The New York City Community Air Survey

Supplemental Report[1]

Nickel Concentrations in Ambient Fine Particles: Winter Monitoring, 2008-2009

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[1] This report is a supplement to *The New York City Community Air Survey. Results from Winter Monitoring 2008-2009* available at www.nyc.gov/health/nyccas. Readers should consult that report for more information about the study.

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Background and Methods

This report summarizes the findings of the New York City Community Air Survey (NYCCAS) on winter concentration and distribution of Nickel (Ni). Nickel is one of several metals that are found in particulates released from the combustion of residual heating fuel. Its concentration was studied to better understand the direct contribution of residual fuel burning to New York City's air pollution, and because evidence suggests that Ni may negatively influence human health.

In 2007, New York City's first comprehensive sustainability plan, PlaNYC, established a range of initiatives to improve the City's air quality. One PlaNYC initiative, the New York City Community Air Survey (NYCCAS) is studying how harmful air pollutants vary across New York City neighborhoods to help inform the City's air quality improvement efforts. Launched in December 2008, NYCCAS is sampling the air at 150 street-level locations (figure 1) in each season of the year.

The sampling began during the winter of 2008-2009, and the first findings were published in a December 2009 report. The report showed that concentrations of four pollutants — fine particles ($PM_{2.5}$), elemental carbon (EC), nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) — varied two-fold or more across the city. Concentrations were higher in areas where fuel combustion sources, especially on-road vehicles and buildings — are more abundant.

This supplemental report presents results for the same winter season for nickel (Ni), a component of fine particles ($PM_{2.5}$). More information about NYCCAS goals and methods, along with the full winter season report, are available at www.nyc.gov/health/nyccas.

Inhaled fine particles ($PM_{2.5}$) penetrate deep into the lungs, causing inflammation of the airways and blood vessels. $PM_{2.5}$ can worsen lung and heart diseases, exacerbating asthma, causing hospital

Figure 1 - NYCCAS monitoring locations
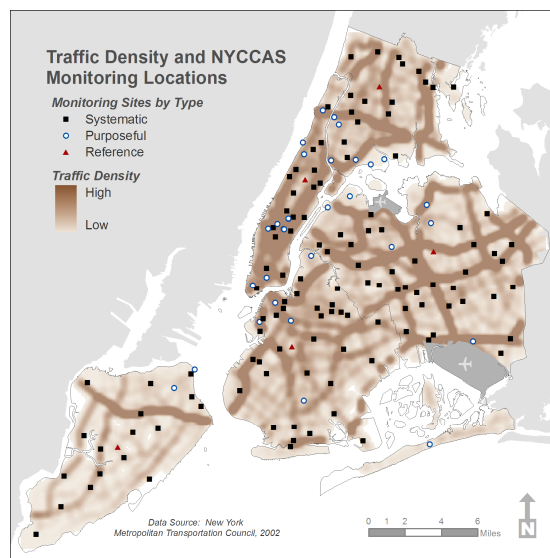
admissions and deaths, and reducing life expectancy (Pope et al., 2009). While $PM_{2.5}$ in urban air is composed of many substances, burning residual fuel oil (#6 fuel oil) to heat buildings releases $PM_{2.5}$ with higher levels of Ni. No. 4 fuel oil — a mix of #6 residual oil and cleaner-burning distillate oil — can also increase Ni concentrations in $PM_{2.5}$. Mounting scientific evidence suggests that these emissions, known as residual oil fly ash (ROFA), may have respiratory and cardiovascular health effects.

NYCCAS uses a laboratory method called X-ray fluorescence (XRF) to estimate the concentrations of Ni and other elements in $PM_{2.5}$ samples. After estimating Ni concentrations for 150 sites across the city, we used a technique called land-use regression (LUR) to relate Ni concentrations to neighborhood emission sources, such as building boilers and traffic. More detail on the all NYCCAS methods, including laboratory methods, LUR analysis and the selection of monitoring sites, is provided in the full report and technical appendices available at www.nyc.gov/health/nyccas.

Results

Across all NYCCAS sites sampled during the winter season, Ni concentrations averaged 13.0 nanograms per cubic meter (ng/m^3), but concentrations did vary greatly across the city.

Higher concentrations of Ni were found in locations with more nearby units permitted to burn #4 or #6 oil (Figure Ni-1) and in areas with high residential population density (Figure Ni-2). Neighborhoods with higher population density tend to have a greater number of large buildings burning residual fuel oil.

Figure Ni-1: Ni levels in areas with high density of heavy oil burning units are nearly 4 times those of those in areas with the low density
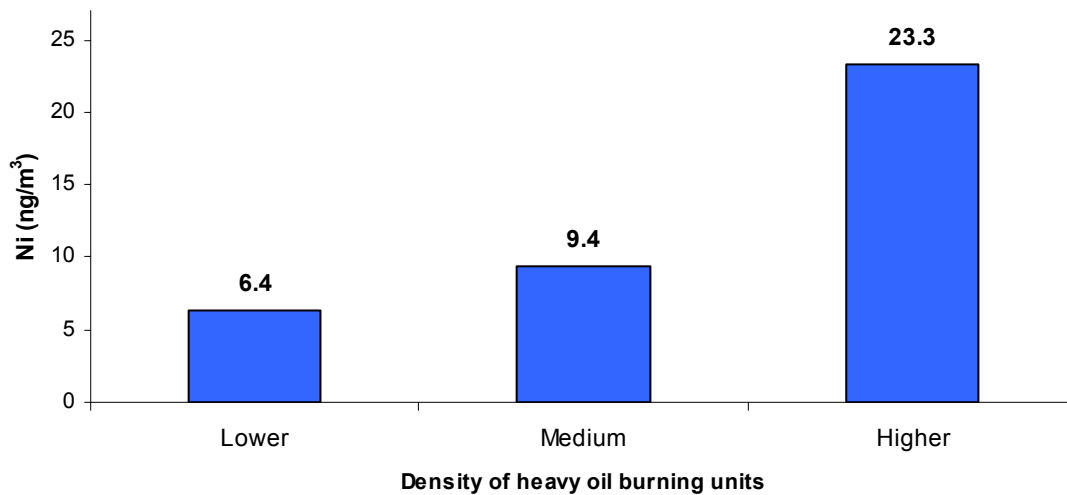
Density of residual oil-burning units estimated as units using #4 or #6 heating oil within 1 km of sampling location. Each category (lower, medium and higher) includes one third of sampling sites, with counts of 0-3, 4-31, and 32-447 permitted oil burning units, respectively. Data source: NYC Department of Environmental Protection (DEP) permitting data.

Figure Ni-2: Ni levels in high residential population density areas are more than 3 times those in areas with low residential population density
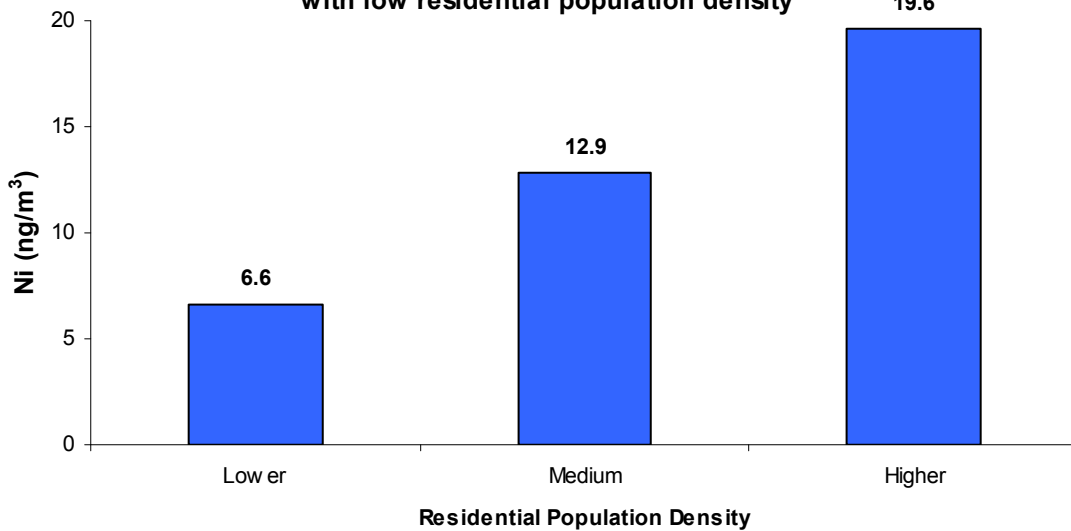

Residential population is estimated within 1 km of sampling location. Each category (lower, medium and higher) includes one third of sampling sites, with residential population of 2 to 22,799, 23,800 to 51,999, and 52,000 to 112,546 persons, respectively. Data source: Oak Ridge National Laboratory LandScan database. See Technical Appendix at www.nyc.gov/health/nyccas for calculation methods.

The most important predictors of Ni concentrations were:

- Number of units permitted to burn #4 or #6 oil within 1 km of the sampling site. Nickel levels in areas with a high density of heavy oil burning units were nearly four times those in areas with low density.

- Residential population density within 1 km. In areas with a high residential population density, Ni levels are three times those where residential population is lower.

The map in Figure Ni-3 depicts wintertime average Ni concentrations across New York City, as predicted by the model. Concentrations are estimated to be higher in more built-up parts of the city, including much of Manhattan and parts of the Bronx, where there are more large building with residual oil-burning units. Unlike many other pollutants examined by NYCCAS, Ni is not strongly associated with roadway traffic patterns. An annex to this report includes a chart summarizing the average and range of estimated Ni concentrations by community district.

Figure Ni-3: Map of estimated Ni concentrations, winter 2008-9*
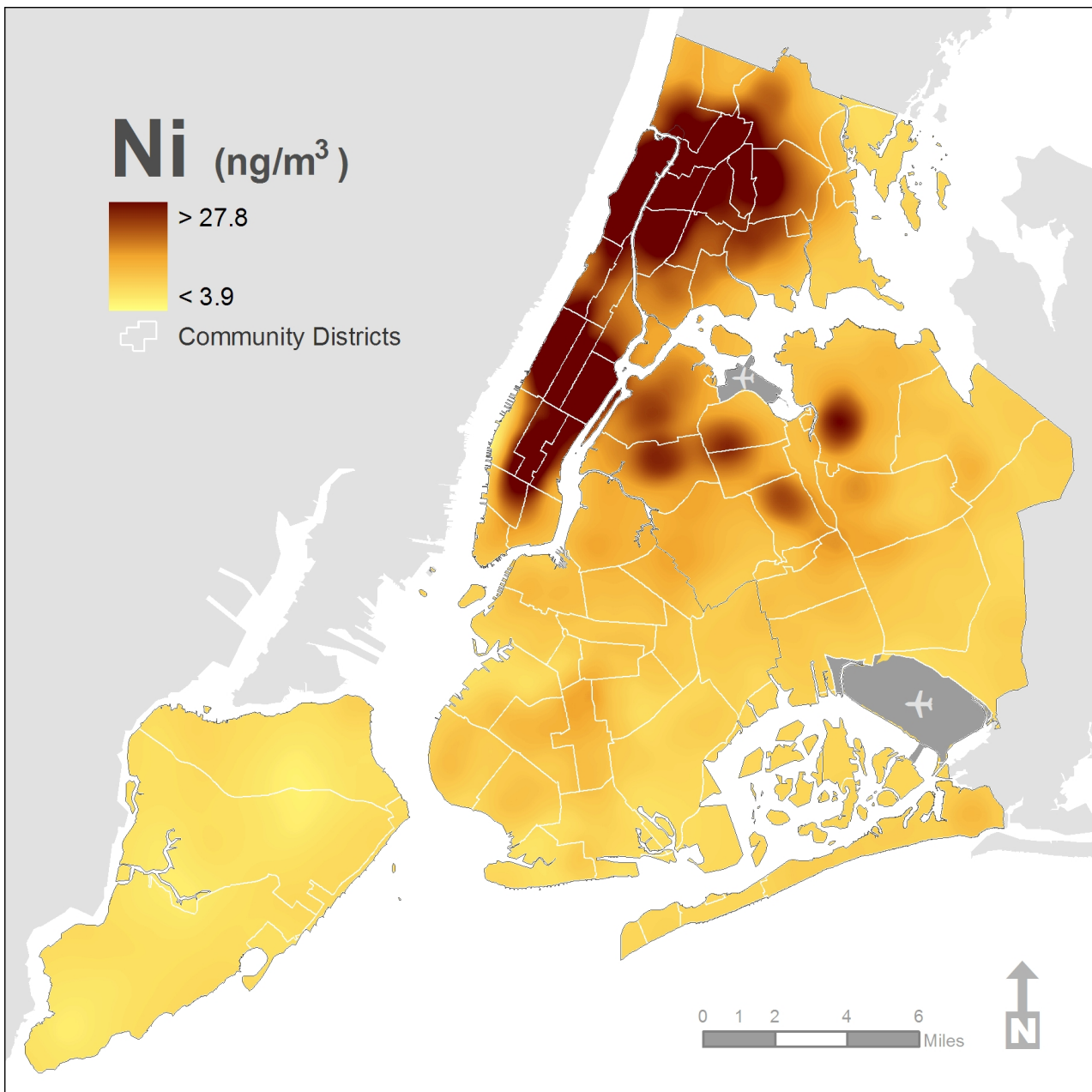
* See Technical Appendix www.nyc.gov/health/nyccas for calculation methods

Discussion and Limitations

These NYCCAS data quantify, for the first time, the extent to which some areas of the city have higher airborne levels of nickel during the winter season. Higher concentrations tend to occur in areas with many residual oil combustion sources, such as oil burning units for heat and hot water in large buildings, which can burn the most polluting types of oil, known as residual oil (#4 or #6 oil). These findings strengthen results from the first NYCCAS report, which suggested that residual fuel oil burning for heating in large buildings contributes importantly to harmful air pollution concentrations (especially for $PM_{2.5}$ and SO_2) in some areas of the city. Like Ni, SO_2 and total $PM_{2.5}$ can exacerbate heart and lung disease, and contribute to premature mortality. Currently, New York City's air does not meet the National Ambient Air Quality Standards for $PM_{2.5}$ (U.S. Environmental Protection Agency, 2004).

Research on the health effects of Ni and other components of residual oil fly ash (ROFA) is still in its early stages. Laboratory animals exposed to ROFA show adverse effects on respiratory and cardiovascular systems (Kodavanti et al., 2001; Lippman et al., 2006; Roberts et al., 2009) as well as allergic sensitization (Lambert et al., 2000). Studies using human cells suggest that ROFA may contribute to inflammation and immune system changes (Carter et al., 1997; Ghio et al., 2002; Salnikow et al., 2004). Two recent epidemiologic studies show that $PM_{2.5}$ with higher nickel concentrations may have greater health effects in humans (Bell et al., 2009; Patel et al., 2009).

In addition to the evidence for health effects of individual pollutants, some research suggests that combined exposures to multiple air pollutants may be especially harmful. NYCCAS results show that residual oil boilers contribute to higher concentrations of total $PM_{2.5}$, Ni and SO_2 in some NYC neighborhoods.

Some limitations of NYCCAS data should be kept in mind when interpreting these results. First, the data were collected during only one winter season. Because of seasonal differences in sources and weather, Ni concentrations during other seasons will likely show different patterns. Average Ni concentrations will also change from year to year, but within-city geographic patterns of annual average pollution concentrations should be relatively consistent, because the locations of large sources (e.g., buildings) are relatively fixed. NYCCAS can provide estimates across the city to show areas with relatively high and low concentrations of nickel, but cannot provide precise concentration estimates for specific locations and times.

Despite these limitations, NYCCAS results underscore the need for continued efforts to reduce harmful emissions from residual oil burning in the city. Careful maintenance can help reduce emissions from existing boilers, but longer-term measures should also include retrofitting residual oil boilers, or replacing them with equipment that burns natural gas or #2 heating oil.

Future NYCCAS reports will provide findings and model results for other seasons, and for annual average air pollution concentrations. Data from NYCCAS will help to inform air quality initiatives in the next version of PlaNYC, to be published in 2011. New York City's second round of sustainability planning will continue to draw upon community involvement to develop these initiatives.

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Annex: Distribution of Estimated Nickel (Ni) Concentrations by Community District, Winter 2008-9
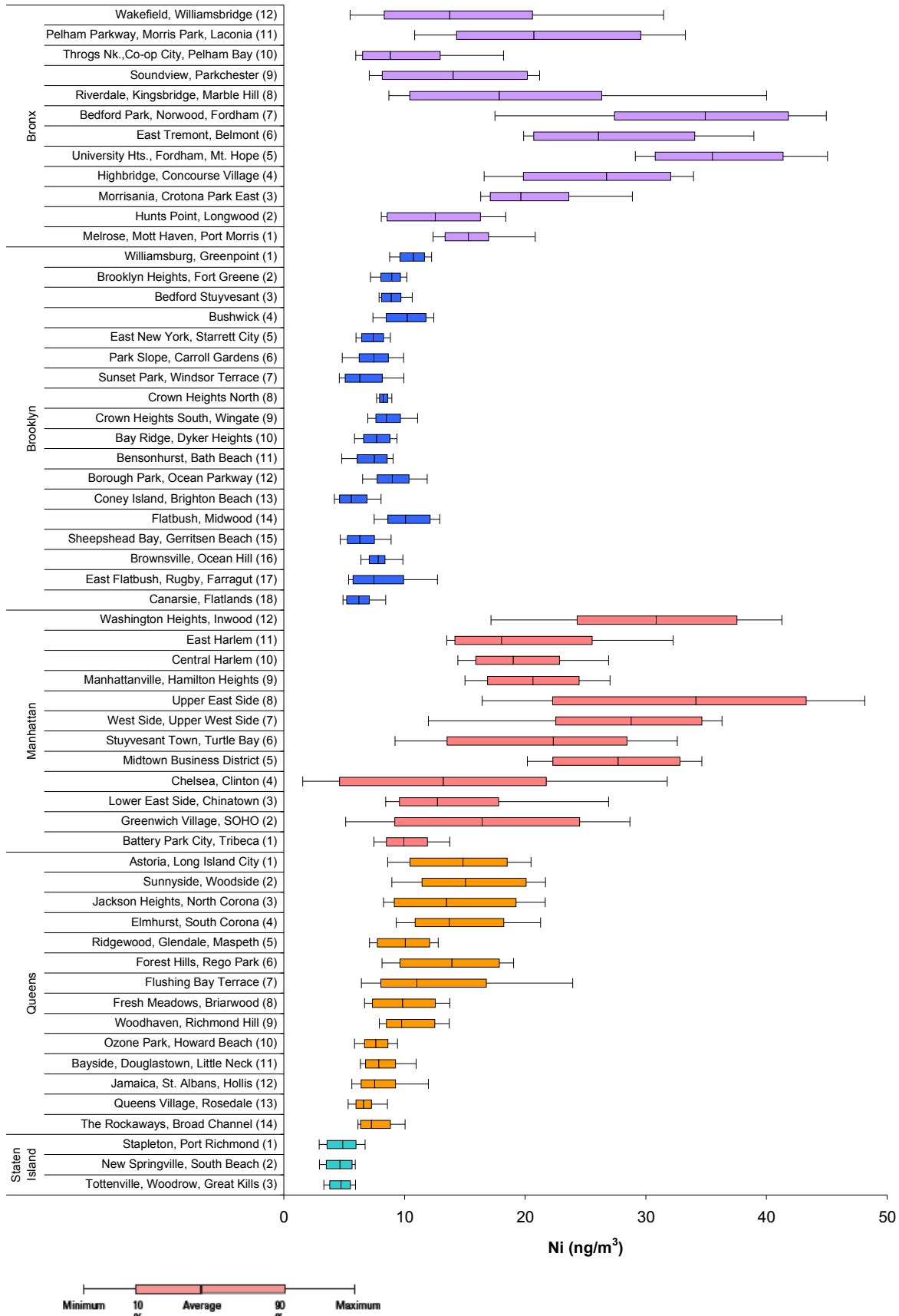

Figure shows the distribution of estimated Nickel concentrations across evenly spaced locations, 100 meters apart, within each New York City Community District. Estimated concentrations for 80% of the area within in each community districts area falls between the 10th and 90th percentiles. See technical appendix (www.nyc.gov/health/nyccas) for calculation method.