WILMAPCO

June 2010 — WILMAPCO DATA REPORT #10

Dirty Roads

Highway Traffic Emissions in New Castle County, Delaware

Overview of Project

This data report compares emissions by highway segment in New Castle County, Delaware for four unique pollutants: fine particulate matter (PM2.5), nitrogen oxides (NOx), hydrocarbons (HC) and carbon monoxide (CO). The heaviest-polluting highway segments for each pollutant are identified, and their impacts on our population are illustrated. Understanding where disproportionate impacts of vehicle emissions may occur, along with their extent, is a critical first step in a possible mitigation process. Due to data availability and time constraints, the emissions displayed and discussed in this report represent *rough estimates*, based on modeled traffic data and averaged arterial and freeway emission rates at speed intervals[1].

Highest Estimated Highway Emissions

The following table shows the top four "dirty roads" in New Castle County for the four pollutants.

- Due to its short length and high volumes, I-295 has the highest highway emissions/length for PM2.5, NOx and HC.
- With the exception of SR 1, the heaviest-polluting highways are in the north of the county.
- I-95 has the greatest total emissions of PM2.5, while SR 1 ranks first for NOx.
- CO, a less common pollutant on expressways, is highest on SR 141 and SR 2.

Table 1: Highest Estimated Highway Emissions, New Castle County

	Emissions (lbs/day)	Emissions / Length (mi)
Fine Particulate Matter (PM2.5)		
I-295	6.7	1.0
US/SR 202	16.0	0.8
I-495	16.0	0.7
I-95	45.9	0.6
Nitrogen Oxides (NOx)		
I-295	411	62
US/SR 202	822	43
I-495	986	43
SR 1	1,406	40
Hydrocarbons (HC)		
I-295	189	29
SR 2	446	26
US/SR 202	479	25
SR 273	350	22
Carbon Monoxide (CO)		
SR 141	4,594	285
SR 2	4,929	282
SR 273	3,888	246
SR 4	3,177	221

[1] The fleet data used in the analysis were simplified to three vehicle classes: automobiles, unit trucks, and combination trucks. The equation used throughout is: ((VMT x ER) / 454) / D, where VMT is vehicle miles traveled of a vehicle class; ER is the emission rate of that class at a given speed in grams/mi; and D is the distance of a given segment. Traffic data used in the analysis are from 2005, based on the free-flow daily average. Sources: DelDOT, DNREC, FHWA, EPA, U of D.

Mobile Sources & Health Effects[2]

Fine Particulate Matter (PM2.5)

- Particulate matter includes a mixture of solid particles and liquid droplets found in the air.
- "Fine" particles, under 2.5 microns in diameter, result from fuel combustion by motor vehicles, particularly diesel.
- Adverse health effects include: increased respiratory problems and disease, decreased lung function, chronic bronchitis, alterations of the body's defense system, and ultimately premature death.
- Sensitive groups include: children, seniors, and those with cardiopulmonary disease such as asthma.

Image Source: Interstate-Guide

Nitrogen Oxides (NOx)

- Nitrogen oxides result from the combination of nitric oxide (NO) and nitrogen dioxide (NO_2).
- Diesel vehicles are the leading on-road mobile source of NOx.
- NOx reacts with ammonia, moisture, and other compounds to form small particles. These small particles can penetrate the lungs, causing or worsening respiratory diseases, such as emphysema and bronchitis. NOx can also aggravate existing heart disease, leading to increased hospital admissions and premature death.
- Children, the elderly, those with lung diseases such as asthma, and people who work or exercise outside are at risk for adverse health effects from NOx.

Hydrocarbons (HC)

- Hydrocarbons, which belong to the volatile organic compound (VOC) family, are gaseous compounds made of carbon and hydrogen. They are a contributor to ground-level ozone (smog).
- HCs result from fuel evaporation and incomplete fuel combustion; cars and motorcycles are the primary on-road mobile source of HC.
- Smog can cause serious health problems such as difficulty breathing, lung damage, and reduced cardiovascular functioning.
- A number of HCs are also considered toxic, and can cause cancer and other health problems.

Carbon Monoxide (CO)

- Carbon monoxide is a colorless, odorless gas that is formed from the incomplete burning of carbon in fuels, such as gasoline, and contributes to the formation of smog.
- High concentrations of CO occur along side roads with heavy traffic, particularly at major intersections, and in enclosed areas, such as garages and poorly ventilated tunnels.
- CO reduces oxygen delivery to the body's organs and tissues, and can subsequently damage the cardiovascular and central nervous systems.
- At extremely high levels, CO is poisonous and can be fatal.

[2] The highways identified in this report with greater-than-average emissions, along with the associated housing in close proximity to them, do not necessarily correspond with unhealthy levels of air emissions. They simply represent deviations from average free-flow highway emissions, by segment. Further study, including the consideration of non-mobile sources, wind direction, etc., is necessary to determine unhealthy exposure to highway emissions.

Highway Emissions by Segment

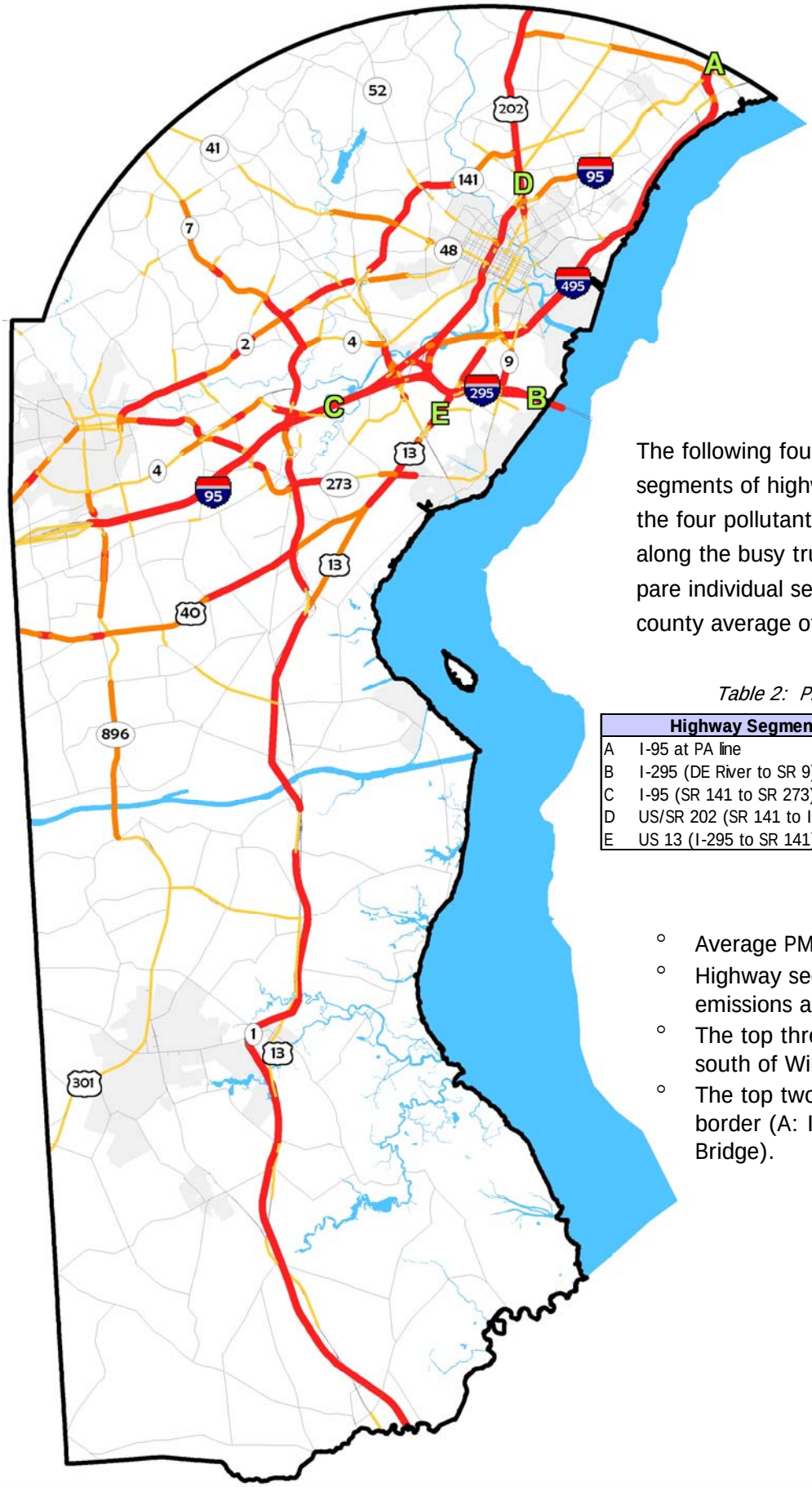


Figure 1:

PM2.5 Emissions by Highway Segment

PM2.5 lbs/mi per Day

- > Triple the Average
- > Double the Average
- > Average

The following four maps illustrate the heaviest-polluting segments of highway. While variations exist between the four pollutants, the highest-emitting segments are along the busy trunk roads in the north. The maps compare individual segment emissions, by length, to the county average of all segments.

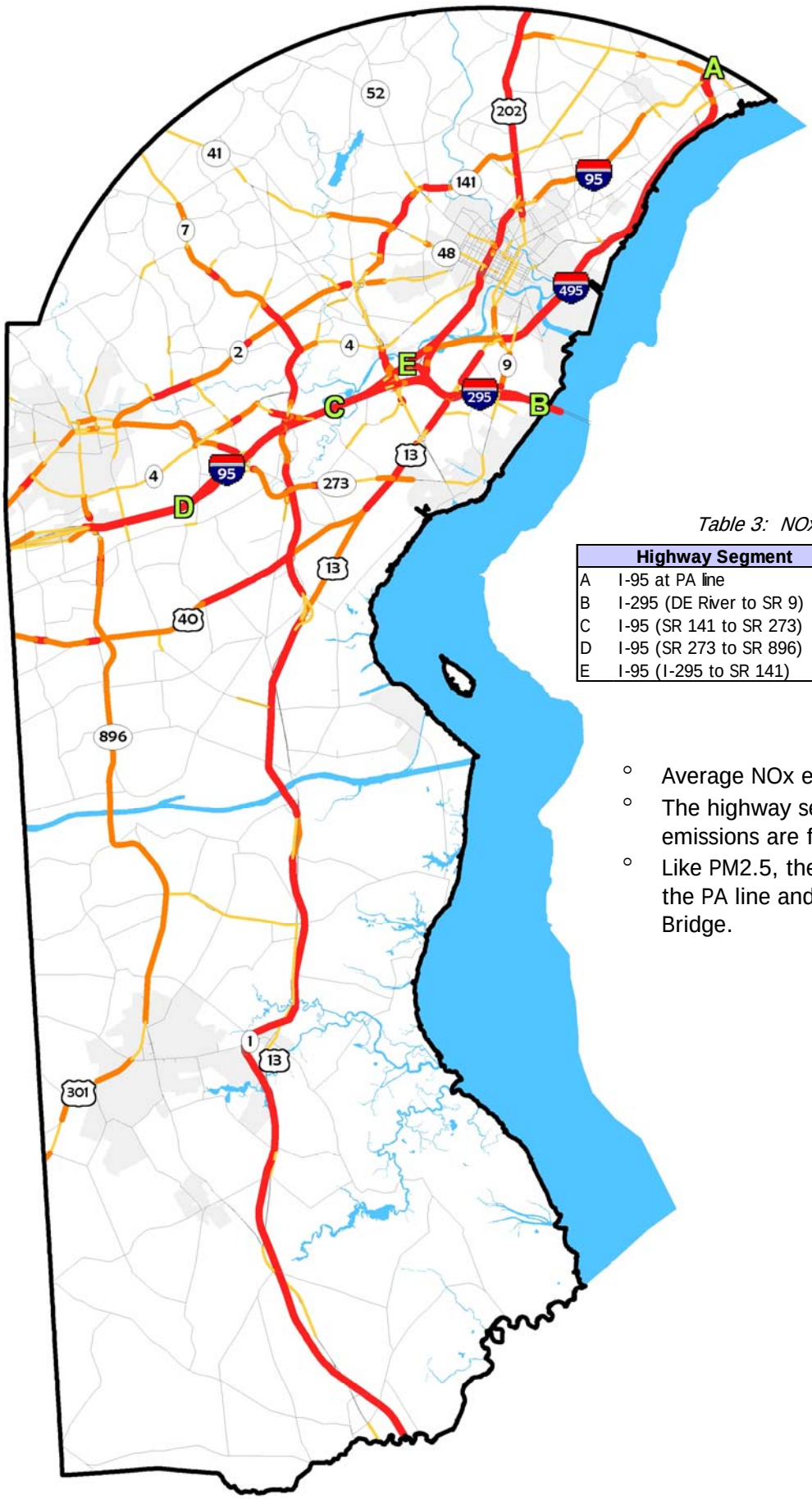
Table 2: PM2.5 Emissions by Highway Segment

	Highway Segment	Emissions (lbs/day)	Emissions / Length (mi)
A	I-95 at PA line	0.7	2.4
B	I-295 (DE River to SR 9)	4.3	2.1
C	I-95 (SR 141 to SR 273)	13.3	1.9
D	US/SR 202 (SR 141 to I-95)	1.2	1.5
E	US 13 (I-295 to SR 141)	1.6	1.5

- Average PM2.5 emissions are 0.2 pounds/mile.
- Highway segments with the greatest PM2.5 emissions are in the northeast of the county.
- The top three are found on interstates north and south of Wilmington.
- The top two highway segments are along the state border (A: I-95 at PA line), (B: Delaware Memorial Bridge).

Figure 2:

NOx Emissions by Highway Segment



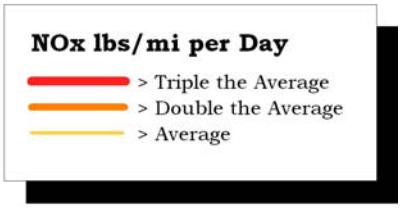


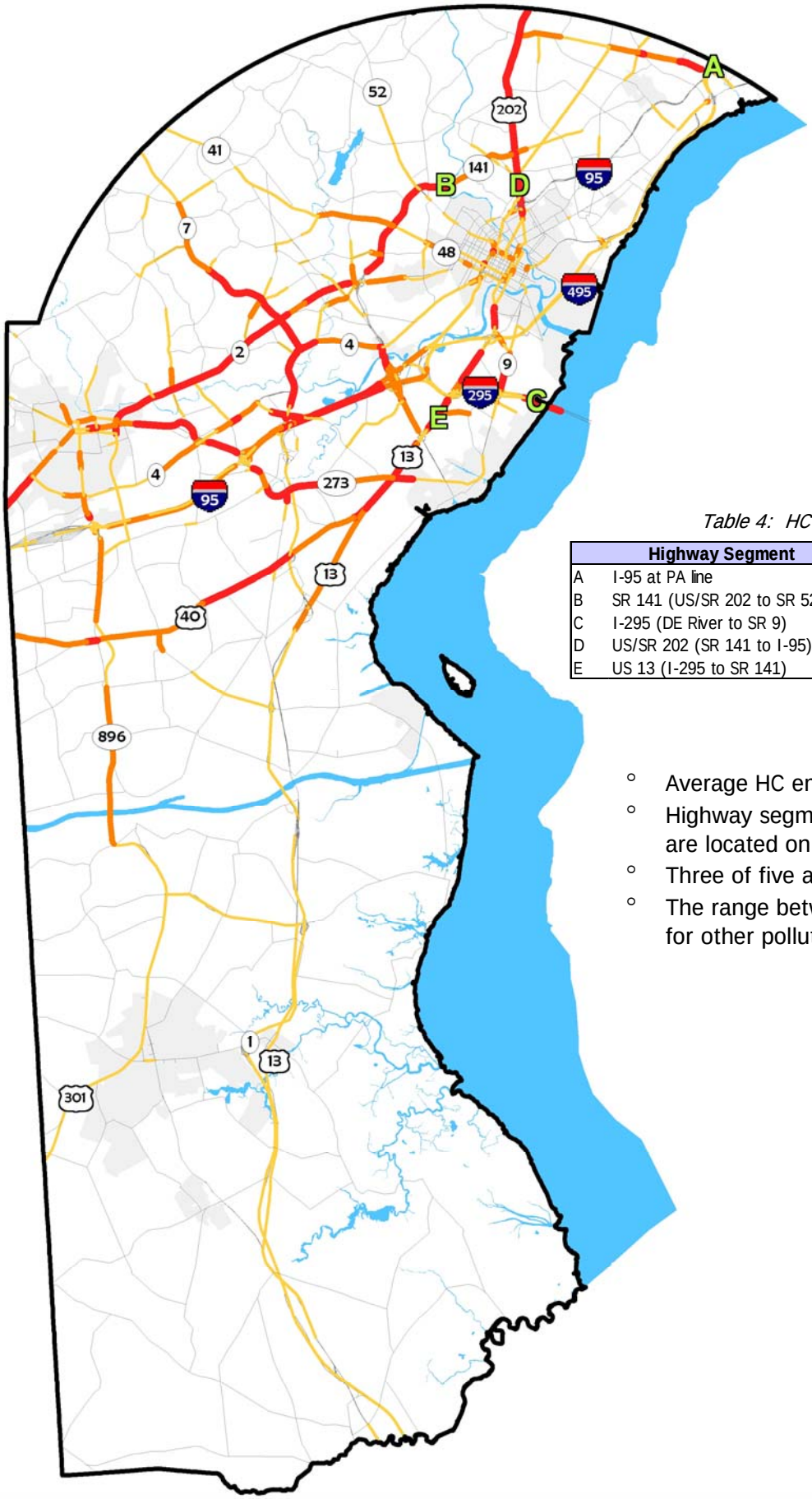
Table 3: NOx Emissions by Highway Segment

	Highway Segment	Emissions (lbs/day)	Emissions / Length (mi)
A	I-95 at PA line	35	118
B	I-295 (DE River to SR 9)	232	116
C	I-95 (SR 141 to SR 273)	732	102
D	I-95 (SR 273 to SR 896)	585	79
E	I-95 (I-295 to SR 141)	51	76

- Average NOx emissions are 12 pounds/mile.
- The highway segments with the greatest NOx emissions are found on I-95 and I-295.
- Like PM2.5, the top pair of NOx segments are I-95 at the PA line and I-295 at the Delaware Memorial Bridge.

Figure 3:

HC Emissions by Highway Segment



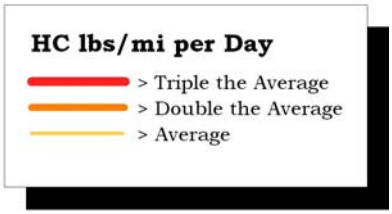


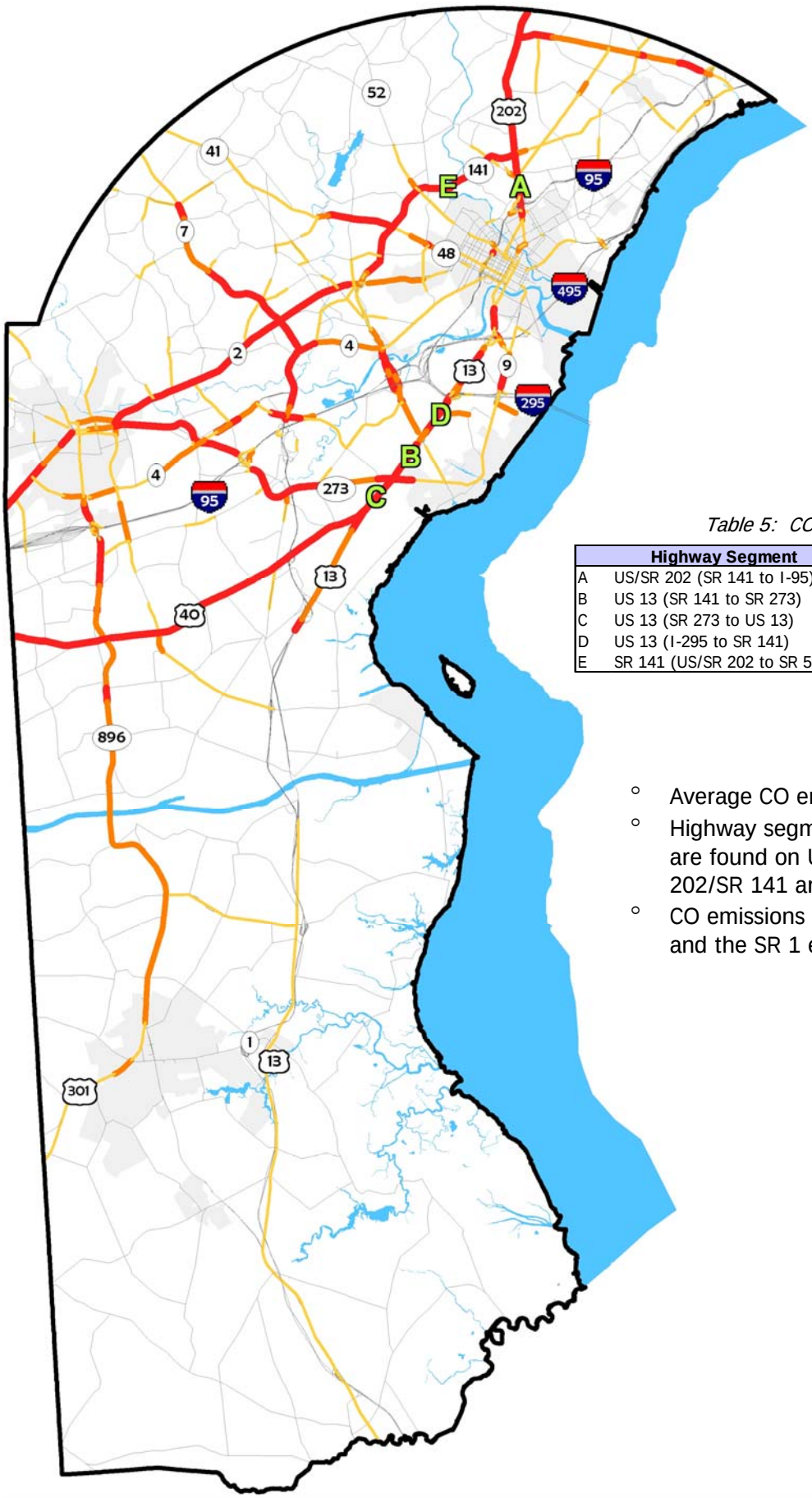
Table 4: HC Emissions by Highway Segment

	Highway Segment	Emissions (lbs/day)	Emissions / Length (mi)
A	I-95 at PA line	38	128
B	SR 141 (US/SR 202 to SR 52)	28	107
C	I-295 (DE River to SR 9)	207	104
D	US/SR 202 (SR 141 to I-95)	53	72
E	US 13 (I-295 to SR 141)	103	68

- Average HC emissions are 10 pounds/mile.
- Highway segments with the greatest HC emissions are located on Wilmington's periphery.
- Three of five are not interstate segments.
- The range between top HC emissions is greater than for other pollutants.

Figure 4:

CO Emissions by Highway Segment



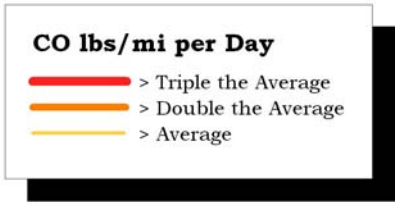


Table 5: CO Emissions by Highway Segment

	Highway Segment	Emissions (lbs/day)	Emissions / Length (mi)
A	US/SR 202 (SR 141 to I-95)	568	779
B	US 13 (SR 141 to SR 273)	411	733
C	US 13 (SR 273 to US 13)	744	729
D	US 13 (I-295 to SR 141)	772	727
E	SR 141 (US/SR 202 to SR 52)	93	711

- Average CO emissions are 103 pounds/mile.
- Highway segments with the greatest CO emissions are found on US 13, south of Wilmington, and the US 202/SR 141 area.
- CO emissions are light along the county's interstates, and the SR 1 expressway.

Highway Emissions by Municipality

The table below shows the total estimated highway emissions, by municipality. Emissions from local roadways are not included.

Table 6: Highway Emissions (lbs/day) by Municipality

	PM2.5	NOx	HC	CO
Wilmington	19.5	1,020	657	4,457
Newark	9.9	473	456	4,599
Middletown	2.9	480	99	1,017
All Others*	5.1	244	414	2,503

*Arden, Ardencroft, Ardentown, Bellefonte, Delaware City, Elsmere, New Castle, Newport, Odessa, Townsend

- The municipalities with the highest estimated highway emissions are the three largest in the county: Wilmington, Newark, and Middletown.
- Wilmington has the highest estimated highway emissions for three of four pollutants (PM2.5, NOx, HC).
- Newark tops the list for CO.
- Newark has approximately double the amount of emissions than the combined "All Others" category for PM2.5, NOx, and CO.
- Wilmington has almost quadruple the amount of emissions than the combined "All Others" category for PM2.5.

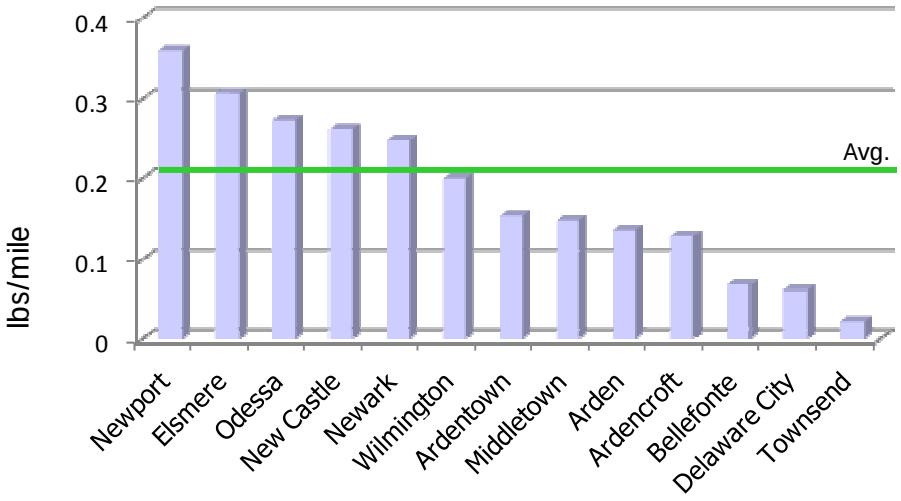
Image Source: WILMAPCO

The following graphs add nuance to the analysis by dividing total municipal highway emissions by highway length (miles).

PM2.5

- The three municipalities with the highest PM2.5 highway emissions by length are small in area and population.
- Newport, Elsmere and Odessa are each home to short, but busy, stretches of highway
- The county average is about 0.2 lbs/mile.
- The range is from 0.02 lbs/mile (Townsend) to just under 0.4 lbs/ mile (Newport).

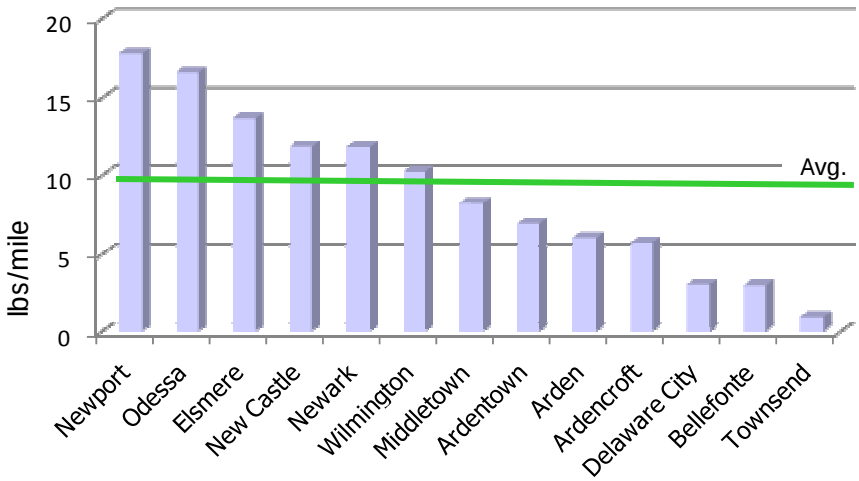
Figure 5: PM2.5 Highway Emissions / Length by Municipality



NOx

- The approximate average is 9 lbs/ mile.
- The range is from 1 lb/mile (Townsend) to 18 lbs/mile (Newport).
- NOx emissions / length in New Castle and Newark are the same (12 lbs/mile).

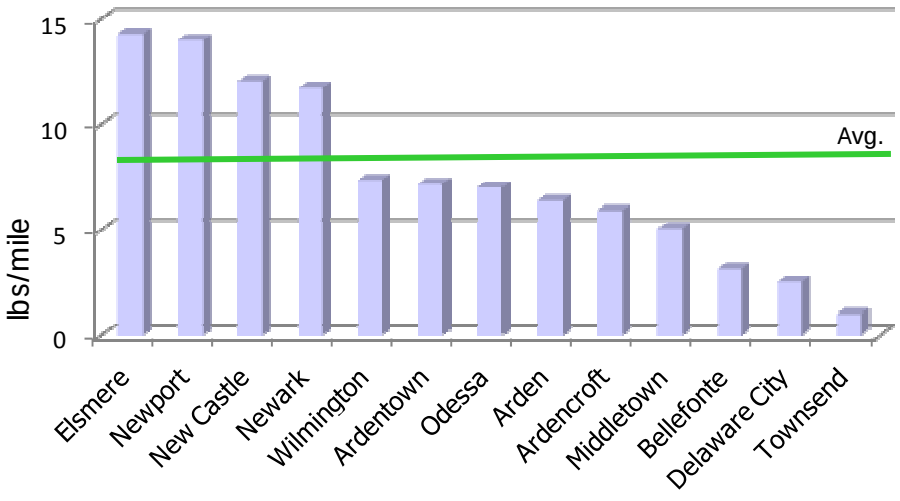
Figure 6: NOx Highway Emissions / Length by Municipality



HC

- Elsmere and Newport are the municipalites with the highest highway emissions / length (14 lbs/mile for both).
- The average is about 8 lbs/mile.
- The range is from 1 lb/mile (Townsend) to 14 lbs/mile (Elsmere).
- Highway emissions / length are the same for Wilmington, Ardentown and Odessa (7 lbs/ mile).

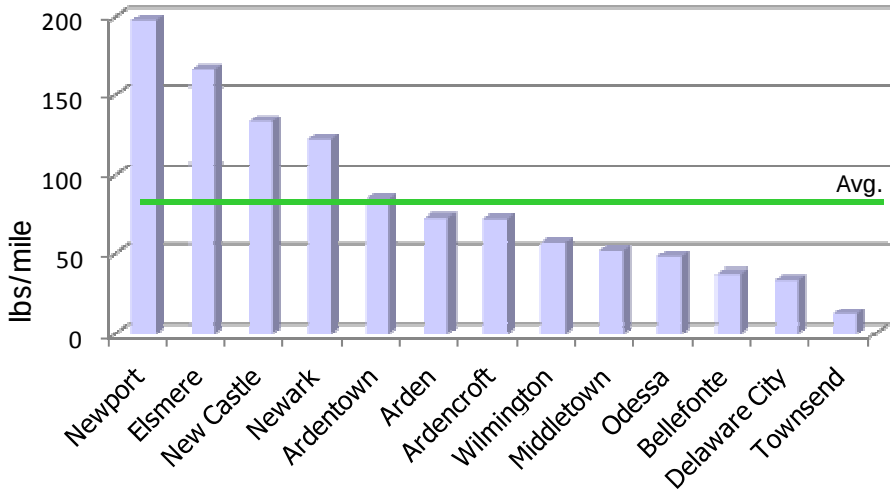
Figure 7: HC Highway Emissions / Length by Municipality



CO

- Newport ranks the highest for CO highway emissions / length (198 lbs/mile).
- The average is about 84 lbs/mile.
- The range is from 12 lbs/mile (Townsend) to 198 lbs/mile (Newport).
- While high PM2.5 and NOx emissions / length were found in Odessa, the town shows average to below average for HC and CO.
- Newport, Elsmere, New Castle and Newark are all above average for each pollutant.

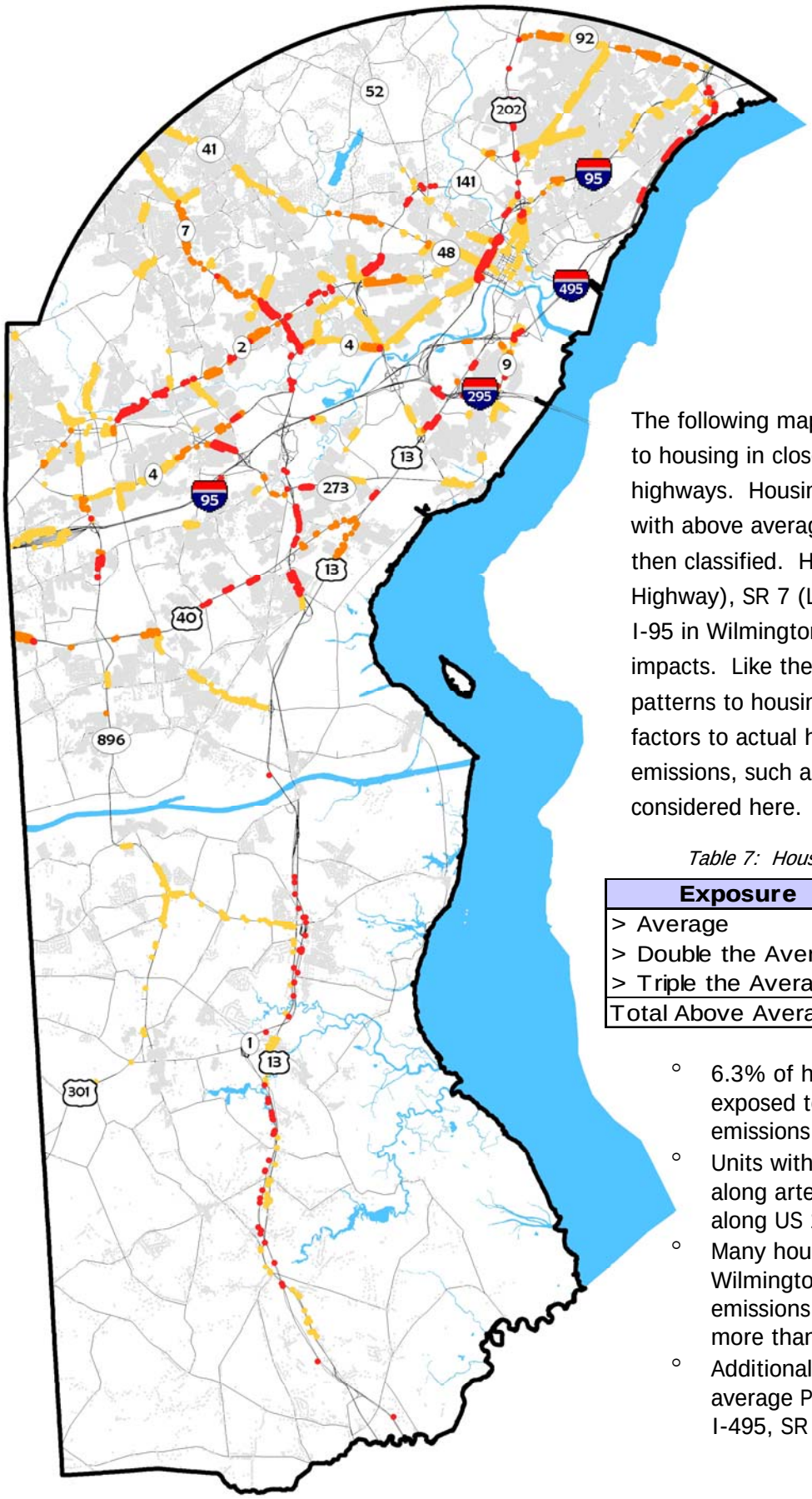
Figure 8: CO Highway Emissions / Length by Municipality



High Near-Road Emissions Impact to Housing

Figure 9:

Housing Unit Exposure to PM2.5 Highway Emissions



PM2.5 lbs/mi per Day
- > Triple the Average
- > Double the Average
- > Average
- < Average

The following map series explores the emission impact to housing in close proximity to New Castle County's highways. Housing units within 300 feet of highways with above average emissions by length are identified, then classified. Housing along SR 2 (Kirkwood Highway), SR 7 (Limestone Road) and under the raised I-95 in Wilmington are among those with the highest impacts. Like the larger analysis, these exposure patterns to housing are rough estimates. Important factors to actual housing exposure to near-road emissions, such as the prevailing wind direction, are not considered here.

Table 7: Housing Units by PM2.5 (lbs/mi) Exposure

Exposure	Housing Units	Percentage
> Average	7,533	4.1%
> Double the Average	2,242	1.2%
> Triple the Average	1,771	1.0%
Total Above Average	11,546	6.3%

- 6.3% of housing units in New Castle County are exposed to above average PM2.5 highway emissions.
- Units with the highest exposures are located along arterials in the north of the county and along US 13 south of the canal.
- Many housing units underneath I-95 in Wilmington are exposed to heavy PM2.5 emissions. 380 units there show exposure of more than triple the county average.
- Additional units with more than triple the average PM2.5 emissions can be found along I-495, SR 2, SR 7, SR 141 and SR 273.

Figure 10:

Housing Unit Exposure to NOx Highway Emissions

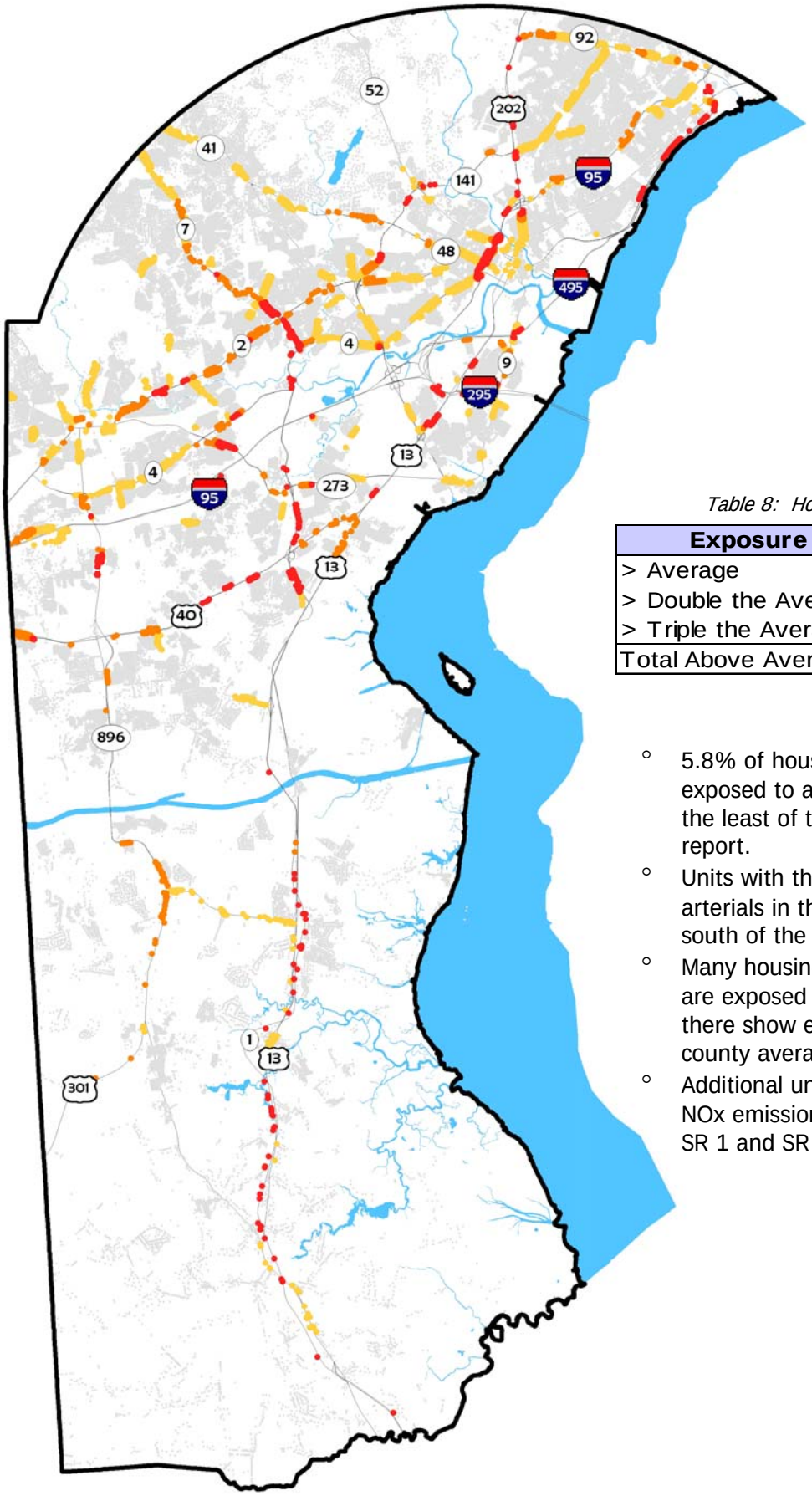


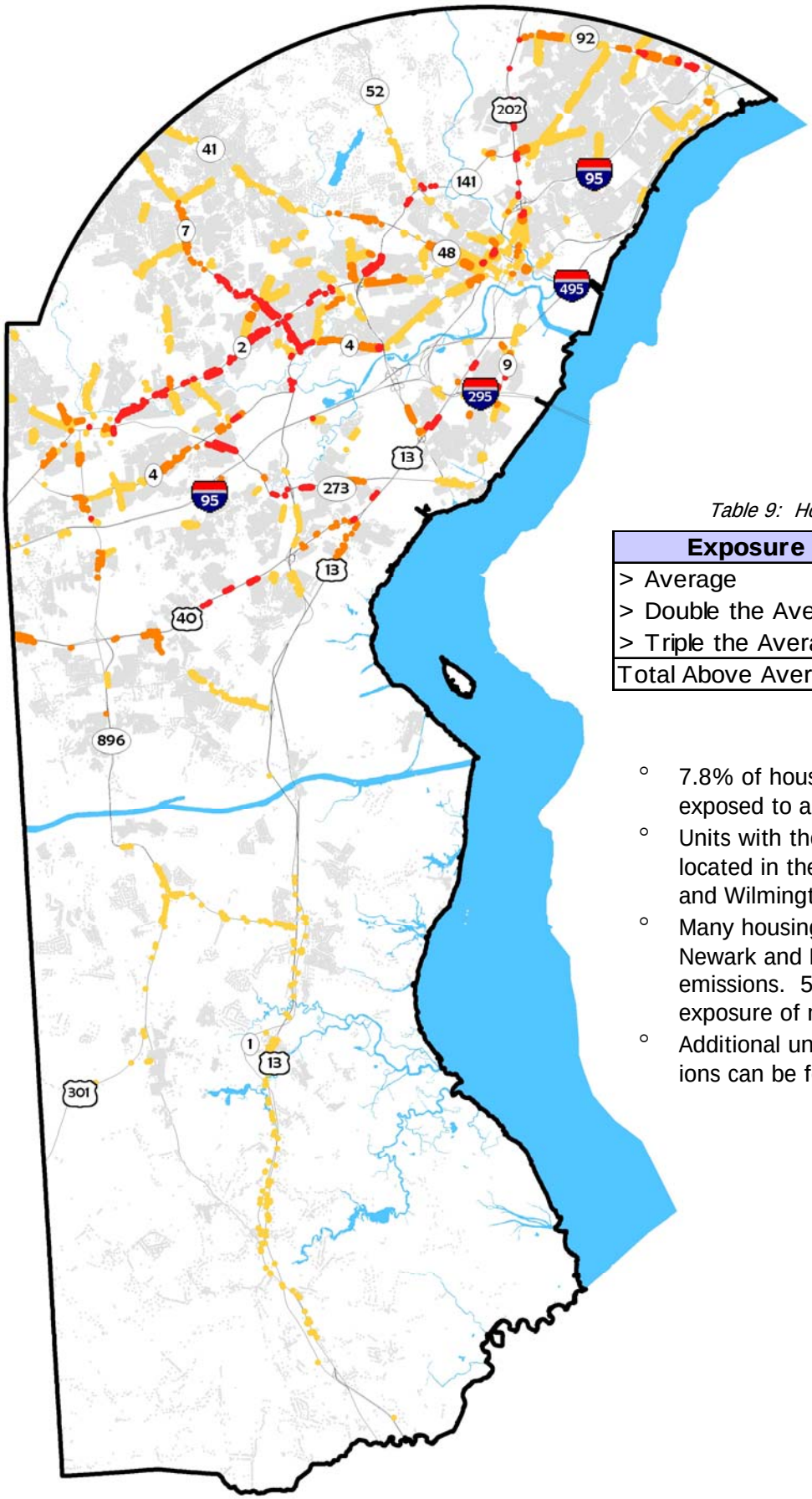
Table 8: Housing Units by NOx (lbs/mi) Exposure

Exposure	Housing Units	Percentage
> Average	6,782	3.7%
> Double the Average	2,527	1.4%
> Triple the Average	1,459	0.8%
Total Above Average	10,768	5.8%

- 5.8% of housing units in New Castle County are exposed to above average NOx highway emissions, the least of the four pollutants considered in this report.
- Units with the highest exposures are located along arterials in the north of the county and along US 13 south of the canal.
- Many housing units underneath I-95 in Wilmington are exposed to heavy NOx emissions. 380 units there show exposure of be more than triple the county average.
- Additional units with more than triple the average NOx emissions can be found primarily along I-495, SR 1 and SR 7.

Figure 11:

Housing Unit Exposure to HC Highway Emissions



HC lbs/mi per Day
- > Triple the Average
- > Double the Average
- > Average
- < Average

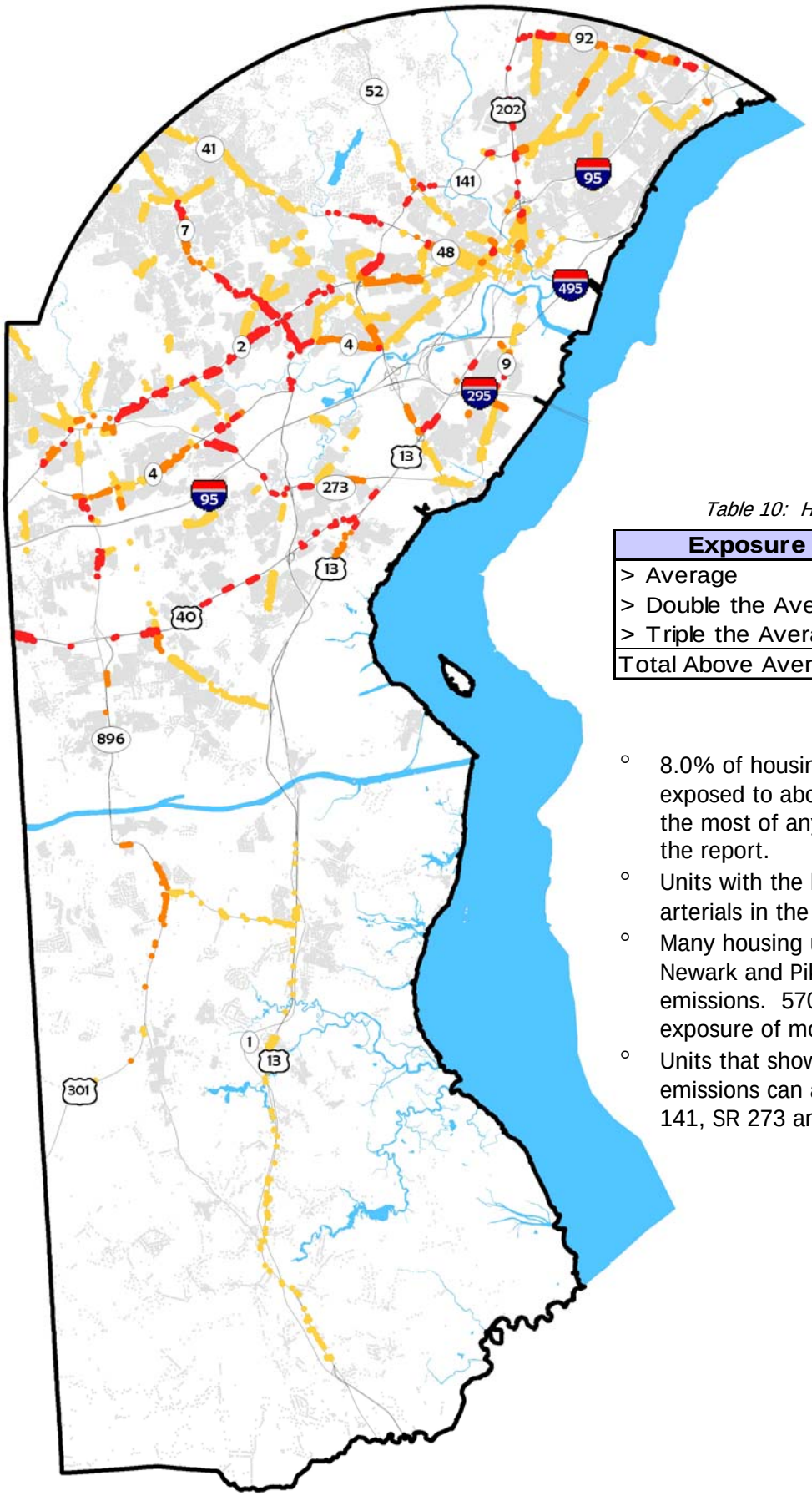
Table 9: Housing Units by HC (lbs/mi) Exposure

Exposure	Housing Units	Percentage
> Average	9,317	5.0%
> Double the Average	3,773	2.0%
> Triple the Average	1,378	0.7%
Total Above Average	14,468	7.8%

- 7.8% of housing units in New Castle County are exposed to above average HC highway emissions.
- Units with the highest exposures are primarily located in the north of the county, between Newark and Wilmington.
- Many housing units along SR 7 and SR 2 near Newark and Pike Creek are exposed to heavy HC emissions. 580 units along these corridors show exposure of more than triple the county average.
- Additional units with more than triple the average ions can be found along SR 141 and SR 273.

Figure 12:

Housing Unit Exposure to CO Highway Emissions



CO lbs/mi per Day
- > Triple the Average
- > Double the Average
- > Average
- < Average

Table 10: Housing Units by CO (lbs/mi) Exposure

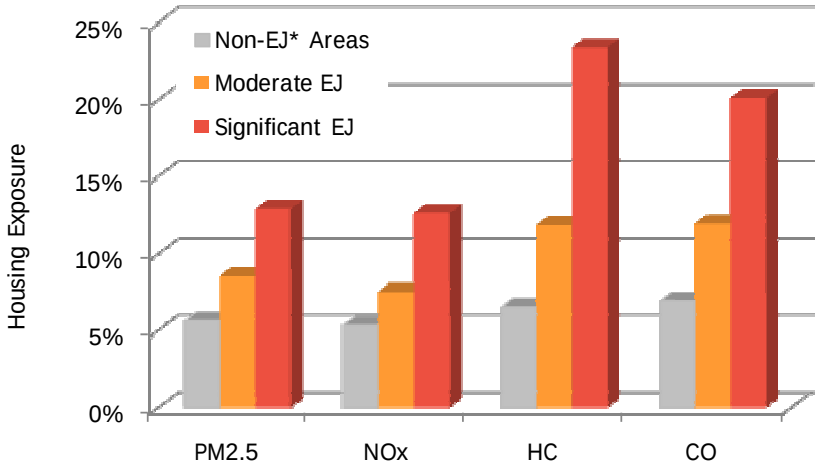
Exposure	Housing Units	Percentage
> Average	9,895	5.4%
> Double the Average	2,326	1.3%
> Triple the Average	2,527	1.4%
Total Above Average	14,748	8.0%

- 8.0% of housing units in New Castle County are exposed to above average CO highway emissions, the most of any of the four pollutants considered in the report.
- Units with the highest exposures are located along arterials in the north of the county.
- Many housing units along SR 7 and SR 2 near Newark and Pike Creek are exposed to heavy HC emissions. 570 units along these corridors show exposure of more than triple the county average.
- Units that show more than triple the average CO emissions can also be found along SR 48, SR 92, SR 141, SR 273 and US 40.

High Near-Road Emissions and Transportation Equity

The final section of this report considers the social equity of highway emissions impacts to housing. As shown in our *2009 Transportation Equity Report: An Environmental Justice (EJ) Study of the WILMAPCO Region*, low-income and minority communities carry more than their fair share of transportation system's burden. In step with this, housing within moderate and significant concentrations of low-income and minority neighborhoods (or EJ areas) is much more likely to face exposure to heavy emissions (lbs/mi) from nearby highways than housing outside.

Figure 13: Percentage of Housing Units with Above Average Near-road Exposure



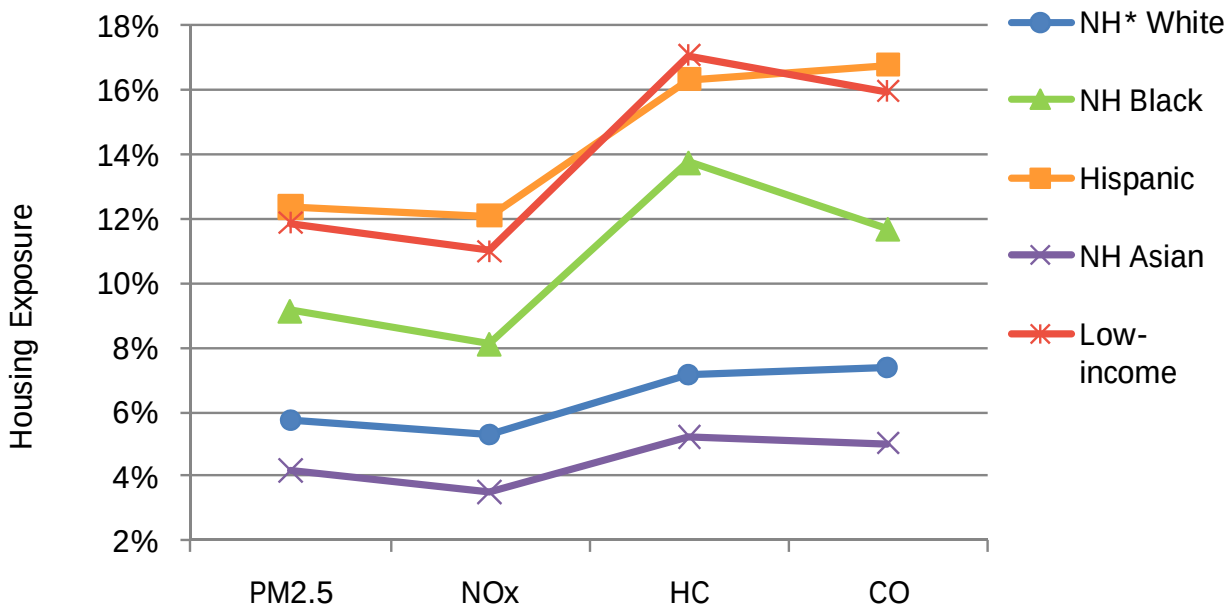
*Moderate and significant EJ areas are as identified in the *2009 Transportation Equity Report* (wilmapco.org/EJ)

- For each pollutant the percentage of housing units with above average near-road exposure increased with the EJ concentration.
- Housing within significant EJ areas is more than twice as likely to face exposure to above average PM2.5 and NOx highway emissions than non-EJ areas.
- For HC and CO emissions, significant EJ area housing is about three times as likely to show exposure.

Image Source: WILMAPCO

Figure 14 adds nuance to the EJ analysis by breaking apart areas with heavy concentrations of low-income households and various ethnic and racial groups.[3]

Figure 14: Percentage of Housing Units with Above Average Near-road Exposure by Group Concentration



* = Non-Hispanic

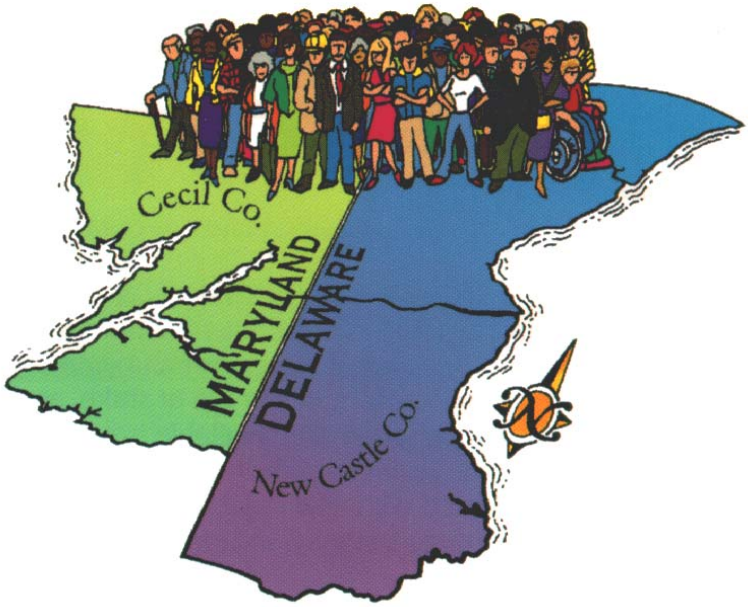
- Households in Hispanic and low-income concentrations experience the highest exposure to above average near-road emissions.
- Households in Asian concentrations experience the lowest emissions for all four pollutants, with White areas showing the second to lowest.
- Black concentrations show exposure levels in between those of the Whites and Hispanics.
- HC emissions were greater than other pollutants for all areas, but rose more sharply in Hispanic, Black, and low-income concentrations.
- Households in Hispanic and low-income areas are about three times more likely to experience greater than average PM2.5, HC, and CO exposure than Asian areas.
- Black concentrations are about one and a half times more likely to experience greater than average NOx exposure than White concentrations, and twice as likely to experience greater than average HC exposure.

[3] Concentrated housing was defined as falling within census block groups with more than double the county's average percentage for a given group. Because they constitute the majority population at 70.9%, the figure used to identify Non-Hispanic White concentrations was set at 80.9%. Low-income areas are defined as those with more than double the county average of households below poverty.

Highway Traffic Emissions, Overall Observations

- With little exception, highway segments along the busy interstates and arterials around the City of Wilmington showed the heaviest emissions (both raw and per capita) for all four pollutants considered. While municipalities with much land and population, such as Wilmington and Newark, showed the highest raw emissions, smaller municipalities with high-volume highway(s), such as Newport and Elsmere, had the heaviest per-capita highway emissions.

- Housing with above average exposure to near-road emissions (lbs/mi) was scattered along highways, generally in the north of the county. Heavy concentrations were found in a few corridors: SR 2 and SR 7 around Pike Creek, and underneath I-95 in Wilmington. Housing exposure was found to be inequitably-distributed, socially, within New Castle County. Housing in low-income and minority concentrations was two to three times more likely to show high near-road emission exposure than housing outside such concentrations. Neighborhoods home to many low-income and Hispanic residents had the highest exposure levels.



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2010 — WILMAPCO DATA REPORT #10

The Wilmington Area Planning Council (WILMAPCO) is a Metropolitan Planning Organization serving New Castle County, DE and Cecil County, MD. Our mission is to serve the residents of our region by creating the best possible transportation plan. This series of data reports summarizes key data to allow both residents and decision-makers to better understand changes within our region. This document was created by the WILMAPCO staff. For more information on this and other data reports, please visit our website at: www.wilmapco.org/data.

Other WILMAPCO Data Reports

Report #1: Regional Population Changes 1980-2000, September 2004

Report #2: Changes in Regional Population & Household Characteristics 1980-2000, December 2004

Report #3: Analysis of Commuter Flows to and from the WILMAPCO Region 1990-2000, July 2005

Report # 4: Regional Population Changes: 2000-2030, January 2006 (updated May 2007)

Report #5: Employment: 1990-2004, July 2006

Report #6: Crash Data: 2000-2006, September 2008

Report #7: Travel Times: 2000-2007, December 2008

Report #8: Transit Trends: 2000-2007, July 2009

Report #9: Travel Patterns (DelDOT Household Survey), July 2009