AGENDA: 4A

PRESENTATION TO BAAQMD ADVISORY COMMITTEE

Proposed Guiding Principles for Consideration in Forwarding Recommendations to the BAAQMD on PM2.5 Regulation

Frances Keeler, CCEEB
July 31, 2020

California Council for Environmental and Economic Balance

The California Council for Environmental and Economic Balance (CCEEB) is a nonpartisan, nonprofit coalition of labor, business, and public leaders that advances strategies for a healthy environment and sound economy. CCEEB represents many facilities that operate in the Bay Area Air Quality Management District.

Guiding Principles

Recommendations from the AC to the BAAQMD should:

- Be based on best peer-reviewed science
- Consider input/lessons learned from other agencies
- Consider $PM_{2.5}$ speciation and source apportionment
- Address regional vs local impacts and control strategies
- Include an economic evaluation
- Prioritize strategies by greatest amount of near-term, cost-effective reductions

Scientifically Based Recommendations

Recommendations:

- Must be informed by the best, scientifically-based data possible
  - *Is more data needed and , if so, what is needed?*
- Should be based on peer-reviewed studies
- Should consider guidance developed by other agencies
- Data collection versus modeling
- Should demonstrate causal relationship before recommending controls
- Should be all inclusive

Coordination Between Agencies

- AC should consult other agencies on health standards
  - *CARB – sets SAAQS*
  - *OEHHA*
  - *CA Air Districts*
- AC Should direct Staff to work with other agencies
- AC should consider measures agencies are implementing to reduce PM and how it might advance the goals of the BAAQMD
  - *CARB is adopting many strategies for mobile sources that will reduce $PM_{2.5}$*
  - *BAAQMD has regulations in the plan and in process to further reduce $PM_{2.5}$*
  - *State is developing strategies to address wildfires*

PM Speciation

- Advisory Council must examine speciation
- There are many contributors to PM2.5
  - *Mobile sources*
  - *Commercial sources (restaurants)*
  - *Residential sources (wood burning fireplaces, fire pits, BBQs)*
  - *Material handling*
  - *Industrial combustion sources*
  - *Secondary formation sources*
  - *Naturally occurring sources*
  - *Wildfires*
- Speciation/source apportionment are key to determining the most effective means of reduction
  - *Not about exoneration, but about effectiveness*

Regional vs Local Controls

- $PM_{2.5}$ levels vary at the localized level
  - *Different sources contribute to $PM_{2.5}$ levels in different communities*
- Are regional reductions more effective than localized reductions?
- What is the goal and how do we best achieve it?
- Have the COVID response measures changed impacts on either the regional or local level and is any of the change permanent?

Economic Impacts

- Need to focus limited resources where they will be most effective
- AC should review research that includes economic analysis of potential PM control strategies and identify/recommend proven strategies that can be implemented expeditiously and economically

Prioritize Recommended Measures

- **Identify the goal and recommend:**
  - *Measures with greatest ground-level concentration reductions*
  - *Measure with greatest impact*
  - *Measures available near-term versus future reductions*
  - *Most cost-effective measures*
  - *Measures that reduce the most impactful portion of $PM_{2.5}$*

Factors Beyond the Scope of the Advisory Council

- District Authority
  - *State and Federal government establish standards/regulate mobile sources*
- CEQA analysis of control options
- Resources
- Cost-effectiveness threshold

BAAQMD Action on Advisory Council Recommendations

- **Action informed by best, scientifically-based data possible**
  - *Will help determine what to regulate first and where/how to get the most effective reductions*
- **Consider input/peer review/actions from other agencies**
  - *What vetted methods are other agencies doing to reduce $PM_{2.5}$ emissions*
  - *How might those regulations benefit the Bay Area?*
- **Regional vs Local Control**
  - *Where should BAAQMD focus its attention first?*
- **Consider $PM_{2.5}$ speciation/source apportionment**
  - *Important to determining the most effective approach*
- **Include economic evaluation**
  - *How to obtain the greatest cost-effective reductions?*

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Assessing the Health Effects of Particulate Matter

Julie E. Goodman, Ph.D., DABT, FACE, ATS
Gradient

Bay Area Air Quality Management District

Advisory Council Meeting
July 31, 2020

Julie E. Goodman, PhD, DABT, FACE, ATS

- SB, Environmental Engineering, MIT, 1996
- ScM, Epidemiology, Johns Hopkins, 2000
- PhD, Toxicology, Johns Hopkins, 2002

- Cancer Prevention Fellow, National Cancer Institute, 2002-2004
- Principal, Gradient, 2004-Present
- Board of Health, Canton, MA, 2008-Present
- Adjunct Faculty, Harvard School of Public Health, 2009-2017

- Diplomate, American Board of Toxicology
- Fellow, American College of Epidemiology
- Fellow, Academy of Toxicological Sciences

Health Sciences

Epidemiology – The study of the distribution and determinants of health effects

Toxicology – The study of potential adverse health effects of substances on living organisms

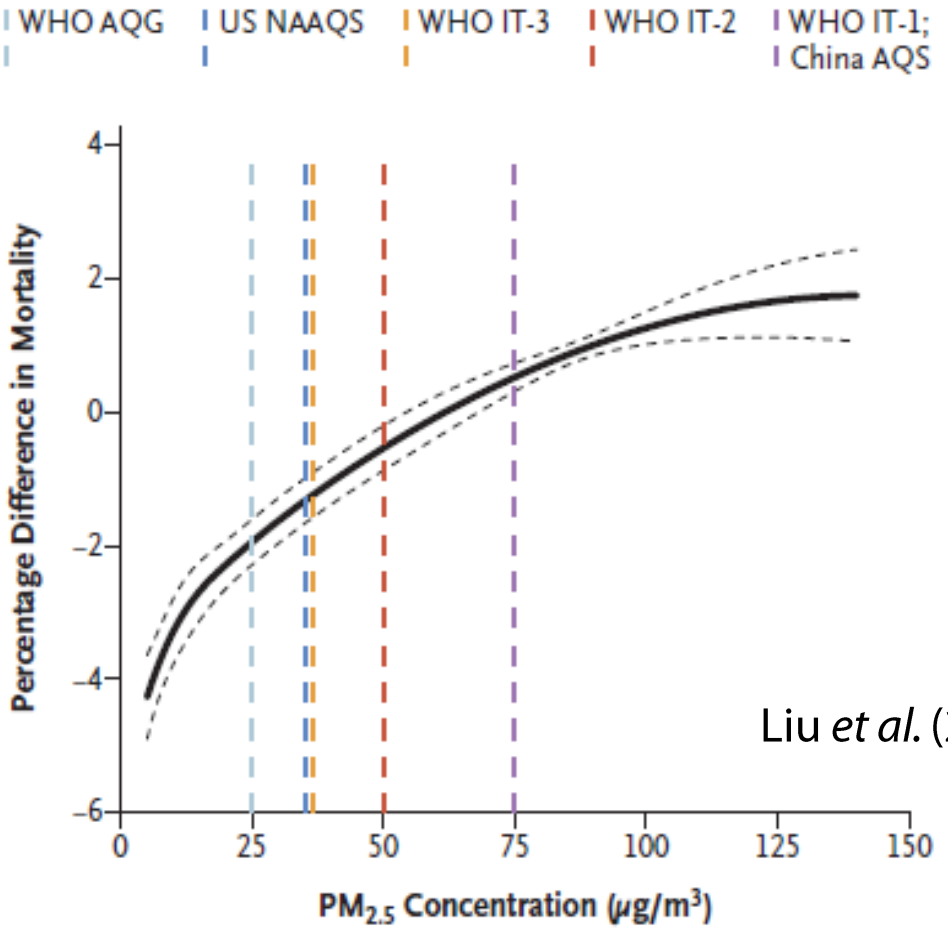
PM Associations vs. Causation

- PM is associated with morbidity and mortality in many traditional epidemiology studies
- Associations, particularly at low concentrations, are small in magnitude
- Association does not always mean causation
- Most likely explanation
  - Bias (*e.g.*, exposure measurement error)
  - Confounding
  - Chance
  - Inappropriate statistical model

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 22, 2019 VOL. 381 NO. 8

Ambient Particulate Air Pollution and Daily Mortality in 652 Cities



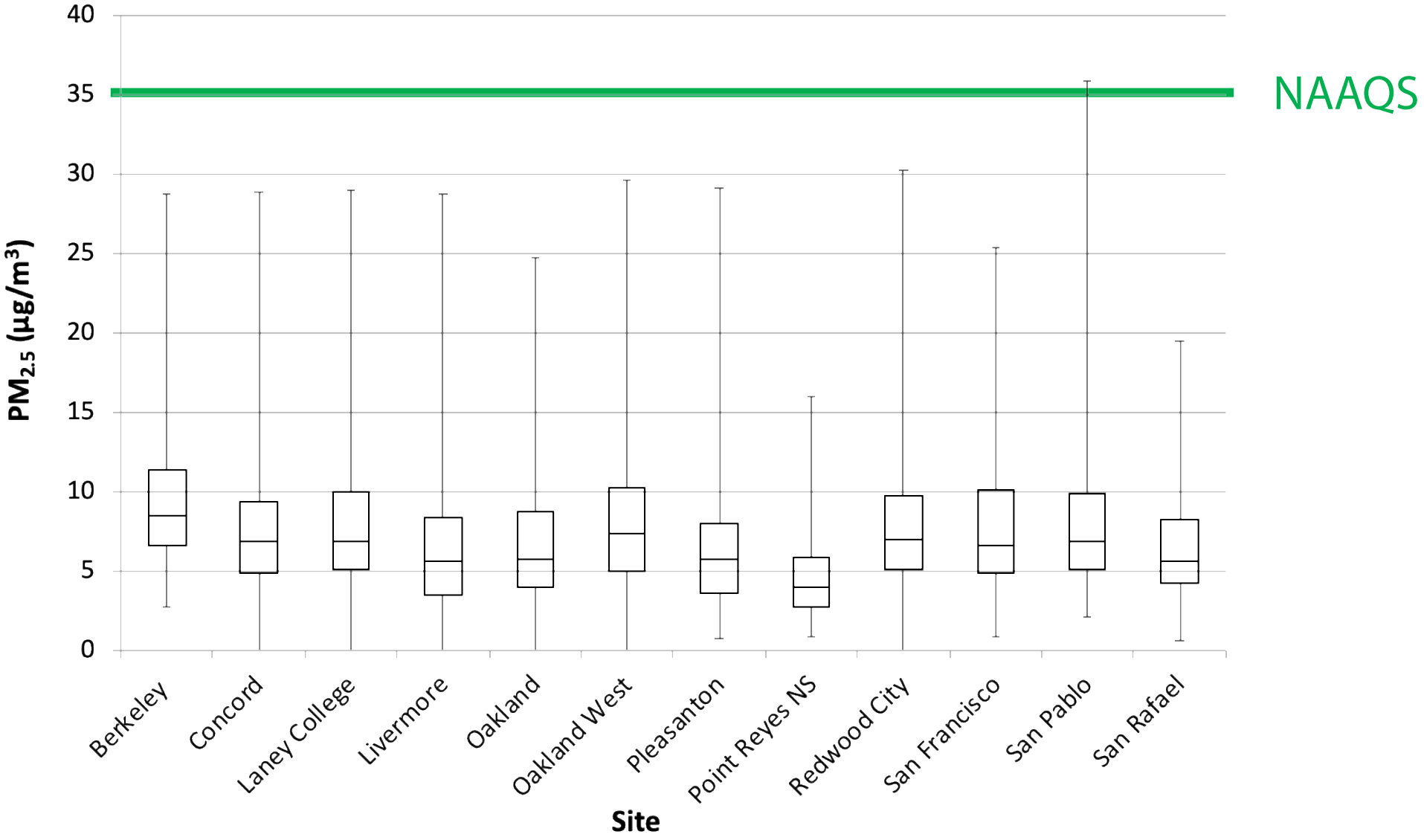
Liu *et al.* (2019)

H. Christopher Frey June Air Quality Presentation, June 2020

- Need to consider population density, multiple pollutants, other factors
- Issues with the validity of using satellite retrieval without ground-based validation
- Larger cities have higher levels of air pollution and an increased opportunity for the spread of disease because there are many more people

There are similar issues with PM epidemiology in general

Daily Average $PM_{2.5}$ Concentrations in the Bay Area, 2019

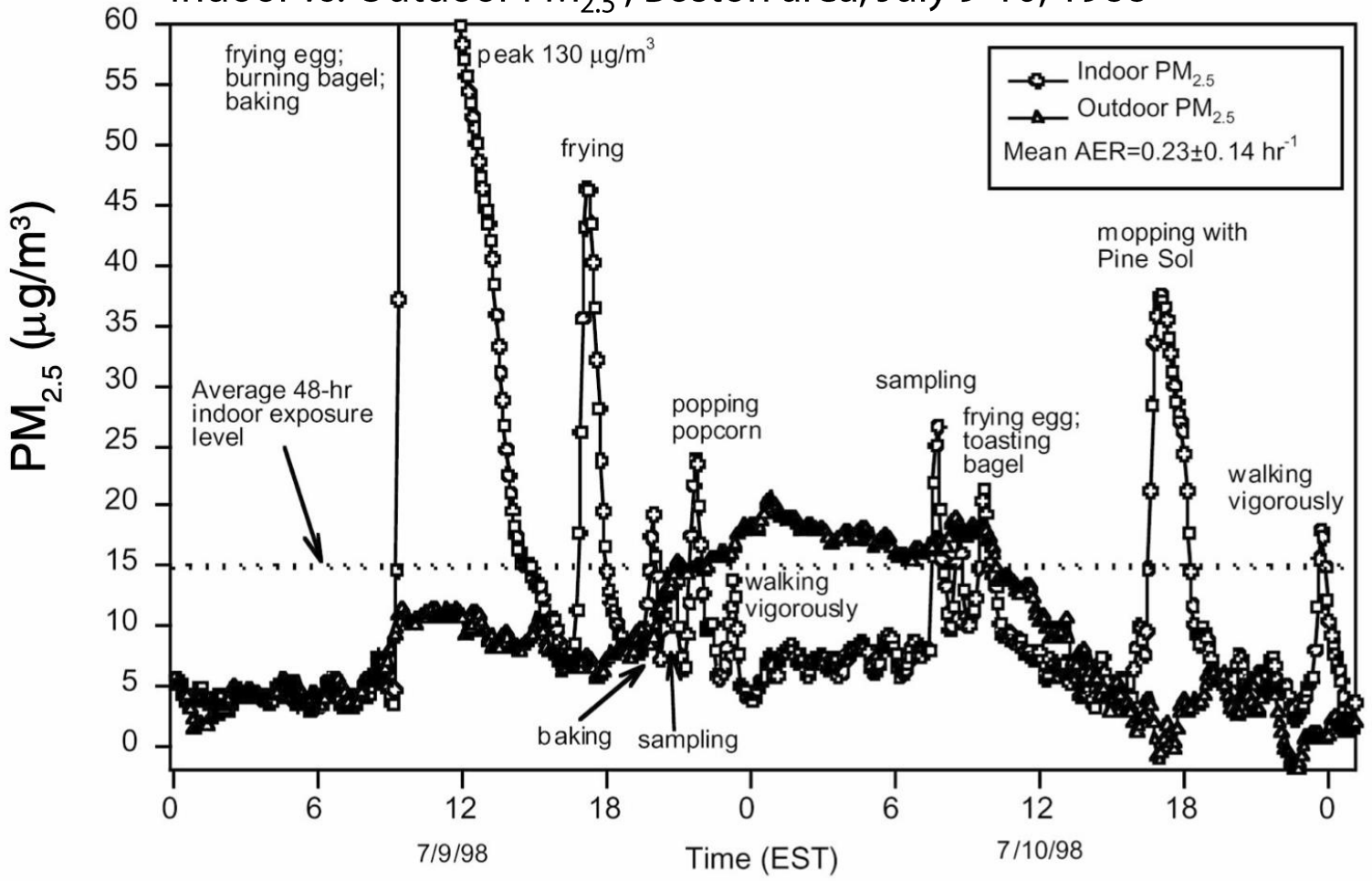


Data from https://www.epa.gov/outdoor-air-quality-data

Exposure Measurement Error – Ambient Air Monitors

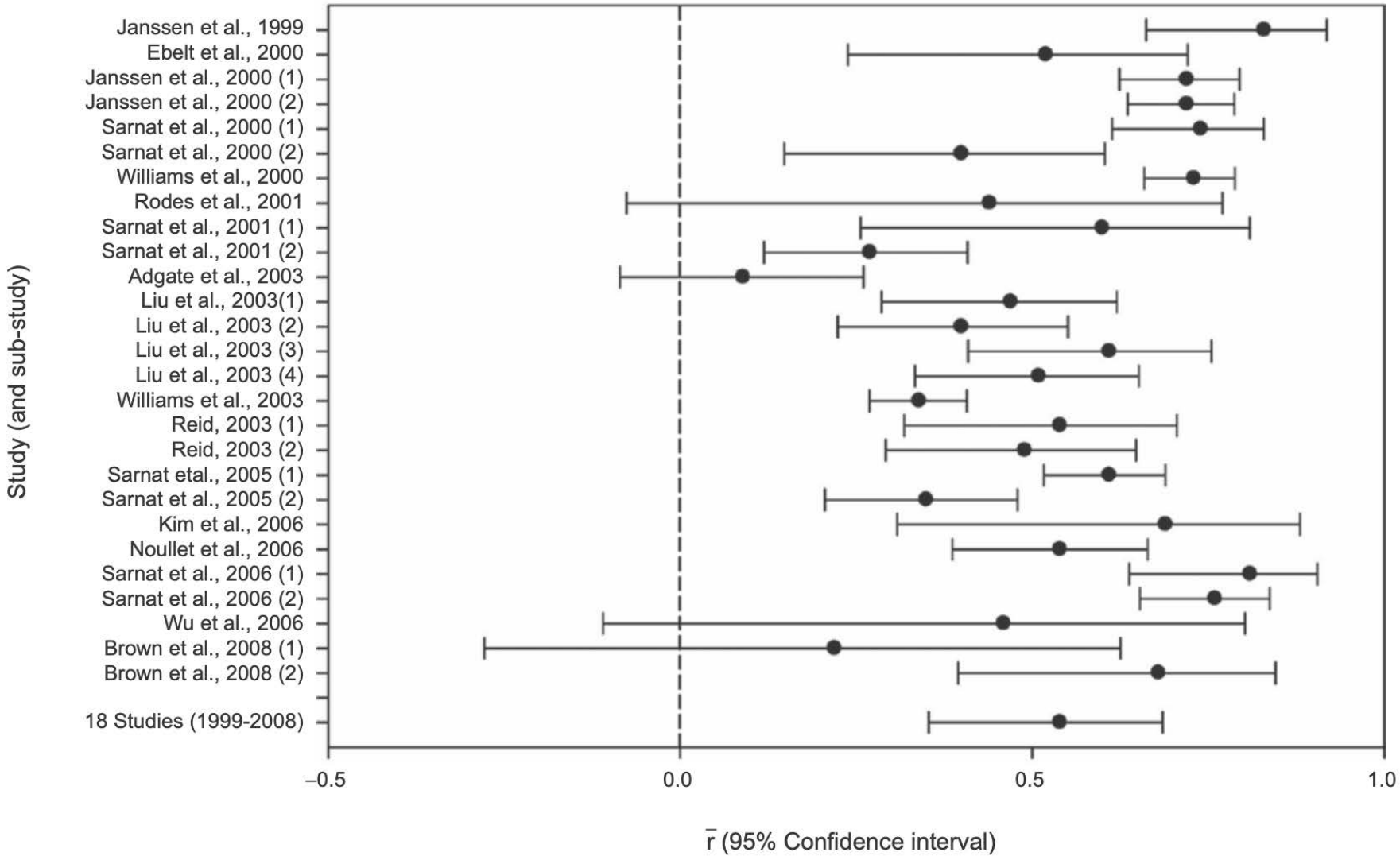
- Most studies use ambient air monitors
- People often spend a lot of time away from home
- People spend most time indoors
- Average PM exposures can be higher indoors

Indoor *vs.* Outdoor $PM_{2.5}$, Boston area, July 9-10, 1988



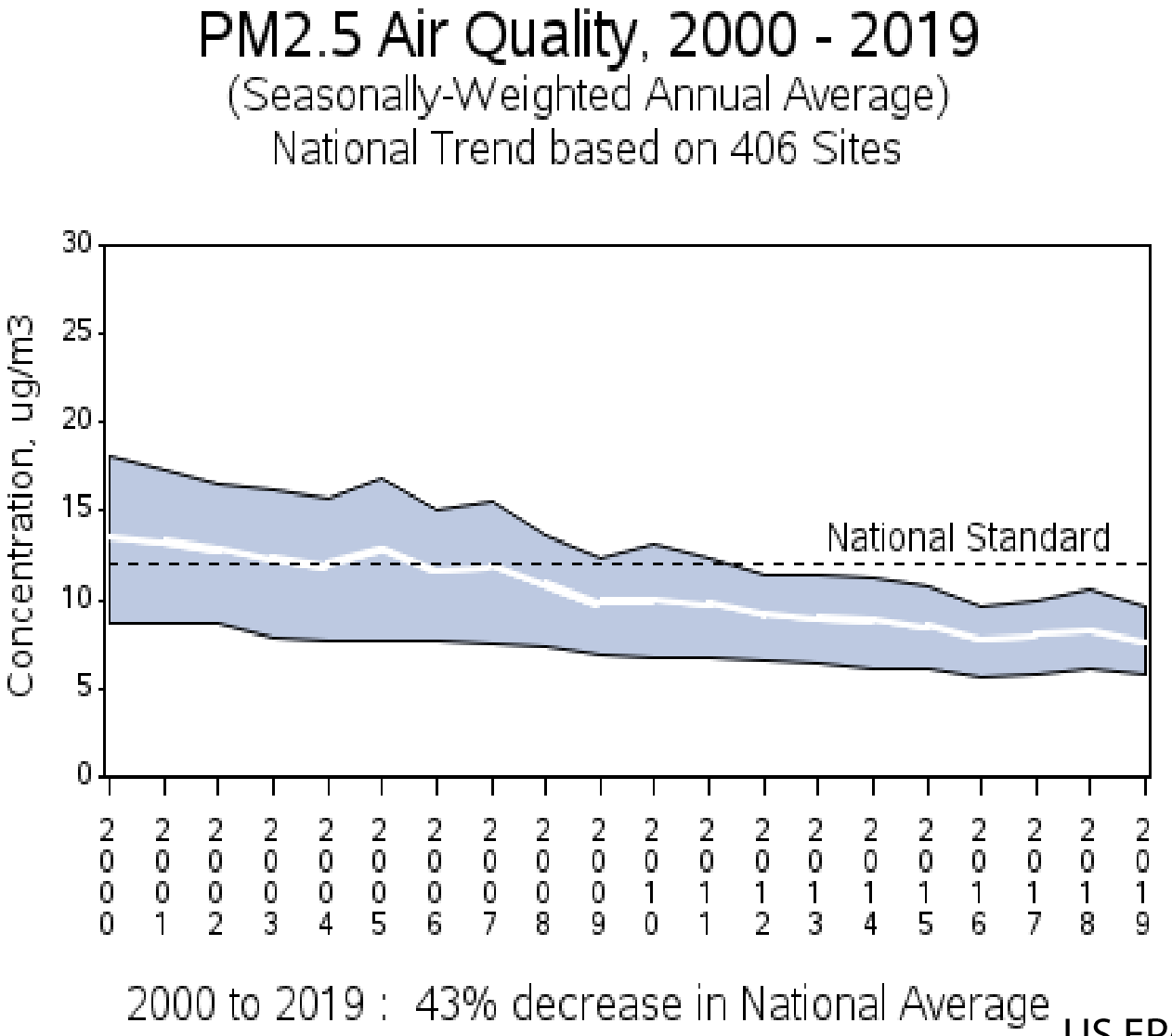
Long *et al.* (2000)
Harvard School of Public Health

Exposure Measurement Error – Personal vs. Ambient $PM_{2.5}$ Associations Vary



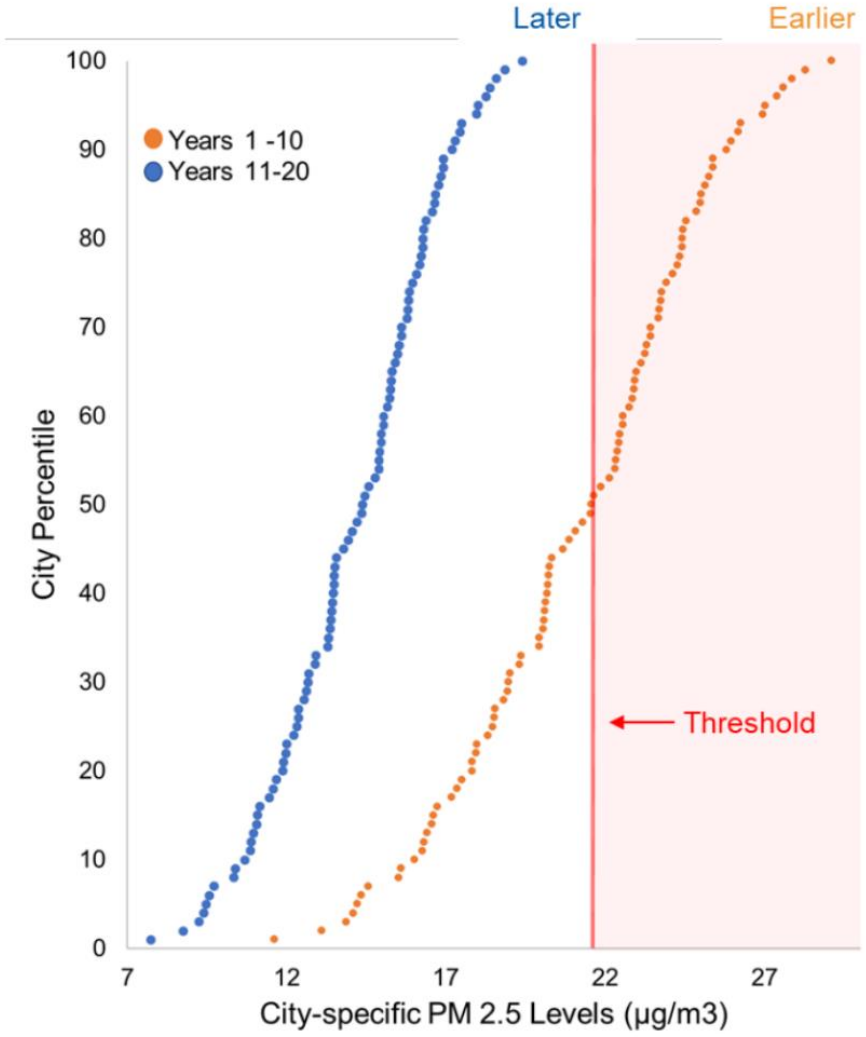
Avery *et al.* (2011)

Exposure Measurement Error – Many Studies Evaluate the Wrong Exposure Window and Overestimate Associations



US EPA, 2020

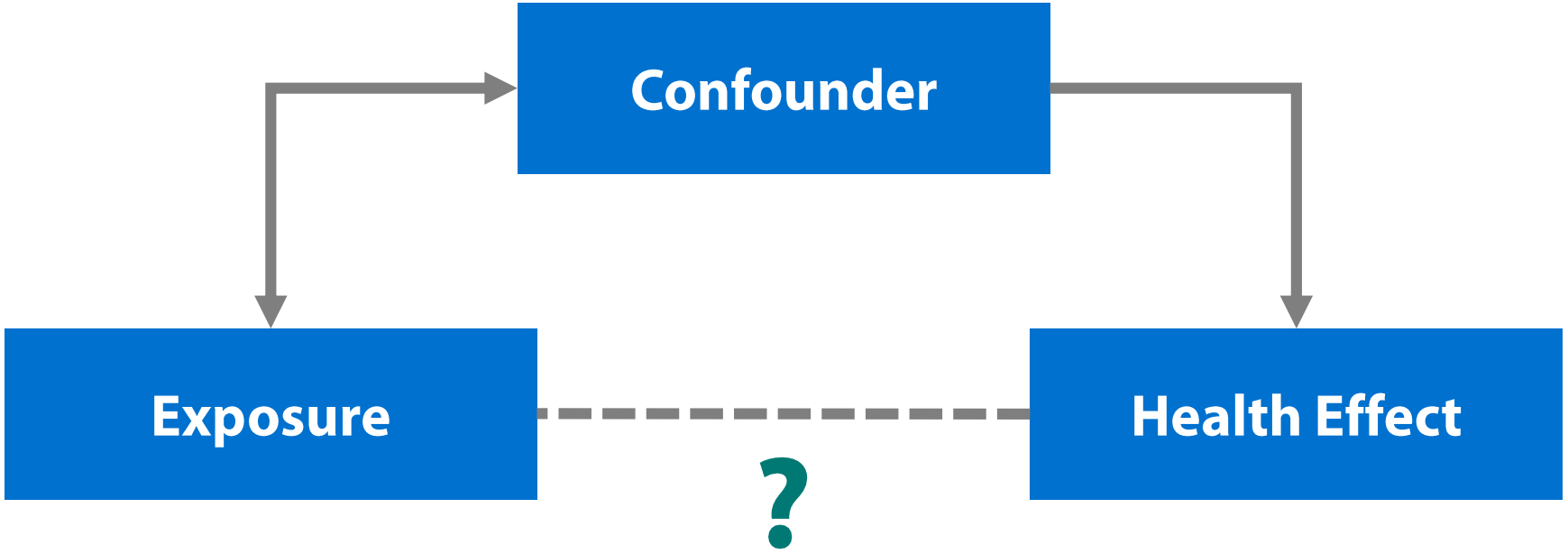
Figure 1. $PM_{2.5}$ Distributions in Illustrative Example



Smith and Chang, 2020

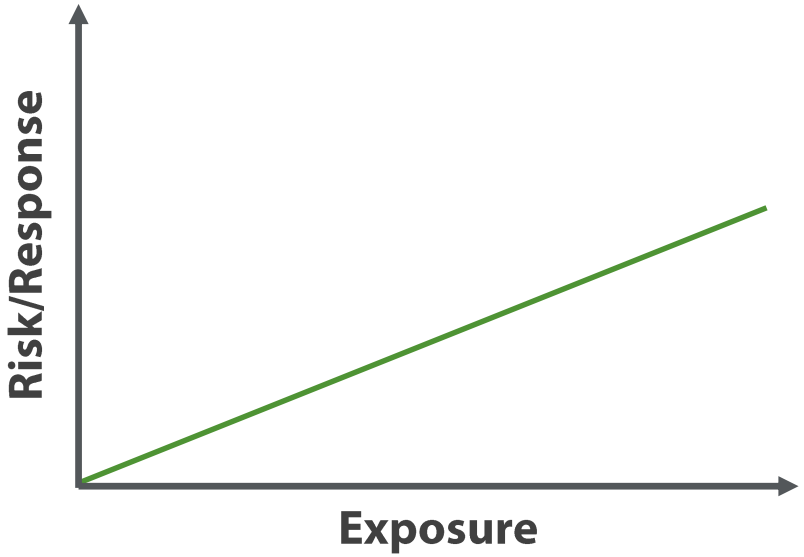
Confounding

- Other exposure window
- Atmospheric conditions
- Other copollutants, allergens
- Socioeconomic status (SES)
- Lifestyle factors (*e.g.*, smoking)
- Access to health care
- Genetics

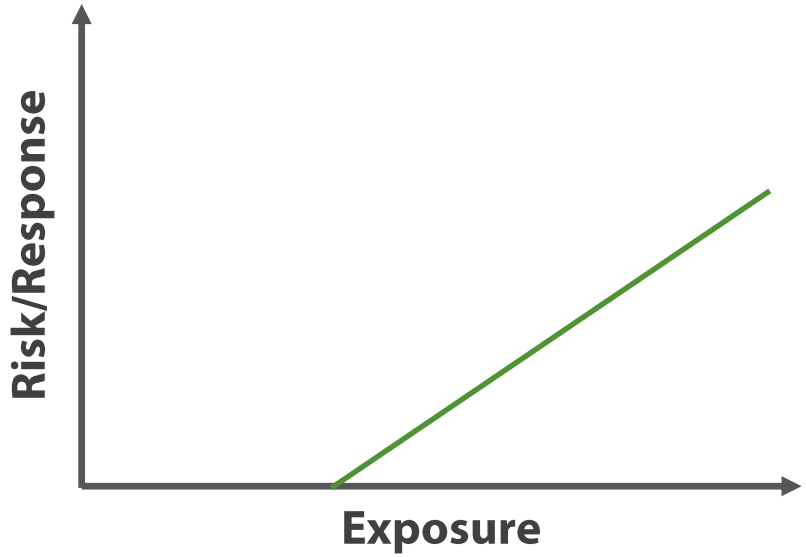


Model Choice and Measurement Error Linearizes Exposure-response Curve

No Threshold



Threshold



Measurement Error Linearizes Exposure-response Curve

REVIEW ARTICLE

Measurement error in environmental epidemiology and the shape of exposure-response curves

Lorenz R. Rhomberg, Juhi K. Chandalia, Christopher M. Long, and Julie E. Goodman

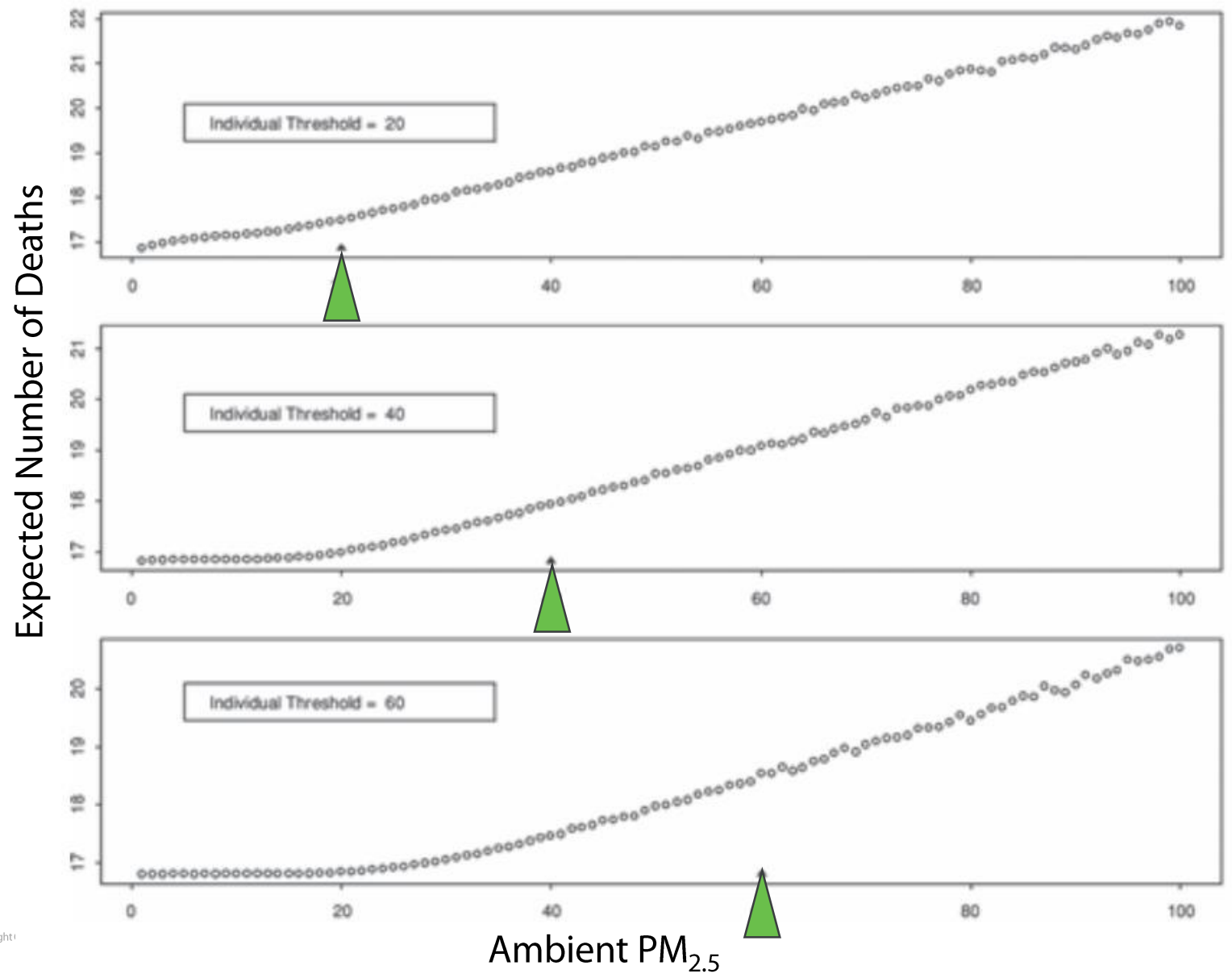
Gradient, Cambridge, Massachusetts, USA

Abstract

Both classical and Berkson exposure measurement errors as encountered in environmental epidemiology data can result in biases in fitted exposure-response relationships that are large enough to affect the interpretation and use of the apparent exposure-response shapes in risk assessment applications. A variety of sources of potential measurement error exist in the process of estimating individual exposures to environmental contaminants, and the authors review the evaluation in the literature of the magnitudes and patterns of exposure measurement errors that prevail in actual practice. It is well known among statisticians that random errors in the values of independent variables (such as exposure in exposure-response curves) may tend to bias regression results. For increasing curves, this effect tends to flatten and apparently linearize what is in truth a steeper and perhaps more curvilinear or even threshold-bearing relationship. The degree of bias is tied to the magnitude of the measurement error in the independent variables. It has been shown that the degree of bias known to apply to actual studies is sufficient to produce a false linear result, and that although nonparametric smoothing and other error-mitigating techniques may assist in identifying a threshold, they do not guarantee detection of a threshold. The consequences of this could be great, as it could lead to a misallocation of resources towards regulations that do not offer any benefit to public health.

Keywords: Epidemiology, exposure, exposure-response, measurement error, risk assessment

Exposure Misclassification Masks or Biases Thresholds



- True exposure was modeled.
- Corresponding risks calculated for simulated population using error based on observed exposure measurement error.

"True" threshold

Brauer *et al.* (2002)
University of British Columbia

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Causal Methods Example – Burns *et al.* (2017)
Health Effects Institute Review of 42 Studies of 38 Interventions

Interventions

- Industrial
- Residential
- Vehicular
- Multiple

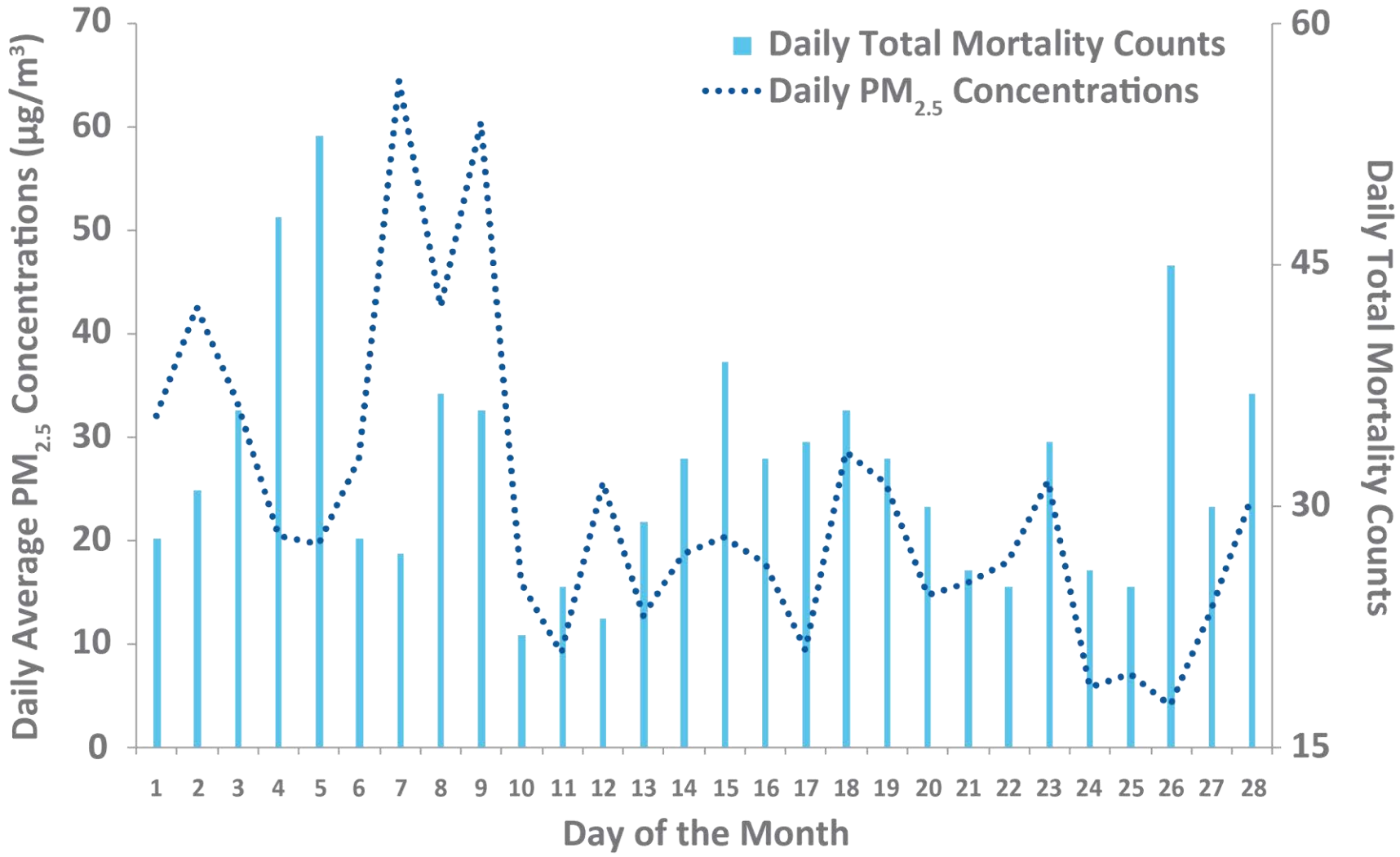
Comparison: *No restrictions*

Primary Outcomes

- All cause mortality
- Cardiovascular Mortality
- Respiratory Mortality
- PM_{10}
- $PM_{2.5}$
- Coarse PM
- Soot
- Black carbon (BC)
- Black smoke (BS)
- Elemental carbon (EC)

Results: "Evidence for effectiveness was mixed. Most included studies observed either no significant association or an association favoring the intervention, with little evidence that the assessed interventions might be harmful."

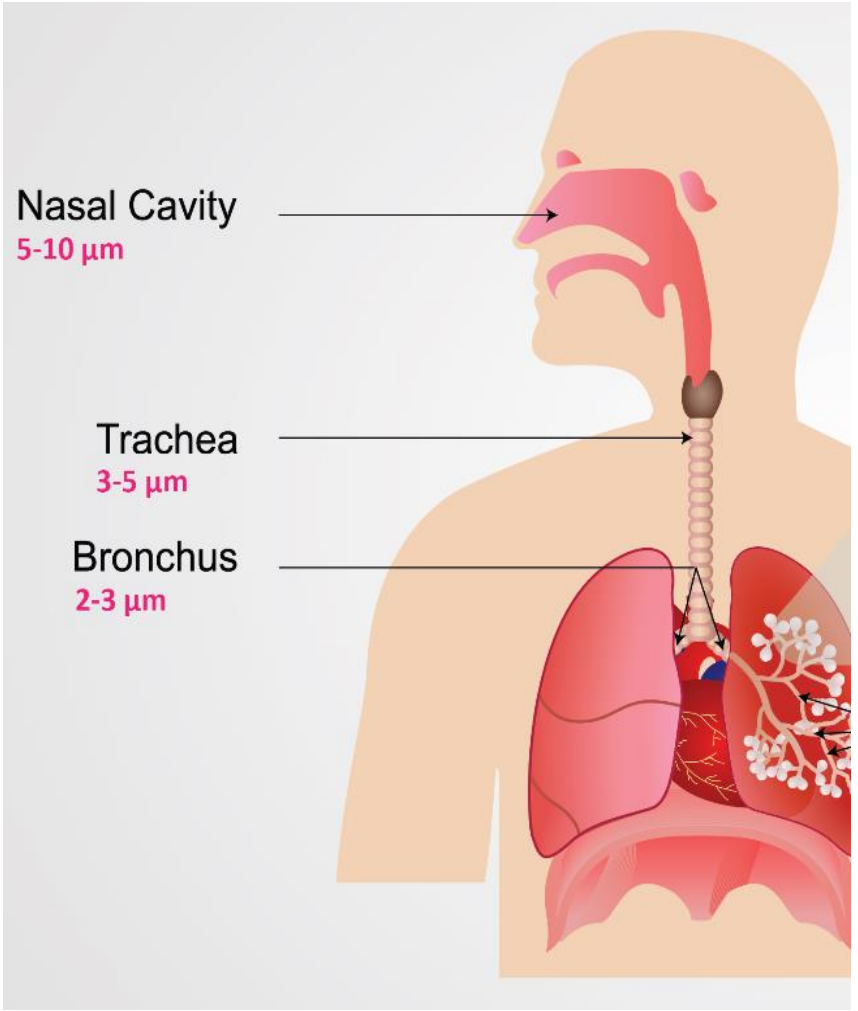
Example: $PM_{2.5}$ and Mortality in Greater Boston, 2002, after Quebec Forest Fires



Zu *et al.* (2016)

Toxicity Studies – There is a threshold below which people can be exposed to PM and not experience health impacts

- If exposures are sufficiently low, PM will not cause adverse health effects because it won't overwhelm the body's natural defenses.
- This is supported by experimental studies in humans and animals.
- CARB relies on this principle for all other non-carcinogenic agents.
- There is no justification for assuming one particle will impact health.



The Peer-review Process Is Not Perfect- Long-term PM and Mortality Example

Sources of Bias and Uncertainty		Crouse *et al.* (2012)	Crouse *et al.* (2015)	Villeneuve *et al.* (2015)	Chen *et al.* (2016)	Pinault *et al.* (2016)	Wong *et al.* (2015)	Beelen *et al.* (2014)	Cesaroni *et al.* (2013)	Lepeule *et al.* (2012)	Hart *et al.* (2015)	Shi *et al.* (2016)	Thurston *et al.* (2016)	Di *et al.* (2017a)
$PM_{2.5}$ Exposure Assessment	Central site monitoring (low spatial resolution)									X				
	No validation for $PM_{2.5}$ data						X						X	
	Temporal variation not accounted for	X	X	X	X			X	X					
	Residential mobility not accounted for	X		X		X	X	X		X		X		
	No evaluation on multiple exposure windows	X	X	X	X	X	X	X	X		X	X	X	X
	Personal activities not accounted for (*e.g.,* time spent indoors)	X	X	X	X	X	X	X	X	X	X	X	X	X
	Mismatch of $PM_{2.5}$ exposure window and mortality	X	X	X	X		X	X	X					X
Individual Covariates	No adjustment of individual covariates											X		
	Information bias (*e.g.,* self-reported covariates)	X	X	X		X	X	X		X	X		X	
	Temporal variation not accounted for	X	X	X	X	X	X	X	X	X			X	
	Unmeasured confounding (*e.g.,* pre-existing conditions)	X	X	X	X	X	X	X	X	X	X	X	X	X
Ecological Covariates	No adjustment of ecological covariates									X				
	Temporal variation not accounted for	X		X	X	X	X	X	X		X	X	X	
	Residential mobility not accounted for	X		X		X	X	X				X		
	Unmeasured confounding (*e.g.,* access to health care, violence)	X	X	X	X	X	X	X	X	X	X	X	X	X
Evaluation of Copollutants	No adjustment of copollutants	X		X	X	X	X			X	X	X		
	Central site monitoring (low spatial resolution)												X	
	No validation for copollutants data												X	
	Temporal variation not accounted for		X					X	X				X	
	Residential mobility not accounted for							X					X	
	Personal activities not accounted for (*e.g.,* time spent indoors)		X					X	X				X	X
	Collinearity/nonlinear relationship with $PM_{2.5}$ not addressed/accounted for												X	
	Mismatch of copollutants window and mortality		X					X	X				X	X
Statistical Analyses	Model assumptions not tested/relaxed		X	X		X	X	X	X		X	X	X	X
	C-R curves sensitive to *df* (natural splines)	X	X	X	X	NR	X	X	X				X	
	Nonlinearity not assessed statistically			X		X					X	X	X	X
	Threshold not assessed	X	X		X		X		X	X	X	X	X	X

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Conclusions – PM Threshold Is Likely Higher than Ambient Concentrations

- High concentrations of PM, and every other substance, can impact morbidity.
- There are clearly statistical associations between PM and morbidity and mortality in many epidemiology studies, even at lower, ambient concentrations.
- Evidence does not indicate associations are causal at ambient concentrations.
- There is a threshold below which people can be exposed to PM and not experience health impacts.

AGENDA: 5

Bay Area Particulate Matter (PM) Modeling-Based Assessments and Next Steps

Advisory Council Meeting
July 31, 2020

Phil Martien, PhD
Director of Assessment, Inventory, & Modeling Division

Overview

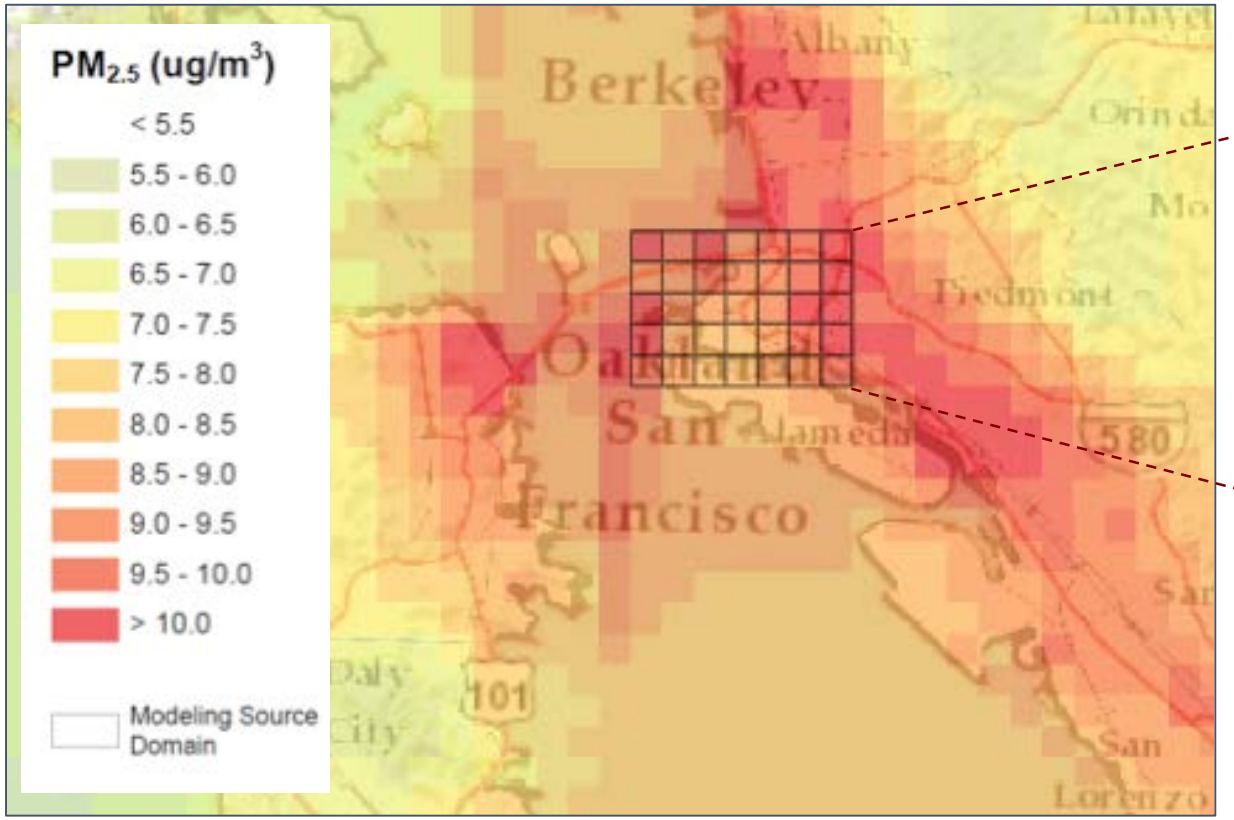
- PM modeling for the West Oakland Community Action Plan
  - Review community-scale assessment
- PM modeling of large industrial sources
  - Chevron Richmond Refinery
- Next Steps

Recent PM Assessments

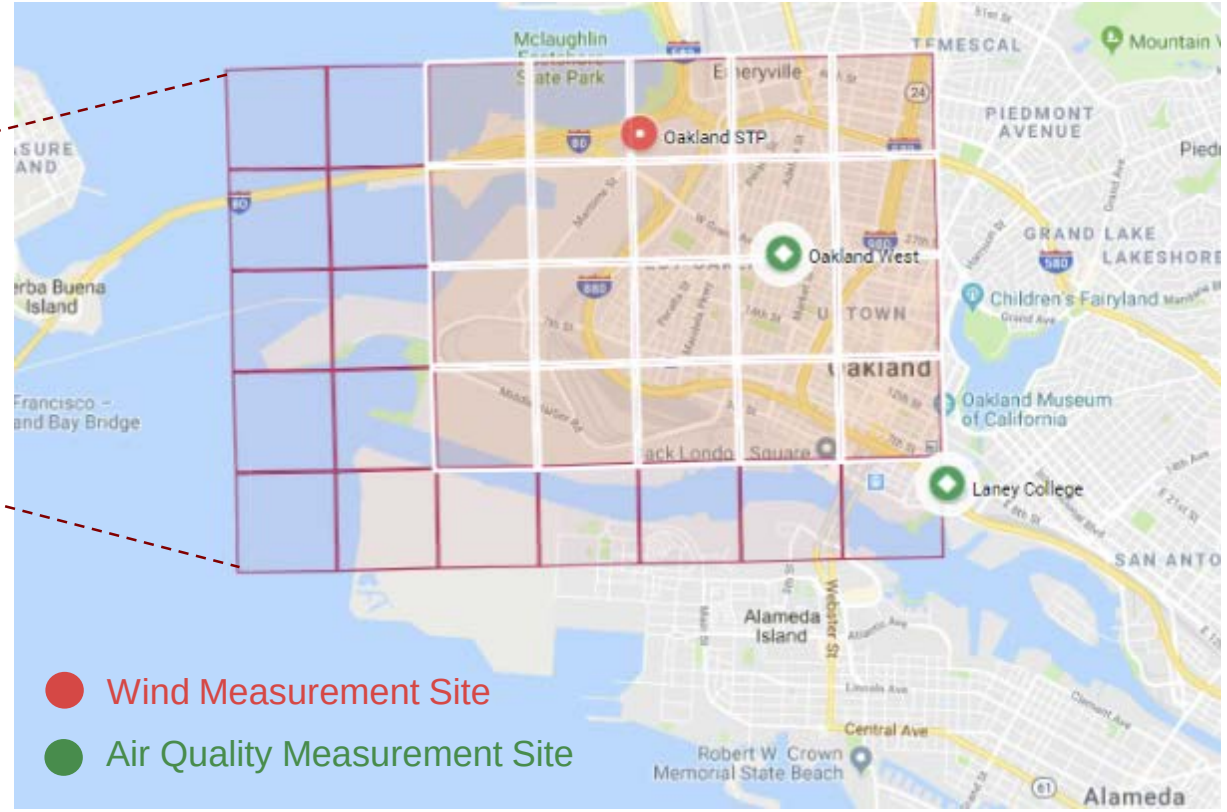
- Identify source-contributions to impacts
  - What is responsible?
- Assess equity of impacts to inform decision-making
  - Support agency goal of reducing air pollution inequities
- Work toward highlighting health risks from fine PM ($PM_{2.5}$) exposures below federal standard
  - Develop a risk framework consistent with “no identified safe level of $PM_{2.5}$”

West Oakland Community Action Plan

Regional-Scale and Community-Scale Modeling (2017)



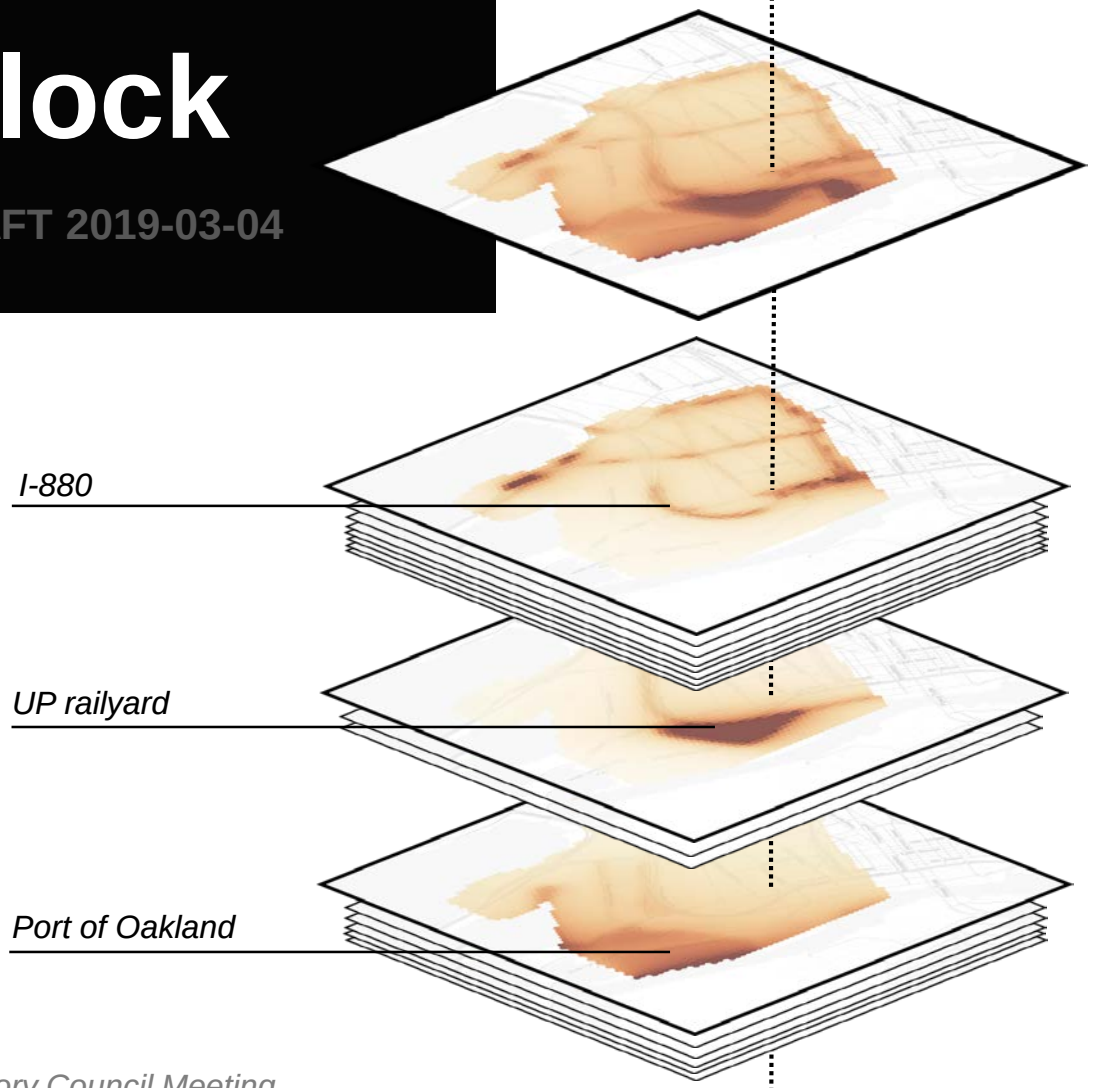
Regional-scale modeling: covers the Bay Area



Local-scale modeling: covers West Oakland, including impacts in receptor area (white) from sources in source area (red)

Block by Block

DRAFT 2019-03-04

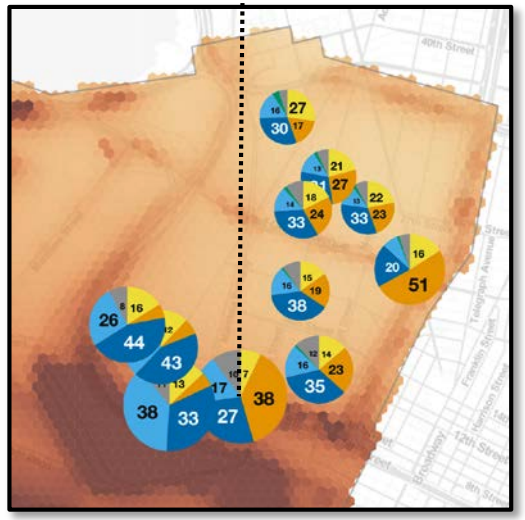


Grand total of modeled impacts from local sources

Sub-total from trucks, cars, and other vehicles on streets and highways

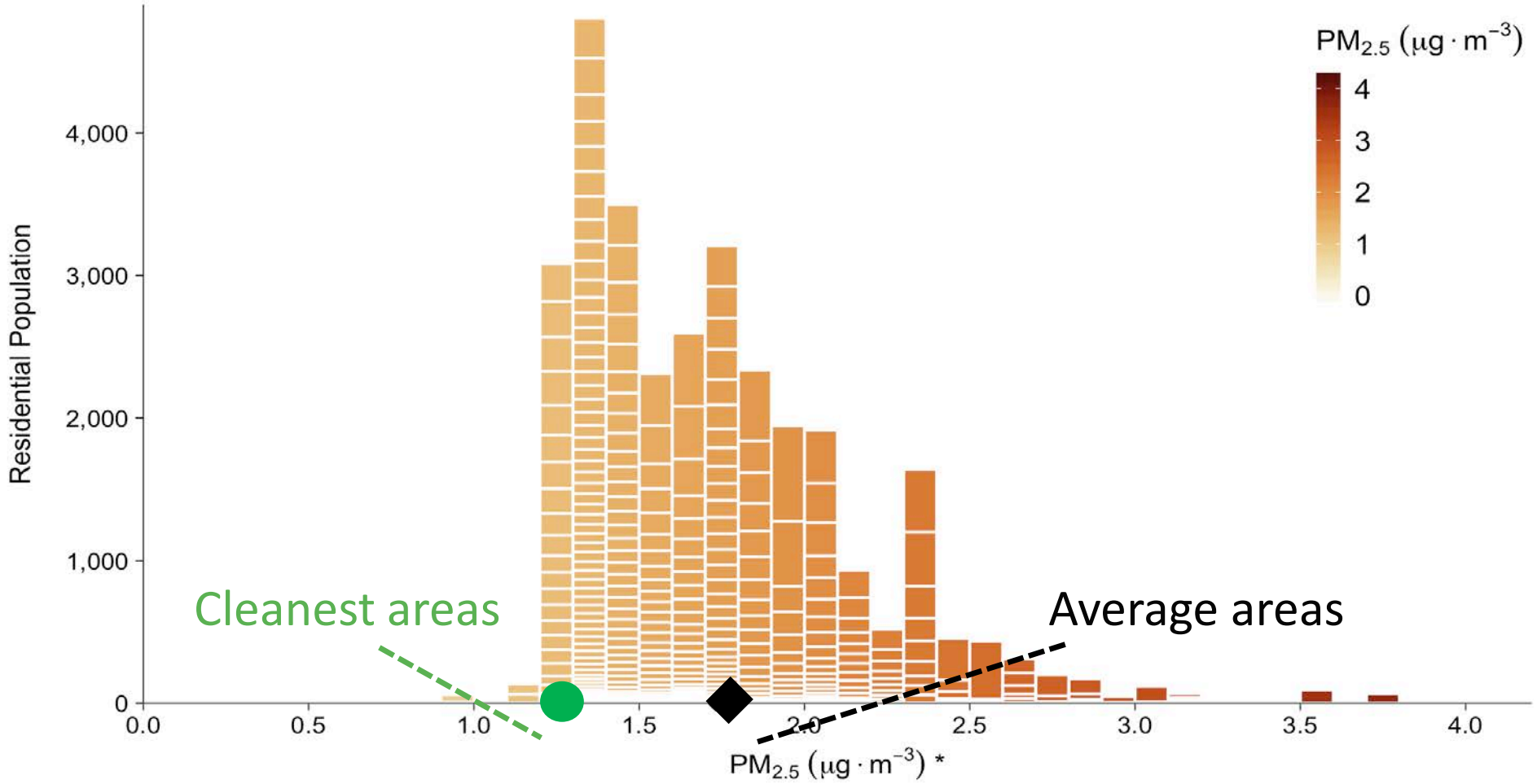
Sub-total from locomotive engines and railyards

Sub-total from harbor craft, ocean-going vessels, drayage, cargo handling, etc.



For any location, we can use the sub-totals to draw pie charts showing the relative impacts of sources A, B, C, etc.

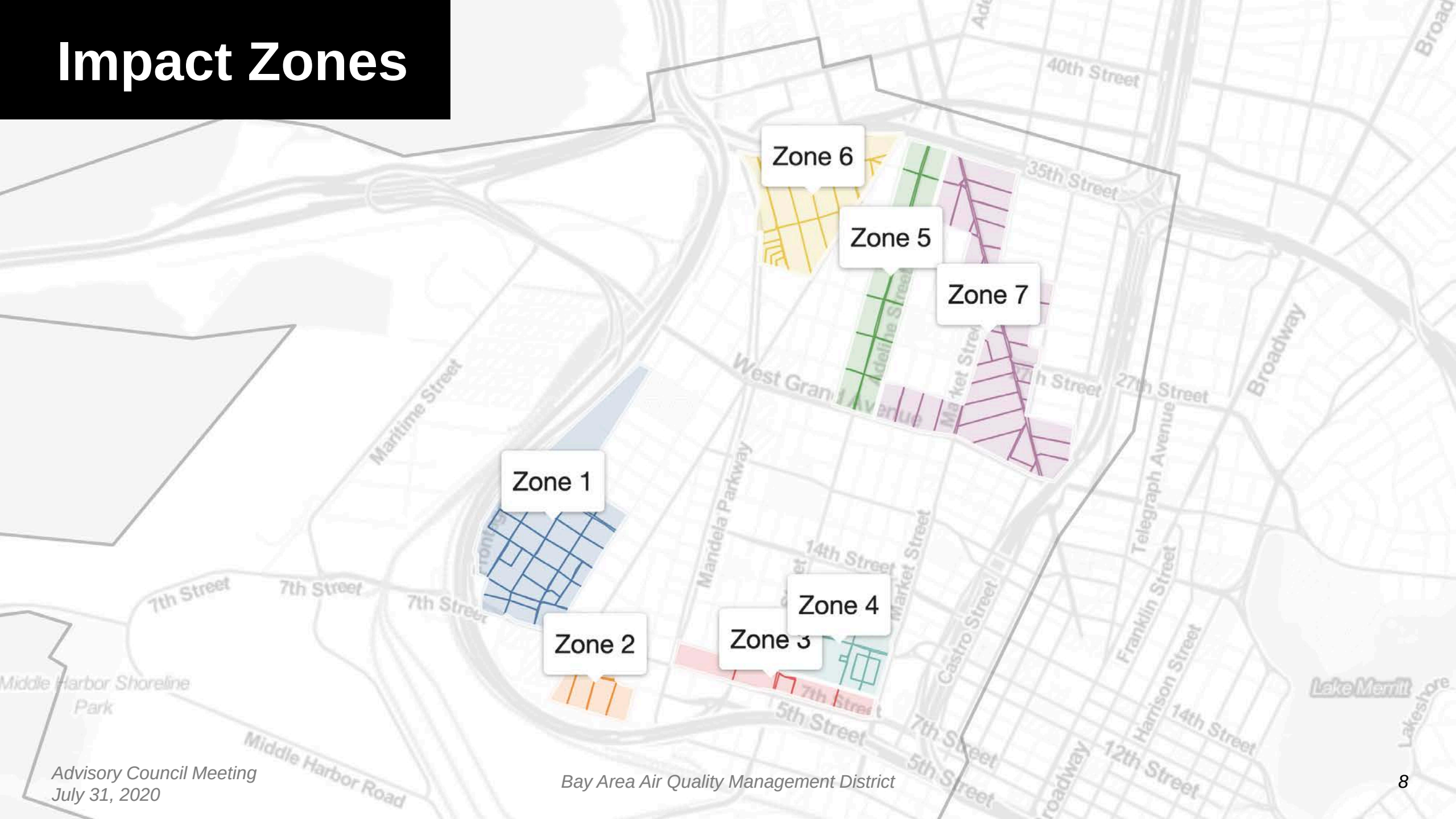
Unequal Impacts: $PM_{2.5}$ Across West Oakland



* Contributed by modeled "present-day" emissions from existing local sources. Impacts from sources outside West Oakland not included.

DRAFT 2019-08-16

Impact Zones

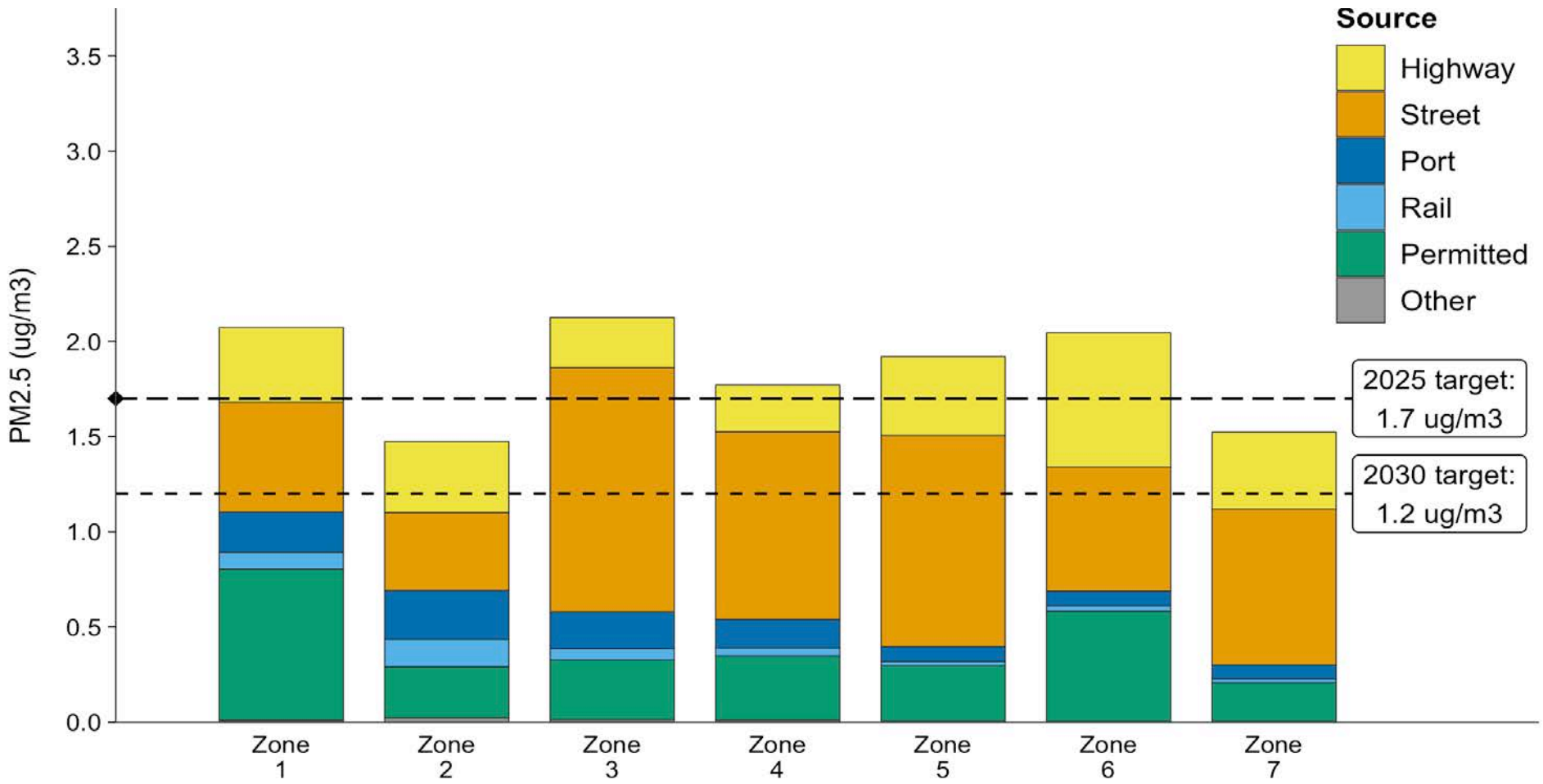


Targets and Source Contributions for $PM_{2.5}$

Targets:

2025 – Today's ***average*** residential neighborhood

2030 – Today's ***cleanest*** residential neighborhood

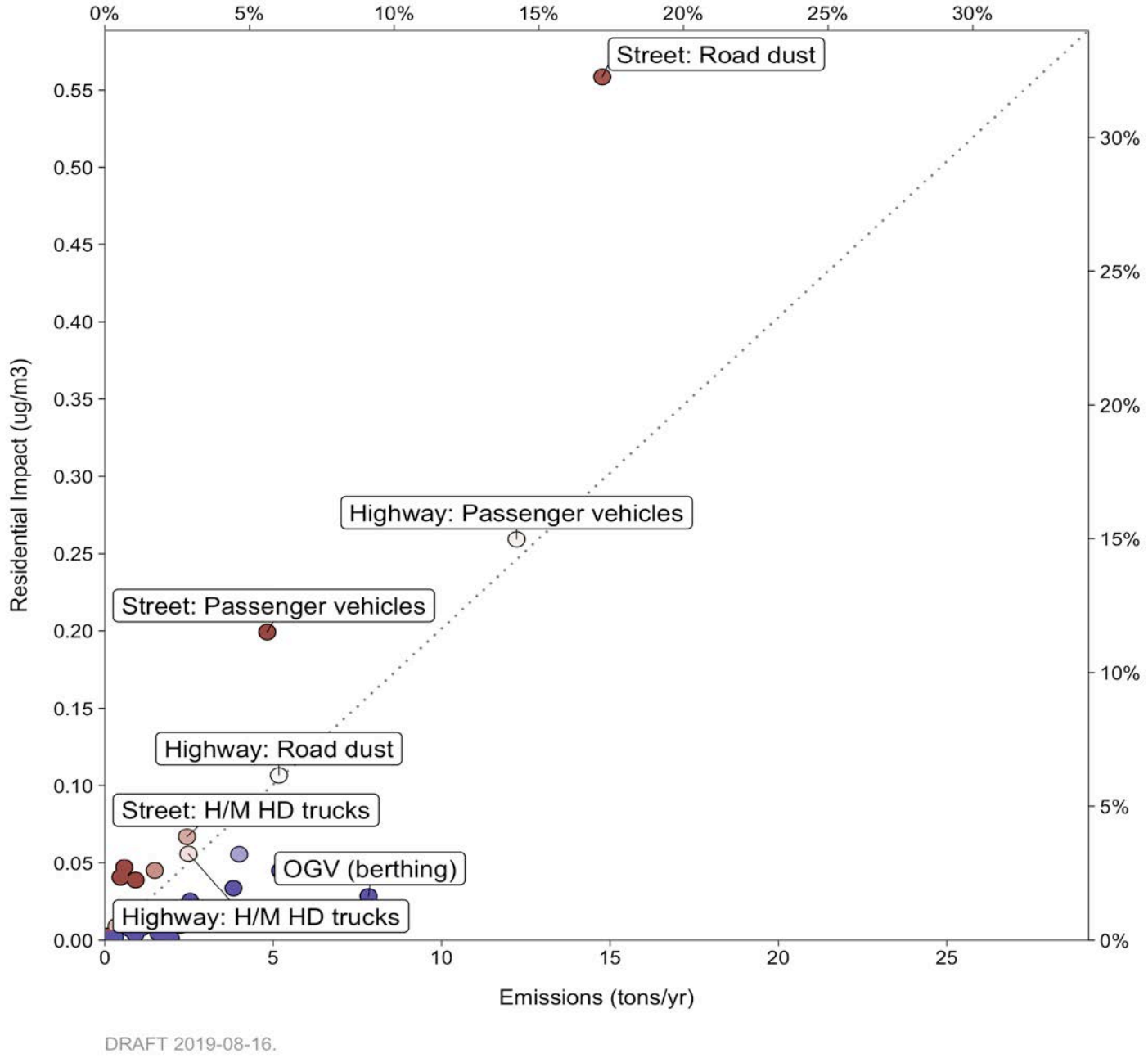


* Contributed by emissions from modeled local sources. Impacts from sources outside West Oakland not included.

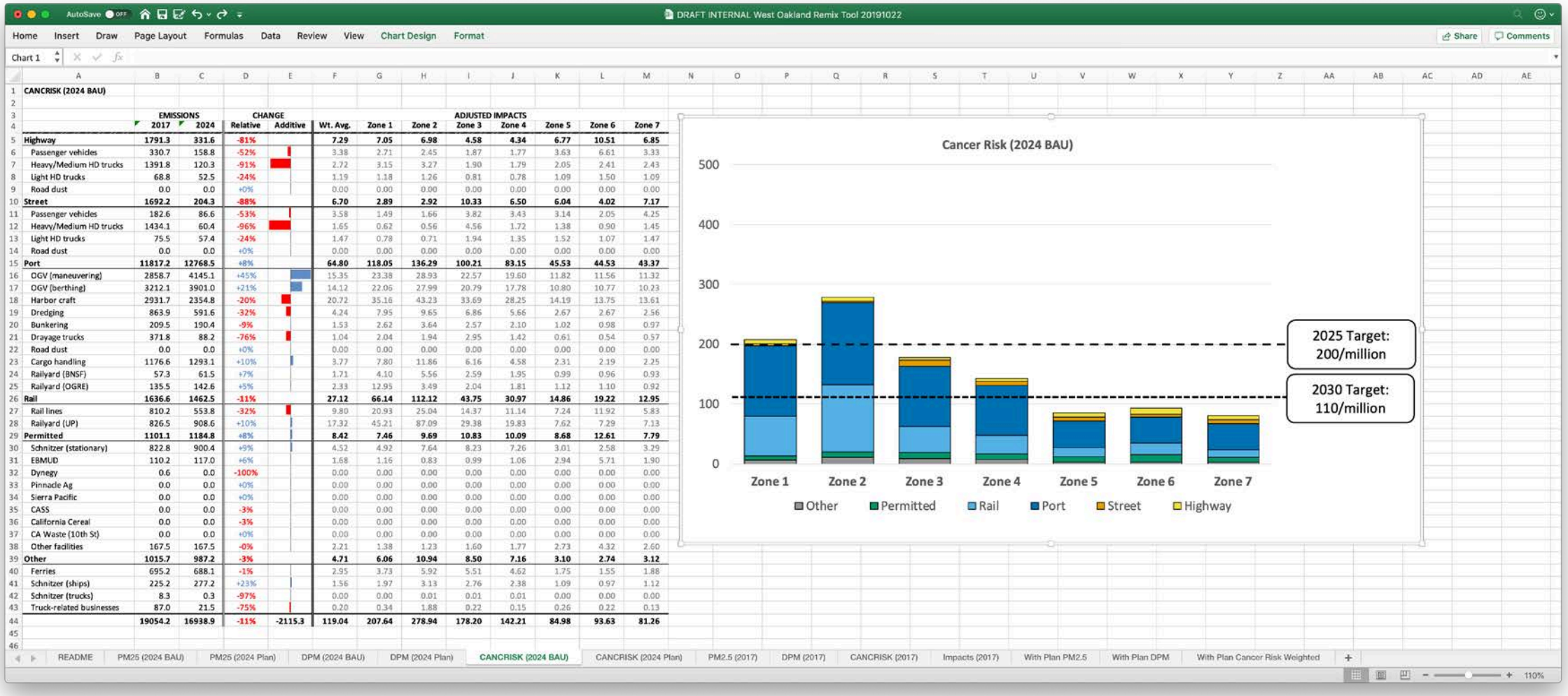
DRAFT 2019-08-16

Impact Per Ton: $PM_{2.5}$ in West Oakland

- Circles are modeled local sources
- Red is more impact, blue is less impact
- Percentages are shares of modeled impact
- Some sources have larger **exposure factors** (steeper slopes)



Finding Solutions: “Scenario Tool”



DRAFT INTERNAL West Oakland Remix Tool 20191022

CANCRISK (2024 BAU)

	EMISSIONS 2017	EMISSIONS 2024	CHANGE Relative	CHANGE Additive	ADJUSTED IMPACTS Wt. Avg.	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Highway	**1791.3**	**331.6**	**-81%**		**7.29**	**7.05**	**6.98**	**4.58**	**4.34**	**6.77**	**10.51**	**6.85**
Passenger vehicles	330.7	158.8	-52%		3.38	2.71	2.45	1.87	1.77	3.63	6.61	3.33
Heavy/Medium HD trucks	1391.8	120.3	-91%		2.72	3.15	3.27	1.90	1.79	2.05	2.41	2.43
Light HD trucks	68.8	52.5	-24%		1.19	1.18	1.26	0.81	0.78	1.09	1.50	1.09
Road dust	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Street	**1692.2**	**204.3**	**-88%**		**6.70**	**2.89**	**2.92**	**10.33**	**6.50**	**6.04**	**4.02**	**7.17**
Passenger vehicles	182.6	86.6	-53%		3.58	1.49	1.66	3.82	3.43	3.14	2.05	4.25
Heavy/Medium HD trucks	1434.1	60.4	-96%		1.65	0.62	0.56	4.56	1.72	1.38	0.90	1.45
Light HD trucks	75.5	57.4	-24%		1.47	0.78	0.71	1.94	1.35	1.52	1.07	1.47
Road dust	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Port	**11817.2**	**12768.5**	**+8%**		**64.80**	**118.05**	**136.29**	**100.21**	**83.15**	**45.53**	**44.53**	**43.37**
OGV (maneuvering)	2858.7	4145.1	+45%		15.35	23.38	28.93	22.57	19.60	11.82	11.56	11.32
OGV (berthing)	3212.1	3901.0	+21%		14.12	22.06	27.99	20.79	17.78	10.80	10.77	10.23
Harbor craft	2931.7	2354.8	-20%		20.72	35.16	43.23	33.69	28.25	14.19	13.75	13.61
Dredging	863.9	591.6	-32%		4.24	7.95	9.65	6.86	5.66	2.67	2.67	2.56
Bunkering	209.5	190.4	-9%		1.53	2.62	3.64	2.57	2.10	1.02	0.98	0.97
Drayage trucks	371.8	88.2	-76%		1.04	2.04	1.94	2.95	1.42	0.61	0.54	0.57
Road dust	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cargo handling	1176.6	1293.1	+10%		3.77	7.80	11.86	6.16	4.58	2.31	2.19	2.25
Railyard (BNSF)	57.3	61.5	+7%		1.71	4.10	5.56	2.59	1.95	0.99	0.96	0.93
Railyard (OGRE)	135.5	142.6	+5%		2.33	12.95	3.49	2.04	1.81	1.12	1.10	0.92
Rail	**1636.6**	**1462.5**	**-11%**		**27.12**	**66.14**	**112.12**	**43.75**	**30.97**	**14.86**	**19.22**	**12.95**
Rail lines	810.2	553.8	-32%		9.80	20.93	25.04	14.37	11.14	7.24	11.92	5.83
Railyard (UP)	826.5	908.6	+10%		17.32	45.21	87.09	29.38	19.83	7.62	7.29	7.13
Permitted	**1101.1**	**1184.8**	**+8%**		**8.42**	**7.46**	**9.69**	**10.83**	**10.09**	**8.68**	**12.61**	**7.79**
Schnitzer (stationary)	822.8	900.4	+9%		4.52	4.92	7.64	8.23	7.26	3.01	2.58	3.29
EBMUD	110.2	117.0	+6%		1.68	1.16	0.83	0.99	1.06	2.94	5.71	1.90
Dynegy	0.6	0.0	-100%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pinnacle Ag	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sierra Pacific	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CASS	0.0	0.0	-3%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
California Cereal	0.0	0.0	-3%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CA Waste (10th St)	0.0	0.0	+0%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other facilities	167.5	167.5	-0%		2.21	1.38	1.23	1.60	1.77	2.73	4.32	2.60
Other	**1015.7**	**987.2**	**-3%**		**4.71**	**6.06**	**10.94**	**8.50**	**7.16**	**3.10**	**2.74**	**3.12**
Ferries	695.2	688.1	-1%		2.95	3.73	5.92	5.51	4.62	1.75	1.55	1.88
Schnitzer (ships)	225.2	277.2	+23%		1.56	1.97	3.13	2.76	2.38	1.09	0.97	1.12
Schnitzer (trucks)	8.3	0.3	-97%		0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00
Truck-related businesses	87.0	21.5	-75%		0.20	0.34	1.88	0.22	0.15	0.26	0.22	0.13
	19054.2	**16938.9**	**-11%**	**-2115.3**	**119.04**	**207.64**	**278.94**	**178.20**	**142.21**	**84.98**	**93.63**	**81.26**

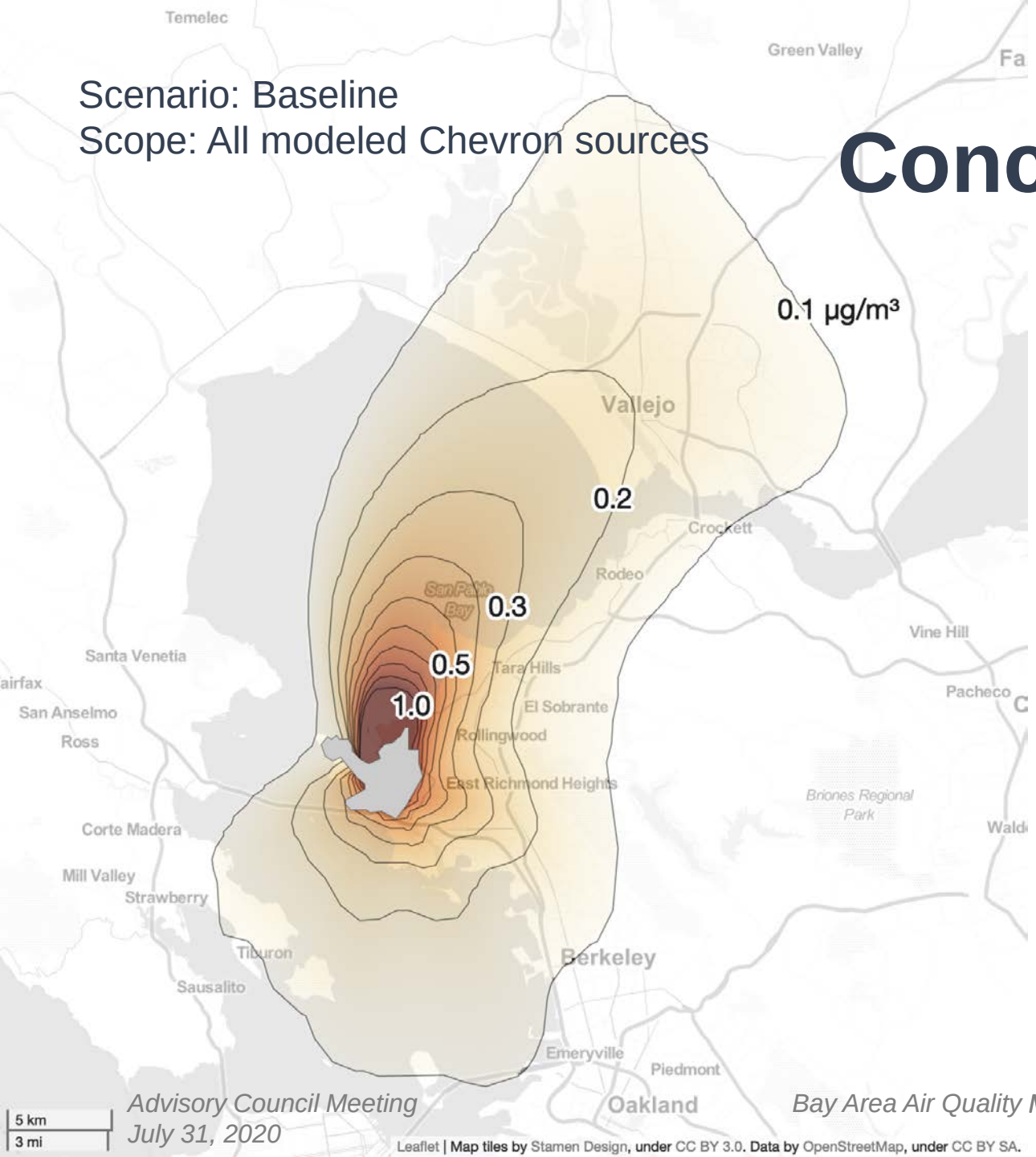
Large Industrial Sources:

Chevron Richmond Refinery

Modeling Study

- **Scope:** Tracking directly emitted (primary) $PM_{2.5}$
  - From all permitted sources at Chevron, including the Fluidized Catalytic Cracking Unit (FCCU)
- **Scenarios:**
  1. Baseline = existing emissions
  2. Additional FCCU emission reductions
- **Approach:** Track plumes with the CALPUFF air quality model to map concentrations (2016-2018)

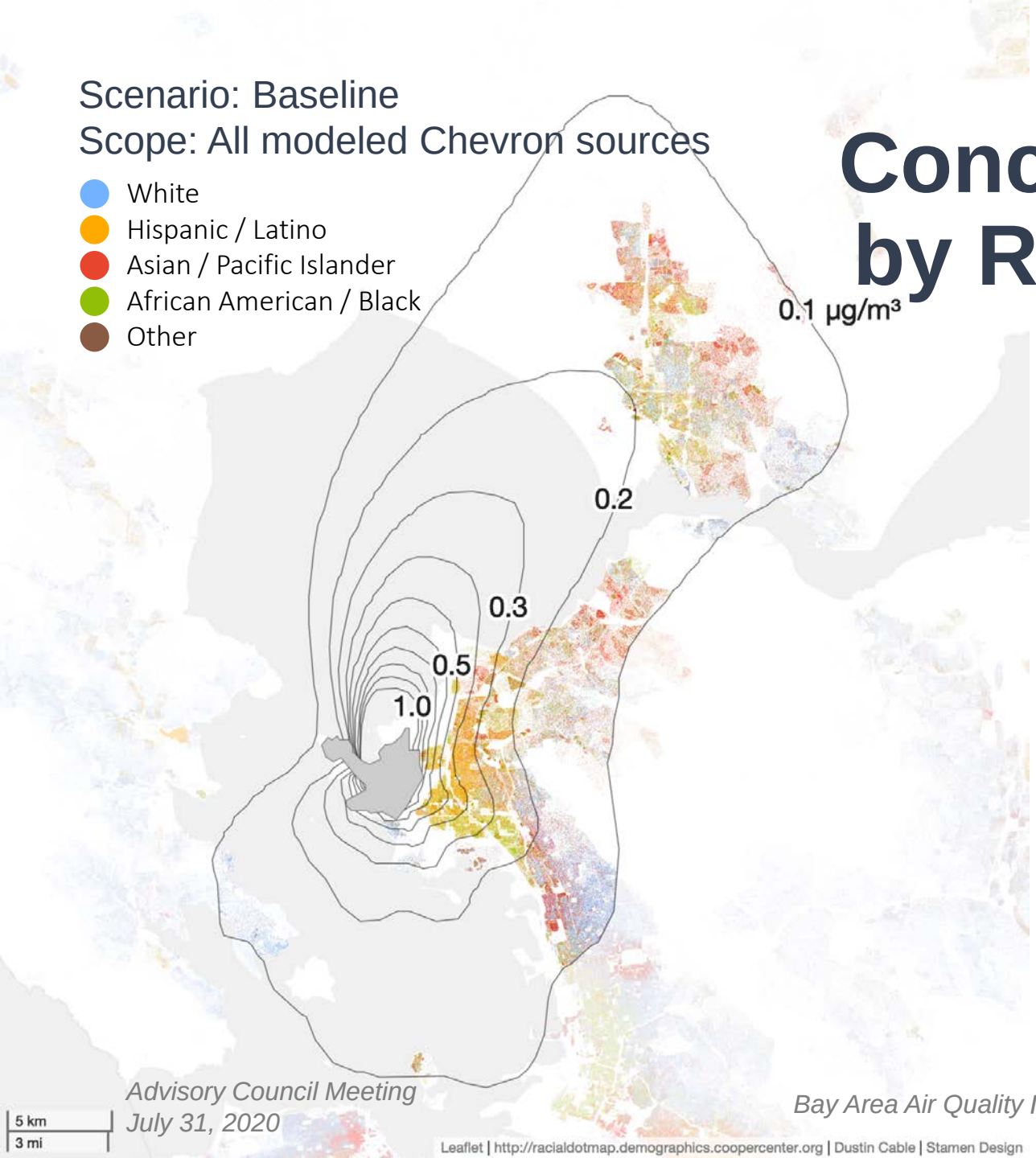
Chevron $PM_{2.5}$ Concentration Impacts by Area



- Modeled annual-average, primary $PM_{2.5}$ concentrations from all sources at Chevron
- Baseline scenario
- Measured annual-average $PM_{2.5}$ at nearby San Pablo site: about 8-10 µg/m³*

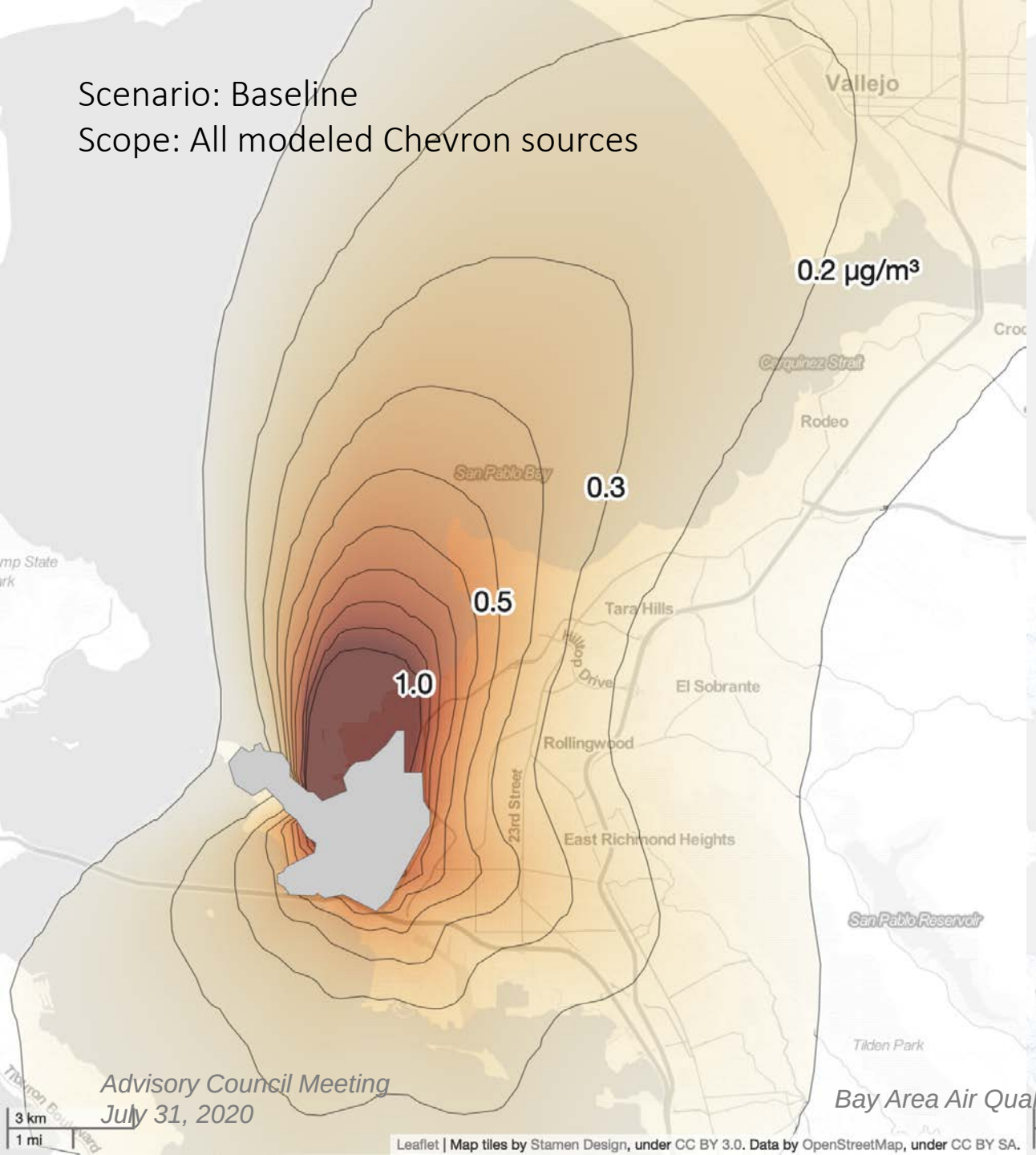
* Excluding 2017-2018 wildfire days; about 8-13 mg/m³ including wildfire days

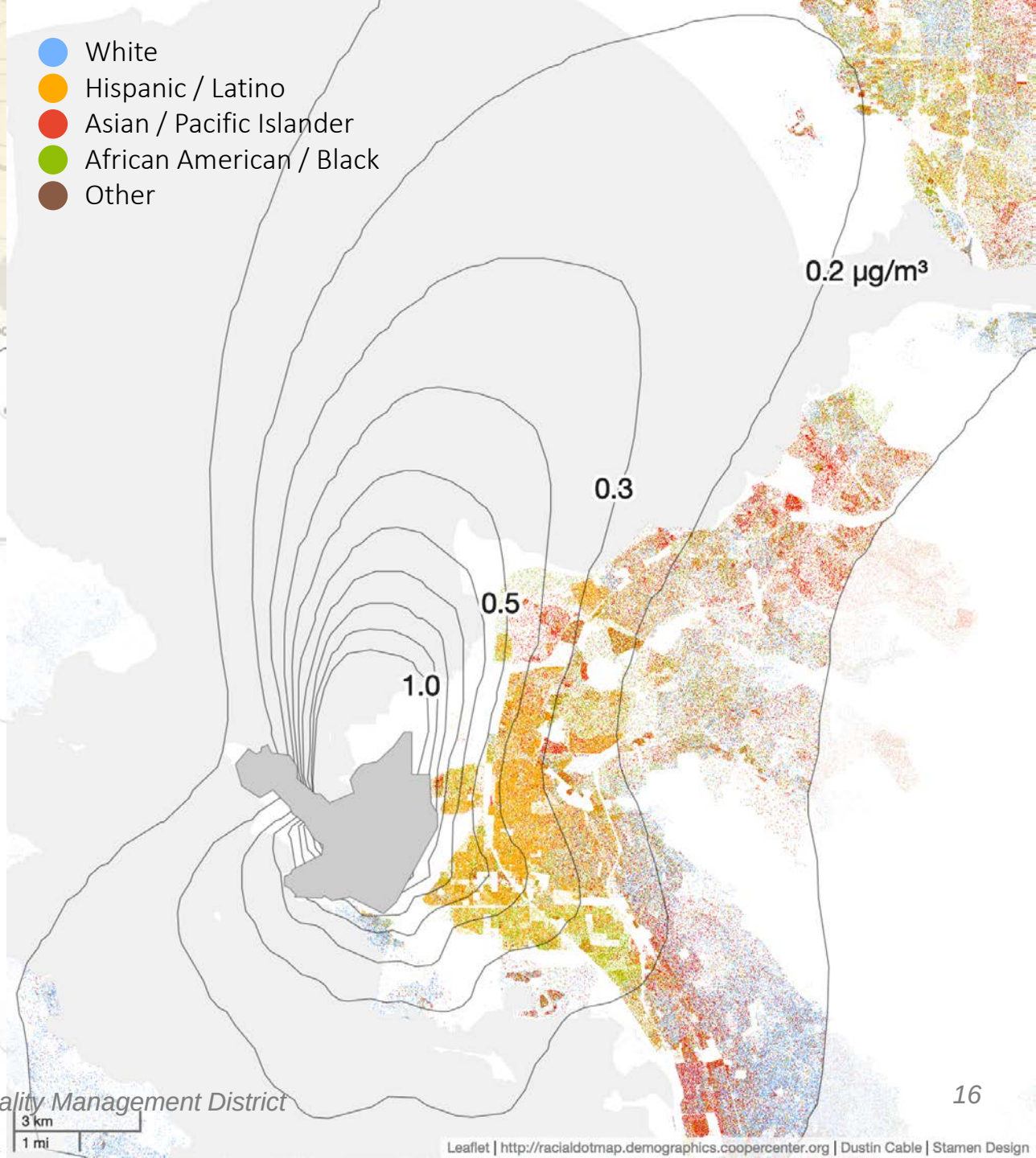
Chevron $PM_{2.5}$ Concentration Impacts by Residents Exposed



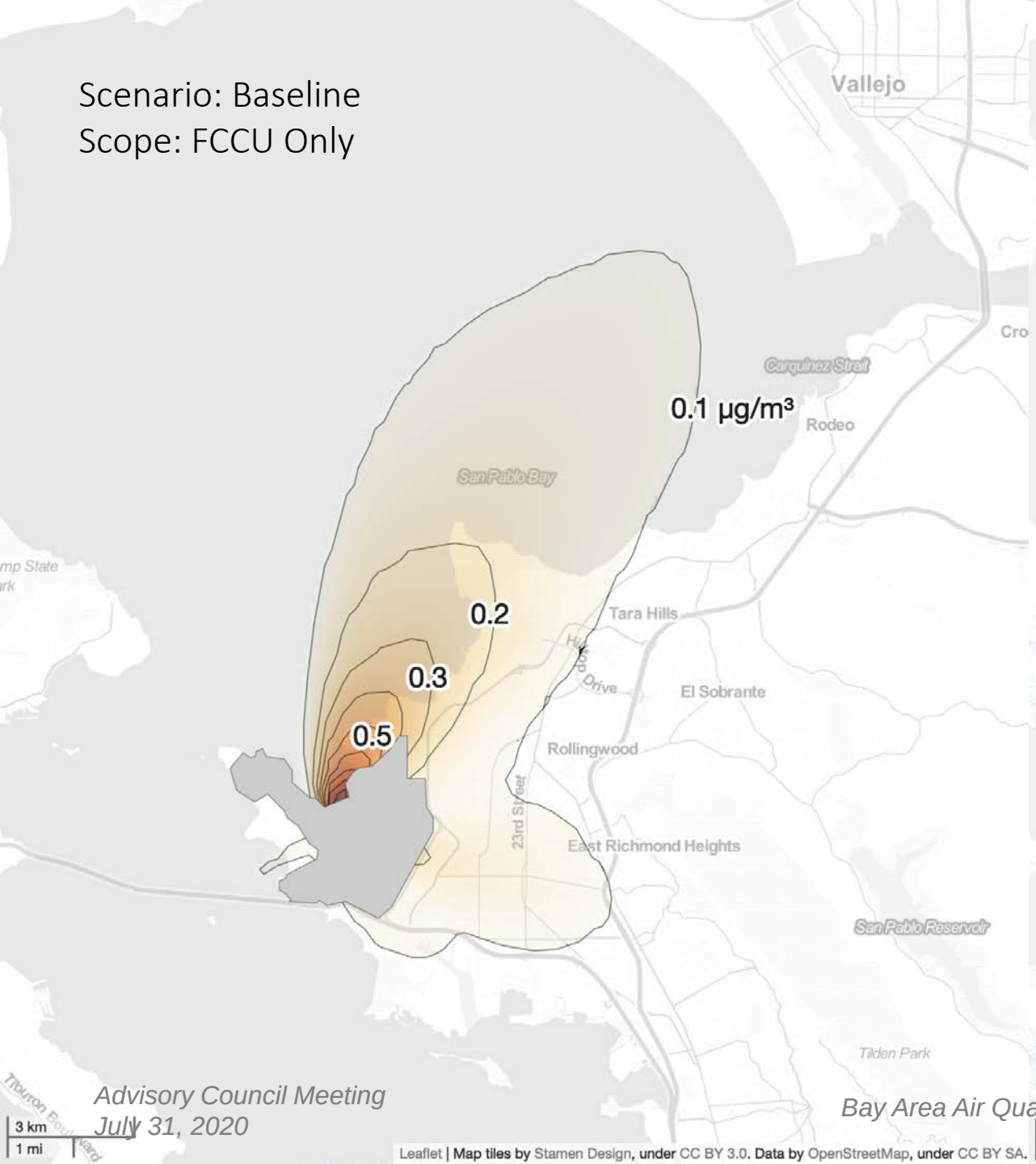
- Each color dot represents one person
- Colors are muted outside the 0.1 $\mu g/m^3$ contour, "the plume"
- Almost half a million people (~449,000) in the plume

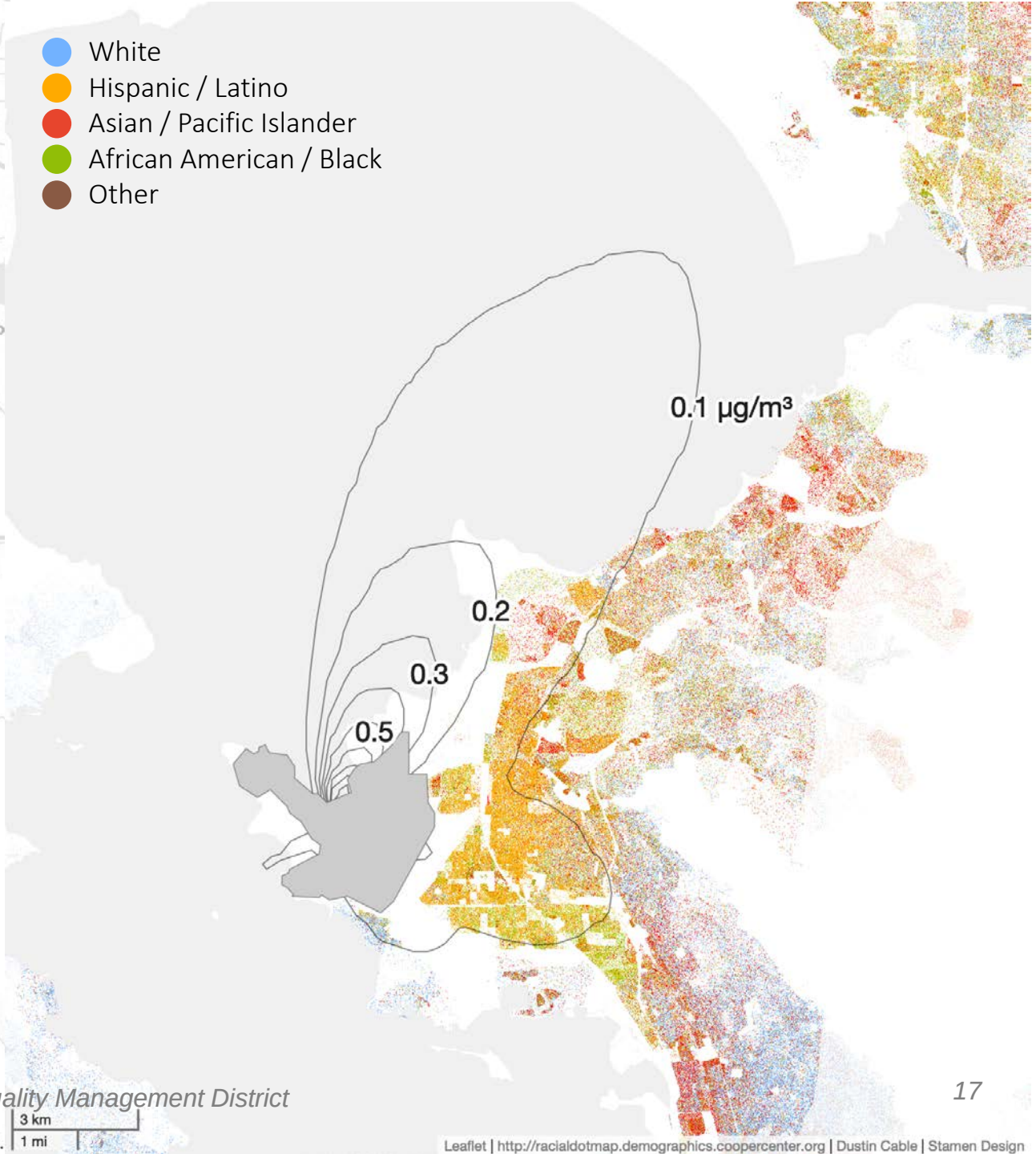
Scenario: Baseline
Scope: All modeled Chevron sources





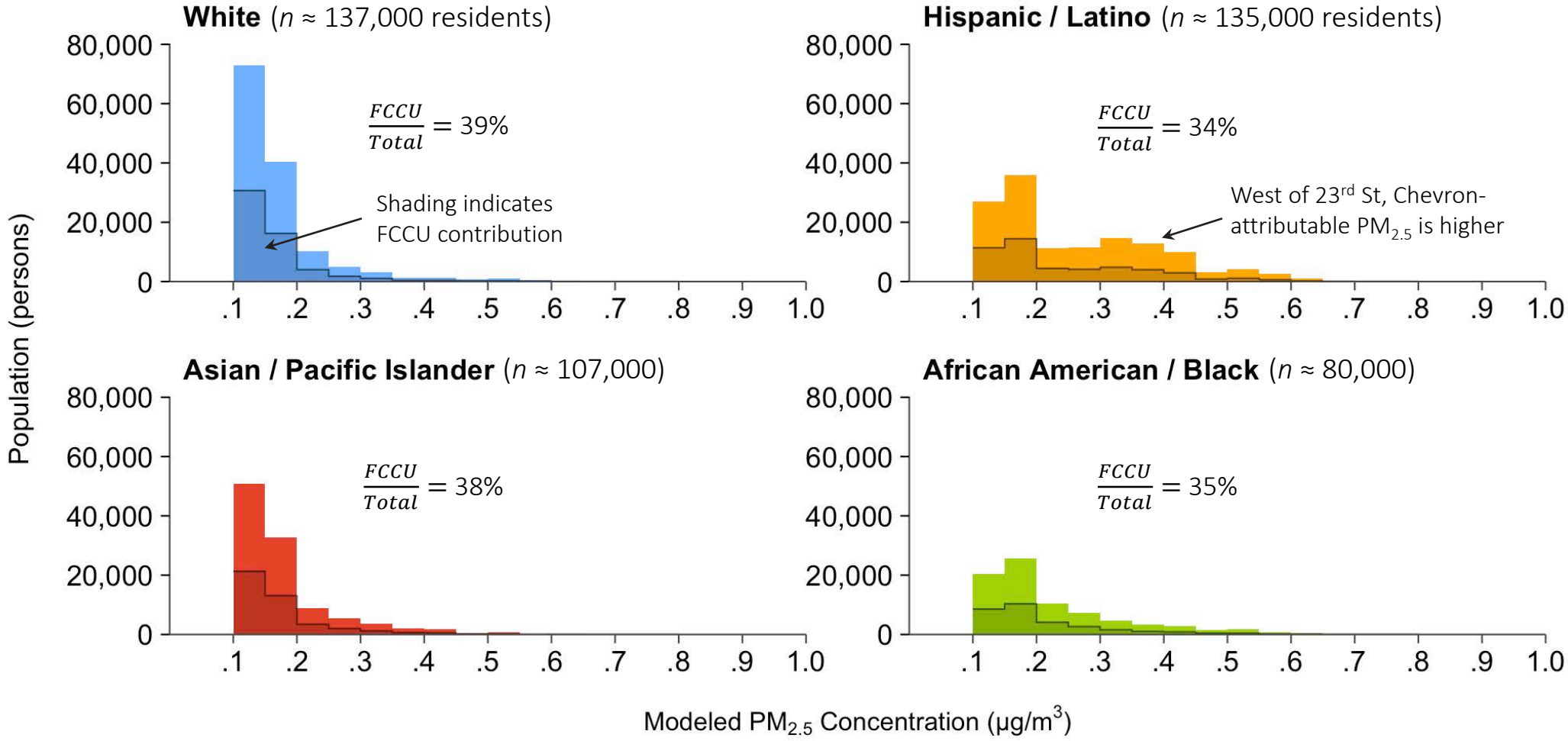
Scenario: Baseline
Scope: FCCU Only





$PM_{2.5}$ Exposures by Race/Ethnicity

Scenario: Baseline
Scope: Census blocks with 0.1 µg/m^3 $PM_{2.5}$ or more from Chevron



Next Steps

- Richmond/San Pablo Community Action Plan
- Additional refineries/large industrial facilities
- Methodology for estimating increased adult mortality risk from local sources of $PM_{2.5}$
  - Highlight risks below the federal standard
  - Based on a recent California epidemiological study
  - Development in partnership with US Environmental Protection Agency (EPA) and the Office of Environmental Health Hazards Assessment (OEHHA)

Summary

- Identify source-contributions to impacts
  - What is responsible?
- Assess equity of impacts to inform decision-making
  - Support agency goal of reducing air pollution inequities
- Work toward highlighting health risks from $PM_{2.5}$ exposures below federal standard
  - Develop a risk framework consistent with “no identified safe level of $PM_{2.5}$”

AGENDA: 6A

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Particulate Matter (PM) Symposium Overview

Advisory Council Meeting
July 31, 2020

Jeff McKay
Chief Financial Officer

PM Symposium Timeline

May 12

Community presentation and Technical/Policy discussion

July 31

Industry presentations and PM modeling presentation

September (?)

Advisory Council discussion

November

Advisory Council discussion

December

Joint Board/Advisory Council meeting

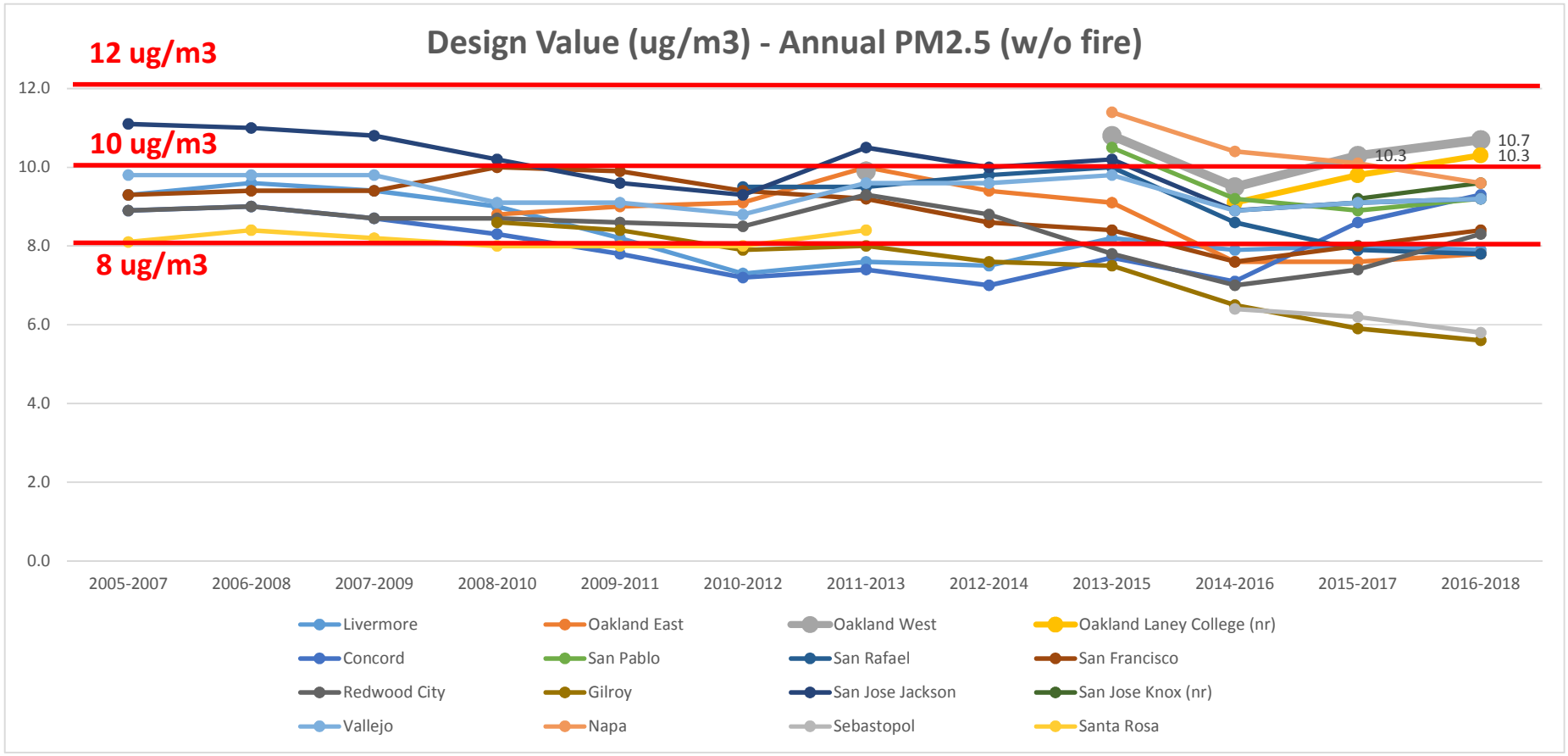
Particulate Matter: Spotlight on Health Protection

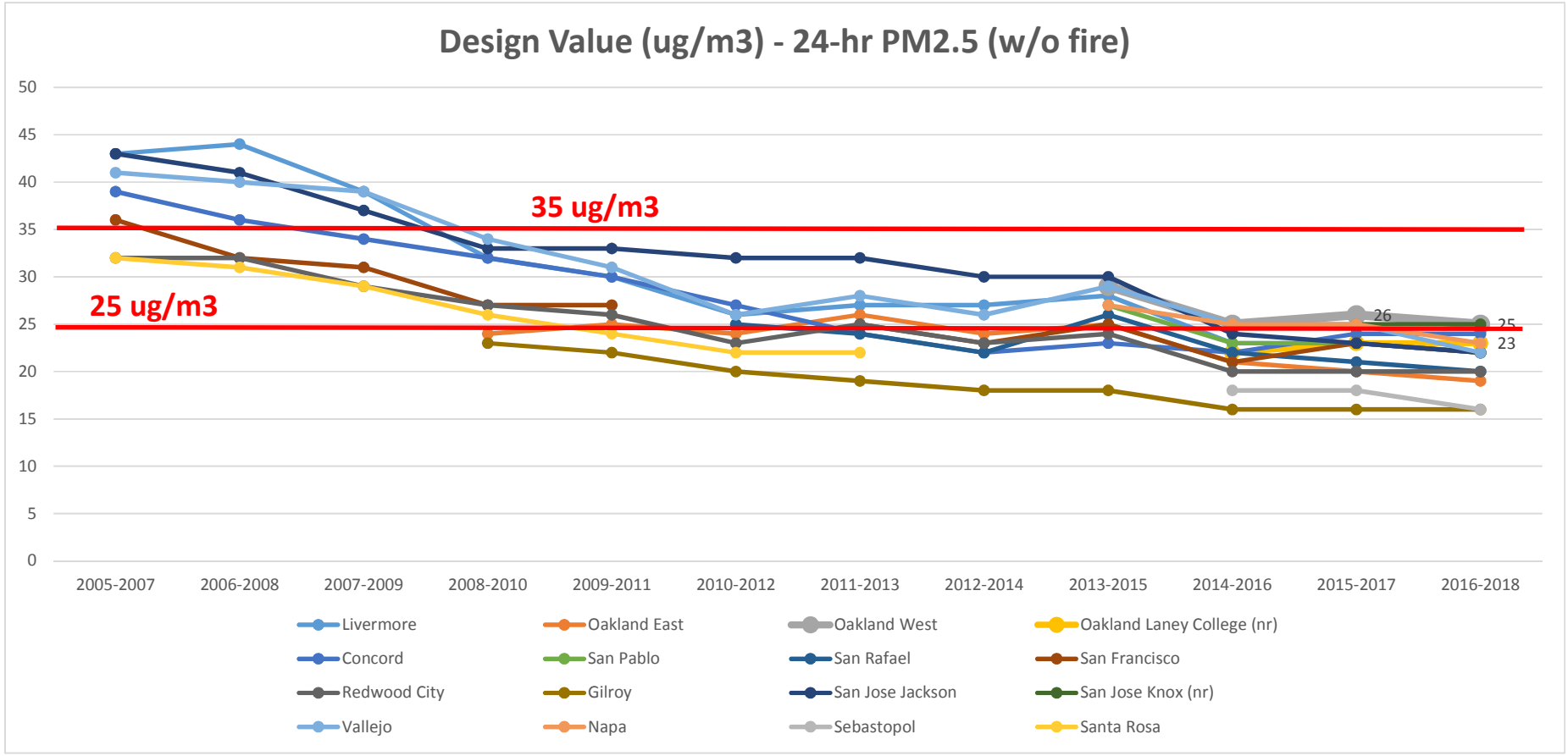
ID	PARTICULATE MATTER REDUCTION STATEMENT	NOTES
PMRS1	Excluding wildfire smoke days as exceptional events, the Bay Area has attained the current federal annual/24-hour (12/35 ug/m3) PM2.5 national ambient air quality standards (NAAQS).	
PMRS2	The current PM NAAQS are not sufficiently health protective .	
PMRS3	The Bay Area also would attain alternative, more stringent 10/25 ug/m3 PM2.5 NAAQS (except for West Oakland, whose annual average PM2.5 in 2018 was above an alternative 10 ug/m3 standard by 0.7 ug/m3, or 7%).	
PMRS4	PM is the health risk driver in Bay Area air, both PM2.5 as a criteria pollutant and diesel PM as a toxic air contaminant.	
PMRS5	There is no evidence of a health effects PM2.5 threshold; thus, additional PM reductions beyond the current standards will achieve additional public health improvement.	
PMRS6	More stringent standards are needed and would save thousands of lives in the U.S. each year.	
PMRS7	An Air District guideline "target" below the current PM2.5 NAAQS is warranted; to be effective, it would need to be at or below an annual average of 10 ug/m3.	
PMRS8	Some PM localized hot-spot areas may experience PM levels significantly higher than their community-average level.	
PMRS9	Wildfire PM could be a serious contributor to PM health effects; early studies are of concern, more research is needed.	

ID	FRAMEWORK FOR EVALUATING PARTICULATE MATTER REDUCTION STRATEGIES	NOTES
F1	Where the Air District has authority, take maximal action.	
F2	The most effective PM reduction measures may differ across communities, due to varying source mix and size, ambient PM concentration levels, physical circumstances (e.g., meteorology, terrain), and other relevant factors.	
F3	The Air District should focus PM reduction in areas with increased exposure, health vulnerability, and the areas with increased impacts and sensitive populations (e.g., children, nonwhite, low SES, elderly) .	
F4	Lower-income populations with higher long-term PM exposure are more susceptible to COVID-19, due to such factors as lesser ability to work from home, denser housing situations (e.g., congregate, multi-family), and poorer access to medical care.	
F5	PM measures should consider regional (Bay Area-wide), local (community-level), and localized hot-spot (block-level) sources.	
F6	PM reduction strategies should consider emission reduction measures for both primary PM and secondary PM formed in the air by photochemical processes (i.e., emissions of precursor ROG, NOx, NH3, and SO2).	
F7	PM reduction strategies will need to address multiple source categories; there is no “silver bullet,” rather, it is more like “silver buckshot.”	

ID	RECOMMENDED ACTIONS	CATEGORY	NOTES
RA1	Make air quality data more accessible and closer to real time.	Monitoring	
RA2	Some species of PM may be more dangerous than others; as yet, no PM species can be exonerated; better PM speciation is needed, along with more monitoring.	Monitoring	
RA3	Monitoring and other studies for UFP are important and should be continued and expanded; further studies linking UFP and health impacts are needed.	Monitoring	
RA4	Set improved UFP filtration requirements for on-road vehicles.	Technology	
RA5	Increase staff for enforcement and accidental release events.	Enforcement	
RA6	Increase staff to implement/enforce Rule 11-18.	Enforcement	
RA7	Devote more staff to risk assessment for air toxics programs like Rule 11-18.	Enforcement	
RA8	Improve emission estimation methods for emerging source categories (e.g., tires & brakes, road dust).	Planning	
RA9	Develop Air District PM action plans for individual highly-impacted communities.	Planning	
RA10	Further develop and implement health protective measures for the community during wild fires.	Planning	
RA11	Encourage telework.	Planning	
RA12	Conduct community-level health exposure assessments.	Planning	
RA13	Expand existing rule limiting visible emissions and trackout (Rules 6-1, 6-6) to address communities that are overburdened or experience continuous construction.	Rules	
RA14	Modify permitting regulations to address hyper-localized health risks.	Rules	
RA15	Adopt rule requiring woodburning devices be disabled or replaced when properties are sold.	Rules	
RA16	Adopt rule to improve the efficiency of water heaters and space heaters.	Rules	
RA17	Expand the existing rule to reduce emissions from commercial cooking equipment such as charbroilers (Rule 6-2).	Rules	
RA18	Update permitting regulations for gas stations and dry cleaners (Regulation 2).	Rules	
RA19	Adopt amendments to Rule 9-1 to limit sulfur dioxide emissions from refineries.	Rules	
RA20	Adopt a new rule to limit site-wide health risk from PM.	Rules	
RA21	Take into account cumulative impact in permitting.	Permitting	
RA22	Close loopholes that allow piecemealing of larger projects into small components.	Permitting	
RA23	Assist local programs to control road dust (e.g., analyze road dust emission rates for local streets).	Funding	
RA24	Seek federal funding for electrification infrastructure.	Funding	
RA25	Work to leverage Senate Bill 1 funding to replace switcher engines in East Bay to reduce other off-road sources.	Funding	
RA26	Seek additional funding to improve transit, bicycles, and pedestrian facilities, and to reduce VMT to reduce road dust, brake & tire wear, and vehicle exhaust.	Funding	
RA27	Seek changes at state level to Air District authority for magnet sources.	Authority	
RA28	Authorize the Air District to regulate fine PM as toxic air contaminant.	Authority	
RA29	Seek authority for the Air District to establish air quality standards for PM.	Authority	
RA30	Support CARB efforts to electrify trucks and other vehicles.	Authority	
RA31	Seek stricter offroad mobile source rules from CARB.	Authority	
RA32	Seek authorization from CARB for stronger at-berth regulations to control emissions from ships that dock at ports and refineries.	Authority	
RA33	PM action plans should include all available "technically feasible" methods of reducing PM emissions and exposures for stationary, area, mobile , and indirect sources of PM.		AD recommendation
RA34	Legislative approaches to secure additional authority to regulate PM emissions should be considered, e.g., indirect source rule (ISR) or indoor air quality.		AD recommendation
RA35	OEHHA and ARB should be petitioned to identify PM as a toxic air contaminant in light of the available health data.		AD recommendation

ID	RECOMMENDED ACTIONS	CATEGORY	NOTES
RA36	A comprehensive study of indoor air quality should be conducted to better understand the pathways of PM exposure and how people can reduce that exposure through changes in habits.		AD recommendation
RA37	PM action plans should include non-traditional partners and approaches such as county health officials, health care providers, and methods of improving indoor air quality. (This could provide added protection during episodic events such as wildfires and facility incidents.)		AD recommendation


Design Value (ug/m3) - Annual PM2.5 (w/o fire)
12 ug/m3
10 ug/m3
8 ug/m3
12.0
10.0
8.0
6.0
4.0
2.0
0.0
10.7
10.3
10.3
2005-2007
2006-2008
2007-2009
2008-2010
2009-2011
2010-2012
2011-2013
2012-2014
2013-2015
2014-2016
2015-2017
2016-2018
Livermore
Oakland East
Oakland West
Oakland Laney College (nr)
Concord
San Pablo
San Rafael
San Francisco
Redwood City
Gilroy
San Jose Jackson
San Jose Knox (nr)
Vallejo
Napa
Sebastopol
Santa Rosa


Design Value (ug/m3) - 24-hr PM2.5 (w/o fire)
50
45
40
35
30
25
20
15
10
5
0
35 ug/m3
25 ug/m3
26
25
23
2005-2007
2006-2008
2007-2009
2008-2010
2009-2011
2010-2012
2011-2013
2012-2014
2013-2015
2014-2016
2015-2017
2016-2018
Livermore
Oakland East
Oakland West
Oakland Laney College (nr)
Concord
San Pablo
San Rafael
San Francisco
Redwood City
Gilroy
San Jose Jackson
San Jose Knox (nr)
Vallejo
Napa
Sebastopol
Santa Rosa