabetical order by county.

FIGURE 4 **Construction Pollution Risk in the San Diego Air Basin**



SAN JOAQUIN VALLEY

This air basin, comprising the southern counties of California's Central Valley, ranks fourth for health and economic damage from construction equipment pollution. For 2005, this includes estimates of:

- nearly 50 premature deaths
- 70 hospitalizations for respiratory and cardiovascular disease
- more than 100 cases of acute bronchitis
- more than 1,200 incidences of asthma attack and other lower respiratory symptoms
- 39,000 days of lost work and school absences
- nearly 100,000 days of restricted activity

This loss of life and productivity cost San Joaquin Valley residents an estimated $401 million.

Within the air basin, 66 cities and towns had active construction permits during 2005 accounting for more than 32,500 acres of land under construction. The seven cities comprising the air basin's top 10 percent of Construction Risk Zones are spread throughout the valley (in six different counties) and correspond to the most populated areas.

TABLE 10 **San Joaquin Valley Construction Pollution Damage**

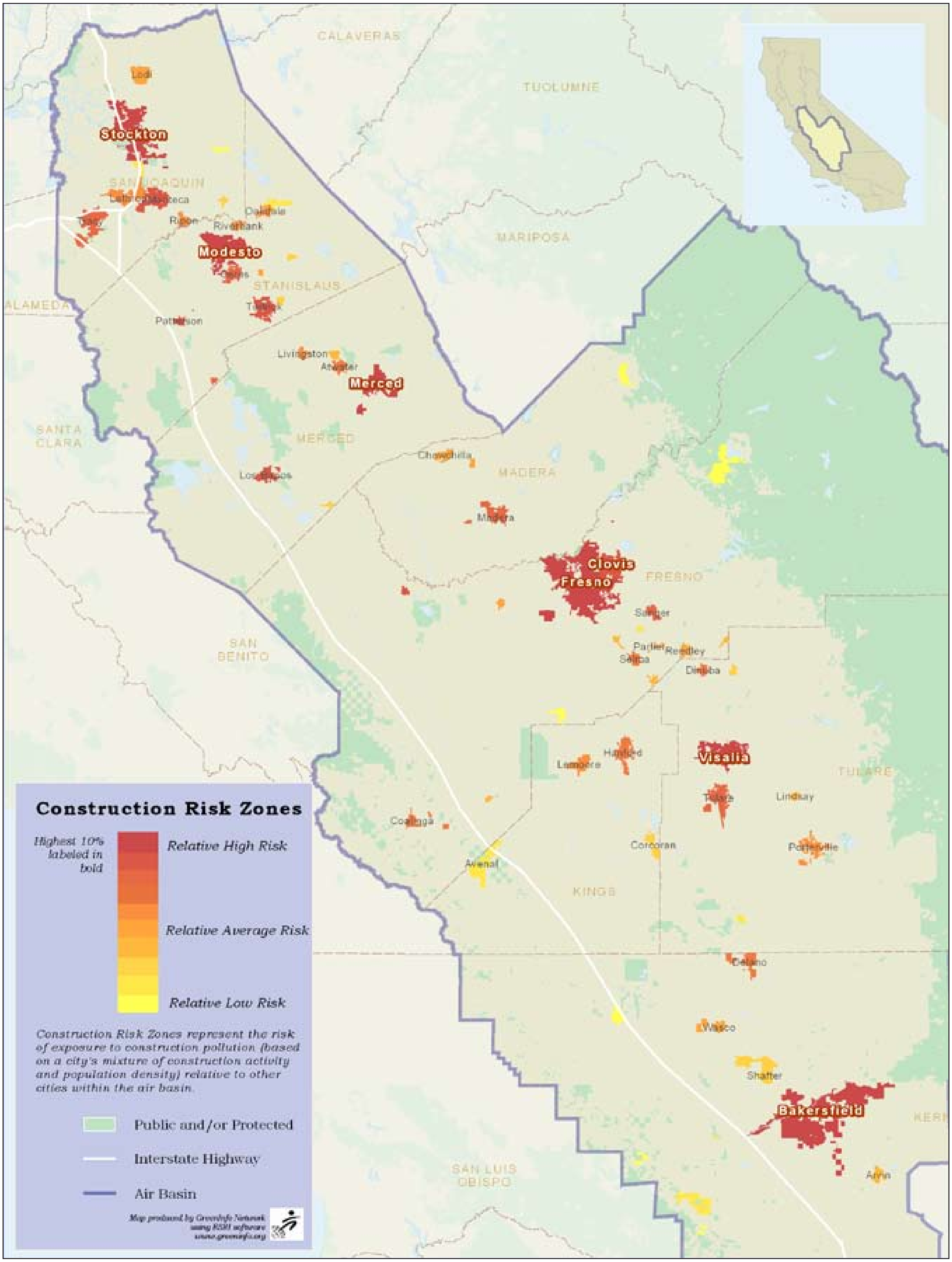
Health Endpoint	Mean Annual Incidences	Annual Costs (in thousands of 2005 dollars)
Premature Deaths	49	**388,547**
Respiratory Hospitalizations	55	**1,858**
Cardiovascular Hospitalizations	14	**592**
Asthma and Other Lower Respiratory Symptoms	1,284	**24**
Acute Bronchitis	107	**45**
Lost Work Days	6,241	**1,123**
Minor Restricted Activity Days	99,585	**5,975**
School Absences	33,282	**2,929**
Total Annual Cost		**401,094**

TABLE 11 **Top 10 Percent of San Joaquin Valley Construction Risk Zones**

City	County
Clovis	Fresno
Fresno	Fresno
Bakersfield	Kern
Merced	Merced
Stockton	San Joaquin
Modesto	Stanislaus
Visalia	Tulare

NOTE: Cities are listed in alphabetical order by county.

FIGURE 5 **Construction Pollution Risk in the San Joaquin Valley Air Basin**



SACRAMENTO VALLEY

This air basin, comprising the northern counties of California's Central Valley, ranks fifth for health and economic damage from construction equipment pollution. For 2005, this includes estimates of:

- nearly 40 premature deaths
- more than 40 hospitalizations for respiratory and cardiovascular disease
- more than 65 cases of acute bronchitis
- 790 incidences of asthma attack and other lower respiratory symptoms
- 22,000 days of lost work and school absences
- more than 50,000 days of restricted activity

This loss of life and productivity cost Sacramento Valley residents an estimated $314 million.

Within the air basin, 52 cities and towns had active construction permits during 2005 accounting for more than 29,000 acres of land under construction. The cities falling in the top 10 percent of Construction Risk Zones include the city of Sacramento and its suburbs Elk Grove, Roseville, and Woodland, along with Yuba City in Sutter County.

TABLE 13 **Top 10 Percent of Sacramento Valley Construction Risk Zones**

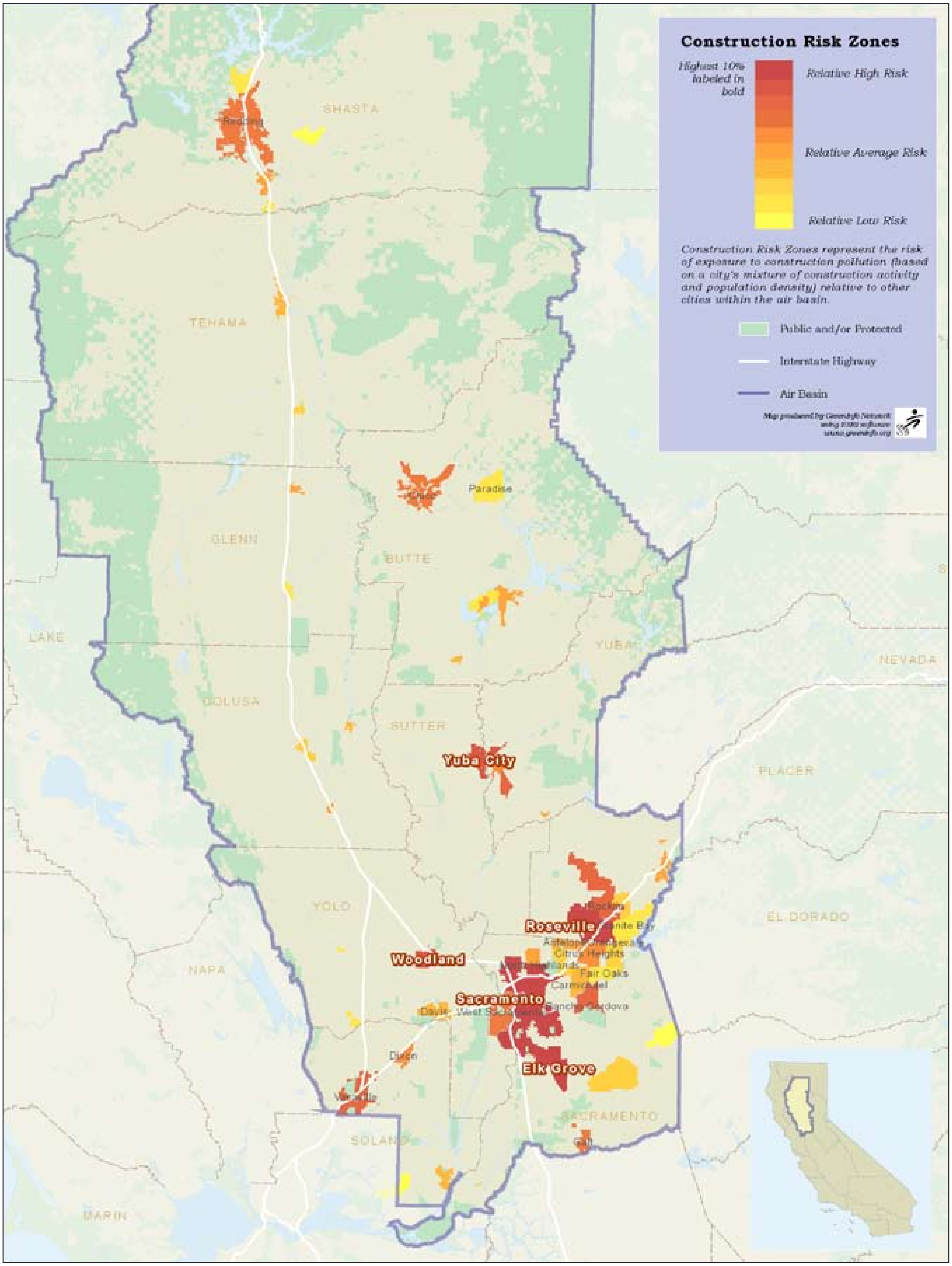
City	County
Roseville	Placer
Elk Grove	Sacramento
Sacramento	Sacramento
Yuba City	Sutter
Woodland	Yolo

NOTE: Cities are listed in alphabetical order by county.

TABLE 12 **Sacramento Valley Construction Pollution Damage**

Health Endpoint	Mean Annual Incidences	Annual Costs (in thousands of 2005 dollars)
Premature Deaths	39	**306,638**
Respiratory Hospitalizations	30	**1,003**
Cardiovascular Hospitalizations	12	**493**
Asthma and Other Lower Respiratory Symptoms	790	**15**
Acute Bronchitis	66	**28**
Lost Work Days	4,617	**831**
Minor Restricted Activity Days	50,408	**3,025**
School Absences	17,492	**1,539**
Total Annual Cost		**313,571**

FIGURE 6 **Construction Pollution Risk in the Sacramento Valley Air Basin**



CONCLUSIONS

Construction equipment is operating in cities and towns throughout California, releasing harmful NOx and PM emissions into the air and raising the risk of exposure to these pollutants for residents who live and work near construction sites. The likelihood of people living or working close to construction sites is highest in densely populated urban areas, but the suburbs are not free of risk from construction equipment pollution. Many projects in these areas, including new commercial and residential developments, require extensive use of construction equipment for land clearing and grading operations. Road construction and maintenance projects occurring throughout the state add additional risk.

Construction equipment pollution is therefore a health concern for all Californians.

Chapter 4
Building a Cleaner Future

Because of its long working life, high replacement cost, and lagging emission standards, diesel construction equipment will continue to pollute for decades. That means Californians will suffer from increased hospital admissions for respiratory and cardiovascular disease, asthma attacks, acute bronchitis, and even premature death—unless the state takes action to dramatically reduce construction equipment pollution.

WHAT CAN CALIFORNIA DO?

Under the federal Clean Air Act, California has the unique authority to regulate construction equipment. The state should use this authority to establish stringent new regulations that would complement its recent efforts to clean up pollution from other on-road and off-road sources of diesel pollution.[10] An effective regulatory regime for diesel construction equipment would:

- reduce diesel PM 75 percent below 2000 levels by 2010 and 85 percent below 2000 levels by 2020—which would reduce estimated annual premature deaths from construction equipment pollution by 790 (70 percent) compared with 2005
- phase out or retire the oldest, most polluting equipment
- install the best available retrofit technology on newer equipment
- require the strongest emission controls near sensitive locations such as schools, nursing homes, hospitals, and day care centers

Incentive programs have also proven effective in cleaning up construction equipment (UCS 2004). These programs should continue to fund equipment cleanup with the goal of achieving emission reductions above and beyond what regulations require.

There are a number of cost-effective ways to reduce emissions from construction and other off-road diesel equipment, allowing for flexibility in meeting reduction targets:[11]

- **Refuel.** Switching to alternative diesel fuels can achieve modest reductions in pollutants. These fuels can also facilitate the use of advanced retrofit technologies, resulting in even less pollution.
- **Repower.** The body or chassis of some equipment can last many decades, beyond the life of the original engine. Installing a new low-emission engine in an older chassis can allow the machine to run cleanly for many more years. California's Carl Moyer incentive program is currently funding some repower projects for construction equipment.[12]
- **Replace.** Replacing old equipment with a new lower-emission model ahead of schedule can result in substantial pollution reductions.

10 CARB has passed numerous regulations under its Diesel Risk Reduction Plan that set strict emission reduction targets for specific types of diesel vehicles and equipment (CARB 2005a, 2005b, 2005c, 2004b, 2003a, 2003b, 2003c, 2000).

11 Previous UCS analysis found that diesel cleanup through California's Carl Moyer incentive program achieves benefits valued at 10 times the cost of cleanup (UCS 2004).

12 Repower projects funded by the Carl Moyer incentive program must meet stringent cost-effectiveness thresholds (CARB 2000a, 2004a).

- **Retrofit.** Existing engines that can be expected to run for many more years can be retrofitted with emission control technologies that reduce PM more than 90 percent.[13]
- **Reduce idling.** Idling equipment not only pollutes, but also wastes fuel. Limiting idle time, on the other hand, saves money by reducing fuel use and wear-and-tear on the engine.

Efforts around the country and around the world are proving that the technology exists to lower construction equipment emissions. In Switzerland, for example, an aggressive regulation to curtail diesel PM emissions from construction sites has resulted in thousands of retrofits (Mayer 2004, 2005). In 2003, New York City passed an ordinance requiring that diesel equipment on all city-funded construction sites use ultra-low-sulfur fuel and be retrofitted with the best available control technology (Bradley 2006). Boston's "Big Dig" incorporated more than 200 retrofit devices on construction equipment, and Connecticut's Harbor Crossing Corridor is following suit.

In California, some air districts are funding repowers and retrofits through the Carl Moyer incentive program and, for large projects, requiring the use of cleaner construction equipment.[14] These and other groundbreaking efforts (MECA 2006) have proven the success of cleanup technology for construction equipment, but statewide action is necessary to achieve the greatest reductions and maximum health benefits.

WHAT CAN YOU DO?

By taking the following actions, individuals can help protect themselves from harmful diesel emissions and make sure that the appropriate decision makers know that Californians want diesel-powered construction equipment cleaned up:

- File a visible smoke complaint with your air district (contact information can be found at *http://www.arb.ca.gov/capcoa/roster.htm*) or CARB (call 800-952-5588 or email *vruiz@arb.ca.gov*) when you see plumes of diesel soot coming from construction equipment. Request that an inspector be sent to the site and investigate the emission source.
- Report illegal idling (commercial trucks that haul dirt or service construction sites cannot idle for more than five minutes) to CARB (visit *http://www.arb.ca.gov/enf/complaints/complaints.htm* or call 800-END-SMOG) or your local air district (contact information can be found at *http://www.arb.ca.gov/capcoa/roster.htm*). Citations for illegal idling can also be issued by local law enforcement.
- Tell your state legislative representatives (contact information can be found at *http://www.leginfo.ca.gov/yourleg.html*) and CARB (*arbboard@arb.ca.gov*) that cleaner construction equipment is important to you.
- Close your windows while diesel-powered equipment is operating near your home or office.
- Raise your concern about emissions from proposed construction in your neighborhood during the public review period, and demand that the project's environmental impact review assesses these emissions and includes a strategy for controlling them.
- Urge your city council to protect residents from construction pollution by enacting a clean-construction ordinance—especially around sensitive sites such as schools and day care centers.

13 CARB has verified retrofit technologies for use on off-road equipment. See *http://www.arb.ca.gov/diesel/verdev/verifiedtechnologies/cvt.htm*.

14 The Sacramento Metropolitan Air Quality Management District (*http://www.airquality.org/ceqa/index.shtml*) and San Luis Obispo County Air Pollution Control District (contact: Andrew Mutziger) require construction equipment pollution mitigation for some projects under the California Environmental Quality Act.

Appendix

Estimating the Health Damage and Economic Costs of Construction Pollution

Our polluted air has provided researchers a real-world laboratory for studying the impact of air pollution on people's health. Numerous epidemiological studies tracking thousands of individuals have linked PM exposure to premature death as well as cardiovascular and respiratory illnesses. Similar studies have been carried out for exposure to ozone pollution. These studies provide the basis for estimating the health benefits of reducing air pollution and are used in this study to estimate the impact of construction pollution.

The health effects quantified in this report are based on peer-reviewed epidemiological studies used by both the EPA and CARB to evaluate the benefits of reducing air pollution. These studies establish a statistically significant relationship between exposure to PM and ozone and increased incidences of specific health endpoints, which can then be quantified through a concentration-response function. The uncertainty in these estimates is quantified by presenting results as both a mean estimate of the number of incidences and a range of estimates representing the 95 percent confidence interval.[15]

Our analysis links health and economic damage to construction equipment pollution by using California-specific air quality monitoring data, county baseline health incidence rates, population estimates, and a diesel construction equipment emission inventory. PM concentrations for specific air basins were measured by CARB when identifying diesel PM as a toxic air contaminant (CARB 1998). And CARB recently evaluated concentration-response functions for specific health endpoints using diesel PM concentration estimates along with population data, baseline health incidence rates, and an inventory of diesel emission sources related to the movement of goods (CARB 2006a). As part of these efforts, air basin-specific factors were estimated (in tons of diesel pollution per incidence) for each health endpoint. UCS used these factors along with CARB's air basin-specific inventory of diesel PM, NOx, and reactive organic gases (ROG) to estimate the health effects of PM and ozone from construction equipment (CARB 2006d).

Each health endpoint covered in this report is assigned a dollar value to estimate the economic impact of diesel pollution. The EPA uses economic valuations of health endpoints to perform cost-benefit analyses of air pollution reduction measures, and our analysis reflects changes made to the EPA's hospitalization endpoints and lost work days to better reflect California-specific wage and health care data (CARB 2006a).

Premature death is the most serious health endpoint related to diesel pollution and has the greatest economic impact. Estimates of premature death resulting from exposure to fine PM are based on long-term exposure for people 30 or older, and include all causes of death (Pope 2002). Individuals with existing respiratory and cardiovascular disease and the elderly are most vulnerable, and life expectancies are shortened by months or even years (Pope 2000). Economic valuation of premature death is based on a review of studies carried

15 For a list of the epidemiological studies used, see CARB 2006a and EPA 2004.

out by the EPA and on society's "willingness-to-pay" to lower the risk of premature death (EPA 1999).

CONSTRUCTION PERMIT DATA

The California State Water Resources Control Board (SWRCB) construction permit database was chosen as the primary source for representing construction activity in California. Residential and commercial building permit data were excluded from the study due to overlapping information with the SWRCB database and the inclusion of projects that may not involve the use of diesel construction equipment.

SWRCB construction permits, which we used to calculate Construction Risk Zones, are required under the federal Clean Water Act for projects that disturb more than one acre of land. According to the SWRCB Fact Sheet for Water Quality Order 99-08-DWQ:

> *Construction activity subject to this General Permit includes clearing, grading, disturbances to the ground such as stockpiling, or excavation that results in soil disturbances of at least one acre of total land area. Construction activity that results in soil disturbances of less than one acre is subject to this General Permit if the construction activity is part of a larger common plan of development that encompasses one or more acres of soil disturbance or if there is significant water quality impairment resulting from the activity.*

Construction projects that disturb more than one acre of land generally involve the use of diesel earthmoving construction equipment. These permits, while not directly representing construction equipment activity, provide the best available indication of where large earthmoving equipment is being used.

Limitations of permit data. There are, however, some limitations to estimating construction activity from SWRCB permits.

Projects under permit may go through many different phases of construction before completion, not all of which require the use of diesel-powered construction equipment or sustained levels of construction equipment activity. Therefore, there is no guarantee that construction equipment was operated on site during a specific period of time, but permitees must pay an annual fee to the SWRCB to keep permits active. This monetary requirement should minimize the number of permitees holding active permits but not performing construction activity.

Additionally, there are some construction projects that will not appear in the SWRCB database. Projects in which storm runoff is captured in a combined sewer/storm water system do not require permits because the water treatment plant that receives the runoff is the permitted entity. Some projects in San Francisco and Sacramento, where a combined sewer system exists, may be excluded from the database as a result, but the majority of California cities do not have combined sewer/storm water systems.

Furthermore, some projects listed in the SWRCB database have incomplete location information. These details can include street address with or without number, street intersections with or without compass directions, pier number, and tract number. Mapping project location by city rather than zip code or street address allowed us to capture 90 percent of the acres under permit.

Because the size of a project is represented by the number of acres disturbed during construction, the amount of construction equipment activity may not have a linear relationship to the size of the project. In general, large-acreage projects will likely have greater construction equipment activity than small-acreage projects. However, urban construction sites that are relatively small in area may have heavy construction equipment activity due to multi-story construction. For instance, a two-acre high-rise construction site in downtown Los Angeles may have a much higher sustained level of construction equipment activity than a two-acre single-family home construction site in the suburbs. The available data did not allow us to distinguish between single-story and multi-story construction.

References

Bell, M.L., F. Dominici, and J.M. Samet. 2005. A meta-analysis of time-series studies of ozone and mortality with comparison to the national morbidity, mortality, and air pollution study. *Epidemiology* 16:436–445.

California Air Resources Board (CARB). 2006a. Appendix A. *Quantification of the health impacts and economic valuation of air pollution from ports goods movement in California.* March. Online at *http://www.arb.ca.gov/planning/gmerp/march21plan/appendix_a.pdf.*

California Air Resources Board (CARB). 2006b. Air quality almanac emissions projections. Online at *http://www.arb.ca.gov/ei/emissiondata.htm.*

California Air Resources Board (CARB). 2006c. Updated off-road emissions inventory. September.

California Air Resources Board (CARB). 2006d. Technical supplement. *Quantification of the health impacts and economic valuation of air pollution from ports goods movement in California.* March. Online at *http://www.arb.ca.gov/planning/gmerp/march21plan/docs/health_analysis_supplement.pdf.*

California Air Resources Board (CARB). 2005a. Staff report. Initial statement of reasons: Notice of public hearing to consider requirements to reduce idling emissions from new and in-use trucks, beginning in 2008. Sacramento: California Environmental Protection Agency.

California Air Resources Board (CARB). 2005b. Staff report. Initial statement of reasons for proposed rulemaking: Public hearing to consider adoption of the proposed regulation for mobile cargo handling equipment at ports and intermodal railyards. Sacramento: California Environmental Protection Agency.

California Air Resources Board (CARB). 2005c. Staff report. Initial statement of reasons: Proposed diesel particulate control measure for on-road heavy-duty diesel-fueled vehicles owned or operated by public agencies and utilities. Sacramento: California Environmental Protection Agency.

California Air Resources Board (CARB). 2004a. The Carl Moyer Program annual status report. Sacramento: California Environmental Protection Agency. February.

California Air Resources Board (CARB). 2004b. Staff report. Initial statement of reasons for proposed rulemaking: Airborne toxic control measure for diesel fueled portable engines. Sacramento: California Environmental Protection Agency, Stationary Source Division Project Assessment Branch.

California Air Resources Board (CARB). 2003a. Staff report. Initial statement of reasons: Proposed diesel particulate matter control measure for on-road heavy-duty residential and commercial solid waste collection vehicles. Sacramento: California Environmental Protection Agency.

California Air Resources Board (CARB). 2003b. Staff report. Initial statement of reasons for proposed rulemaking: Airborne toxic control measure for stationary compression ignition engines. Sacramento: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch.

California Air Resources Board (CARB). 2003c. Staff report (revised). Initial statement of reasons for proposed rulemaking: Airborne toxic control measure for in-use diesel fueled transport refrigeration units (TRU) and TRU generator sets, and facilities where TRUs operate. Sacramento: California Environmental Protection Agency, Stationary Source Division Emissions Assessment Branch.

California Air Resources Board (CARB). 2002a. Staff report. Public hearing to consider amendments to the ambient air quality standards for particulate matter and sulfates. Sacramento: California Environmental Protection Agency, Air Resources Board and Office of Environmental Health Hazard Assessment.

California Air Resources Board (CARB). 2002b. The Carl Moyer Program annual status report. Sacramento: California Environmental Protection Agency. March 26.

California Air Resources Board (CARB). 2000a. The Carl Moyer air quality standards attainment program (the Carl Moyer Program) guidelines—approved revision 2000. Sacramento: California Environmental Protection Agency.

California Air Resources Board (CARB). 2000b. Risk reduction plan to reduce particulate matter emissions from diesel-fueled engines and vehicles. Sacramento: California Environmental Protection Agency, Stationary Control Division and Mobile Source Control Division.

California Air Resources Board (CARB). 1998. Proposed identification of diesel exhaust as a toxic air contaminant: Health risk assessment for diesel exhaust. Sacramento: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment.

California Department of Finance (CDF). 2006. Annual data of residential and non-residential construction permits. Online at *http://www.dof.ca.gov/HTML/FS_DATA/LatestEconData/FS_Construction.htm.*

California Department of Transportation (CALTRANS). 2005. Division of Construction on-going contracts database. Recent data online at *http://www.dot.ca.gov/hq/construc/statement.html.*

California State Water Resources Control Board (SWRCB). 2005. Construction permit database. Online at *http://www.swrcb.ca.gov/stormwtr/databases.html.*

Koren, H.S. 1995. Associations between criteria air pollutants and asthma. Presented at the Workshop on Air Toxics and Asthma—Impacts and End Points, Houston, February 4. U.S. Environmental Protection Agency Health Effects Research Laboratory.

Krewski, D., R.R. Burnett, M.S. Goldberg, K. Hoover, J. Siemiatycki, M. Jerrett, M. Abrahamowicz, and W. H. White. 2000. Reanalysis of the Harvard Six Cities Study and the American Cancer Society study of particulate air pollution and mortality. Cambridge, MA: Health Effects Institute. Online at *http://www.healtheffects.org/pubs-special.htm.*

Manufacturers of Emission Controls Association (MECA). 2006. Case studies of construction equipment diesel retrofit projects. Washington, DC. March. Online at *http://www.meca.org/galleries/default-file/Construction%20Case%20Studies%200306.pdf.*

Mayer, A., J. Czerwinski, J.-L. Petermann, M. Wyser, and F. Legerer. 2004. Reliability of DPF-systems: Experience with 6000 applications of the Swiss retrofit fleet. SAE paper no. 2004-01-0076.

McConnell, R., K. Berhane, F. Gilliland, S.J. London, T. Islam, W.J. Gauderman, E. Avol, H.G. Margolis, and J.M. Peters. 2002. Asthma in exercising children exposed to ozone: a cohort study. *Lancet* 359(9304):386–391.

M.J. Bradley and Associates (Bradley). 2006. Local law 77: DDC ultra low sulfur diesel manual. Prepared for City of New York Department of Design and Construction.

Northeast States for Coordinated Air Use Management (NESCAUM). 2003. Interim report. Evaluating the environmental and occupational impact of nonroad diesel equipment in the Northeast. Boston. June 9. Online at *http://64.2.134.196/mobile/rpt030609nonroad.pdf.*

Pope III, C.A. 2000. Epidemiology of fine particulate air pollution and human health: Biological mechanisms and who's at risk? *Environmental Health Perspectives* 108 (supplement 4):713–723. Online at *http://www.ehponline.org/members/2000/suppl-4/713-723pope/pope-full.html*.

Pope III, C.A., R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *Journal of the American Medical Association* 287(9):1132–1141.

Samet, J., S. Zeger, F. Dominici, F. Curriero, I. Coursac, D. Dockery, J. Schwartz, and A. Zanobetti. 2000. The National Morbidity, Mortality, and Air Pollution Study. Report no. 94. Cambridge, MA: Health Effects Institute. May.

Thurston, G.D. and K. Ito. 2001. Epidemiological studies of acute ozone exposure and mortality. *Journal of Exposure Analysis and Environmental Epidemiology* 11:286–294.

Thurston, G.D., K. Ito, C.G. Hayes, D.V. Bates, and M. Lippmann. 1994. Respiratory hospital admissions and summertime haze air pollution in Toronto, Ontario: Consideration of the role of acid aerosols. *Environmental Research* 65:271–290.

Thurston, G.D., K. Ito, P.L. Kinney, and M. Lippmann. 1992. A multi-year study of air pollution and respiratory hospital admissions in three New York State metropolitan areas: Results for 1988 and 1989 summers. *Journal of Exposure Analysis and Environmental Epidemiology* 2:429–450.

Union of Concerned Scientists (UCS). 2004. *Sick of soot: Reducing the health impacts of diesel pollution in California*. Cambridge, MA. June.

United States Environmental Protection Agency (EPA). 2004. Final regulatory analysis: Control of emissions from nonroad diesel engines. EPA420-R-04-007. Washington, DC: Office of Transportation and Air Quality. May.

United States Environmental Protection Agency (EPA). 1999. Appendix H. The benefits and costs of the Clean Air Act 1990–2010. EPA-410-R-99-001. Washington, DC: Office of Air and Radiation. November. Online at *http://www.ehponline.org/members/2000/suppl-4/713-723pope/pope-full.html*.

White, M.C., R.A. Etzel, W.D. Wilcox, and C. Lloyd. 1994.Exacerbations of childhood asthma and ozone pollution in Atlanta. *Environmental Research* 65:56–68.

Digging Up Trouble

The Health Risks of Construction Pollution in California

Diesel engines may conjure up images of big rigs or transit buses, but construction equipment is a leading source of diesel pollution in California. Air pollution caused by construction equipment can result in severe cardiovascular and respiratory illnesses, asthma attacks, acute bronchitis, and even premature death.

This study quantifies the effect of construction pollution on California's public health and economy, both across the state and in the five most-affected regions. The risk of exposure to construction activity is evaluated for cities in each of these regions.

Construction equipment will continue to be a significant source of pollution over the next two to three decades unless California acts now. By adopting the cost-effective technology solutions that already exist (and those that will become available over the next few years), the state can reduce this public health threat and help all Californians breathe easier.

National Headquarters
Two Brattle Square
Cambridge, MA 02238-9105
Phone: (617) 547-5552
Fax: (617) 864-9405

West Coast Office
2397 Shattuck Ave., Ste. 203
Berkeley, CA 94704-1567
Phone: (510) 843-1872
Fax: (510) 843-3785

Washington, DC, Office
1707 H St. NW, Ste. 600
Washington, DC 20006-3962
Phone: (202) 223-6133
Fax: (202) 223-6162

Union of Concerned Scientists
Citizens and Scientists for Environmental Solutions

Website www.ucsusa.org **Email** ucs@ucsusa.org

Printed on recycled paper