CAPHE PHAP-RM

5. AIR POLLUTANT SOURCES, EXPOSURES & HEALTH IMPACTS

2016

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5. AIR POLLUTANTS SOURCES, EXPOSURES AND HEALTH IMPACTS

5.1 Source types and data sources

5.1.1 Source and pollutant types

Data describing emissions are contained in "emissions inventories." These inventories use several classifications of sources and pollutants. There is a degree of overlap among these categories.

Source types

Point sources range in size from very large industrial facilities with tall smoke stacks, such as major power plants (Figure 5-1), to small or modestly-sized industries with small stacks, e.g., small factories or paint shops. An industrial facility, that is, an entity under single control, may have one to several dozens of point sources, e.g., the Ford Dearborn Assembly plant has many dozens of small facilities that are small point sources of pollutants. Typically, a relatively small number of sources and facilities accounts for the bulk of point source emissions.

Figure 5-1. Arial photo of the Trenton Channel power plant, which can burn coal, natural gas, fuel oil and residual paint solids, is an example of a major point source in southwest Detroit. Each stack is over 560 feet tall. Photo from Google Maps.

In this report, a facility is an entity under single control that may have one to several dozens of point sources (e.g., stacks). Facility-level emissions sum emissions across the various stacks. Facilities also may be associated with non-point emissions (fugitive, area and mobile emissions).

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Mobile sources include on-road vehicles (cars and trucks driven on roads), off-road or non-road sources (locomotives, aircraft, marine, off-road vehicles), and non-road equipment (such as lawn and garden equipment).

On-road emissions include exhaust emissions (e.g., diesel exhaust), brake wear, tire wear, and running losses (e.g., evaporation of fuel). On-road vehicles also cause emissions of windblown dust (silt) and pavement wear; this is sometimes considered as an area source (see below).

Area sources are defined by US EPA as stationary source of air pollutants that are not "major" sources. These consist of smaller facilities that release emit than 10 tons per year of a single air pollutant or less than 25 tons per year of a combination of pollutants. In addition to smaller factories and point sources, area sources include many types of sources, including, for example, entrained dust (from waste piles, roads, etc.), natural sources (pollen), residential fuel combustion, construction, and forest fires. Though emissions from individual area sources can be relatively small, collectively their impact can be considerable, particularly where large numbers of sources are located in or near heavily populated areas.[1]

Pollutant types

Criteria or conventional pollutants include NO_x, PM (including $PM_{2.5}$, PM_{10}, and others), CO, O_3, and VOCs. O_3 is not included in emissions inventories as it is a secondary pollutant formed from precursors NO_x and VOCs.

Toxic pollutants are pollutants that are not criteria pollutants and that may pose health or environmental risks. These include many metals, specific VOCs, semivolatile compounds, and mixtures such as diesel exhaust.

Greenhouse gas (GHG) pollutants include some conventional and criteria pollutants, as well as CO_2, N_2O, CH_4 and others. Emissions of GHGs are not discussed in this report.

Emission inventories provide estimates of only "primary" emissions. Primary emissions can form "secondary" pollutants, e.g., emissions of gases form a significant amount of secondary $PM_{2.5}$ (e.g., organic aerosols and ammonium sulfate particles). This information is not indicated by emission inventory data.

5.1.2 Data sources

Information regarding emissions from point sources was obtained from multiple sources, outlined in Table 5-1. This report discusses MAERS, TRI and NEI sources in depth; other sources are used to revise, confirm and supplement the data and to allow dispersion modeling and the quantitative health impact analyses. Other sources of data include permit to install (PTI) applications and state implementation plans (SIPs). These databases are not harmonized, and differences in emissions and other data can be large. Section 5.2.4 discusses discrepancies in the $PM_{2.5}$ point source emissions inventories, an important issue in the health impact analyses given the significance of this pollutant.

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Table 5-1. Datasets used for emission data and modeling analyses.

Dataset (Abbreviation)	Approach	Parameters and Pollutants	Years
National Emission Inventory (NEI)	EPA takes state level data from inventories and does adjustments using emission factors and other means, public access.	Stack parameters and locations. Stack level annual average emissions of conventional air pollutants (CAP) and hazardous air pollutants (HAP).	Every 3 years (2002, 2005, 2008, 2011)
Michigan Air Reporting System (MAERS)	Derived by MDEQ for emissions data at the facility level, public access.	Facility level annual average emissions of conventional pollutants: CO, NH_3, NMOC, NO_x, Pb, $PM_{2.5}$, PM_{10}, PM, SO_2, TNMOC, TOC, VOC	Annual (1999 to 2014)
Toxic Release Inventory (TRI) System	Self-reported data by industry using variety of approaches (judgment, emission factors, and measurements.	Facility level annual discharges/emissions, to air, water, off-site transfers. Nearly 600 toxics and some conventional pollutants	Annual (1999 to 2014)
MDEQ Emissions (FOIA)	Compiled by MDEQ from industry data and MDEQ calculations	Facility emissions of all CAPs and HAPs	1998 to 2008
MDEQ Stack Parameters (MDEQ-STACK) (FOIA)	Compiled by MDEQ from industry data	Stack parameters and locations	2009 to 2013
Stack Parameters (FOIA-STACK)	Compiled by MDEQ from industry data	Stack parameters and locations	1998 to 2008
Permit to Install (PTI) applications for specific sources	Compiled by MDEQ with input from industry	Allowable emission data and some stack parameters	When PTI is filed
State Implementation Plans (SIPs)	Compiled by MDEQ with input from industry	Allowable emission data and some stack parameters	When air quality non-attainment

FOIA: Freedom of Information Act

MDEQ: Michigan Department of Environmental Quality

The Michigan Air Emission Reporting System (MAERS) provides a record of estimated “actual” emissions in Michigan at the “stack” level for conventional pollutants, e.g., $PM_{2.5}$, PM_{10}, NO_x, SO_2, lead, CO, VOCs, and several other pollutants (e.g., ammonia). This public access reporting system is maintained by MDEQ and report actual emissions on an annual basis. This inventory is not necessarily used for compliance purposes, although it is often cited in permits and SIPs. It provides an indication of discharges to air for point sources. As indicated below, not all information is consistent, and trends in MAERS and the other emissions inventories must be interpreted cautiously.

5.2 Point sources

5.2.1 Conventional pollutants

This section discusses emission of conventional pollutants, drawing heavily on the Michigan Air Emissions Reporting System (MAERS). All data reported in MAERS (1999 to 2014) is considered. Most analyses use the most recent 5 year period available (2010 to 2014). Stack-level data reported in MAERS was consolidated to the facility level.

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In the 7 county SE Michigan area (Lenawee, Livingston, Macomb, Monroe, Oakland, Washtenaw, and Wayne Counties) and over the 1999-2014 period, MAERS included a total of 871 facilities. A large number of these facilities no longer report emissions in MAERS, primarily due to the shuttering of many industrial, manufacturing, and commercial facilities over the past decade or more. A smaller number of facilities report emissions in the 2010-2014 period, as shown in Table 5-2. Some facilities are relative small emitters, thus, the table shows facilities reporting both any emissions as well as emissions over 1 ton/yr. The table includes facilities reporting emissions for at least one year in the 2010-2014 period; some of these may have been shuttered since 2010 as well.

Table 5-2. Summary of number of facilities by county listing emissions in the 2010-2014 period in MAERS.

Type	County	NOx	SO2	PM2.5	PM10	VOC	CO
Number of Facilities Reporting Emissions Over 1 tons/yr							
	Wayne	88	24	38	70	109	83
	Washtenaw	26	4	7	12	20	23
	Oakland	56	12	16	32	61	46
	Monroe	14	4	5	19	8	13
	Macomb	43	5	13	29	60	38
	Livingston	8	0	1	4	11	5
	Lenawee	9	3	2	9	10	10
	Total	244	52	82	175	279	218
Number of Facilities Reporting Any Emissions							
	Wayne	125	125	115	143	157	117
	Washtenaw	28	28	28	29	31	28
	Oakland	68	70	66	84	101	63
	Monroe	16	16	14	21	16	15
	Macomb	51	49	49	58	67	49
	Livingston	8	9	8	13	14	8
	Lenawee	13	13	10	16	16	11
	Total	309	310	290	364	402	291

Table 5-3 uses 1999 to 2014 MAERS data to show how a few dozen facilities account for the bulk of NO_x, SO_2 and $PM_{2.5}$ point source emissions. For example, for SO_2, 5 facilities account for 95% of emissions in the 7-county area. These larger facilities can cause a large "footprint" in which concentrations and exposures are elevated, and thus the large facilities warrant special attention. However, smaller point sources can also be important if emissions are released near ground level and near populated areas.

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Table 5-3. Summary of emissions at the facility level in the 7 county southeast Michigan area from MAERS. Shows total long-term average emissions (1999-2014 average), the number of facilities that account for 85, 90, 95 and 99% of emissions, the number of sources with emissions, and the total number of facilities.

	NOx	SO2	PM2.5	PM10	VOC	CO	CO	Lead
Total Emissions (tons/year)	62398	148647	1523	5980	14994	264	42116.2	7.3
No. Facilities to get 85%	12	3	21	38	86	12	18	9
No. Facilities to get 90%	21	4	40	67	128	20	29	12
No. Facilities to get 95%	49	5	75	126	210	37	62	18
No. Facilities to get 99%	158	12	177	249	383	100	160	34
Source with Emissions	548	527	423	423	618	768	508	234
Total Number of Facilities	871	871	871	871	871	871	871	871

5.2.2 Trends in point source emissions of conventional pollutants

Figure 5-2 shows trends at the county level for eight pollutants. With the exception of CO, emissions have been declining over the 1999 to 2014 period. This figure also shows that for most pollutants, point sources located in Monroe and Wayne counties account for most of point source emissions in southeast Michigan. Further data on this is presented later in Section 5.5 and Table 5-10 in particular.

Trends based on emission data must be interpreted cautiously. In particular, there is considerable uncertainty in PM emissions, mobile emissions, and other nonpoint emissions (area sources).[2] This arises due to the changing methodologies used to estimate emissions, changes in which sources and pollutants are included, and changes in associated data (emission factors, activity estimates, etc.). For example, for mobile sources, important uncertainties include the availability and accuracy of the data providing on-road and off-road gasoline and diesel fuel consumption, the age and composition of the fleet, and the emission factors. Emission trends for CO, SO_2, and possibly NO_x and lead (Pb) should be more reliable than PM.

[2] Milando, C, L Huang, S Batterman. 2016. Trends in PM2.5 emissions, concentrations and apportionments in Detroit and Chicago, *Atmospheric Environment*, 129, 197-209..

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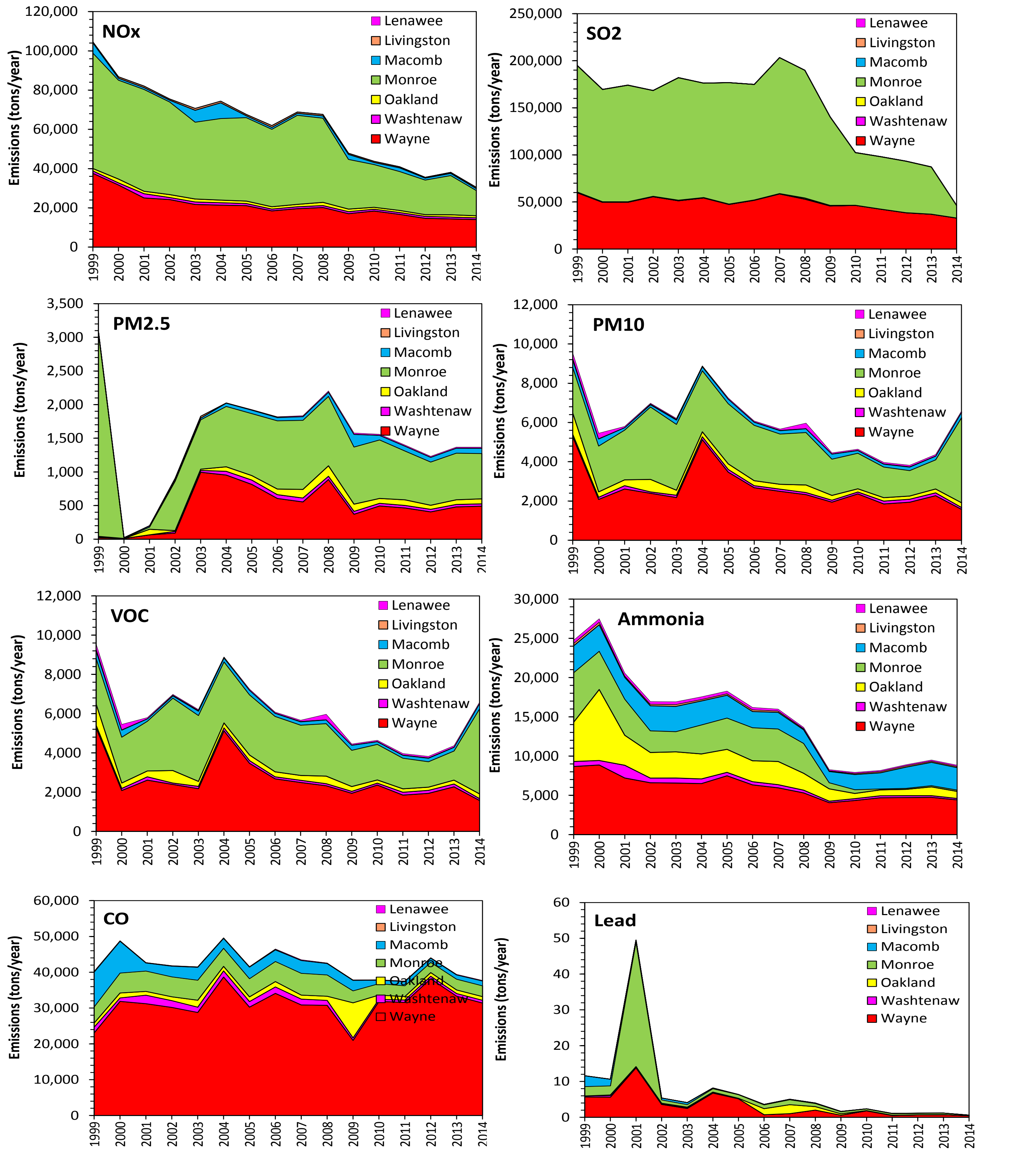
Figure 5-2. Trends of emissions of conventional pollutants from point sources from 1999 to 2014 by county. Based on MAERS data. Trends for $PM_{2.5}$ and PM_{10} are suspect due to methodological issues.



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Emission data for 2010-2014 at the facility level[3] are summarized in Table 5-4. This table lists sources in rough order of emissions for six pollutants (sorted by summing the weighted sum of the six pollutants, using weights that give a similar weight to each pollutant). For each facility, the current representative annual average emissions was estimated. This value was designed to be robust, account for year-to-year variation, and reflect the best estimate of current emissions. The year-to-year variation in reported emissions can be significant, e.g., high or low emission rates may represent ramp-up of production, temporary repairs or other anomalies, or permanent shut-downs. For pollutants other than $PM_{2.5}$, the representative emission estimate was calculated using 2010 to 2014 MAERS data, and the 5-year average if year-to-year variation was small. If the variation was high, the very high or low observations were removed. If the more recent years (2013, 2014) showed significant variation from earlier years, then more recent years were weighted more heavily. For $PM_{2.5}$, due to large discrepancies in the emission data (see Section 5.2.4), a consolidated inventory was developed that incorporated MAERS, NEI, emission factors, and other data; some of revised $PM_{2.5}$ estimates in the consolidated inventory considerably exceeded MAERS figures.

The locations of these sources are shown in maps included in the area-specific sections of this manual.

Table 5-4 also estimates recent emission trends, using the five year period. Trends were calculated if 5 years of data is available for the 2010-2014 period and if a straight-line regression explains at least 50% of the v variance (R^2>0.5). Trends exceeding 15% are noteworthy; small changes are not likely to be meaningful. Increases in the table are shown in pink, and decreases in blue.

Most facilities do not show significant trends over the 5-year period, although a number of facilities have slightly reduced emissions over this period. NO_x shows the most variation, and of the top 100 sources, 21% show reductions that exceed 10% per year for the five year period; only 1 facility increased NO_x emissions by over 10% per year (Eagle Valley Recycle & Disposal Facility in Orion Township increased by about 21% per year.) For $PM_{2.5}$, two facilities in the top 100 increased emissions by more than 10% per year (City of Wyandotte Municipal Power Plant by 61% per year, and Marathon Ashland Petroleum LLC by 97% per year).

Again, as discussed later (Section 5.2.4), PM data in MAERS may not be accurate, and thus PM data in Table 5-4 and elsewhere should be interpreted cautiously.

[3] Facility information is aggregated using the facility's state source number (SRN) assigned by MDEQ.

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Table 5-4A. Point source emissions (tons/yr) of conventional pollutants in the SE Michigan area. Trends from MAERS. Shows 5-year average emissions (filtered to exclude some variations, see text), and rate of change over 5 year period (see text). Note indicates type of variation. 1= one or two low values excluded; 2=one or two high values excluded; 3=based on last two years of data.

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			NOx			SO2			PM2.5			PM10			VOC			CO		
Order	Facility Information	City	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)
1	DETROIT EDISON - MONROE POWER PLANT	MONROE	13,818		-12	47,402	(1)	-22	63.9	(1)		2,999.6	(3)		0.5	(1)	31	2,111		-3
2	ROUGE STEEL COMPANY	DEARBORN	567		-8	700			64.8			356.1			49.7		13	14,844		-8
3	J. R. WHITING PLANT	ERIE	2,274			6,132			366.3			851.2			0.2	(1)		243		
4	NATIONAL STEEL CORPORATION GREAT LAKES	ECORSE	1,522		-15	3,245	(1)	-28	97.7			270.9		-20	54.2	(1)	-42	12,393		
5	TRENTON CHANNEL POWER PLANT	TRENTON	4,409		-12	20,824		-9	22.2			646.3	(3)		1.1	(1)	24	473		3
6	GUARDIAN INDUSTRIES CORP FLOAT GLASS M/	CARLETON	2,061			569			293.3		-4	310.6		-4	59.6			15		
7	DETROIT EDISON RIVER ROUGE POWER PLANT	RIVER ROUGE	3,416			10,443		-10	6.4	(1)		25.1	(1)		3.6		18	380		-6
8	MARATHON ASHLAND PETROLEUM LLC	DETROIT	408			163		24	94.6	(3)	43	94.5			558.9		-10	128		
9	DAIMLERCHRYSLER AG, WARREN TRUCK ASSEI	WARREN	104			1		7	5.5			8.2		18	1,240.4		19	76		9
10	EES COKE BATTERY LLC	RIVER ROUGE	1,193	(1)		2,050	(1)		18.9	(1)		433.5	(3)		200.0	(3)		370	(1)	
11	DEARBORN INDUSTRIAL GENERATION, L.L.C.	DEARBORN	391			622		19	55.8		-9	57.4		-10	3.8		-8	96	(1)	-42
12	FORD MOTOR CO. - ROUGE COMPLEX (ASMBL'	DEARBORN	53			0		2	8.0			18.2		-12	722.2			17		-19
13	JEFFERSON NORTH ASSEMBLY PLANT, DAIMLE	DETROIT	59			0			2.7	(1)	-68	24.3	(1)		587.6	(1)	21	19	(1)	-34
14	RESEARCH & ENGINEERING CENTER	DEARBORN	86			5			5.7			6.0			62.4			1,458		
15	STERLING HEIGHTS ASSEMBLY PLANT, DAIMLE	STERLING HTS	58			0		9	9.8	(1)	35	8.0		29	447.5		7	56		8
16	FORD MOTOR CO. - WAYNE COMPLEX-STMP & .	WAYNE	61			2		-14	3.4			6.0	(1)		412.6			14		-5
17	AUTOALLIANCE INTERNATIONAL, INC.	FLAT ROCK	52		6	0		7	4.4		5	18.4	(1)	38	394.2			10		6
18	GREATER DETROIT RESOURCE RECOVERY FA(	DETROIT	1,162		-13	141			0.2			22.1	(1)	26	6.4	(1)		283		
19	MARBLEHEAD LIME COMPANY - RIVER ROUGE	RIVER ROUGE	553		7	640		15	5.0		7	67.4		9	0.0			72		7
20	GENERAL MOTORS CORPORATION DETROIT -	DETROIT	186	(1)	-13	302			5.1	(1)	-14	5.7	(1)	-25	233.0			74		-12
21	WOODLAND MEADOWS RDF	WAYNE	32			12		4	13.4			69.7			9.4		8	155		
22	NORTH STAR STEEL COMPANY-MICHIGAN DIVIS	MONROE	154			23			2.3	(3)		31.3			30.7			546		
23	PINE TREE ACRES, INC.	LENOX	76			38	(1)	-30	7.7			56.4	(1)	27	24.0	(1)	38	368	(1)	29
24	THE UNIVERSITY OF MICHIGAN	ANN ARBOR	318		4	10	(3)		13.7		5	14.7		5	12.8		2	173		
25	AUTOMATIC TRANSMISSION NEW PRODUCT CE	LIVONIA	49		6	1	(1)	-47	3.3			3.6			24.0			674		
26	CITY OF WYANDOTTE MUNICIPAL POWER PLAN	WYANDOTTE	237	(1)	-50	138	(2)	-34	8.1	(3)	25	12.3			4.1	(3)	63	87	(2)	-34
27	DAIMLERCHRYSLER TECHNOLOGY CENTER	AUBURN HILLS	147			9			10.3			13.0			30.8	(1)		280	(1)	15
28	ARBOR HILLS LANDFILL	NORTHVILLE	99		-5	17	(1)		0.9	(1)		83.0	(1)		9.0	(1)	-25	122		
29	CARLETON FARMS LANDFILL	NEW BOSTON	113		-8	20			0.0	(1)		28.6	(1)		14.5			357		
30	GENERAL MOTORS PONTIAC SITE OPERATION	PONTIAC	134		-5	7		-12	7.0		-13	7.8		-9	7.9	(2)	-49	86		
31	VISTEON CORPORATION STERLING PLANT	STERLING HTS	58			0		4	10.5		14	12.3			32.5			6		14
32	Green Plains Holdings II LLC	RIGA	69			1		-2	9.8		-3	17.8			19.3			14		-2
33	EAGLE VALLEY RECYCLE & DISPOSAL FACILITY	ORION TWP	45	(1)	21	5		8	5.2		-5	29.0	(1)	18	5.4	(1)	25	158	(1)	20
34	ROMEO GAS PROCESSING PLANT	ROMEO	69	(1)		0			5.3			5.3			30.5		-23	88	(1)	
35	ROUSH INDUSTRIES	LIVONIA	53		-12	1	(2)	-28	3.2	(1)	-27	1.6	(2)	-25	27.6	(3)		712	(3)	
36	GENERAL MOTORS CORPORATION - ORION AS	LAKE ORION	58			5	(1)		2.7			10.9	(3)	38	125.2	(1)	27	22		
37	SUMPTER ENERGY ASSOCIATES	LENOX TWP	121			42		8	0.0			8.0			20.3			222		
38	DETROIT WASTEWATER TREATMENT PLANT	DETROIT	281			56			0.1	(3)		4.7			56.1			2	(1)	
39	FORD MOTOR COMPANY - ROMEO ENGINE PLA	ROMEO	11			0		-10	7.0			8.0			42.0		-12	3	(1)	-59
40	FORD MOTOR COMPANY - LIVONIA TRANSMISS	LIVONIA	30			0			8.2			8.2			26.6	(1)		7		
41	HOWELL COMPRESSOR STATION	HOWELL	488			0			0.0			0.0			8.2			15		
42	SAUK TRAIL HILLS DEVELOPMENT, INC.	CANTON TWP	21	(1)		14	(1)		0.8	(1)	-59	24.6			1.6	(1)	-61	42	(1)	
43	FREEDOM COMPRESSOR STATION	MANCHESTER	252			0		8	3.8			3.9			9.7			31		
44	EAGLE INDUSTRIES INC	WIXOM	0			0			0.0			0.0			110.5		12	0		
45	ST. MARYS CEMENT, INC. (U.S.)	DETROIT	5			0			0.0			42.6			0.0			4		
46	SOLUTIA INC.	TRENTON	0			0			0.0			1.5			105.8			0		
47	RIVERVIEW LAND PRESERVE	RIVERVIEW	51	(1)		79	(1)	36	2.1	(3)		20.0		-13	3.9			76	(1)	
48	RAY COMPRESSOR STATION	ARMADA	73			0			1.9	(2)	-25	1.9	(2)	-25	15.4			62		
49	OAKLAND HEIGHTS DEVELOPMENT, INC.	AUBURN HILLS	16		-10	3		-11	4.5		-10	20.1	(1)	28	0.6			26		-10
50	GEORGIA PACIFIC CORP	MILAN	3			0			6.5		-6	13.0		-7	1.5		10	2		

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Table 5-4B. Point source emissions of conventional pollutants (tons/yr) in the SE Michigan area. (continued).

			NOx			SO2			PM2.5			PM10			VOC			CO		
Order	Facility Information	City	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)	5 Year Filtered Ave	Note	Annual Change (%/yr)
51	Shelby Foam Systems, a Division of Magna Seating	SHELBY TWP	0			0			0.0			0.0			99.0			0		
52	WESTPORT LD, INC.	PLYMOUTH TWI	206	(3)		14	(3)		29.0	(3)		29.0	(3)		0.0	(3)		46	(3)	
53	WOODBRIDGE FOAM CORPORATION	ROMULUS	0			0			0.0			0.0			97.2			0		
54	GM TECHNICAL CENTER	WARREN	76			1		9	3.0			5.0			13.3			61		4
55	AJAX MATERIALS CORP	ROMULUS	6			1			3.3			17.2			7.1			29		
56	FORD MOTOR COMPANY-ELM STREET BOILER	DEARBORN	92			0			4.8			4.8			3.5			26		
57	BEACON HEATING PLANT	DETROIT	96	(1)	-30	0	(1)		4.6	(1)		4.6	(1)		3.7	(1)		48	(1)	
58	CONCEPP TECHNOLOGIES	WYANDOTTE	0			0			0.0			2.6			80.7			0		
59	ANGELOS CRUSHED CONCRETE INC	WARREN	5			1			2.8			15.6			6.0			24		
60	WARREN WASTE WATER TREATMENT PLANT	WARREN	17			2			0.5			0.9			39.6			84		
61	SYLVANIA CO LTD PARTNERSHIP	BERLIN TWP	0			0			0.0			31.8		21	0.0			0		
62	Heat Treating Services Corp of America - Plant 1	PONTIAC	6		27	0		27	0.5	(1)		0.5	(1)		17.5	(3)	55	5		27
63	JOHNSON MATTHEY VEHICLE TESTING & DEVE	TAYLOR	3			6		-8	6.0		-8	6.0		-8	1.6			6		
64	FLAT ROCK METAL, INC.	FLAT ROCK	4		10	0		10	4.6		9	4.6		9	17.7		16	3		10
65	WALSH-HIGGINS IRS COMPUTER CTR	DETROIT	0	(1)	-99	0	(1)		0.0	(1)		0.0	(1)	-99	0.0			0	(1)	-99
66	VISTEON CORPORATION MILAN PLANT	MILAN	0	(1)		0	(1)		0.0	(1)		0.0	(1)		0.0	(1)		0	(1)	
67	VIENNA JUNCTION LANDFILL	ERIE	5			0			0.1	(1)		23.5			0.3			17		
68	VENTRA FOWLERVILLE LLC	FOWLERVILLE	4		4	0		4	0.3		4	0.3		4	67.4		16	3		4
69	U S SILICA COMPANY-ROCKWOOD PLANT	ROCKWOOD	5	(1)	20	0	(1)	20	4.6			9.4			0.3	(1)	20	4	(1)	20
70	EDW C LEVY CO PLANT 1	DETROIT	0			0			0.0			12.2	(1)	-44	0.0			0		
71	DETROIT DIESEL CORPORATION	DETROIT	55	(1)	-31	7		-9	2.0		-10	3.0		-8	13.6			32		-8
72	BP - RIVER ROUGE TERMINAL	RIVER ROUGE	0	(3)		0	(3)		0.0	(3)		0.0	(3)		71.2			0	(3)	
73	DAIMLERCHRYSLER TRENTON ENGINE PLANT	TRENTON	19		-3	0	(1)		1.0		-12	7.4		-1	15.0	(1)	40	107	(1)	35
74	DU PONT MT. CLEMENS PLANT	MOUNT CLEMEI	5		20	0	(3)	34	0.4		18	0.6		22	62.7		3	4		18
75	VECTOR PIPELINE LP	HIGHLAND	35		-7	1		-5	4.3		-5	4.3		-5	1.4		-5	15		-10
76	ROMEO RIM, INC.	ROMEO	0			0			0.0			0.0			68.4			0		
77	MARATHON PIPE LINE COMPNAY	WOODHAVEN	0	(1)		0			0.0			0.0			66.9		3	1	(1)	
78	VECTOR PIPELINE L.P.	WASHINGTON	41	(1)	-26	2	(1)		4.0			4.0			1.3			4	(1)	-77
79	WAYNE STATE UNIVERSITY	DETROIT	37		-4	1		14	3.0		-7	3.9			2.2		-6	32		-7
80	VISTEON CORPORATION SALINE PLANT	SALINE	13			0			1.0		7	1.0			44.4			5		
81	WILLIAM BEAUMONT HOSPITAL	ROYAL OAK	38	(1)		0		5	2.5			2.9			2.5	(1)		29	(1)	
82	EASTERN MICHIGAN UNIVERSITY	YPSILANTI	81			1			2.0			2.6			1.2			25		
83	EQ-SITE #2	BELLEVILLE	35	(1)		1			0.0	(1)		9.2			1.2			21		-11
84	DARLING INTERNATIONAL	MELVINDALE	4			1		-14	4.4		-14	3.1	(3)	61	3.2		-14	4		
85	HENKEL SURFACE TECHNOLOGIES	WARREN	1		7	0		8	3.9			3.9			2.8			1		7
86	HEAT TREATING SERVICES CORP	PONTIAC	10			0			3.6		15	3.6		15	1.0		9	8		
87	MICHIGAN AGRICULTURAL COMMODITIES	BLISSFIELD	1	(1)		0	(1)		2.1		2	12.2		2	0.0	(1)		0		
88	MAGNI INDUSTRIES INC	DETROIT	0			0			0.0			6.3		6	34.4		5	0		
89	X-CEL INDUSTRIES INC	SOUTHFIELD	0			0			0.0			0.0			49.6		13	0		
90	GENERAL MOTORS CORP. - MILFORD PROVING	MILFORD	37			1			1.9			2.8			12.6	(3)		23		2
91	FEDERAL-MOGUL TECHNICAL CENTER	PLYMOUTH	16			1			1.3			1.3			1.1			80		5
92	BASF CORPORATION	WYANDOTTE	5			0	(2)	-22	0.0			11.9			16.2			2	(1)	25
93	Global Engine Manufacturing Alliance (GEMA)	DUNDEE	6	(1)		0	(1)		0.1			7.3		11	5.8			71	(1)	
94	Umicore Autocat USA Inc.	AUBURN HILLS	3		-10	1		-7	1.2		-7	1.2		-7	1.0			25	(1)	-72
95	SILBOND CORPORATION	WESTON	3			0			0.1		3	0.1		3	43.1		4	2		3
96	PARKEDALE PHARMACEUTICALS, INC.	ROCHESTER	99		1	1			1.0			1.0			6.5			12		
97	FITZGERALD FINISHING COMPANY	DETROIT	6		10	0		10	0.4		10	0.4		10	36.7		20	5		10
98	ANGELOS CRUSHED CONCRETE INC	ROCHESTER HI	3			0			1.6			8.3			3.4			14		
99	CURTIS METAL FINISHING CO	STERLING HTS	9		4	0		7	0.7		4	0.9		6	32.3			4		
100	LOTUS ENGINEERING, INCORPORATED	ANN ARBOR	7	(2)		0	(1)		0.5	(1)		0.5	(1)		6.8	(3)		124	(1)	

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5.2.3 Toxic pollutants

Releases of toxic pollutants are reported in the Toxic Release Inventory (TRI) database, which contains industry-reported estimate of annual emissions and other data for approximately 594 chemicals and 31 chemical groups. This inventory is separate from MAERS and is not used for most compliance or other regulatory purposes. TRI provides an indication of discharges to air, water, land and off-site transfers. Not all information is consistent, and chemicals and sources have been added over the years, and thus trends must be interpreted cautiously.

Table 5-5 summarizes air emissions in Wayne County by chemical group from 2010 to 2014. Table 5-6 provides a summary by pollutant. Table 5-7 lists of emissions by facility and pollutant category. The ranking of sources in this table was based on the tonnage released as averaged over 2010-2014, which provides only a crude measure of toxicity. The tables include sources releasing more than a few pounds/year of the TRI chemicals over the 2010-2014 period. All source reporting emissions (of at least a few pounds) for this period were included in the table. A number of sources may have been shuttered by the time of this report.

Over the 2010-2014 period, 133 facilities reported toxic emissions in Wayne County in the TRI database. Of these, about 90 facilities had emissions exceeding a few pounds per year. The remainder reported very low emission rates. Of the nearly 600 chemicals listed in the TRI, facilities reported about 90 chemicals in amounts that exceeded 100 lbs/yr. In comparison, MAERS includes a larger number of facilities in Wayne County (about 160 in the study period) that report emissions of conventional pollutants.

Table 5-6 shows that over the 5-year period, releases of acids decreased by about 23% per year. Most of the acids are hydrochloric acid aerosols, and most were released by the DTE Trenton Channel Power Plant, the DTE River Rouge Power Plant, and the Dept. of Municipal Services Power Plant. Emissions of nitrogen compounds increased by about 11% per year; most of these emissions were ammonia, and most arose from US Steel Corp Great Lakes Works, Marathon Petroleum Co LP - Michigan Refining Div., and the EES Coke Battery LLC.

Table 5-5. Summary of TRI emissions (lbs/year) in Wayne County by compound class for 2010 through 2014 from TRI. Shows number of facilities emitting more than 100 lbs/year, 5-year average, and rate of change over 5 year period (see text).

Pollutant	No. Facilities	Emissions by Year (lbs/year)						Trend
Group	>100 lbs/yr	2010	2011	2012	2013	2014	Average	(%/yr)
Acids	24	3,118,877	3,116,265	2,291,049	1,116,278	1,557,573	2,240,050	-22.9
Volatile Organic	146	1,667,892	1,606,954	1,816,728	1,510,531	1,270,963	1,578,108	-
Metals and Metal Compounds	49	89,120	118,454	107,459	84,790	74,299	94,909	-
Nitrogen Componds	18	92,168	100,807	96,265	143,111	136,347	113,740	11.5
Sulfur Compounds	2	28	35	42,298	41,801	38,904	41,001	-
Other	20	406,223	451,495	406,919	487,002	400,923	430,959	-
Total	222	5,374,308	5,394,010	4,760,717	3,383,512	3,479,008	4,498,767	-12.9

Notes: Acids include: Hydrochloric, Sulfuric acid, Nitric acid, Acrylic acid, Formic acid

Nitrogen compounds include: Ammonia (includes Hydrogen cyanide, Nitrate compounds, Sodium nitrite, Diethanolamine, Dimethylamine, and Cyanide compounds

Sulfur compounds include: Hydrogen sulfide, Carbon disulfide

Other includes: Certain glycol ethers, Hydrogen fluoride, Vinyl acetate, Chlorine, Hydroquinone

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Table 5-6A. Emissions of toxics in Wayne County by pollutant and year from TRI. Ranked by tonnage of emissions. Shows number of facilities emitting more than 100 lbs/year, 5-year average, and rate of change over 5 year period (see text).

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Rank by lbs/yr	Pollutant Type	No. Facilities >100 lbs/yr	Emissions by Year (lbs/year) 2010	2011	2012	2013	2014	Average	Trend (%/yr)
1	Hydrochloric acid (acid aerosols ir	13	2,867,653	2,840,441	2,047,655	916,106	1,335,314	2,001,434	-24.9
2	Xylene (mixed isomers)	14	293,572	318,706	481,317	334,919	270,829	339,869	-
3	1,2,4-Trimethylbenzene	10	281,403	291,279	369,514	306,145	228,656	295,399	-
4	Certain glycol ethers	13	269,751	299,650	275,625	310,384	293,523	289,787	-
5	Sulfuric acid (acid aerosols includ	3	246,895	270,759	238,639	193,734	212,071	232,420	-6.3
6	n-Butyl alcohol	9	283,263	205,759	249,821	235,750	166,008	228,120	-9.0
7	Hydrogen fluoride	4	118,187	135,493	114,327	160,209	87,259	123,095	-
8	Benzene	7	134,847	135,993	100,412	104,966	121,998	119,643	-
9	Ethylene	3	135,434	113,385	89,377	98,953	106,513	108,732	-
10	Methanol	13	97,379	115,178	130,086	67,089	70,084	95,963	-
11	Toluene	16	84,301	90,604	77,831	77,863	79,702	82,060	-
12	Ammonia (includes anhydrous ar	5	86,160	64,978	63,955	100,465	81,491	79,410	-
13	Zinc compounds	10	67,454	96,942	87,756	60,832	53,979	73,392	-
14	Ethylbenzene	7	50,696	54,687	91,437	58,330	47,462	60,522	-
15	Propylene (Propene)	2	96,731	58,163	23,877	45,128	47,190	54,218	-
16	Methyl isobutyl ketone	5	46,968	35,608	31,390	70,049	36,708	44,145	-
17	n-Hexane	8	49,357	54,904	40,102	30,735	17,481	38,516	-22.8
18	Hydrogen sulfide	2	-	-	42,262	41,773	38,874	40,970	-
19	Hydrogen cyanide	1	900	30,001	26,473	30,603	31,624	23,920	25.9
20	Vinyl acetate	1	16,977	15,651	16,195	15,649	19,377	16,770	-
21	Cyclohexane	2	17,519	16,175	17,823	8,890	12,003	14,482	-12.6
22	Acetaldehyde	1	11,587	12,324	13,452	11,044	11,815	12,044	-
23	Naphthalene	5	8,399	9,212	25,179	9,540	5,323	11,530	-
24	Formaldehyde	3	6,414	7,485	20,384	11,402	9,833	11,104	-
25	Chloromethane (Methyl chloride)	1	-	14,807	10,804	10,647	10,626	11,721	-
26	Dichloromethane (Methylene chlor	3	23,235	15,995	3,523	2,749	750	9,250	-62.9
27	N-Methyl-2-pyrrolidone	4	9,875	24,620	3,479	3,238	3,462	8,935	-
28	Butyraldehyde	1	9,221	10,337	8,515	8,255	8,009	8,867	-5.1
29	Nitric acid	5	3,829	4,535	4,470	5,408	9,749	5,598	22.7
30	Nitrate compounds (water dissoci	3	78	343	760	7,606	18,632	5,484	80.9
31	Manganese compounds	8	4,486	4,622	6,190	5,495	4,669	5,093	-
32	Styrene	2	2,438	4,694	4,110	6,848	6,867	4,991	22.1
33	Sodium nitrite	4	4,426	4,575	4,613	3,827	4,055	4,299	-
34	Phenol	4	11,389	1,851	1,734	1,823	2,486	3,857	-
35	Barium compounds (except for ba	3	4,285	3,417	2,668	4,152	2,042	3,313	-
36	Cumene	2	1,560	3,214	9,789	53	1,141	3,151	-
37	Trichlorofluoromethane (CFC-11)	1	2,174	1,994	2,810	2,208	3,463	2,530	11.0
38	1,3-Butadiene	1	1,992	3,820	333	2,387	2,171	2,141	-
39	Methyl methacrylate	1	1,650	1,550	1,450	2,710	1,447	1,761	-
40	Aluminum (fume or dust)	1	1,608	1,624	1,824	1,740	1,740	1,707	-
41	Propylene oxide	1	1,000	1,000	5,050	542	588	1,636	-
42	Diisocyanates (includes 20 specif	1	1,042	1,679	1,067	1,422	1,497	1,342	-
43	Lead compounds	4	1,134	1,408	1,404	1,499	910	1,271	-
44	Nickel	2	1,820	1,529	242	283	261	827	-52.8
45	Copper compounds (this category	3	717	708	750	762	917	771	5.9

continued

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Table 5-6B. Emissions of toxics in Wayne County by pollutant and year from TRI. Continued.

Rank by lbs/yr	Pollutant Type	No. Facilities >100 lbs/yr	2010	2011	2012	2013	2014	Average	Trend (%/yr)
46	Chlorine	1	750	701	772	760	764	749	-
47	Chromium compounds (except fo	3	609	591	1,099	448	646	679	-
48	Ethylene glycol	3	879	824	355	484	438	596	-20.5
49	Ethylene oxide	1	500	500	1,350	79	175	521	-
50	Zinc (fume or dust)	1	500	500	500	507	507	503	0.4
51	Copper	4	509	74	12	945	953	499	-
52	Acrylic acid	2	500	500	255	775	439	494	-
53	Ethyl acrylate	1	500	500	500	590	310	480	-
54	Acrylonitrile	1	500	500	500	336	403	448	-8.0
55	Mercury compounds	2	392	450	514	432	414	440	-
56	Nickel compounds	3	473	526	541	328	296	433	-12.7
57	Manganese	1	1,468	155	157	165	149	419	-62.8
58	Butyl acrylate	1	500	500	500	367	202	414	-17.6
59	Diethanolamine	3	397	703	277	298	375	410	-
60	Polycyclic aromatic compounds (i	1	484	512	435	426	180	407	-17.1
61	Vanadium compounds	1	412	395	293	306	249	331	-12.5
62	tert-Butyl alcohol	1	500	500	500	71	82	331	-38.3
63	Phthalic anhydride	1	1,000	500	-	-	-	750	-
64	Phenanthrene	1	651	672	1	1	161	297	-55.6
65	sec-Butyl alcohol	1	255	255	503	175	173	272	-
66	4,4'-Isopropylidenediphenol	2	-	-	-	615	661	638	-
67	Arsenic compounds	1	446	459	124	117	98	249	-41.7
68	Toluene diisocyanate (mixed isom	1	292	341	342	34	165	235	-
69	Selenium compounds	1	529	545	3	3	3	217	-73.6
70	Dimethylamine	1	197	197	177	187	167	185	-3.8
71	Chromium	1	-	-	263	265	104	211	-
72	Antimony compounds	1	271	271	24	23	20	122	-61.5
73	Hydroquinone	1	559	-	-	-	-	559	-
74	Lead (when lead is contained in st	0	135	93	49	51	97	85	-
75	Formic acid	1	-	30	30	255	-	105	-
76	Methyl tert-butyl ether	1	59	25	65	58	107	63	-
77	Chloroform	1	-	250	-	-	-	250	-
78	Barium	0	42	42	34	36	24	36	-11.8
79	Cyanide compounds	1	10	10	10	125	3	32	-
80	Carbon disulfide	0	28	35	36	28	30	31	-
81	Anthracene	1	139				-	35	-
82	Tetrachloroethylene (Perchloroeth	0	16	16	22	10	15	16	-
83	m-Xylene	0	-	69	-	-	-	69	-
84	p-Xylene	0	-	69	-	-	-	69	-
85	3-Iodo-2-propynyl butylcarbamate	0	58	-	-	-	-	58	-
86	Molybdenum trioxide	0	-	-	18	23	-	21	-
87	Benzo(g,h,i)perylene	0	7	4	5	13	5	7	-
88	Dibenzofuran	0	25	4	4	1	-	9	-
89	Di(2-ethylhexyl) phthalate (DEHP)	0	10	2	-	13	4	7	-
90	Polychlorinated biphenyls (PCBs)	0	4	8	5	8	2	5	-

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Table 5-7A. Emissions of toxics (lbs/year) by facility in Wayne County by pollutant type. Average over 2010-2014. Categories are defined in Table 4. Ranked by total TRI emissions.

Facility Rank, Name and Address				TRI Emissions by Chemical Class (lbs/year)					
Rank	FACILITY_NAME	STREET_ADDRESS	CITY_NAME	Acids	Volatile Organic Compounds	Metals and Metal Compounds	Nitrogen Componds	Sulfur Compounds	Other
1	DTE ELECTRIC CO - TRENTON CHANNEL POWER PLANT	4695 W JEFFERSON AVE	TRENTON	699,000	64	581	0	0	65,200
2	DTE ELECTRIC COMPANY- RIVER ROUGE POWER PLANT	1 BELANGER PARK DR	RIVER ROUGE	268,400	51	186	0	0	57,600
3	DEPARTMENT OF MUNICIPAL SERVICES-POWER PLANT	2555 VAN ALSTYNE	WYANDOTTE	81,001	0	62	0	0	0
4	FORD MOTOR CO DEARBORN TRUCK PLANT	3001 MILLER RD	DEARBORN	72	37,269	24	124	0	135,526
5	GENERAL MOTORS GM VA DETROIT-HAMTRAMCK ASSEI	2500 E GENERAL MOTORS	DETROIT	52,600	17,381	362	0	0	3,397
6	SOUTHWIN - LIVONIA PLANT	11800 SEARS DR	LIVONIA	0	12,885	0	0	0	0
7	CARMEUSE LIME INC RIVER ROUGE FACILITY	25 MARION AVE	RIVER ROUGE	51,185	153	2	0	0	0
8	EES COKE BATTERY LLC	1400 ZUG ISLAND	RIVER ROUGE	41,754	13,500	24	14,246	15,740	0
9	FCA US JEFFERSON NORTH ASSEMBLY PLANT	2101 CONNOR AVE	DETROIT	15	8,933	236	3	0	89,580
10	SOLUTIA INC	5100 W JEFFERSON AVE	TRENTON	0	10,456	0	0	0	16,770
11	MARATHON PETROLEUM CO LP - MICHIGAN REFINING DI	1300 S FORT ST HES DEP	DETROIT	9,759	12,763	101	15,484	7,513	21
12	US STEEL CORP GREAT LAKES WORKS	1 QUALITY DR	ECORSE	1,342	33,537	4,075	13,214	0	0
13	FORD MOTOR CO MICHIGAN ASSEMBLY PLANT	38303 MICHIGAN AVE	WAYNE	0	14,890	24	0	0	11,522
14	FLAT ROCK ASSEMBLY PLANT	1 INTERNATIONAL DR	FLAT ROCK	10	10,592	33	2	0	11,978
15	DETROIT TUBULAR RIVET	1213 GROVE	WYANDOTTE	0	12,484	0	0	0	0
16	FORD MOTOR COMPANY-WAYNE ASSEMBLY	37625 MICHIGAN AVE	WAYNE	0	7,288	5	0	0	5,563
17	FITZGERALD FINISHING LLC	17450 FILER AVE	DETROIT	3,064	9,433	0	0	0	0
18	AK STEEL DEARBORN WORKS	4001 MILLER RD	DEARBORN	15,448	67	4,375	0	0	0
19	RED SPOT PAINT & VARNISH CO INC	550 S EDWIN ST	WESTLAND	0	1,473	0	0	0	3,908
20	AJAX METAL PROCESSING INC	4651 BELLEVUE AVE	DETROIT	268	7,376	0	0	0	13,595
21	FINTEX LLC	8900 INKSTER RD	ROMULUS	0	7,168	0	0	0	0
22	NEW BOSTON RTM INC	19155 SHOOK RD	NEW BOSTON	0	2,767	0	0	0	0
23	APPLIED PROCESS INC	12238 NEWBURGH RD	LIVONIA	0	0	0	3,447	0	0
24	3M CO-DETROIT	11900 E 8 MILE RD	DETROIT	0	1,583	0	0	0	0
25	DETROIT DIESEL CORP REDFORD FACILITY	13400 OUTER DR W	DETROIT	0	384	0	0	0	12,630
26	CADON PLATING CO	3715 11TH ST	WYANDOTTE	11	0	0	0	0	6,162
27	DOUBLE EAGLE STEEL COATING CO	3000 MILLER RD	DEARBORN	4,480	0	2	0	0	0
28	MAGNI INDUSTRIES INC	2771 HAMMOND	DETROIT	0	1,994	719	0	0	0
29	DIFCO LABORATORIES INC	920 HENRY ST	DETROIT	0	1,227	0	0	0	0
30	EQ DETROIT INC	1923 FREDERICK	DETROIT	1,319	1,220	3	1,650	0	1,691
31	MARATHON PIPE LINE LLC WOODHAVEN TERMINAL	24400 ALLEN RD	WOODHAVEN	0	893	0	0	0	0
32	ASH STEVENS INC	18655 KRAUSE ST	RIVERVIEW	0	800	0	0	0	0
33	DURCON INC	8464 RONDA DR	CANTON	0	750	0	0	0	0
34	FRITZ PRODUCTS	255 MARION	RIVER ROUGE	14,813	0	0	0	0	721
35	BASF CORP	1609 BIDDLE AVE	WYANDOTTE	445	730	25	1,997	0	8
36	MCGEAN-ROHCO INC	38521 SCHOOLCRAFT AVE	LIVONIA	39	1,873	0	13	0	0
37	V&S DETROIT GALVANIZING LLC	12600 ARNOLD ST	REDFORD	0	0	600	0	0	0
38	AIR PRODUCTS & CHEMICALS INC/DETROIT HYDROGEN I	1025 OAKWOOD BLVD	DETROIT	0	55	0	3,078	0	0
39	CYGNET AUTOMATED CLEANING LLC	45889 MAST ST	PLYMOUTH	0	410	0	0	0	0
40	Z TECHNOLOGIES CORP	26500 CAPITOL AVE	REDFORD	0	416	0	15	0	25
41	ALCO PRODUCTS LLC	580 ST JEAN ST	DETROIT	0	328	0	0	0	0
42	TOWER AUTOMOTIVE PLYMOUTH	43955 PLYMOUTH OAKS BI	PLYMOUTH	0	0	311	0	0	0
43	MARATHON PETROLEUM CO - ROMULUS MI TERMINAL	28001 CITRON DR	ROMULUS	0	376	0	0	0	0
44	INTERNATIONAL PRECAST SOLUTIONS LLC	60 HALTINER AVE	RIVER ROUGE	284	0	0	0	0	0
45	BP PRODUCTS NA INC RIVER ROUGE TERMINAL	205 MARION ST	RIVER ROUGE	0	361	0	0	0	0

continued

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Table 5-7B. Emissions of toxics (lbs/year) by facility in Wayne County by pollutant type. Continued.

Facility Rank, Name and Address				TRI Emissions by Chemical Class (lbs/year)					
Rank	FACILITY_NAME	STREET_ADDRESS	CITY_NAME	Acids	Volatile Organic Compounds	Metals and Metal Compounds	Nitrogen Componds	Sulfur Compounds	Other
46	ARCO ALLOYS CORP	1891 TROMBLY	DETROIT	0	0	250	0	0	0
47	CUL-MAC INDUSTRIES INC	3720 S VENOY RD	WAYNE	0	500	0	0	0	0
48	WOODBRIDGE CORP	15573 OAKWOOD DR	ROMULUS	0	176	0	261	0	0
49	HOUGHTON INTERNATIONAL INC	9100 FREELAND AVE	DETROIT	0	0	0	0	0	1,073
50	FAURECIA EMISSIONS CONTROL TECHNOLOGIES	24850 NORTHLINE RD	TAYLOR	0	0	207	0	0	0
51	PARK METALLURGICAL CORP	8074 MILITARY AVE	DETROIT	0	0	24	533	0	0
52	EQ RESOURCE RECOVERY INC	36345 VAN BORN RD	ROMULUS	0	191	0	0	0	0
53	UNIVAR USA INC ROMULUS BRANCH	13395 HURON RIVER DR	ROMULUS	0	166	0	0	0	65
54	CHEMETALL US INC	13177 HURON RIVER DR	ROMULUS	250	4	55	189	0	127
55	EDW C LEVY CO - PLANT 3	100 WESTFIELD	ECORSE	0	0	127	0	0	0
56	POLYCHEMIE INC	38070 VAN BORN RD	WAYNE	0	135	0	185	0	0
57	EDW C LEVY CO - PLANT 6	13800 MELLON	DETROIT	0	0	109	0	0	0
58	INLAND WATERS POLLUTION CONTROL DETROIT FACILIT	4086 MICHIGAN AVE	DETROIT	0	89	0	0	0	0
59	AMERICAN JETWAY CORP	34136 MYRTLE	WAYNE	0	76	0	0	0	103
60	EFTEC NORTH AMERICAS LLC	20219 NORTHLINE RD	TAYLOR	0	1	127	0	0	0
61	ALPHA RESINS LLC	17350 RYAN RD	DETROIT	0	49	0	0	0	20
62	MT ELLIOTT TOOL & DIE MANUFACTURING	3675 E OUTER DR	DETROIT	0	0	46	0	0	0
63	FORD MOTOR CO - LIVONIA TRANSMISSION PLANT	36200 PLYMOUTH RD	LIVONIA	0	0	63	0	0	0
64	WINDSOR MACHINE & STAMPING (US) LTD	26655 NORTHLINE RD	TAYLOR	0	0	2	83	0	0
65	FORD MOTOR CO WOODHAVEN STAMPING PLANT	20900 W RD	WOODHAVEN	0	0	39	0	0	0
66	PVS NOLWOOD CHEMICALS INC	9000 HUBBELL AVE	DETROIT	163	8	10	8	0	29
67	SUPERIOR MATERIALS 32	8911 W JEFFERSON	DETROIT	0	56	0	0	0	0
68	PVS TECHNOLOGIES INC	10825 HARPER AVE	DETROIT	0	0	0	0	0	28
69	DETROIT AXLE PLANT	6700 LYNCH RD	DETROIT	0	0	7	0	0	0
70	PLASTOMER CORP	37819 SCHOOLCRAFT RD	LIVONIA	0	24	0	0	0	0
71	FORD MOTOR CO DEARBORN ENGINE PLANT	3001 MILLER RD	DEARBORN	0	22	16	8	0	0
72	ST MARY'S CEMENT INC	9333 DEARBORN ST	DETROIT	0	0	17	0	0	0
73	FORD MOTOR CO DEARBORN TOOL & DIE PLANT	3001 MILLER RD	DEARBORN	0	20	0	0	0	12
74	FORD MOTOR CO DEARBORN STAMPING PLANT	3001 MILLER RD	DEARBORN	0	7	14	0	0	0
75	WAYNE DISPOSAL INC	49350 N I-94 SERVICE DR	BELLEVILLE	125	15	2	49	0	64
76	FORD MOTOR CO DEARBORN DIVERSIFIED MANUFACTU	3001 MILLER RD	DEARBORN	3	18	10	0	0	7
77	FORD MOTOR CO WAYNE INTEGRAL STAMPING	37500 VAN BORN	WAYNE	0	19	3	0	0	15
78	KREHER WIRE PROCESSING	34822 GODDARD RD	ROMULUS	8	8	0	0	0	0
79	NORTHFIELD	36506 SIBLEY RD	NEW BOSTON	0	12	0	0	0	0
80	CONCEPP TECHNOLOGIES INC	1609 BIDDLE AVE (PART O	WYANDOTTE	10	0	0	4	0	0
81	DYNAMIC SURFACE TECHNOLOGIES INT INC	7784 RONDA DR	CANTON	0	0	0	7	0	0
82	FORD MOTOR CO WOODHAVEN FORGING PLANT	24189 ALLEN RD	WOODHAVEN	0	0	6	0	0	0
83	UNISTRUT INTERNATIONAL CORP	4205 ELIZABETH ST	WAYNE	0	0	3	0	0	0
84	DCI AEROTECH	7515 LYNDON	DETROIT	0	0	0	7	0	0
85	MICHIGAN DAIRY	29601 INDUSTRIAL RD	LIVONIA	7	0	0	0	0	0
86	BORGWARNER POWDERED METALS INC	32059 SCHOOLCRAFT	LIVONIA	0	0	3	0	0	0
87	SAFETY-KLEEN SYSTEMS ROMULUS (ROM)	10480 HARRISON RD	ROMULUS	0	5	0	0	0	0
88	CADILLAC OIL CO	13650 HELEN	DETROIT	0	3	0	2	0	0
89	CANTON MANUFACTURING CORP	7295 HAGGERTY RD	CANTON	0	0	2	0	0	0
90	POOF-SLINKY INC	45605 HELM ST	PLYMOUTH	0	2	0	0	0	0

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5.2.4 Emission data accuracy

While often technically feasible, very few facilities actually use continuous measurements of emissions. Only the large coal fired power plants have continuous emission monitoring systems (CEMS) for NO_x, CO, and SO_2 and opacity, a surrogate for PM. In most cases, emissions are estimated using a variety of means, e.g., emission factor calculations or fuel sulfur content.

In general, for NO_x and SO_2, emission estimates appear reliable, as seen by agreement between facility emissions listed in MAERS, the FOIA request data, and NEI emissions for the NEI years.

For PM, emission estimates have considerable uncertainty, and much of the data reported are not believed to be accurate. Several issues limit comparisons and potentially represent large discrepancies among PM emission estimates. For example, in many cases MAERS shows that filterable $PM_{2.5}$ emissions exceed primary $PM_{2.5}$ emissions, anomaly because, by definition, primary $PM_{2.5}$ is the sum of filterable $PM_{2.5}$ and condensable PM. As noted, PM emissions at the stack or facility level are rarely measured. The large coal-fired power plants do measure opacity, which is related to PM emissions, but these data are not typically used to estimate PM emissions (but rather are used to verify operation of the emission control systems.)

As an example of discrepancies, Table 5-8 assembles PM estimates for the recent Permit to Install application filed by MDEQ and DTE in March, 2016 for the Trenton Channel Power Plant, a large coal-fired facility with significant emissions of PM, NO_x and SO_2. Considering only Boiler 9A at this facility, and using the most recent test of PM emissions identified at this facility (12/12/2002) and the 2-year average heat rate, PM emissions are an estimated 356.9 tons/year: this represents an average "actual" emission rate. By comparison, MAERS give only 15 tons/year, and the NEI 2011 gives 210 tons/year. The estimate of 356.9 tons/year may be most accurate, but again, there are few measurements available, and thus uncertainty is considerable.

Emission data reported in Table 5-3 earlier in this report used a series of checks to provide "best" estimates; these estimates incorporated the data sources listed in Table 5-1, and they utilized a number of quality checks and revisions.

Emissions inventory data discussed later for mobile and non-point sources (Sections 5.3 and 5.4) also have large uncertainties; these are very difficult to quantify. No formal analysis of the uncertainty of these data has been performed.

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Table 5-8. PM emission estimates for the Trenton Channel power plant showing variation among estimates and emissions inventories.

Type	Factor	Unit	Basis	Unit	Annual Average		notes 1, 2
Maximum	0.0248	lb / MMBTU	Compliance test on 7/19/12, filterable + condensible	Boiler 9A	492.1	PM ton/yr	note 1
	0.0300	lb / MMBTU	from above with MATS	Boiler 9A	595.2	PM ton/yr	note 1
	0.0270	lb PM/1000 lbs	Compliance plan on 12/12/02	Boiler 9A	769.6	PM ton/yr	note 8
	0.0314	lb / MMBTU	Compliance test on 7/19/12, scaled	Boilers 16-19	415.9	PM ton/yr	notes 1, 2
125-11C Permit Limi	0.15	lbs PM per 1000 lbs exhaust gas using test protocol		Boiler 9A	42.8	PM ton/yr	note 3
"Actuals"	MAERS average 2010-2014			Boiler 9A	15.0	PM ton/yr	note 2
	MAERS average 2010-2014			Boilers 16-19	7.2	PM ton/yr	note 2
	National Emission Inventoryfor 2008			Boilers 9A, 16-19	749.7	PM ton/yr	note 4
	National Emission Inventoryfor 2011			Boilers 9A, 16-19	210.6	PM ton/yr	note 4
	Permit 125-11C, "Creditable Decreases due to shutdown of high side boilers			Boilers 16-19	158.6	PM ton/yr	note 5
	Compliance test, scaled, with estimated 5 year average heat rate			Boilers 16-19	158.0	PM ton/yr	note 6
	Compliance test (7/19/12) and 2 year average heat rate			Boiler 9A	356.9	PM ton/yr	note 7

note 1: Based on Rated Heat Capacity - Boiler 9A of 4,530 MMBTU/hr, Boilers 16-19 of 3,012 MMBTU/hr collectively. Emission factor from RTP Environmental Associates Inc., Air Pollution Control Permit to Install Application, MATS Compliance, Trenton Channel Power Plant, Oct. 27, 2014

note 2: Scaled up emission factor by PM ratio in permit 11-125 for boilers 16-19 compared to boiler 9A

note 3: Volumetric flow based on eq. 8 in MDEQ 2004, Calculating Air Emissions for the Michigan Air Emissions Reporting System (volumetric flow of 6,507,682 lb/hr sat air for Boiler 9A and 4,341,764 lb/hr sat air for Boilers 16-19, collectively) and bitum coal, saturated air density of 0.07344 lb/cf, and 99% removal by the electrostatic precipitator.

note 4: Combines all boilers at facility

note 5: Based on 125-11C Public Participation Document, Table 2, Net emission changes.

note 6: Uses scaled emission factor (note 2) with estimated heat rate, based on scaling (note 7) using average of 2010-2014 SO_2 emissions at Boiler 9A and Boilers 16-19, and assuming same coal source.

note 7: Uses compliance test (note 1) and average heat rate in DTE Trenton Channel MATS assessment of 28,781,800 BTU/yr.

note 8: Uses compliance test for EP plan and maximum volumetric flow in note 3

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5.3 Mobile sources – on road

This section examines mobile on-road emissions, which result from cars and trucks driven on roads, and considers exhaust emissions, brake wear, tire wear, and running losses (e.g., evaporation of fuel). Entrained dust and other emissions are discussed in Section 5.4.

On road emissions from NEI are summarized by county in Table 5-9. These emissions result from all types of vehicles traveling on roads, e.g., motorcycles, passenger cars, light duty trucks, buses, medium duty trucks, and heavy duty diesel vehicles. On-road emissions represent over half of total emissions (considering point and area sources) of CO and NO_x (Table 5-9). They represent 27% of VOC emissions, 15% of $PM_{2.5}$ emissions, but only 0.4% of SO_2 emissions. SO_2 emissions will decline further in 2016 with the implementation of the Tier 3 fuel standards that will reduce fuel sulfur content to 10 ppm.

Table 5-9. On-road mobile source emission estimates by county. From NEI 2011. % of total emissions shows fraction of total emission in the NEI inventory for the 7-county area.

	Emissions (tons/year)								
Pollutant	Lenawee	Livingston	Macomb	Monroe	Oakland	Washtenaw	Wayne	Total	% of Total Emissions
PM2.5	109	150	458	128	875	259	1,098	3,077	14.6
PM10	164	279	839	239	1,615	481	2,035	5,651	8.3
SO2	9	21	64	18	124	37	156	430	0.4
CO	12,844	18,001	61,955	15,087	107,527	29,608	129,647	374,668	56.5
Nox	2,659	4,062	12,634	3,476	23,694	6,956	29,767	83,248	50.1
VOC	1,493	1,819	6,665	1,514	11,095	2,953	13,193	38,732	26.7

Diesel emissions

Most on-road $PM_{2.5}$ emissions arise from diesel vehicles, and heavy duty diesel vehicles in particular. Diesel exhaust emissions of $PM_{2.5}$ are of considerable interest given its toxicity. Based on NEI 2011 data, across the 7-county area, on-road diesel emission of $PM_{2.5}$ total 2,074 tons/year; $PM_{2.5}$ emissions from gasoline-powered vehicles, which are much more numerous, represent about half as much $PM_{2.5}$ (1,002 tons/yr in the 7 counties). Most on-road $PM_{2.5}$ emissions in the 7-county area arise in Wayne and Oakland Counties (Table 5-11).

As described in the next section, on-road vehicles cause additional $PM_{2.5}$ emissions that include windblown dust (silt) on roads, and pavement wear. These emissions total 2,432 tons/year, comparable to the diesel-related fraction of on-road exhaust emissions. (Most of the PM emissions from wind-blown dust are actually PM_{10}, but $PM_{2.5}$ is estimated to constitute about one-third of the total.)

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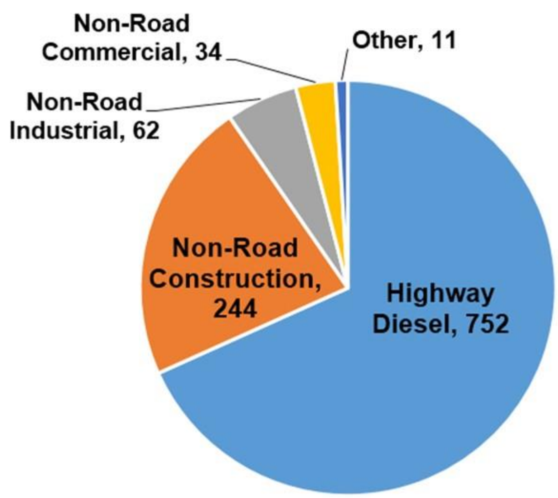
An apportionment of diesel-related emissions for Wayne County is shown in Figure 5-3. (Additional detail is provided in Table 5-11 for each county). On-road emissions of diesel exhaust emissions total 725 tons/yr, compared to 1,098 tons per year for all on-road emissions in the county. Off-road diesel equipment and vehicles contributes an additional 401 tons/yr. As further described in the next section, on-road vehicles cause additional emissions of windblown dust (silt) on roads, and pavement wear. In Wayne County, vehicle-associated emissions of $PM_{2.5}$ as dust, silt and road wear are estimated to be 573 tons/yr. However, these emissions are highly uncertain, as they depend on many variable factors, such as road condition, silt loading, and weather.

Emission estimates were also derived using our Detroit on-road link-based (by road) emissions inventory, which covered about 33% of Wayne County by area and 2,205 km compared to 4,134 km of roads in Wayne County (freeways, arterials, and collectors, not minor roads). In the inventory, $PM_{2.5}$ totaled 472 tons/year, representing about half of that shown in Table 5-9. Most of these emissions were due to heavy-duty diesel trucks, and most occurred on the largest roads. For Detroit, our detailed emission inventory indicates that $PM_{2.5}$ emissions occur primarily on freeways (43% of total $PM_{2.5}$ exhaust emissions), other principal arterials (31%), and the balance on smaller arterials, collectors and minor roads. This emphasizes the importance of major roads, especially major roads with extensive truck traffic, for $PM_{2.5}$ emissions.

Figure 5-3. Apportionment of diesel-related emissions in Wayne County. Tons per year shown. Highway diesel includes exhaust (725 ton/yr), brake wear (22 ton/yr), and tire wear (5 ton/yr). Derived from NEI 2011.



5.4 Area and non-road mobile sources

This section summarizes other pollution sources, called "non-point" and "area" sources, e.g., emissions occurring at smaller facilities. Area sources also include entrained dust (from waste piles, roads, etc.), natural sources (pollen), residential fuel combustion, construction, and forest fires.

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Table 5-10 summarizes emissions estimates from area sources and non-road mobile sources at the county level for CO, PM_{10}, $PM_{2.5}$, SO_2, NO_x, and VOCs, data derived from the NEI 2011. This national level database estimates emissions using many data types and sources, e.g., activity (e.g., extent of unpaved surfaces), emission factors, meteorology (precipitation), and population (density, city size). Emissions from on-road and point sources, discussed in previous sections, are also shown in the table (with a blue background).

Some key results for the pollutants emphasized in this Resource Manual are noted below.

- $PM_{2.5}$. As noted earlier, the most important sources of $PM_{2.5}$ are related to non-road mobile sources (1,182 tons/yr in Wayne County). These include large contributions from off-road vehicles, vehicles on paved roads, and emissions from unpaved roads. As noted above, vehicles also have sizable on-road emissions, particularly diesel exhaust from heavy duty vehicles.

  Unpaved roads can emit significant amounts of $PM_{2.5}$, especially in rural counties, e.g., Monroe county emissions from unpaved roads is several times larger than that from paved roads. These emissions in Wayne Country are small, however. Most of these emissions are PM_{10}, but a sizable fraction is $PM_{2.5}$.

- SO_2. Emissions are small compared to point sources (commercial, industrial and residential sources totaled only 1,101 tons/yr).
- CO. Most CO emissions come from mobile sources, particularly off-highway gasoline vehicles (e.g., construction equipment).
- VOCs. Area source emissions of VOCs are large collectively, in part due to releases from fuel distribution and storage losses.

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Table 5-10A. Annual emission estimates (tons/year) from area, point and mobile sources by county. From NEI, 2011.

Pollutant	Source Group	Lenawee	Livingston	Macomb	Monroe	Oakland	Washtenaw	Wayne	Grand Total
PM2.5	**Total**	**2,271**	**1,428**	**2,565**	**2,751**	**4,210**	**2,776**	**5,131**	**21,133**
	Industrial Processes	33	87	282	57	724	152	489	1,823
	Miscellaneous Area Sources	993	116	130	599	39	293	27	2,197
	Mobile Sources	519	651	551	589	1,155	672	689	4,825
	Stationary Source Fuel Combustion	412	159	735	202	772	1,136	725	4,142
	Waste Disposal, Treatment, and Recovery	96	153	0	106	0	0	0	355
	Non-road mobile	72	95	269	97	491	199	493	1,715
	On-road	109	150	458	128	875	259	1,098	3,077
	Point	37	17	140	975	154	67	1,610	2,999
PM10	**Total**	**10,241**	**7,348**	**6,740**	**10,438**	**14,181**	**9,060**	**10,085**	**68,094**
	Industrial Processes	128	528	830	248	3,734	462	836	6,765
	Miscellaneous Area Sources	4,966	581	648	2,994	194	1,464	132	10,979
	Mobile Sources	4,317	5,505	3,223	4,788	7,114	5,151	3,241	33,340
	Stationary Source Fuel Combustion	415	162	754	207	817	1,145	770	4,271
	Waste Disposal, Treatment, and Recovery	106	175	0	117	0	0	0	398
	Non-road mobile	75	100	282	101	516	208	515	1,797
	On-road	164	279	839	239	1,615	481	2,035	5,651
	Point	70	19	165	1,744	190	149	2,557	4,893
SO2	**Total**	**66**	**68**	**349**	**55,706**	**532**	**188**	**43,266**	**100,176**
	Industrial Processes	2	0	0	0	0	0	0	2
	Miscellaneous Area Sources	0	0	0	0	1	0	1	2
	Mobile Sources	1	1	1	9	2	1	131	145
	Stationary Source Fuel Combustion	34	38	178	49	344	96	363	1,101
	Waste Disposal, Treatment, and Recovery	3	3	0	3	0	0	0	9
	Non-road mobile	2	3	11	3	16	6	20	61
	On-road	9	21	64	18	124	37	156	430
	Point	15	1	95	55,623	46	48	42,596	98,424
CO	**Total**	**21,584**	**29,862**	**106,479**	**30,844**	**181,357**	**54,569**	**238,788**	**663,483**
	Industrial Processes	28	37	98	15	176	57	194	604
	Miscellaneous Area Sources	0	0	0	0	0	0	0	0
	Mobile Sources	20	12	14	84	23	10	107	270
	Natural Sources	943	741	501	718	876	879	642	5,300
	Stationary Source Fuel Combustion	2,835	1,219	5,807	1,587	6,346	8,098	6,347	32,238
	Waste Disposal, Treatment, and Recovery	297	752	9	327	5	0	27	1,416
	Non-road mobile	4,485	8,841	36,948	9,829	65,021	15,073	65,491	205,688
	On-road	12,844	18,001	61,955	15,087	107,527	29,608	129,647	374,668
	Point	132	259	1,147	3,198	1,382	845	36,335	43,298

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Table 5-10B. Annual emission estimates (tons/year) from area sources by county. Continued

Pollutant	Source Group	Lenawee	Livingston	Macomb	Monroe	Oakland	Washtenaw	Wayne	Grand Total
Nox	**Total**	**4,436**	**6,409**	**20,831**	**25,987**	**34,626**	**11,614**	**62,411**	**166,314**
	Industrial Processes	13	16	5	1	11	5	4	54
	Miscellaneous Area Sources	0	1	3	0	4	1	7	16
	Mobile Sources	137	93	106	589	166	70	872	2,033
	Natural Sources	392	186	145	305	151	261	167	1,607
	Stationary Source Fuel Combustion	300	495	2,528	412	4,202	1,136	5,087	14,159
	Waste Disposal, Treatment, and Recovery	19	34	3	26	0	0	170	253
	Non-road mobile	776	996	3,670	1,182	5,334	2,259	6,847	21,064
	On-road	2,659	4,062	12,634	3,476	23,694	6,956	29,767	83,248
	Point	139	526	1,738	19,996	1,066	925	19,489	43,879
VOC	**Total**	**8,528**	**9,982**	**22,618**	**9,161**	**35,352**	**14,804**	**44,727**	**145,174**
	Industrial Processes	331	168	59	10	139	53	120	881
	Miscellaneous Area Sources	0	0	0	0	0	0	0	0
	Mobile Sources	7	4	5	30	8	3	39	96
	Natural Sources	3,829	4,363	2,304	3,188	5,431	4,661	3,356	27,132
	Solvent Utilization	1,201	1,337	5,819	1,704	8,023	2,629	12,310	33,024
	Stationary Source Fuel Combustion	479	194	928	238	840	1,390	824	4,893
	Storage and Transport	270	503	1,686	545	2,564	1,030	3,962	10,560
	Waste Disposal, Treatment, and Recovery	31	64	45	60	62	9	363	633
	Non-road mobile	738	1,354	2,993	1,442	6,342	1,756	5,016	19,639
	On-road	1,493	1,819	6,665	1,514	11,095	2,953	13,193	38,732
	Point	149	176	2,114	432	848	319	5,544	9,582

Because of its importance, some additional details are provided for $PM_{2.5}$ emissions in Table 5-11. This excludes point and on-road mobile sources.

This work is made possible by National Institute of Health and Environmental Sciences, RO1ES022616, and the Fred A. and Barbara M. Erb Family Foundation. Additional support was provided by the Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), #P30ES017885.

Table 5-11. $PM_{2.5}$ emission estimates (tons/year) from non-point, point and mobile sources by county. From NEI, 2011.

Source and Sub-Group	Lenawee	Livingston	Macomb	Monroe	Oakland	Washtenaw	Wayne	Grand Total
Total	**2,271**	**1,428**	**2,565**	**2,751**	**4,210**	**2,776**	**5,131**	**21,133**
Non-point	**2,053**	**1,166**	**1,698**	**1,552**	**2,690**	**2,252**	**1,930**	**13,342**
Industrial Processes	**33**	**87**	**282**	**57**	**724**	**152**	**489**	**1,823**
Construction: SIC 15 - 17	8	46	57	7	307	31	17	473
Food and Kindred Products: SIC 20	22	37	222	31	386	117	450	1,265
Mining and Quarrying: SIC 14	3	3	3	18	31	3	22	83
Oil and Gas Exploration and Production	0	1	0	0	0	0	0	2
Miscellaneous Area Sources	**993**	**116**	**130**	**599**	**39**	**293**	**27**	**2,197**
Agriculture Production - Crops	993	116	129	599	39	293	26	2,196
Agriculture Production - Crops - as nonpoint	0	0	0	0		0	0	0
Other Combustion	0	0	0		0	0	0	1
Mobile Sources	**519**	**651**	**551**	**589**	**1,155**	**672**	**689**	**4,825**
Marine Vessels, Commercial			0	0			7	7
Paved Roads	144	171	379	162	739	264	573	2,432
Railroad Equipment	4	3	3	18	5	2	19	54
Unpaved Roads	370	478	169	408	412	406	91	2,332
Stationary Source Fuel Combustion	**412**	**159**	**735**	**202**	**772**	**1,136**	**725**	**4,142**
Commercial/Institutional	8	14	79	11	208	46	202	567
Industrial	1	1	5	1	6	1	8	22
Residential	404	144	651	191	559	1,088	515	3,553
Waste Disposal, Treatment, and Recovery	**96**	**153**		**106**				**355**
Open Burning	96	153		106				355
Non-road mobile	**72**	**95**	**269**	**97**	**491**	**199**	**493**	**1,715**
CNG	0	0	1	0	1	0	1	3
LPG	1	1	8	1	9	2	12	35
Off-highway Vehicle Diesel	54	60	176	63	292	145	348	1,137
Off-highway Vehicle Gasoline, 2-Stroke	12	22	61	23	135	38	94	386
Off-highway Vehicle Gasoline, 4-Stroke	2	4	14	3	31	7	25	85
Pleasure Craft	3	8	9	6	22	6	13	68
Railroad Equipment	0	0	0	0	0	0	0	1
On-road	**109**	**150**	**458**	**128**	**875**	**259**	**1,098**	**3,077**
Highway Vehicles - Compressed Natural Gas (CNG)	0	0		0	0	0	0	1
Highway Vehicles - Diesel	79	100	300	87	584	175	748	2,074
Highway Vehicles - Gasoline	30	50	158	41	290	83	349	1,002
Point	**37**	**17**	**140**	**975**	**154**	**67**	**1,610**	**2,999**
External Combustion		**0**	**6**	**0**	**1**	**3**	**18**	**28**
External Combustion Boilers	**5**	**0**	**15**	**528**	**17**	**23**	**246**	**834**
Industrial Processes	**27**	**12**	**59**	**436**	**74**	**11**	**904**	**1,523**
Internal Combustion Engines	**4**	**1**	**34**	**6**	**43**	**27**	**260**	**374**
Mobile Sources	**1**	**3**	**2**	**3**	**8**	**3**	**85**	**105**
Petroleum and Solvent Evaporation	**0**		**12**	**0**	**0**		**52**	**64**
Waste Disposal	**0**		**13**	**1**	**12**	**0**	**46**	**72**

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5.5 Exposure and health impacts

5.5.1 Approach

This section estimates the human health impacts that potentially result from exposure of SO_2, NO_x, and $PM_{2.5}$ emitted by the major point sources in and near Detroit, MI., as well as impacts from primary $PM_{2.5}$ emissions from on-road vehicles. For point sources, health impacts are estimated separately for the 16 industrial facilities with the highest emissions of SO_2, NO_x, and $PM_{2.5}$, as well as for all point sources in the area.

Health outcomes depend on the pollutant and age of individual considered. We consider both children and adults, and consider the following types of health effects:

- Mortality including all-cause mortality, lung cancer, and ischemic heart disease (IHD);
- Hospitalizations for chronic obstructive pulmonary disease (COPD), pneumonia, cardiovascular disease (CVD), non-fatal heart attacks, and emergency department (ED) visits for asthma;
- Asthma exacerbations due to cough, shortness of breath and wheeze, and other symptoms; and
- Restricted activity days and work loss days due to respiratory or other symptoms.

We also consider summary measures that consolidate and summarize these impacts, specifically, monetized health impacts (using dollar figures with valuations used by US EPA); and disability-adjusted life years (DALY), which account for the severity and duration of impacts. DALYs estimate the number of years of healthy life that are lost each year due to pollutant exposure.

Exposures and health impacts for Detroit and downriver communities are estimated using a system of models and algorithms called FRESH-EST.[4] This system integrates: (1) estimates of current emissions (see Section 5.2.2); (2) facility-specific stack parameters; (3) the AERMOD dispersion model; (4) hourly meteorology for 2012; rasterization and other spatial interpolation techniques to estimate concentrations at the Census block level; (5) population and demographic data at the Census block or other level, as available;[5] (6) disease incidence data

[4] Framework for Rapid Emission Scenario and Health Impact Estimation

[5] Population data from the American Community Survey at the block level were stratified based on the age distribution of the block group to which the block belongs. US Census Bureau, 2015. TIGER/Line® with Selected Demographic and Economic Data [WWW Document]. URL http://www.census.gov/geo/maps-data/data/tiger-data.html (accessed 7.2.15); US Census Bureau. American Community Survey 5-year Estimates. URL https://www.census.gov/programs-surveys/acs/ [accessed 2-16-16].

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at the ZIP code or county level, as available;[6] and (7) health impact functions and parameters for health outcomes relevant to air pollutants.[7]

For mobile source impacts, annual average concentrations of $PM_{2.5}$ were predicted at over 27,000 receptors using a 150 m grid, the RLINE dispersion model, a link-based emission inventory consisting of 8700 links, and hourly meteorology, and methods described by Batterman et al. 2014.[8] The modeled network includes Detroit and some nearby areas, and includes 883,638 persons based on the 2010 census. Receptor concentrations were interpolated to a 25 m raster in ArcGIS using inverse distance weighting (IDW power of 2 with the 12 nearest neighbors), loaded into ArcGIS, and the zonal statistics tool calculated the average concentrations of raster grid cells that overlapped the block polygons. Results are similar to methods in FRESH-EST. Most but not all of the FRESH-EST blocks are covered by the receptor grid (e.g., portions of the downriver section are excluded). Concentrations were predicted 18,944 blocks, representing 87% of the original study area population. $PM_{2.5}$ concentrations in excluded portions are assumed to be 0. For mortality estimates, health impact functions use the annual average concentration at the block level. For morbidities, the annual average is substituted for the daily average. This does not significantly alter results because the health impact functions are nearly linear over the concentration range considered.

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[6] Mortality rates use ZIP code level data and reported deaths for 2009-2013. Asthma hospitalization and ED visits use ZIP code level data for Detroit and county level data outside of Detroit; asthma exacerbation rates use Detroit data (Batterman et al. in prep). Rates of COPD, CVD and pneumonia hospitalizations are available at the county level. Area-specific rates of non-fatal heart attacks, MRAD and work loss days are unavailable, so nationally representative rates are used. See: DeGuire, P., Cao, B., Wisnieski, L., Strane, D., Wahl, R., Lyon-Callo, S., Garcia, E., 2016. Detroit: The current status of the asthma burden. Michigan Department of Health and Human Services; Michigan Department of Health and Human Services [MDHHS], 2016. Michigan Asthma Surveillance, Data and Reports [WWW Document]. URL http://www.michigan.gov/mdhhs/0,5885,7-339-71550_5104_5279-213824--,00.html (accessed 2.8.16); Michigan Department of Health and Human Services [MDHHS], 2014. Hospitalizations by Selected Diagnosis [WWW Document]. URL http://www.mdch.state.mi.us/pha/osr/CHI/hospdx/frame.html (accessed 2.8.16); National Hospital Discharge Survey [NHDS], 2007. Number and rate of discharges by first-listed diagnostic categories [WWW Document]. Data Highlights- Selected Tables. URL http://www.cdc.gov/nchs/nhds/nhds_tables.htm#number (accessed 11.24.14); US Environmental Protection Agency [US EPA], 2015. BenMAP User's Manual Appendicies. Research Triangle Park, NC.

[7] For $PM_{2.5}$, the health impact assessment uses the same health impact functions as a previous case study of $PM_{2.5}$ health impacts in Wayne County, MI. See Martenies, S.E., Wilkins, D., Batterman, S.A., 2015. Health impact metrics for air pollution management strategies. Environment International 85, 84–95. For SO_2 and NO_x health impact functions, concentration response coefficients are drawn from epidemiological studies. See: Yang, Q., Chen, Y., Krewski, D., Burnett, R.T., Shi, Y., McGrail, K.M., 2005. Effect of short-term exposure to low levels of gaseous pollutants on chronic obstructive pulmonary disease hospitalizations. Environ. Res. 99, 99–105. doi:10.1016/j.envres.2004.09.01; Li, S., Batterman, S., Wasilevich, E., Elasaad, H., Wahl, R., Mukherjee, B., 2011. Asthma exacerbation and proximity of residence to major roads: a population-based matched case-control study among the pediatric Medicaid population in Detroit, Michigan. Environ Health 10, 34; Schildcrout, J.S., Sheppard, L., Lumley, T., Slaughter, J.C., Koenig, J.Q., Shapiro, G.G., 2006. Ambient Air Pollution and Asthma Exacerbations in Children: An Eight-City Analysis. Am. J. Epidemiol. 164, 505–517; Linn, W.S., Szlachcic, Y., Gong, H., Kinney, P.L., Berhane, K.T., 2000. Air pollution and daily hospital admissions in metropolitan Los Angeles. Environ Health Perspect 108, 427–434

[8] Batterman, S., R Ganguly, V Isakoff, J Burke, S Arunachalam, M Snyder, T Robins, T Lewis. 2014. Dispersion Modeling of Traffic-Related Air Pollutants: Exposure and Health Effects among Children with Asthma in Detroit, Michigan. Transportation Research Record (TRR), *Journal of the Transportation Research Board*, No. 2452, 105–113.

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5.5.2 Health impacts from point source emissions

Table 5-12 summarizes the results of the quantitative health impact evaluation for major point sources in the Detroit area. Current emissions of NO_x, SO_2, and $PM_{2.5}$ from point sources incur a total of 971 DALYs per year and $550 million per year in monetized health impacts. Of these impacts, 398 DALYs and $223 million in monetized health impacts are attributed to emissions at the largest 16 facilities alone.

Considering health impacts from all point sources and the three pollutants, emissions and exposures of $PM_{2.5}$ tend to cause the greatest impact.

- Exposure to $PM_{2.5}$ causes all of the mortality (including all-cause, IHD, lung cancer, and infant). In addition, $PM_{2.5}$ causes most of the hospitalizations, including all hospitalizations for asthma, CVD, pneumonia, and non-fatal heart attacks. For asthma exacerbations, $PM_{2.5}$ causes all ED visits for asthma, and all cases of shortness of breath, minor restricted activity days, and work loss day. For the summary measures, $PM_{2.5}$ causes 98.4% of the total DALYs and 99.3% of the monetized impact.
- Exposure to NO_x causes 32% of hospitalizations for asthma, 38% of ED visits for asthma, 54% of hospitalizations for COPD, and 57% of asthma aggravations with one or more symptoms.
- Exposure to SO_2 causes 39% of the hospitalizations for asthma, 47% of ED visits for asthma, 100% of ED visits for asthma using the Detroit-based epidemiology study, and 45% of hospitalizations for COPD.

The results shown in Table 5-12 and percentages discussed above depend on the concentration-response function and the literature. They consider only the health effects that well supported by literature.

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Table 5-12. Summary of health impacts (per year) associated with SO_2, $PM_{2.5}$ and NO_x emissions and exposure from point sources in Detroit.

Health Outcome or Metric (age)	DTE Monroe	DTE Trenton Channel	DTE River Rouge	JR Whiting Co.	US Steel	EES Coke	AK Steel	Carmeuse Lime	Dearborn Industrial Generation	Guardian Industries	GM Hamtramck	Marathon Petroleum	Greater Detroit Resource Recovery	Carleton Farms Landfill	Daimler Chrysler Technology	A123 Systems	Other Point Sources	**Total Point Sources**
Mortality (number of cases)																		
All Cause (>29)	0.1	0.2	0.0	0.4	3.7	0.4	2.2	0.2	0.6	1.1	0.1	0.5	0.1	0.6	0.2	1.1	19.1	**28.6**
IHD (>29)	0.1	0.2	0.0	0.4	3.1	0.4	1.8	0.2	0.5	0.9	0.0	0.4	0.1	0.5	0.2	0.9	15.4	**23.4**
Lung Cancer (>29)	0.0	0.0	0.0	0.1	0.6	0.1	0.3	0.0	0.1	0.2	0.0	0.1	0.0	0.1	0.0	0.2	2.9	**4.3**
Infant (0-1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	**0.3**
Hospitalizations (number of cases/events)																		
Asthma (0-64)	1.7	1.0	1.1	0.4	2.6	1.0	0.9	0.8	0.6	0.5	0.2	0.4	0.6	0.2	0.1	0.2	6.1	**17.9**
COPD (>64)	10.6	6.4	6.8	2.2	12.4	5.9	3.2	5.0	3.3	2.4	1.4	2.1	4.2	1.1	0.5	0.0	20.7	**86.7**
CVD (>64)	0.0	0.0	0.0	0.1	0.8	0.1	0.5	0.1	0.1	0.3	0.0	0.1	0.0	0.1	0.1	0.3	4.4	**6.6**
Pneumonia (>64)	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	2.1	**3.1**
Non-fatal heart attack (>17)	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	1.2	**1.7**
ED visit for asthma (0-17)	20.6	11.8	13.2	4.6	26.3	11.0	8.3	8.8	7.2	4.5	2.7	3.9	6.8	2.1	1.0	1.1	49.7	**179.6**
ED visit for asthma-Detroit CR (0-17)	18.8	12.1	12.0	3.7	19.4	8.1	5.7	5.7	6.3	0.9	2.0	1.8	0.9	0.3	0.1	0.0	2.0	**99.9**
Asthma exacerbations and restricted days (number of cases, days)																		
Cough (6-14)	31	78	6	175	1,521	170	932	96	247	429	21	188	49	233	93	453	7,875	**11,818**
Shortness of breath (6-14)	3	8	1	17	149	17	91	9	24	42	2	18	5	23	9	44	779	**1,165**
Wheeze (6-14)	2	6	0	14	117	13	72	7	19	33	2	14	4	18	7	35	613	**917**
One or more symptoms (6-14)	1,496	873	973	312	1,781	855	468	754	497	332	203	311	654	149	78	0	3,320	**12,847**
One or more symptoms - Det CR (6-14)	4,375	2,842	2,816	861	4,655	1,945	1,374	1,401	1,538	219	452	447	208	67	13	0	654	**23,868**
Minor restricted activity day (18-64)	51	129	10	287	2,474	281	1,445	155	383	712	35	305	81	389	150	750	12,833	**19,181**
Work loss day (18-64)	9	22	2	50	428	49	250	27	66	123	6	53	14	67	26	130	2,229	**3,327**
Summary measures																		
Total DALYs (years)	4.4	7.6	1.7	15.0	127.6	15.4	73.4	8.8	19.9	36.3	2.1	16.0	5.1	19.6	7.9	37.0	573.7	**971.4**
Monetized Impact (2010 $millions)	2.0	4.1	0.6	8.5	71.3	8.4	41.7	4.7	11.1	21.0	1.1	9.0	2.6	11.3	4.4	21.6	327.0	**550.5**

5.5.3 Areas affected from point source emissions

This section includes a large number of maps to show those areas that are affected by point source emissions. First, some results for SO_2 are shown in Figure 5-4 (left panel), which depicts the number of SO_2 attributable asthma exacerbations attributable to current emissions from US Steel, which is located within the study area in close proximity to populated areas. While impacts extend across the study area, clusters of exacerbations are expected to occur in southwest Detroit and the area near Hamtramck. The right panel of Figure 5-4 shows

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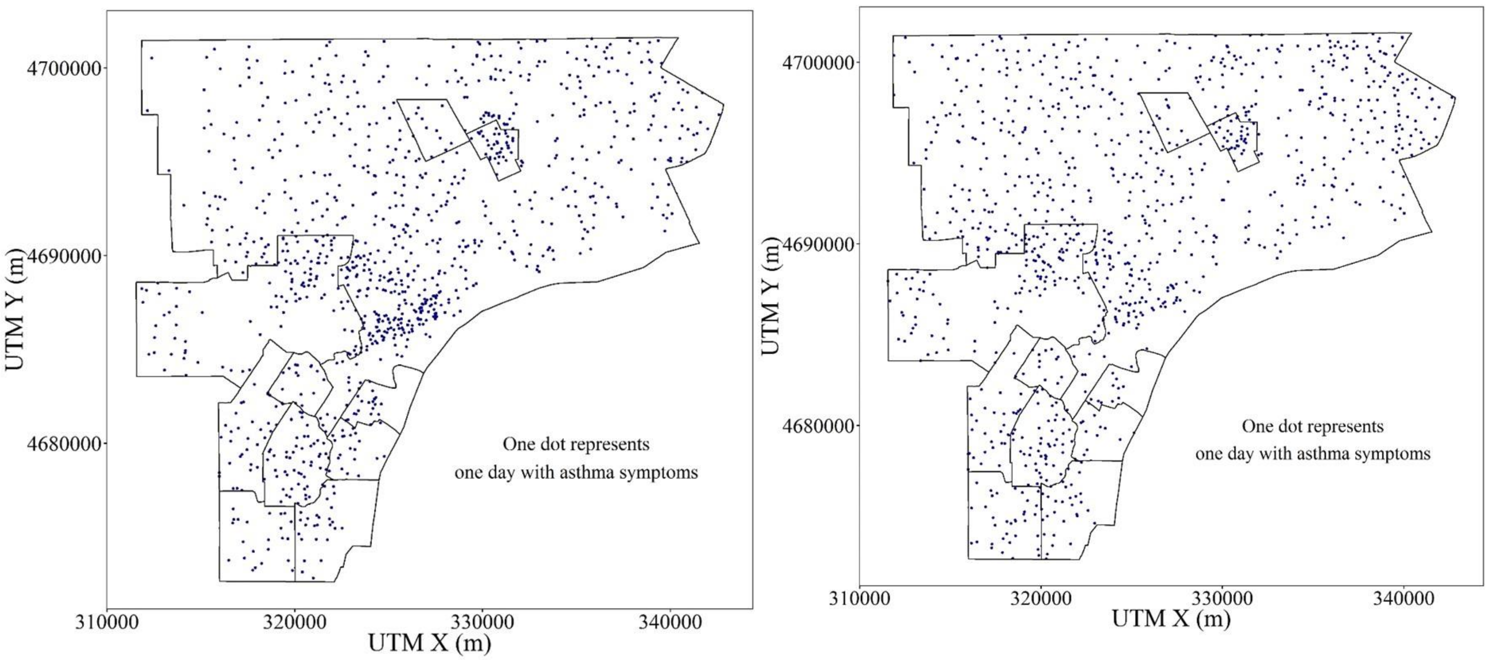
results for DTE Monroe, which is outside of the study area. This map is much more uniform since this source is distant from the study area, the facility has tall stacks, and emissions are well dispersed by the time they reach the population. Each of the two maps represent over 1000 asthma exacerbations each year. These two facilities represent 37% of all of the SO_2-attributable asthma exacerbations from point source emissions.

Figure 5-4. Maps showing days per years of asthma aggravations (at least 1 symptom) for SO_2 emissions from US Steel (left panel) and DTE Monroe (right panel).



A total of 72 additional maps are shown in three sets:

- The left panels (red maps) of Figures 5-5A show the highest daily 24-hr daily $PM_{2.5}$ concentrations across the Detroit area for the top 12 emitting sources. Figures 5-6A – L (left panels) show comparable information for SO_2. Figures 5-7A – L (left panels) shows comparable information for NO_x. These maps indicate areas that may receive high concentrations of pollutants. This measure is relevant to acute (short-term) exposures that can cause, for example, asthma exacerbations. Note that the scales on these figures change, depending on the concentrations predicted.
- The right panel (blue maps) of Figures 5-5 to 5-7 indicate the pollution-attributable risk of asthma exacerbations, defined as an individual having a day with one or more symptoms such as cough, wheeze, and shortness of breath. Again, separate maps are provided for SO_2, NO_x and $PM_{2.5}$, and for emissions at largest 12 sources of each of these pollutants in the Detroit area. Asthma exacerbations are shown because these impacts are common, caused by all three pollutants, and occur among children, an important subpopulation, as well as adults. Scales on these figures change, depending on the risk level.

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The maps are ordered based on the total tonnage of pollutant emitted. They show a number of features:

- Each source affects different areas.
- Many sources affect much of the Detroit area. A notable exception is Carmeuse Lime, which causes a local SO_2 "hotspot" due to its relatively short stack height. MDEQ has negotiated with this facility a State Implementation Plan that will raise the height of the stack to increase pollutant dispersion.
- Areas affected can be distant from the source and often span the different sections of Detroit and communities outside Detroit. Thus, for point sources, proximity is not necessary a good measure of impact.
- Spatial patterns of areas potentially affected by pollutants are complex. Dispersion of pollutants depends on many parameters, including stack height and other facility characteristics, as well as local meteorology. In addition, the spatial pattern of health impacts depends on population density, population demographics (e.g., fraction children), and health status (e.g., asthma incidence).
- The spatial patterns of other short-term health impacts attributable to point source emissions, e.g., CVD due to exposure from a particular source, is likely to be similar to that shown for asthma. However, health impacts associated with chronic exposure, e.g., cancer, will differ.

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Figure 5-5A. JR Whiting Co. Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

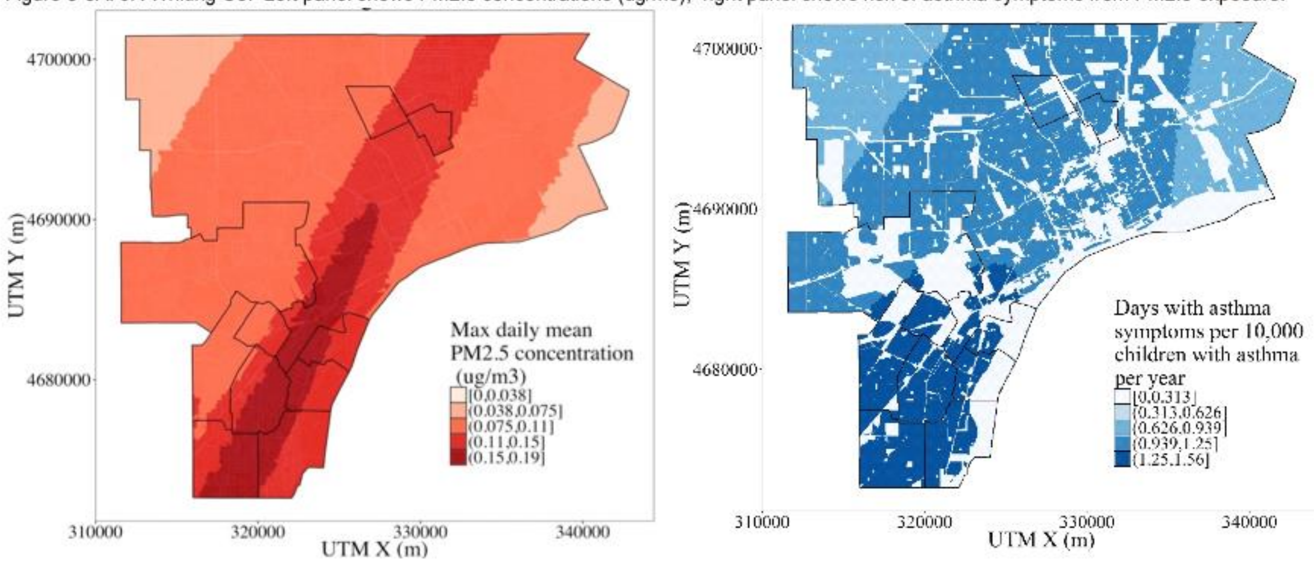


Figure 5-5B. Guardian Industries Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

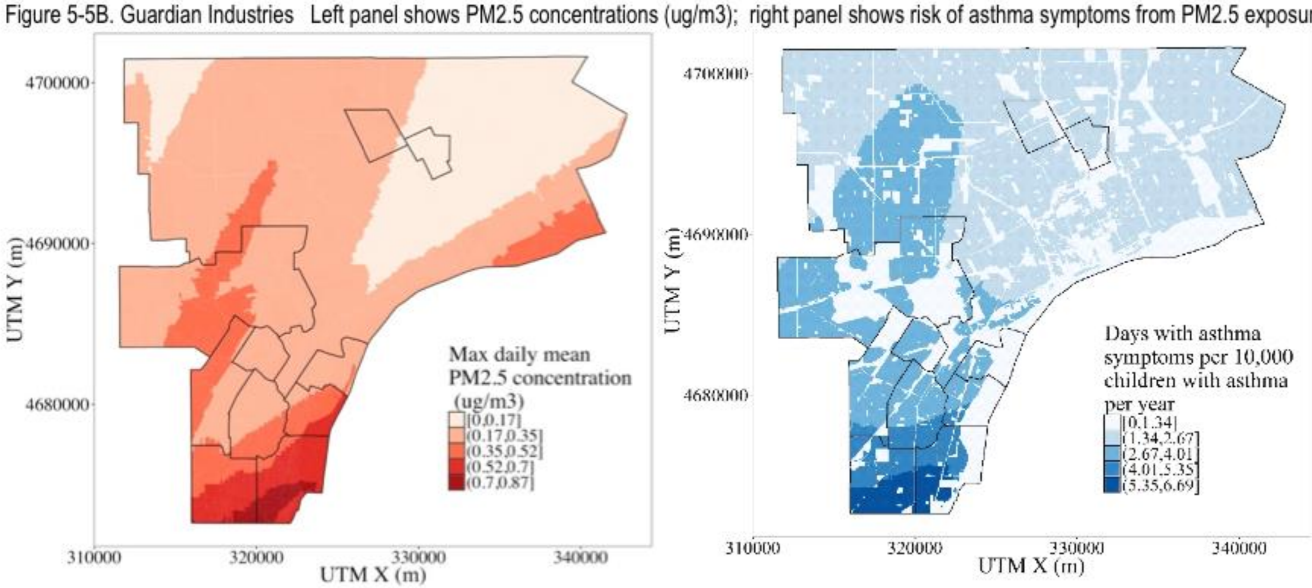


Figure 5-5C. US Steel Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

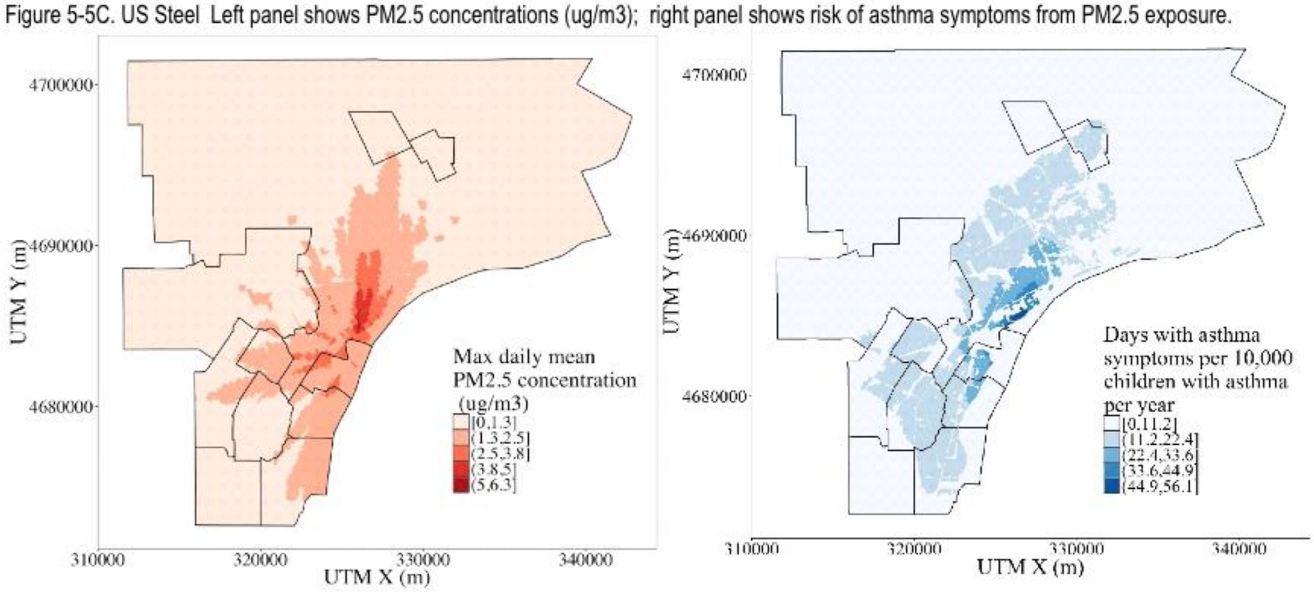


Figure 5-5D. Trenton Channel Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

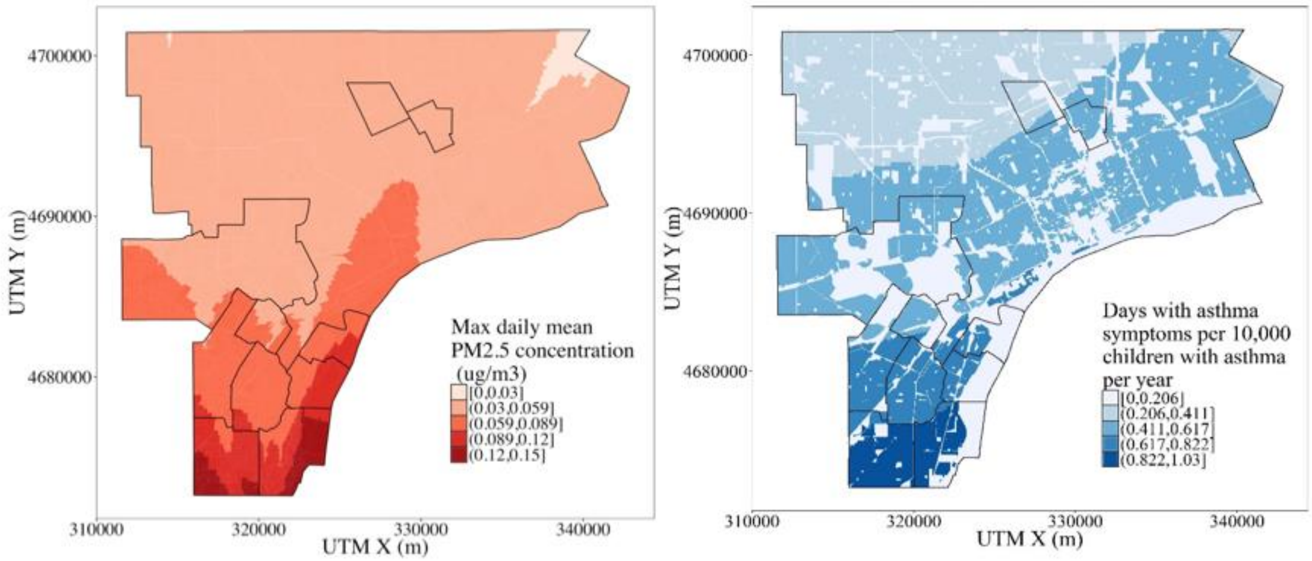


Figure 5-5E. AK Steel Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

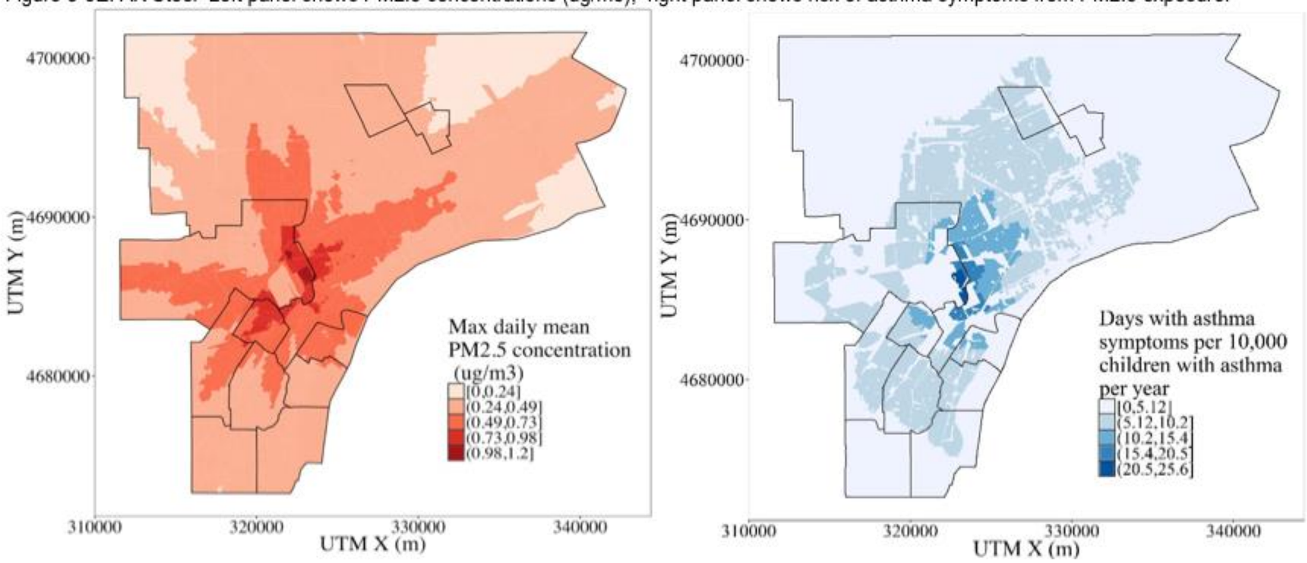


Figure 5-5F. EES Coke Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

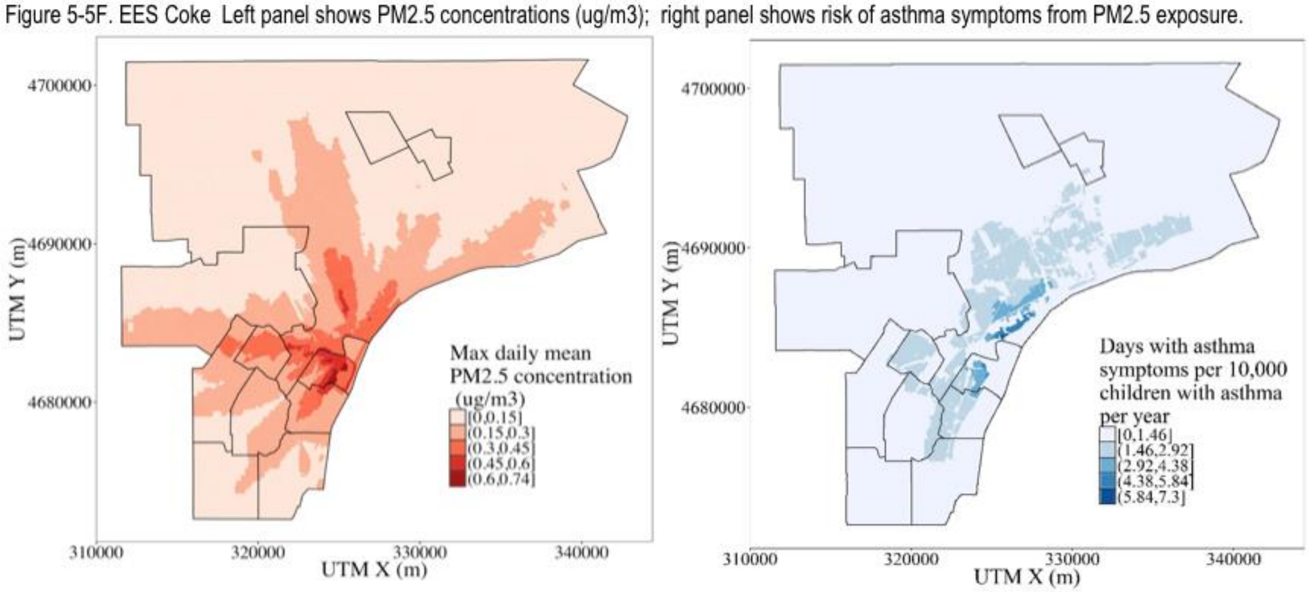


Figure 5-5G. DTE Monroe Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

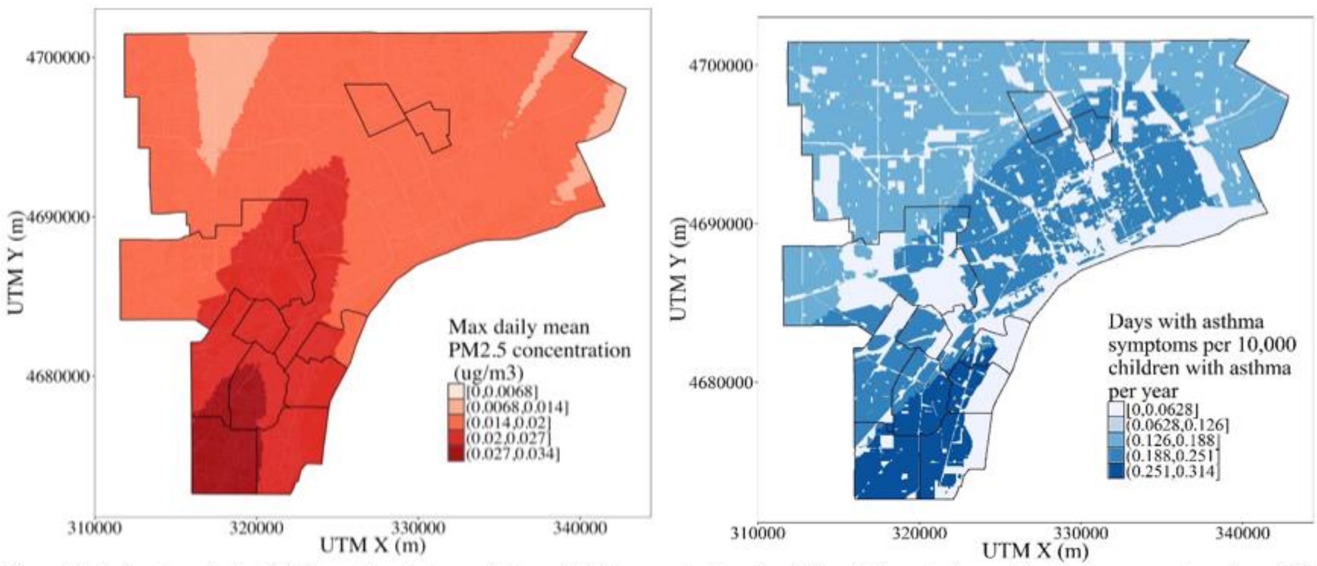


Figure 5-5H. Dearborn Industrial Generation Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

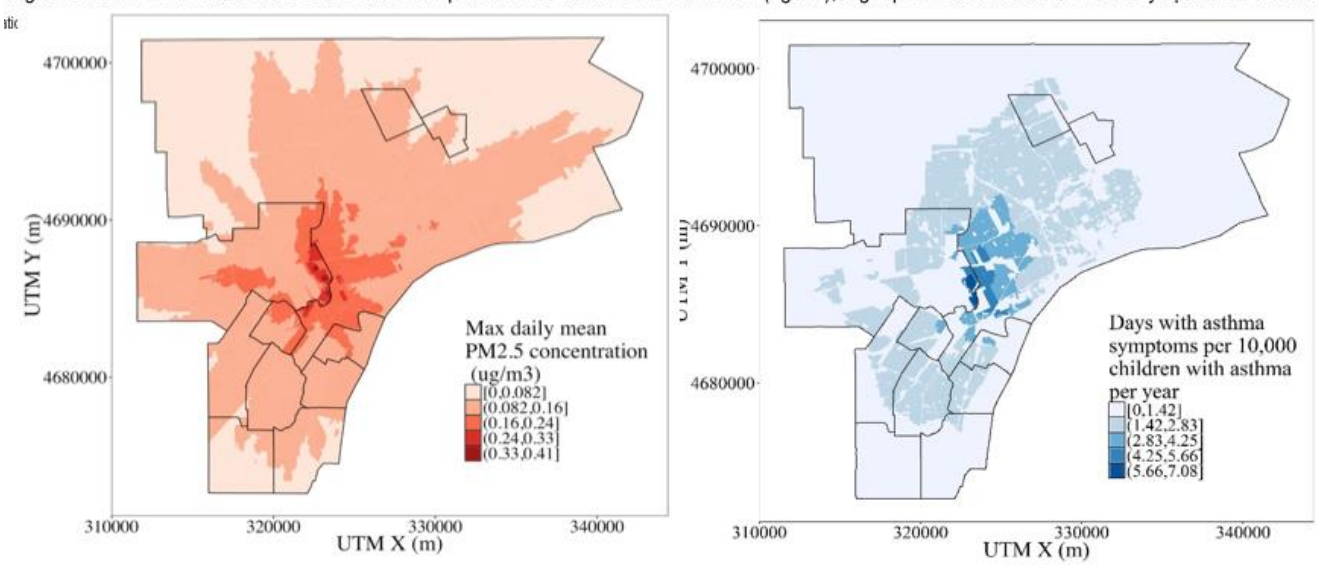


Figure 5-5I. Marathon Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

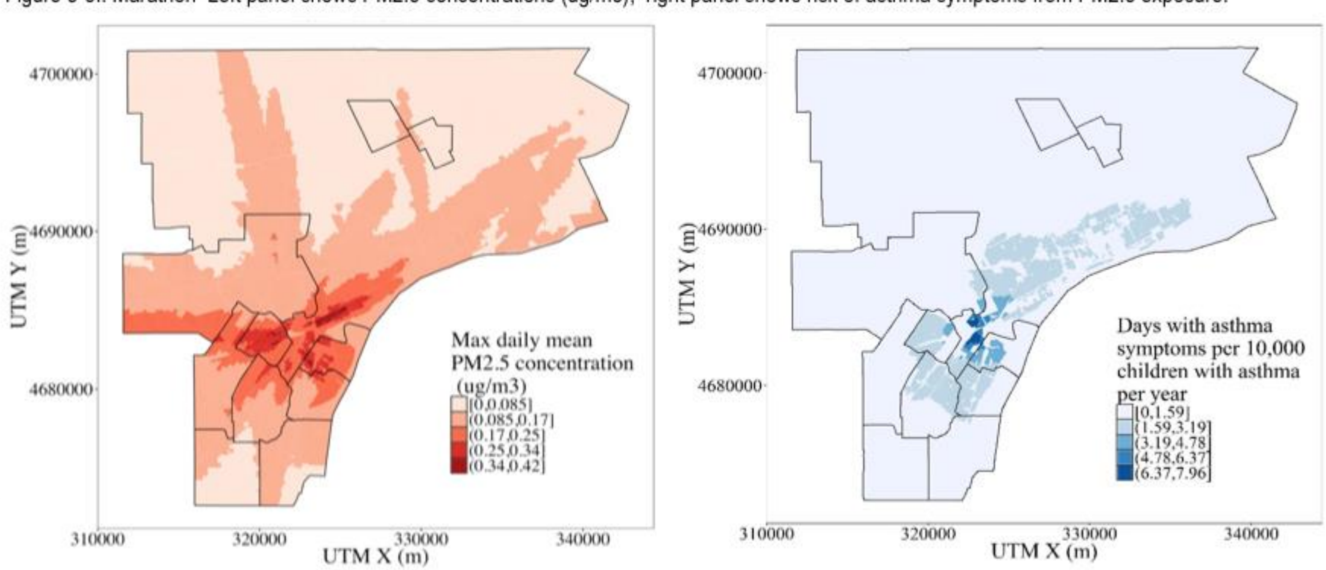


Figure 5-5J. A123 Systems Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

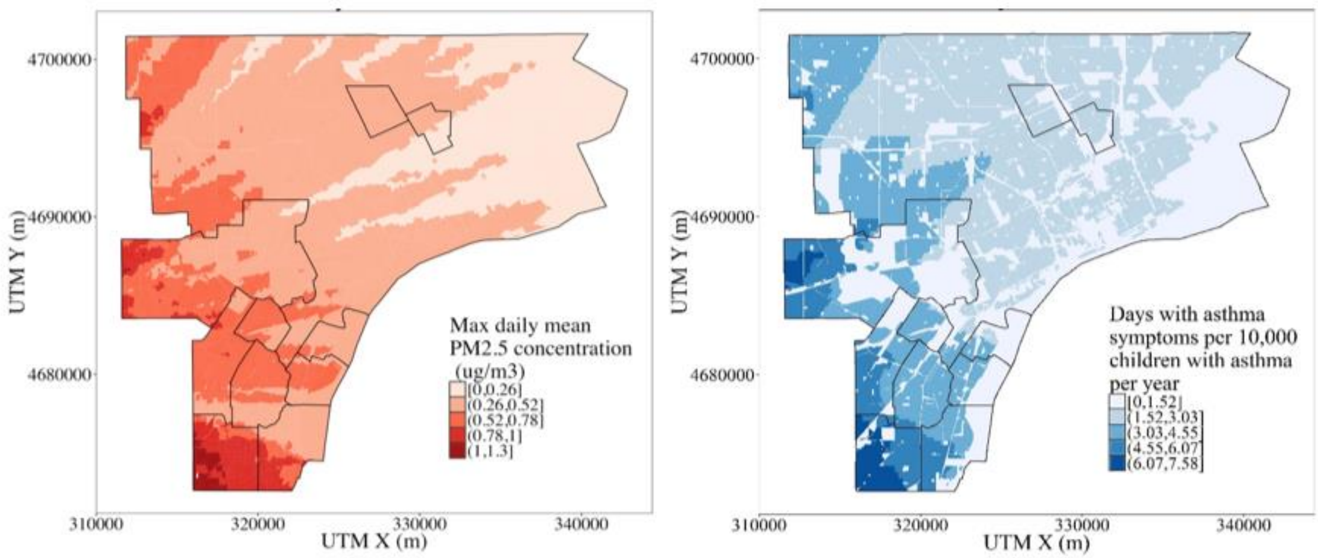


Figure 5-5K. Carleton Farms Landfill Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

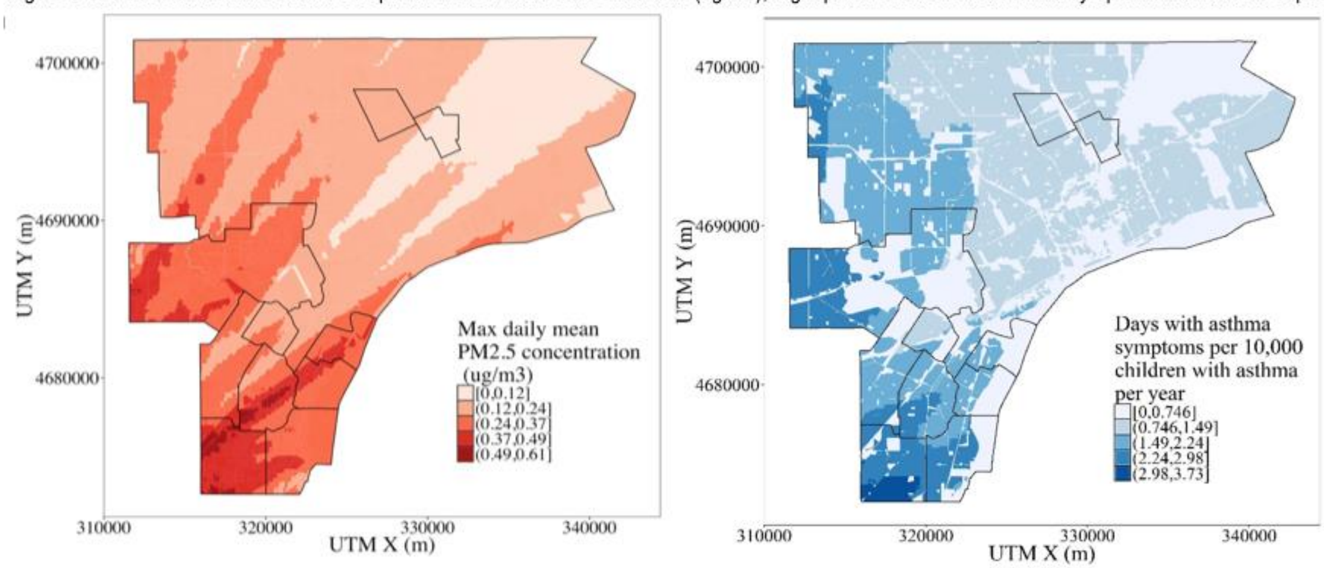


Figure 5-5L. Daimler Chrysler Technology Center Left panel shows PM2.5 concentrations (ug/m3); right panel shows risk of asthma symptoms from PM2.5 exposure.

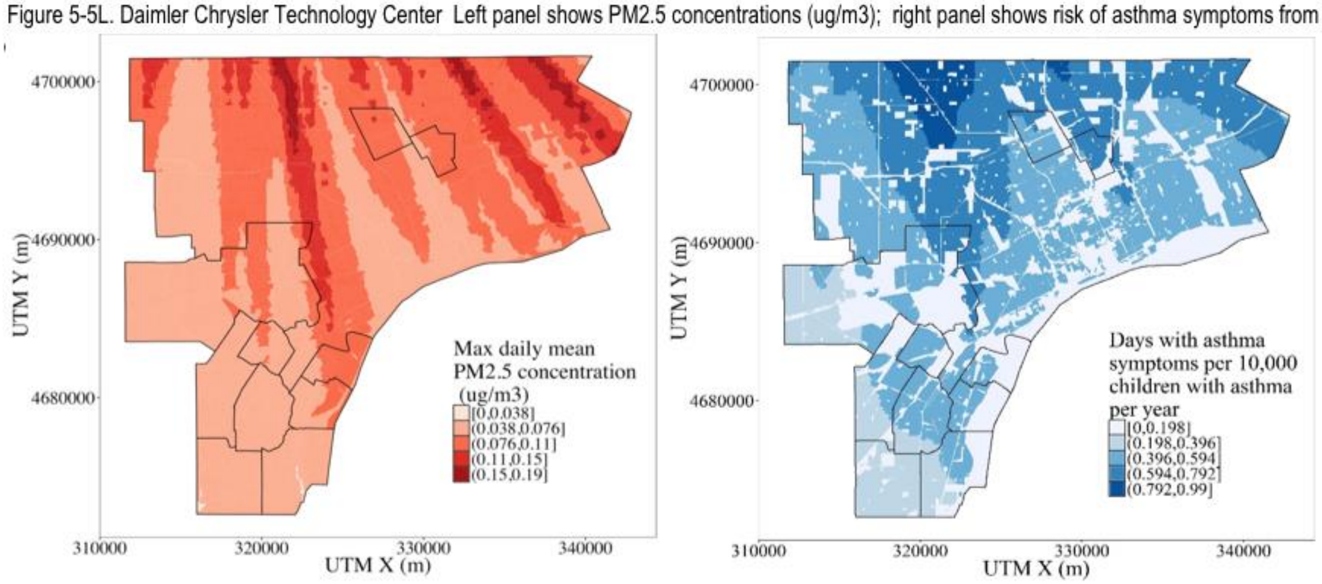


Figure 5-6A. DTE Monroe Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

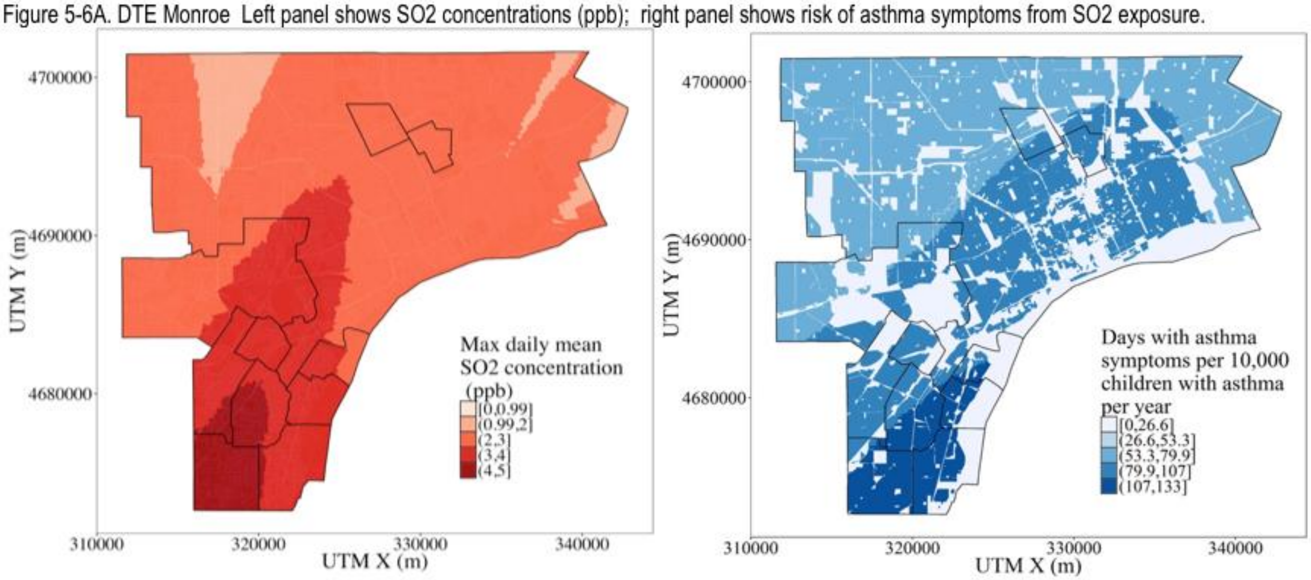


Figure 5-6B. DTE Trenton Channel Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

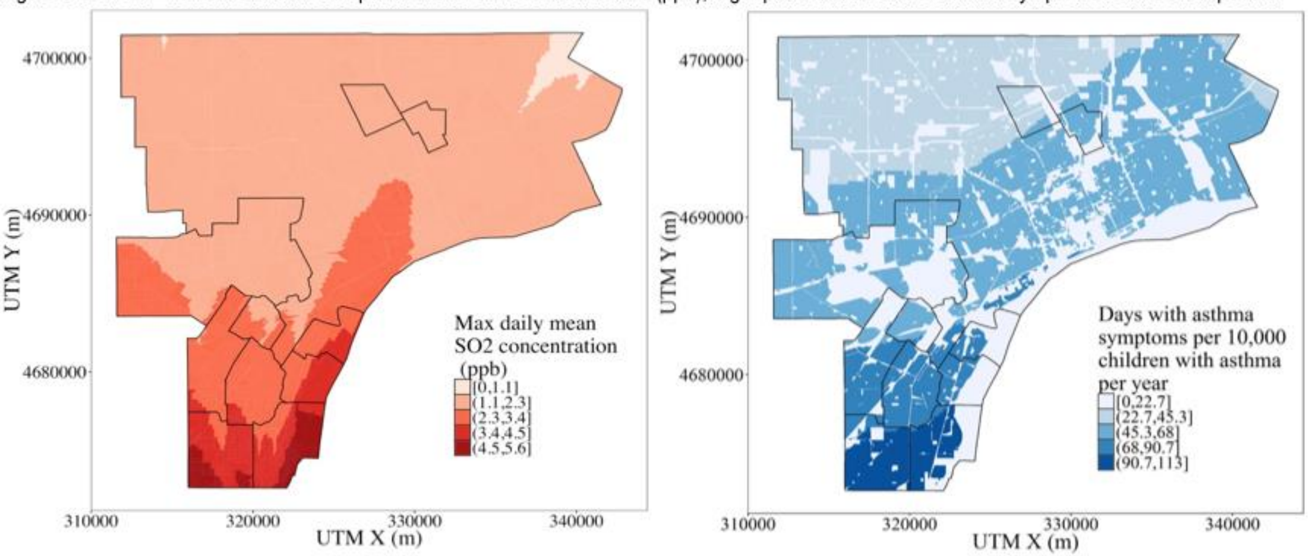


Figure 5-6C. DTE River Rouge Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

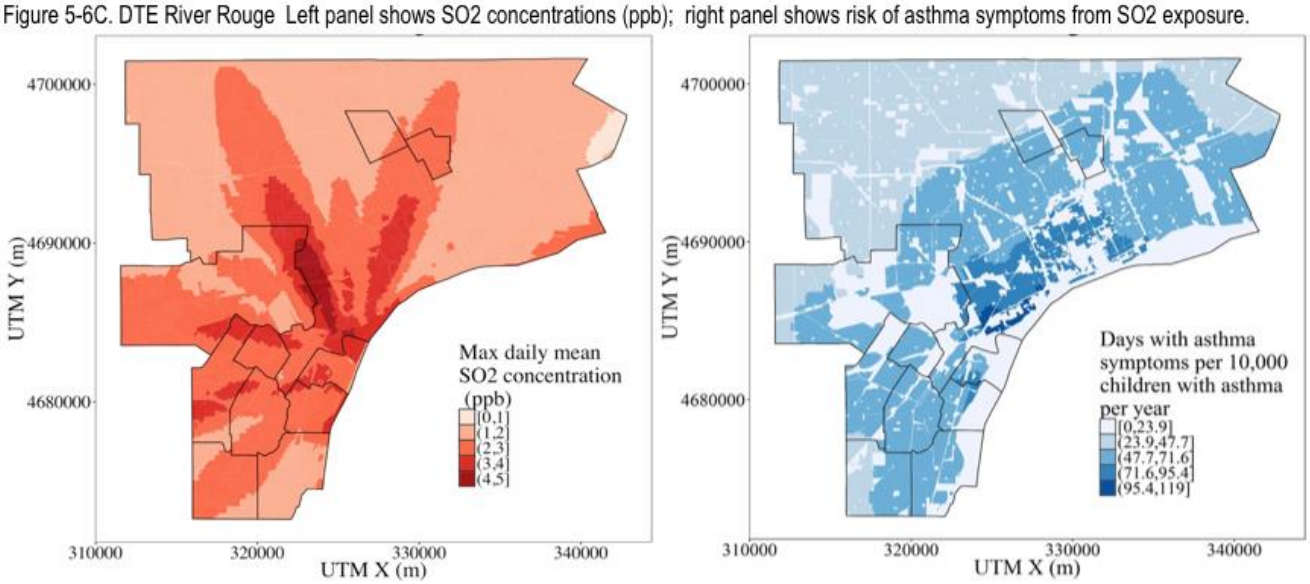


Figure 5-6D. Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

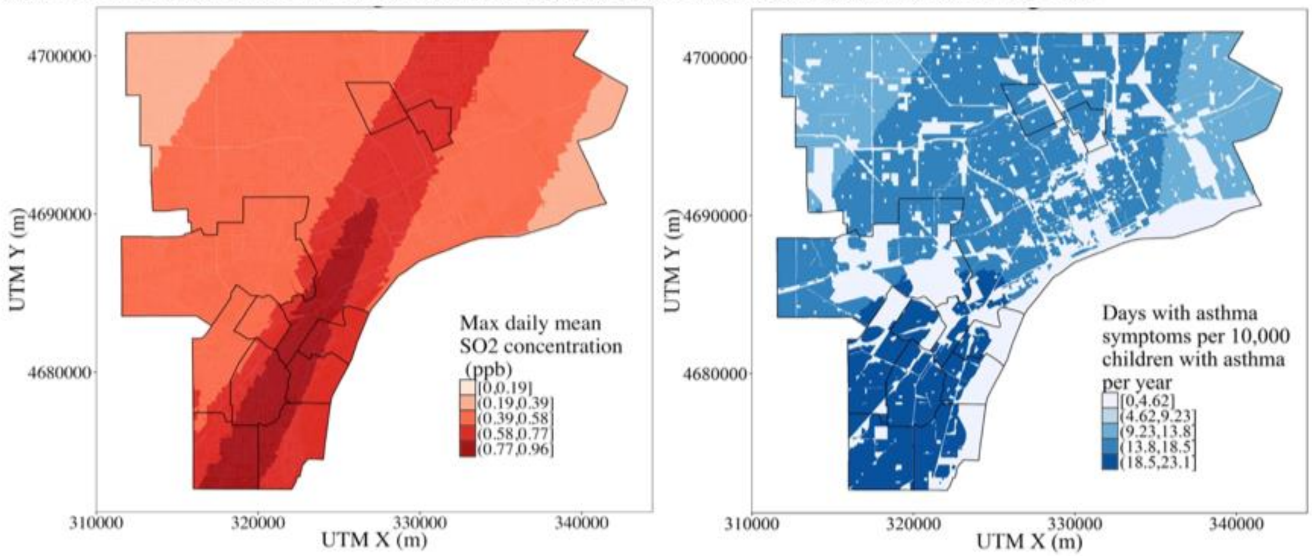


Figure 5-6E. US Steel Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

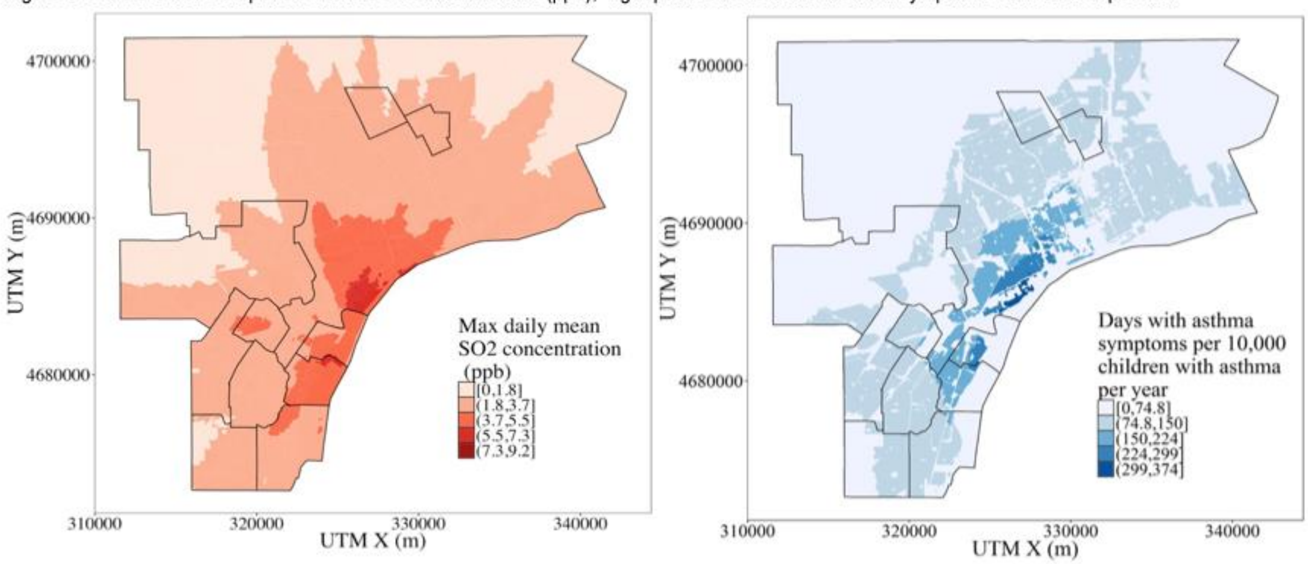


Figure 5-6F. EES Coke Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

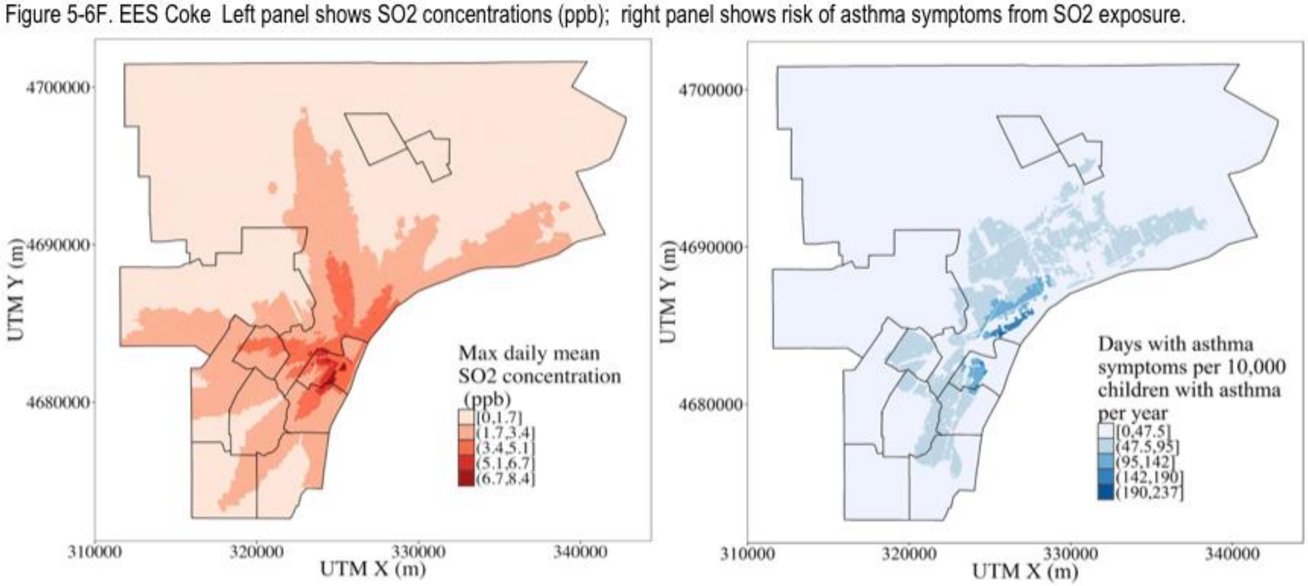


Figure 5-6G. AK Steel Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

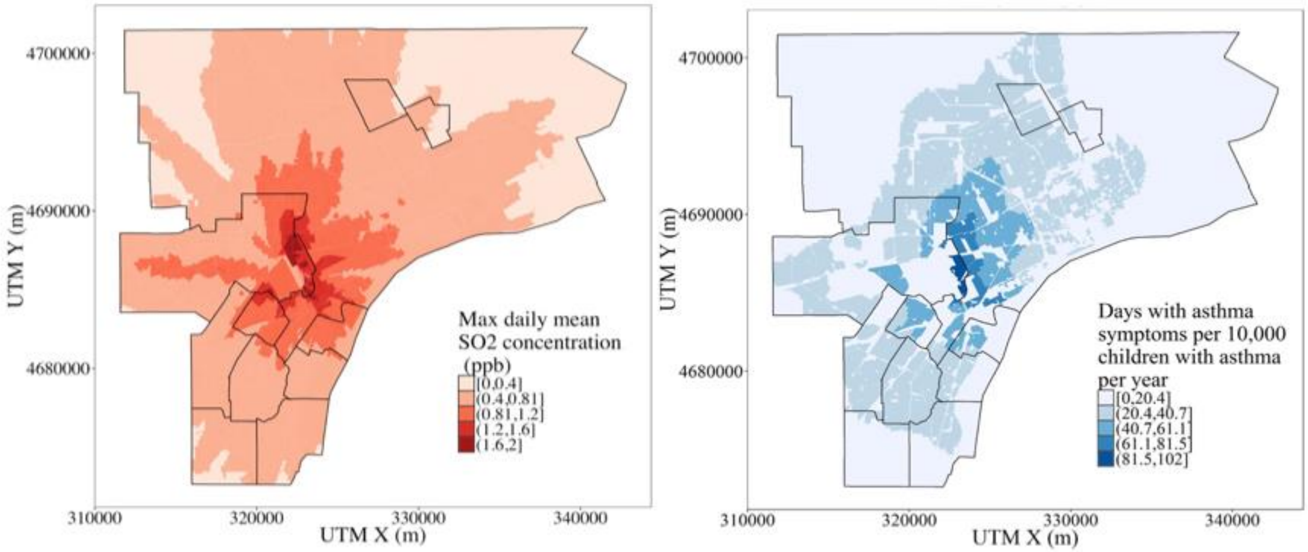


Figure 5-6H. Carmeuse Lime Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

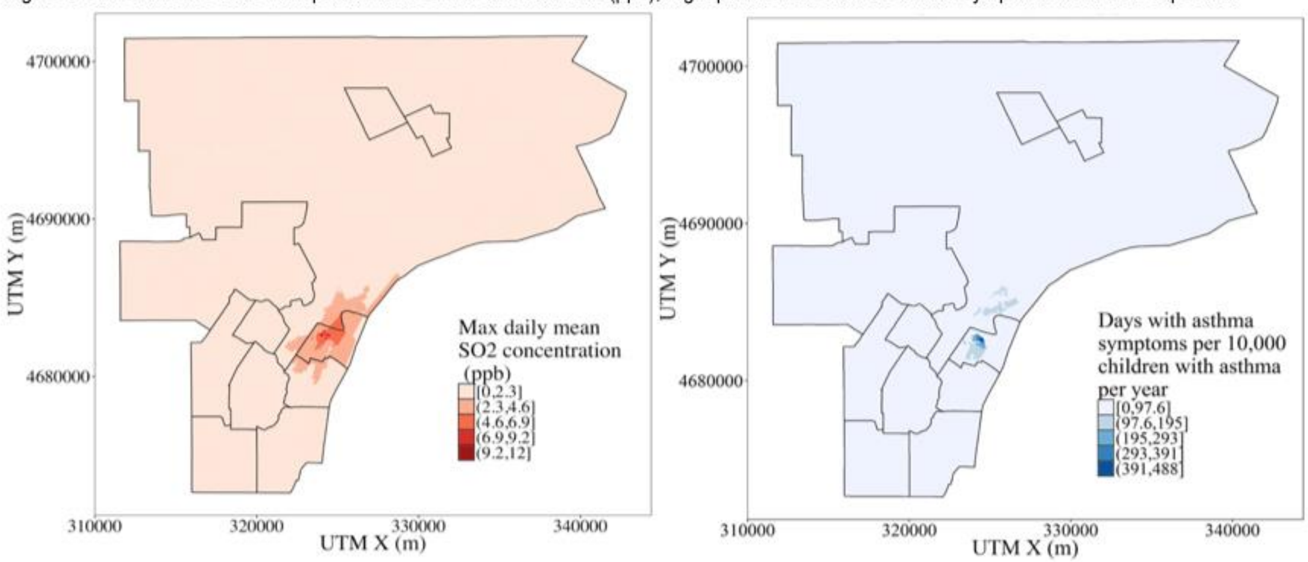


Figure 5-6I. Dearborn Industral Generation Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

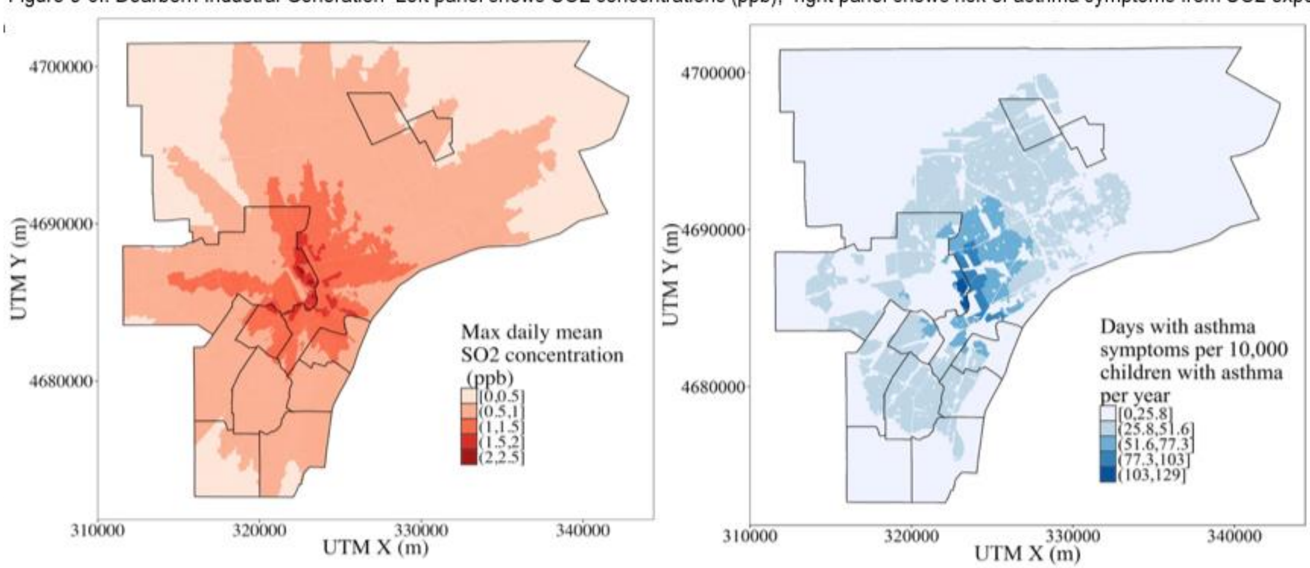


Figure 5-6J. Guardian Industries Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

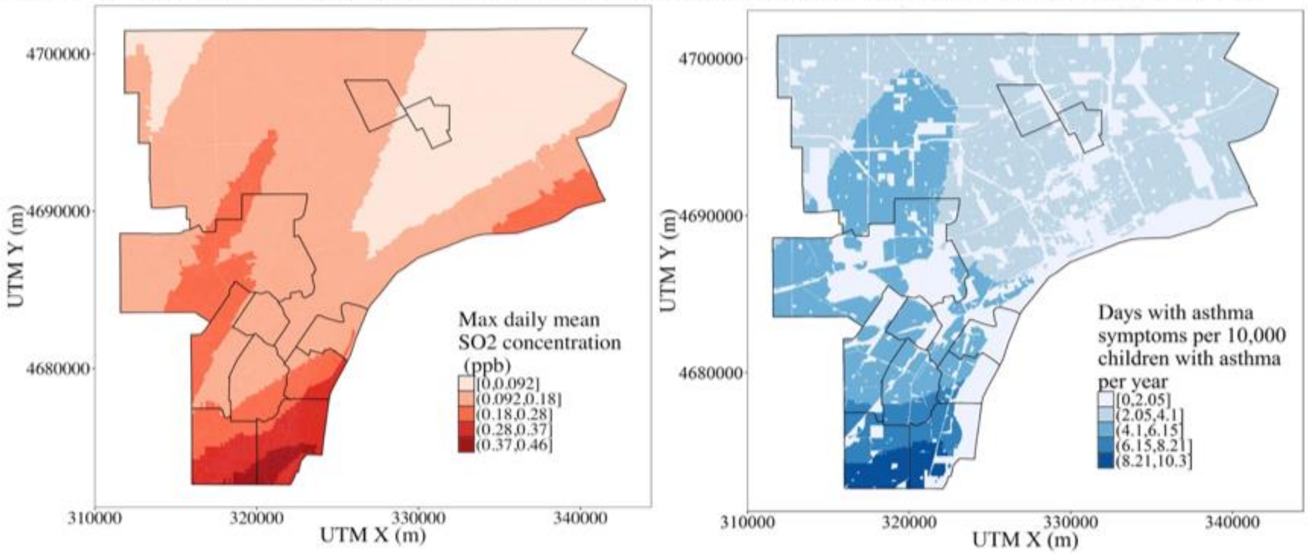


Figure 5-6K. General Motors Hamtramck Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

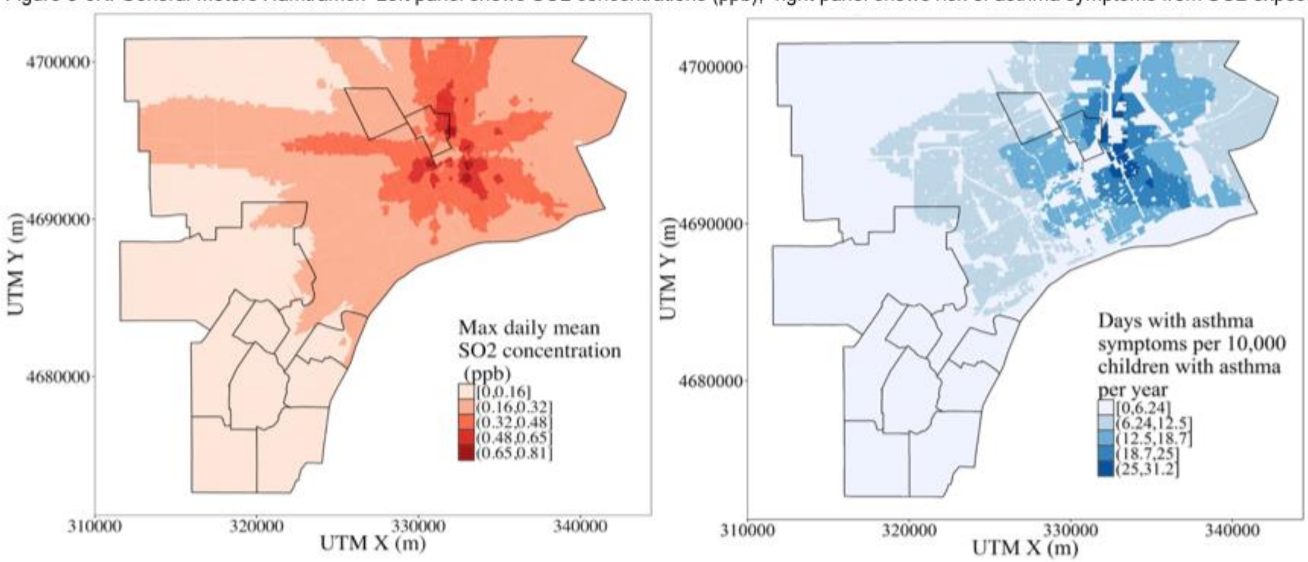


Figure 5-6L. Marathon Left panel shows SO2 concentrations (ppb); right panel shows risk of asthma symptoms from SO2 exposure.

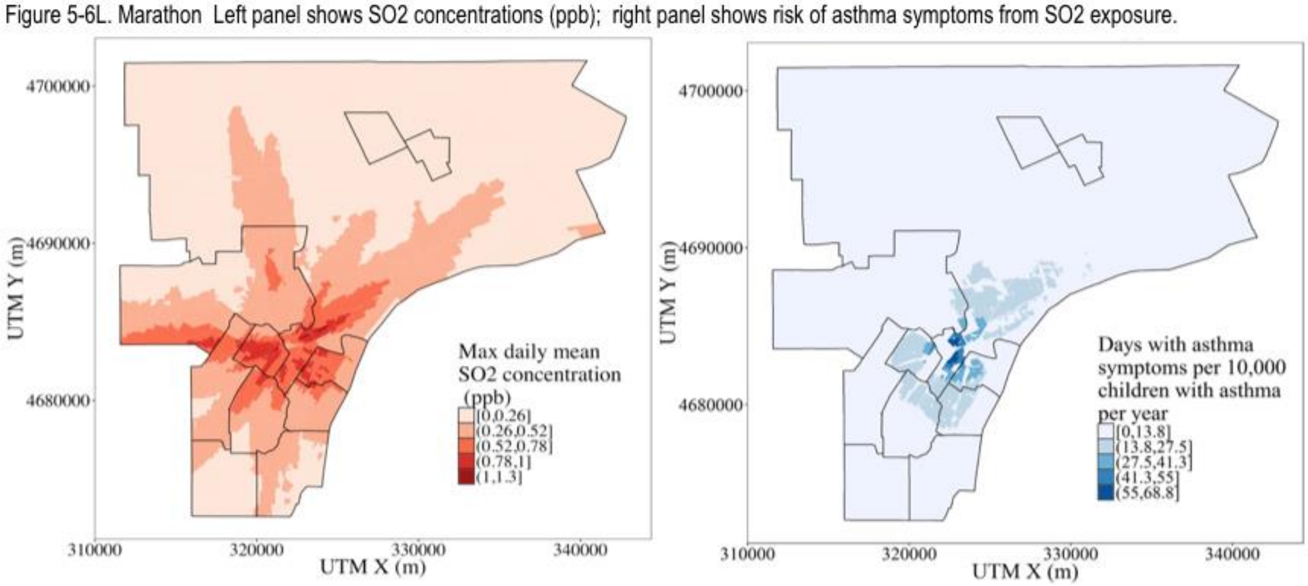


Figure 5-7A. DTE Monroe Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

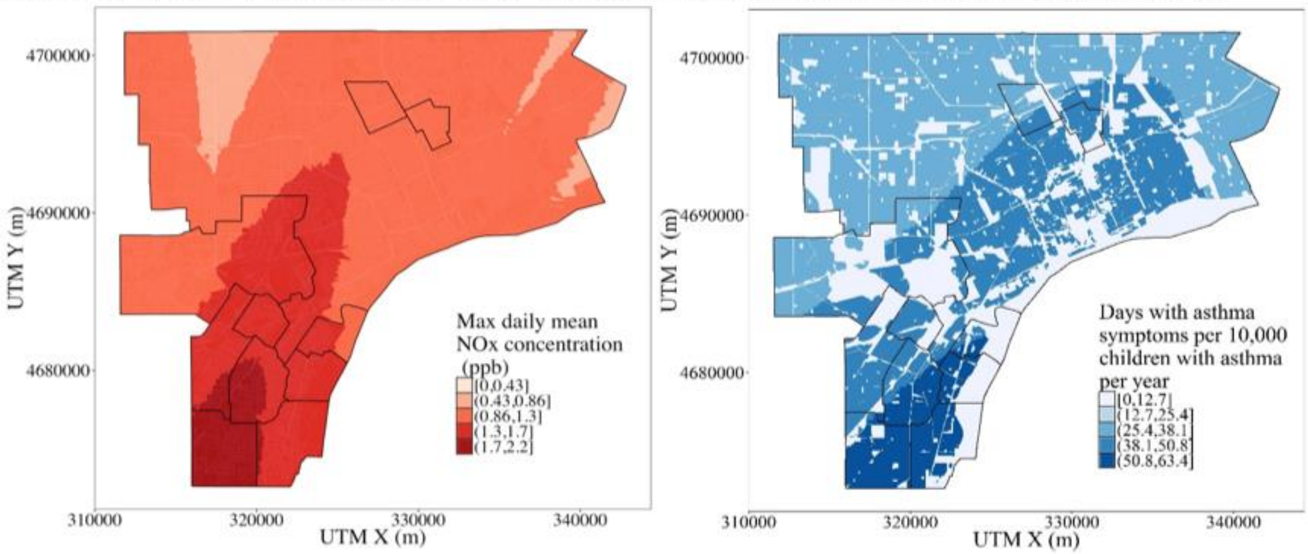


Figure 5-7B. DTE Trenton Channel Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

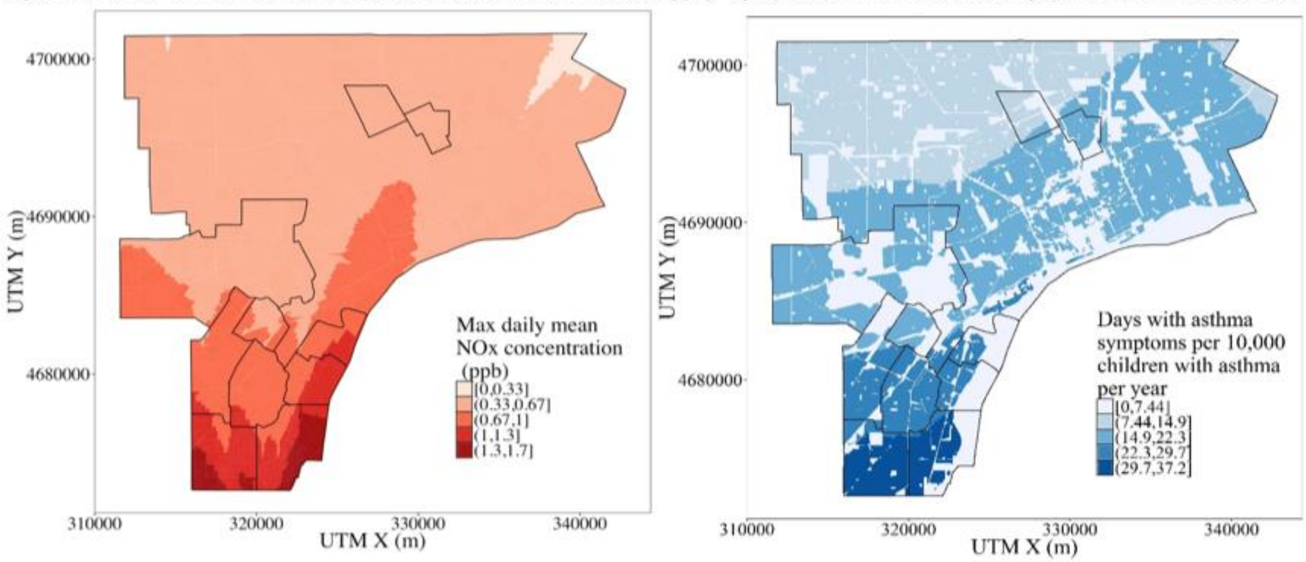


Figure 5-7C. DTE River Rouge Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

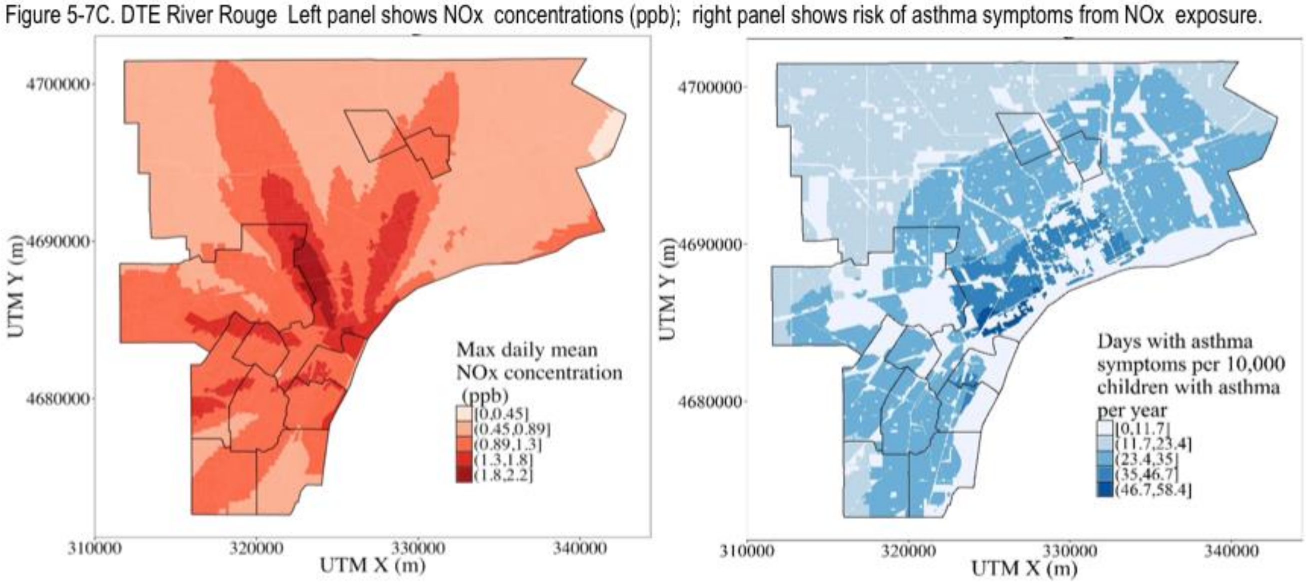


Figure 5-7D. JR Whiting Co. Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

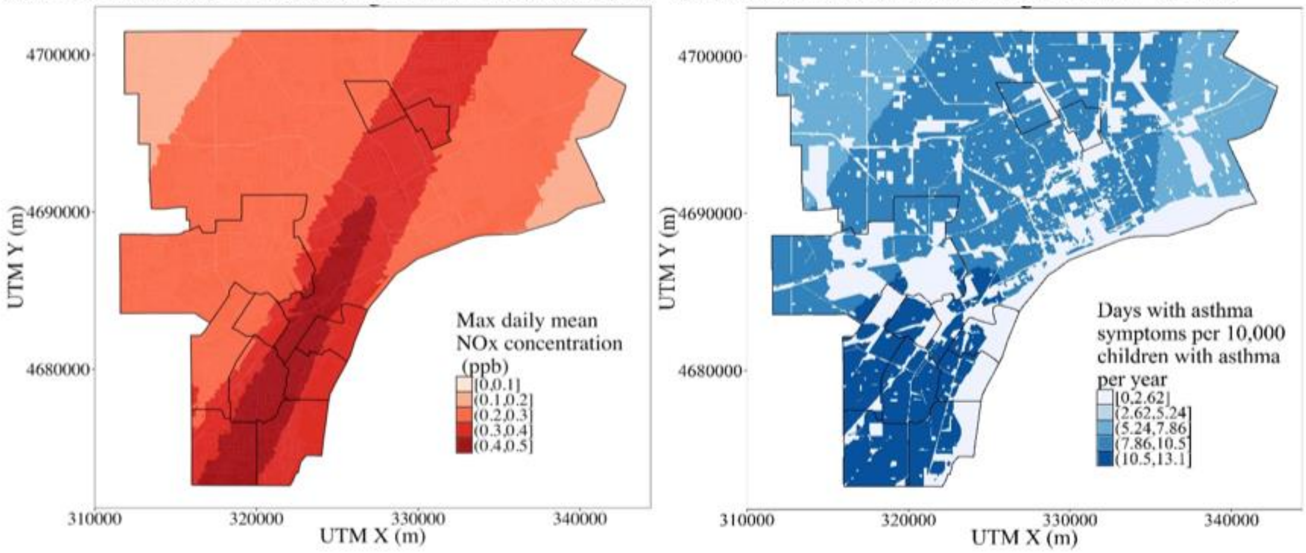


Figure 5-7E. Guardian Industries Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

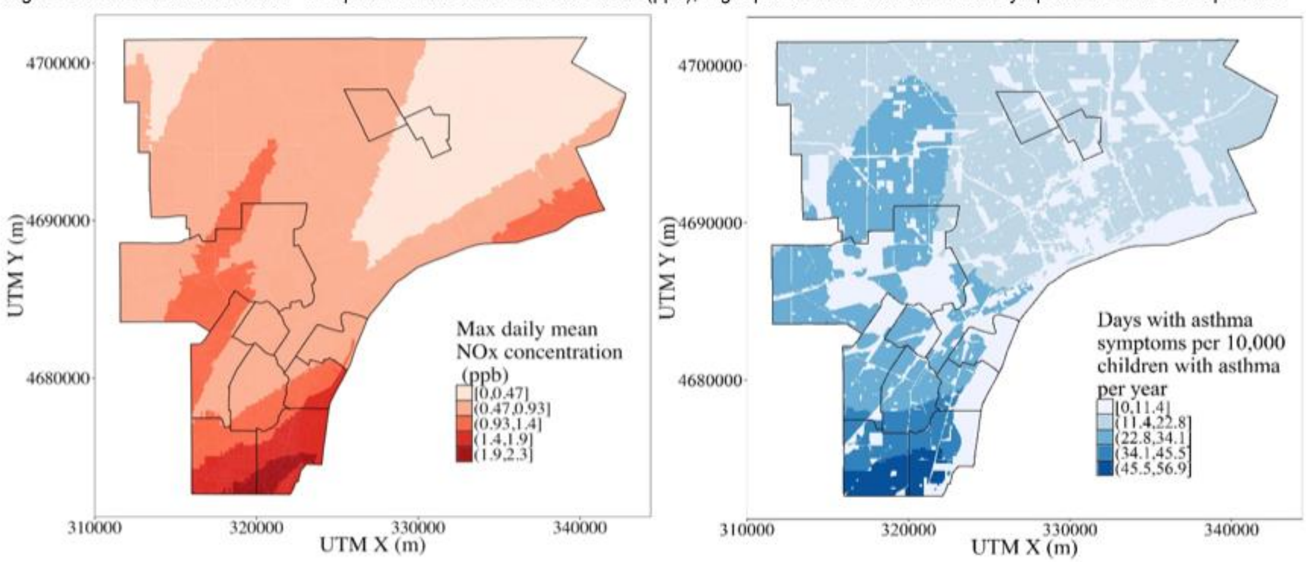


Figure 5-7F. US Steel Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

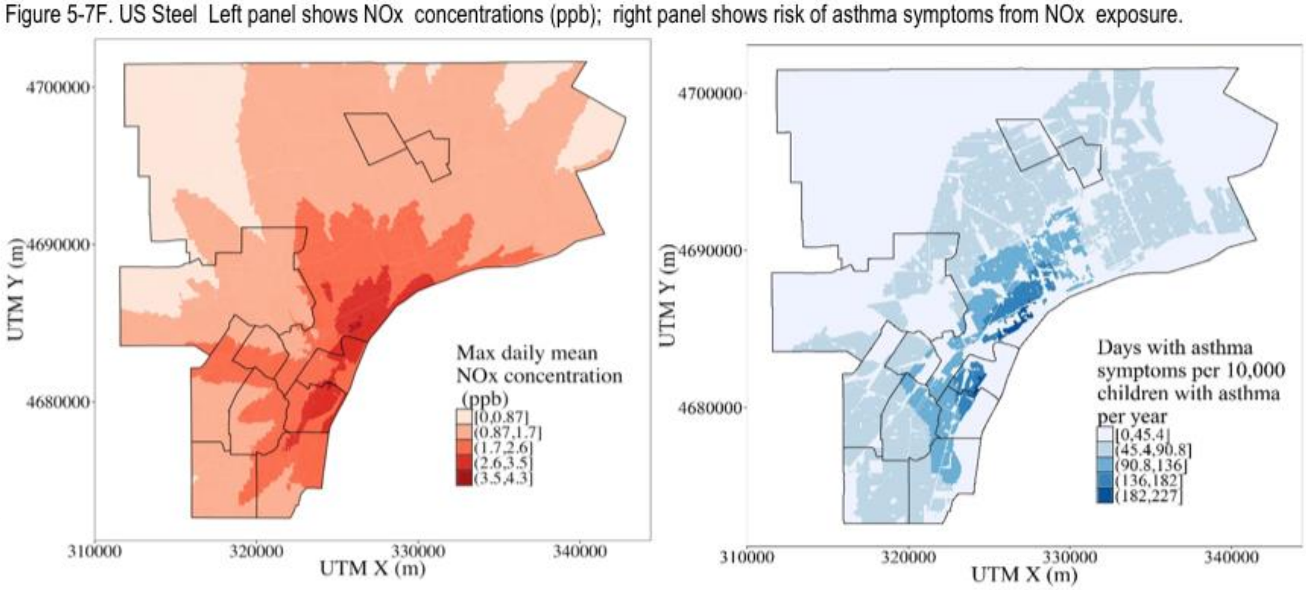


Figure 5-7G. EES Coke Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

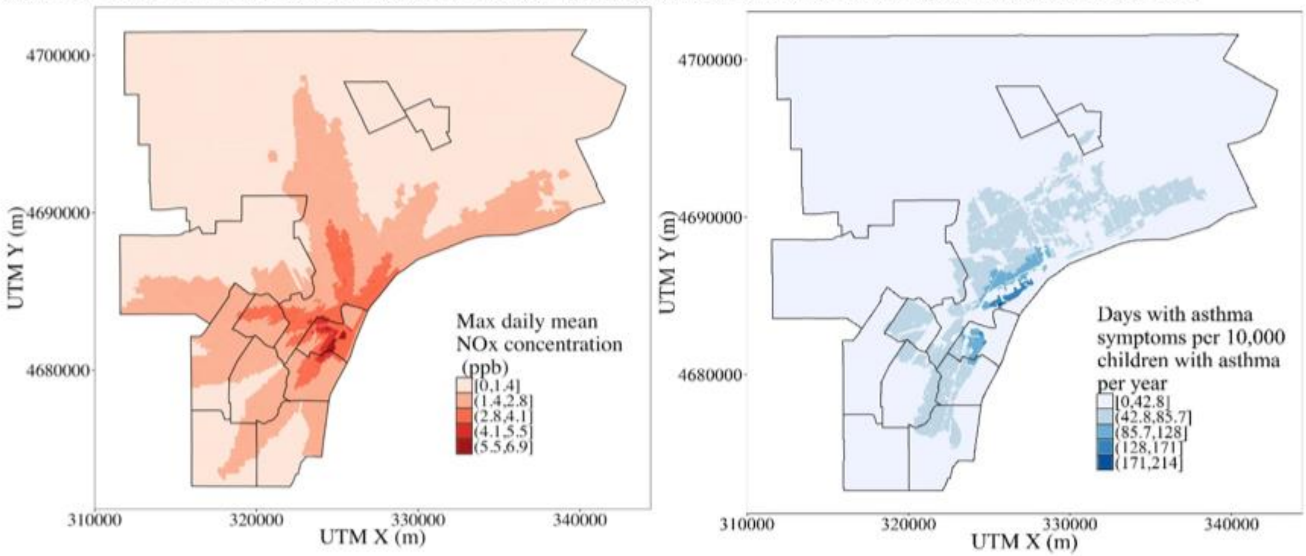


Figure 5-7H. Greater Detroit Resource Recovery Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

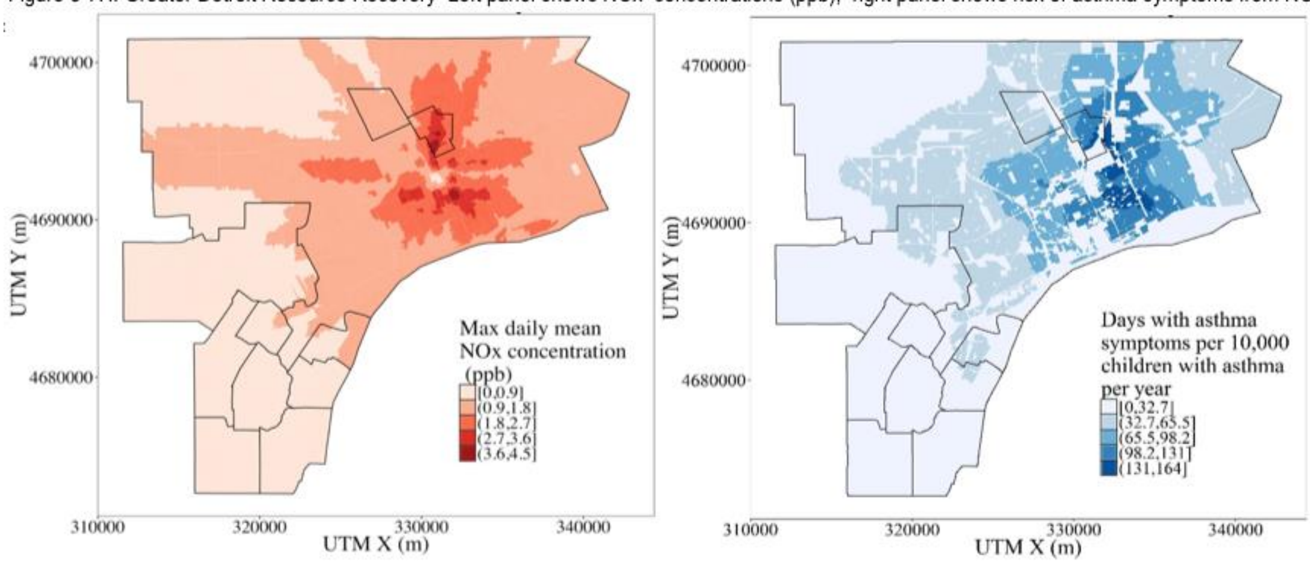


Figure 5-7I. AK Steel Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

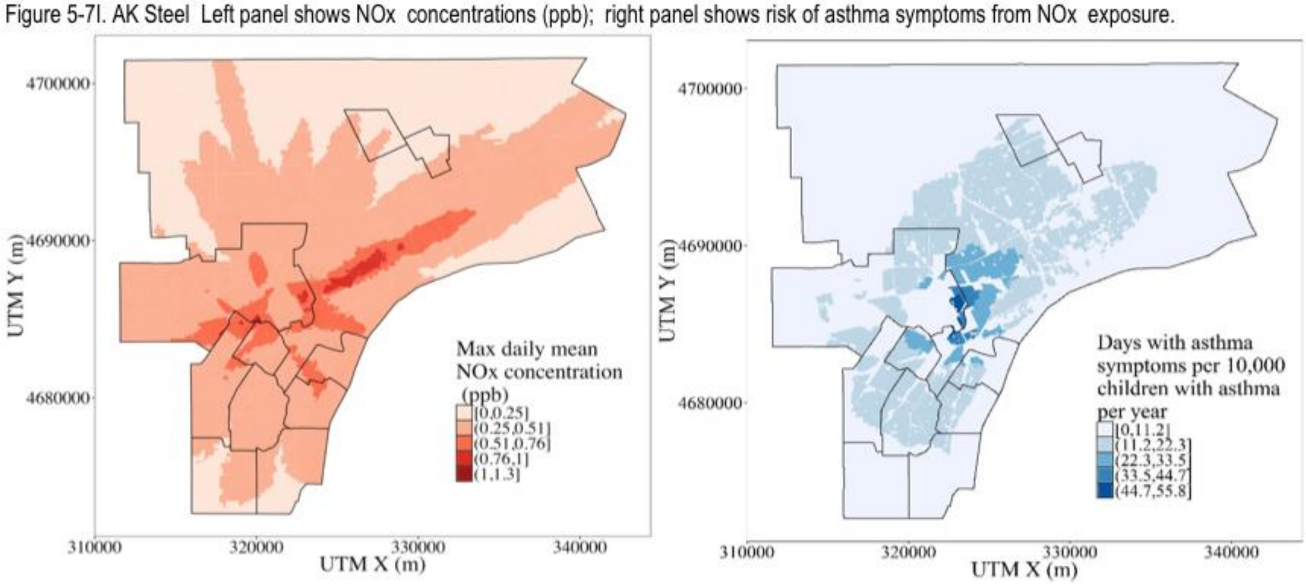


Figure 5-7J. Carmeuse Lime Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

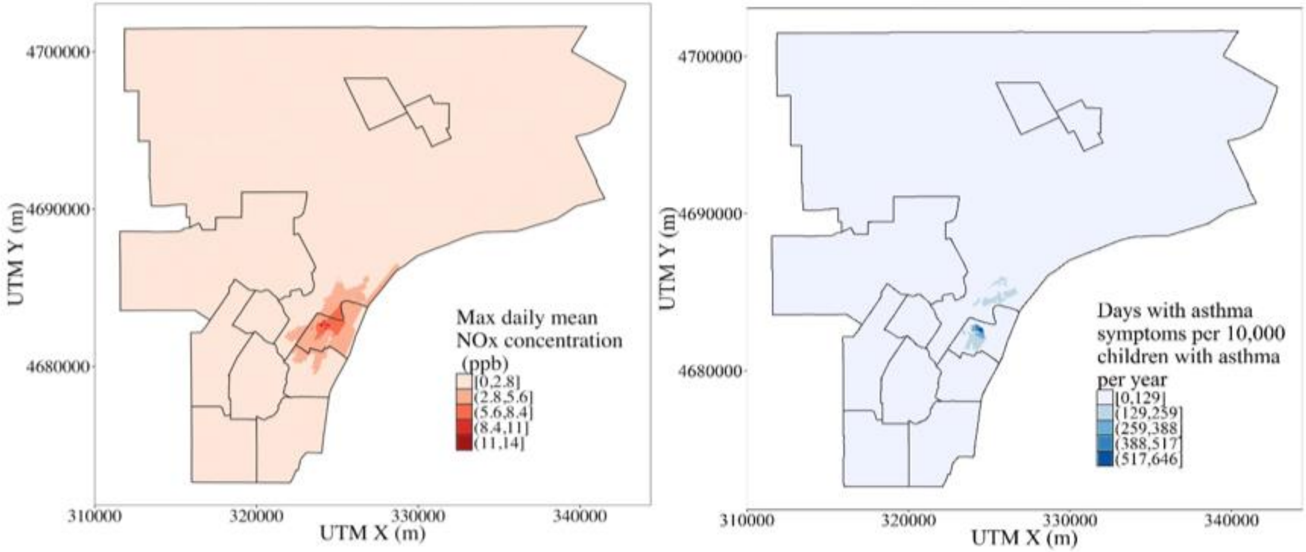


Figure 5-7K. Marathon Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.

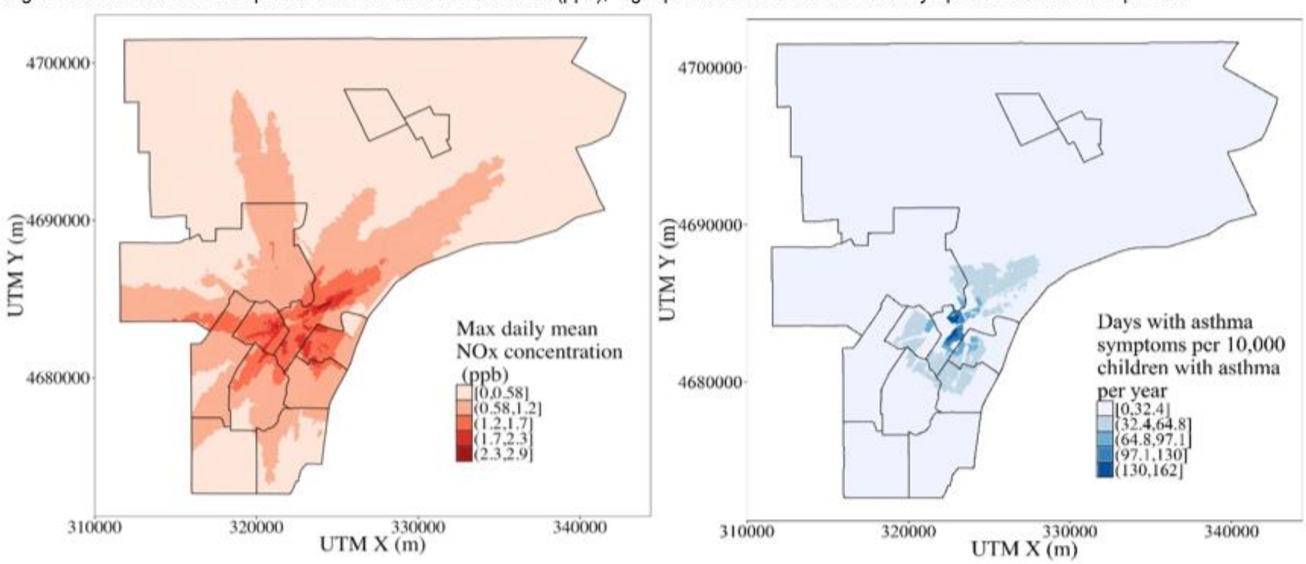
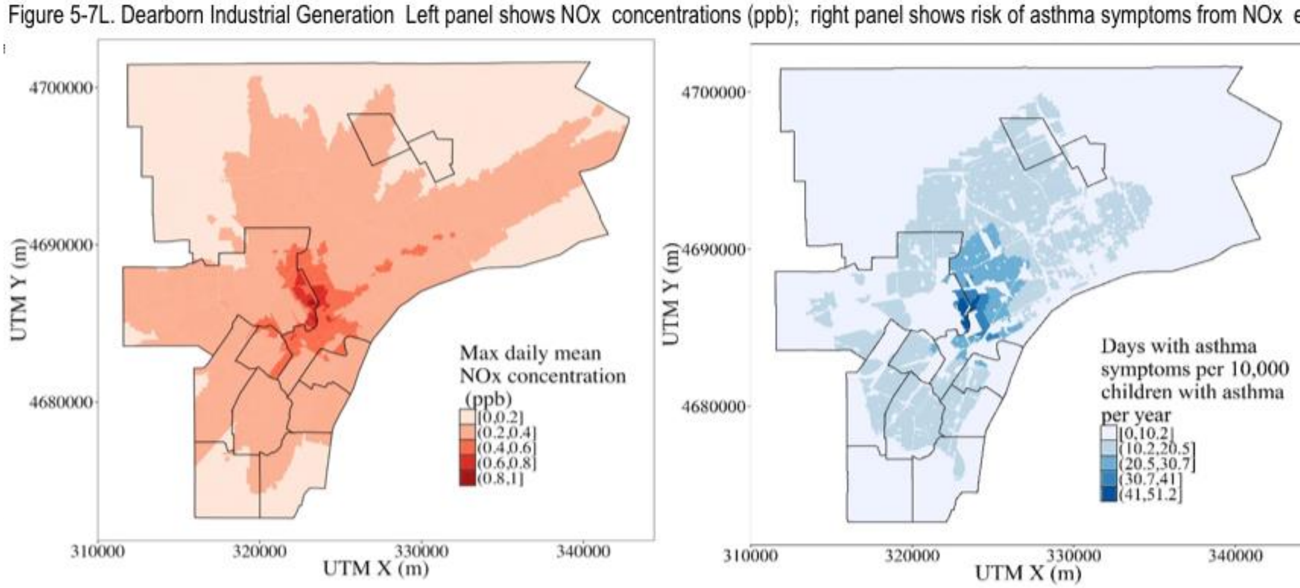


Figure 5-7L. Dearborn Industrial Generation Left panel shows NOx concentrations (ppb); right panel shows risk of asthma symptoms from NOx exposure.



5.5.4 Health impacts and areas affected by mobile source emissions

Figure 5-8 shows annual average $PM_{2.5}$ concentrations due to on-road exhaust emissions across the modeled area. Concentrations are highest at or near major roads, and concentrations drop quickly moving away from roadways. Using block-level data, the annual average $PM_{2.5}$ concentration across the study area averaged 0.35 $\mu g/m^3$, the 99th percentile was 1.65 $\mu g/m^3$, and the highest concentration was 3.25 $\mu g/m^3$. These estimates exclude entrained dust, pavement wear, tire wear, brake wear, and other non-exhaust PM. They also consider only primary emissions of $PM_{2.5}$.

Figure 5-8. Annual $PM_{2.5}$ concentrations predicted in the Detroit area due to on-road mobile source exhaust emissions for the 25 m raster based on interpolating the 150 m receptor grid

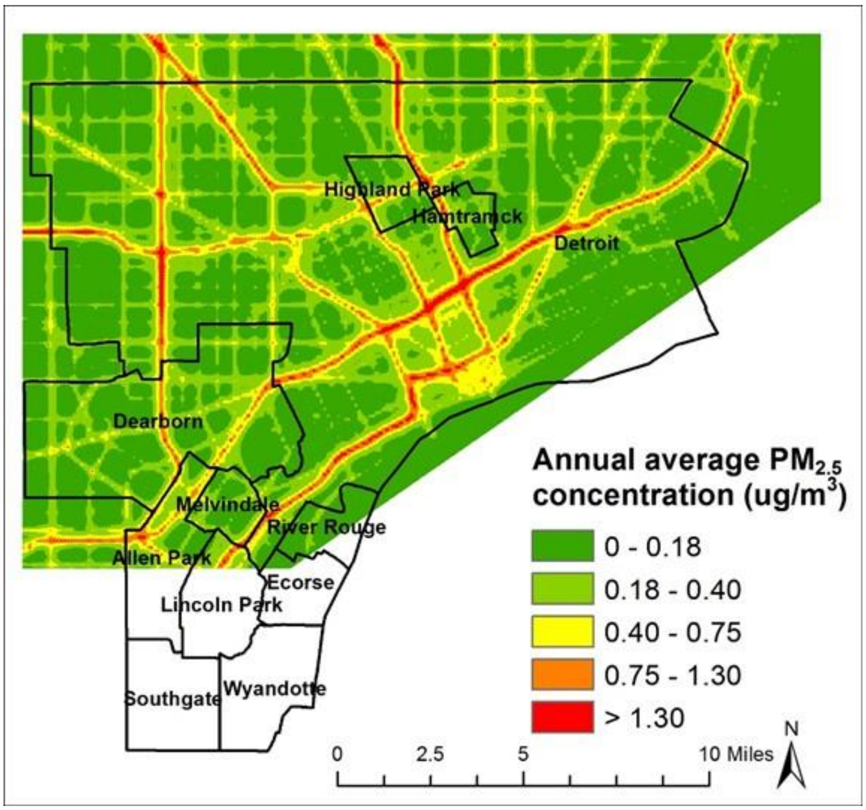


Table 5-13 (left portion) summarizes the total health burden attributable to $PM_{2.5}$ exposures in Detroit, Highland Park, Hamtramck, and the Down River communities. The estimated health impacts represent impacts to the entire study area, not just the portion covered by the mobile source receptor grid. Health impacts attributable to $PM_{2.5}$ exposures from on-road mobile sources in the study region (right portion of Table 5-13), include 1 pneumonia hospitalization, over 7,000 minor-restricted activity days, 209 DALYs, and \$106 million in monetized impacts, most of which (96%) was due to premature mortality.

This work is made possible by National Institute of Health and Environmental Sciences, RO1ES022616, and the Fred A. and Barbara M. Erb Family Foundation. Additional support was provided by the Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), #P30ES017885.

The burden of disease due to on-road emissions (as DALYs) is approximately 0.3% of the total health burden attributable to $PM_{2.5}$ exposures. This percentage may appear small, but collectively it represents a significant health burden. Still, the health impacts from traffic emissions are smaller than those estimated for point sources (Table 5-12). This results for several reasons: (1) relatively few people live very close to major roads;[9] (2) vehicle emissions vary over the day (higher at rush hour, lower the rest of the day); (3) predicted concentrations and exposures from on-road emissions represent a relatively small part of the total $PM_{2.5}$ concentration, and (4) the region with estimates of on-road $PM_{2.5}$ did not include some of the Down River communities (but 88% of the population was covered). However, estimated health impacts likely underestimate actual health impacts for several reasons: (1) only primary on-road emissions of $PM_{2.5}$ were considered, and entrained $PM_{2.5}$, secondary $PM_{2.5}$, and other pollutants were not considered; (2) health impact functions used to estimate impacts were based on studies that may not fully reflect the greater toxicity of diesel exhaust and other traffic-related pollutants; (3) exposure in vehicle cabins and to commuters was not considered; (4) time activity patterns were not considered, i.e., people were assumed to stay at home; (5) the susceptibility of the Detroit population and the population living in Detroit was only partially addressed; and (6) results use annual concentrations (although the daily or hourly fluctuations in $PM_{2.5}$ are not expected to significantly affect these results).

Table 5-13. Summary of health impacts (per year) associated with $PM_{2.5}$ exposures from all sources and exposure from exhaust emissions from mobile sources in Detroit.

Outcome (age group)	Impacts attributable to $PM_{2.5}$ exposures from all sources (per year)	Impacts attributable to $PM_{2.5}$ emissions from mobile sources (per year)
All-cause mortality (>29)	554	11
Infant mortality (0-1)	7	0
Asthma hospitalization (<65)	107	2
COPD hospitalization (>65)	21	0
CVD hospitalization (>65)	130	2
Pneumonia hospitalization (>65)	58	1
Non-fatal heart attack (18+)	25	1
Asthma ED visit (0-17)	374	11
Asthma exacerbation (as cough, 6-14)	224,799	4,311
Asthma exacerbation (as wheeze, 6-14)	18,003	423
Asthma exacerbation (as SOB, 6-14)	22,833	333
Minor restricted activity day (18-64)	365,937	7,238
Work loss day (18-64)	64,441	1,252
DALYs	10,367	209
Monetized impacts (million 2010$)	5,449	106

[9] An estimated 28% of the population lives in census blocks that adjacent (or within 200 m) of freeways and state highways. However, because blocks can be large, many fewer individuals actually live very near these major roads.

This work is made possible by National Institute of Health and Environmental Sciences, RO1ES022616, and the Fred A. and Barbara M. Erb Family Foundation. Additional support was provided by the Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), #P30ES017885.

Abbreviations: COPD: chronic obstructive pulmonary disease; CVD: cardiovascular disease; DALYs: disability-adjusted life years; ED: emergency department; SOB: shortness of breath.

This work is made possible by National Institute of Health and Environmental Sciences, RO1ES022616, and the Fred A. and Barbara M. Erb Family Foundation. Additional support was provided by the Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), #P30ES017885.