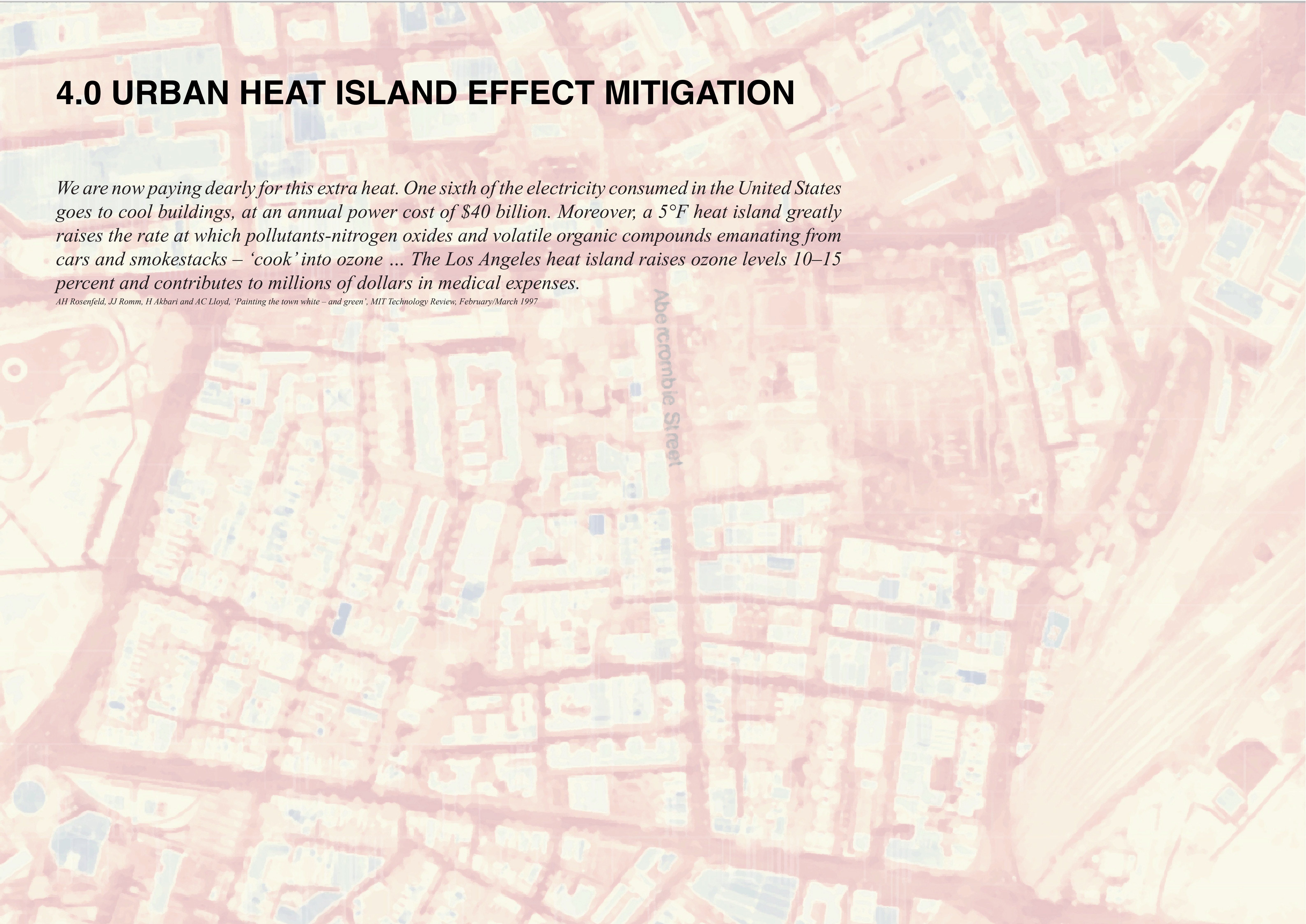
4.0 URBAN HEAT ISLAND EFFECT MITIGATION

We are now paying dearly for this extra heat. One sixth of the electricity consumed in the United States goes to cool buildings, at an annual power cost of $40 billion. Moreover, a 5°F heat island greatly raises the rate at which pollutants-nitrogen oxides and volatile organic compounds emanating from cars and smokestacks – 'cook' into ozone ... The Los Angeles heat island raises ozone levels 10–15 percent and contributes to millions of dollars in medical expenses.

AH Rosenfeld, JJ Romm, H Akbari and AC Lloyd, 'Painting the town white – and green', MIT Technology Review, February/March 1997



The Urban Heat Island (UHI) effect occurs when an urban area is warmer than surrounding areas. This typically happens in city suburbs and towns as the land surface is modified with materials that retain heat, such as dark roads, roofs etc. Lack of trees and greenbelts contribute to the problem. Waste heat created by energy use also contributes. Mitigation strategies include planting more trees to create canopy, using pale surfaces on roads and paths, and greening roofs. In this chapter we look at studies from around the world.

DARK ROADS

Black roads and roofs and lack of trees cause soaring summer temperatures in Chippendale. By replacing these with pale roads and roofs and creating tree canopy over half the roads we could reduce the summer heat in the suburb by 6–8 degrees!

This map shows the temperatures of the suburb's roads between 1 am and 6 am on 6 February 2009. The roads – which constitute over 23 per cent of the suburb's land area – were over 34 degrees and the houses and private land and parks were around 29 degrees. The hot roads – almost a quarter of the suburb – act like night-time radiators; they surround the suburb with hot air. They make the buildings hotter at night than they need be. Because the roads are still hot when the sun rises, that next day is hotter than it need be – inside the houses and on the streets.

The heat dries out the trees and soil and stunts tree and vegetation growth. To stay cool residents and businesses turn on air conditioners. Thus, the suburbs' roads are driving up electricity costs for everyone, and increase the pollution from coal-fired power stations, which provide the electricity. Think of all the electricity we'd save, and how much less pollution in the atmosphere simply by creating pale reflective roads and increasing tree canopy cover.

The hottest roads on the map run east-west. They have the widest and largest amount of exposed black road surface and the most exposure to the hot eastern and western sun. They are the least protected by buildings and trees.

Chippendale is 6 to 8 degrees hotter in summer than it should be.

The north-south roads are partly protected from the hot western summer sun by the buildings and have larger tree canopy (and some of the trees grow larger than others in the east-west streets).

The effect of the roads, however, no matter the direction they face, is to increase the temperature of the whole suburb. This burdens it – and all that lives within it – with an invisible island of hot, damaging air.

No law, design directions or goals have been put in place to make these hot roads cool. Until now. This plan offers affordable, easily built and maintained solutions to the Heat Island Effect of Chippendale.

And we can learn from suburbs and cities which have implemented changes to great effect. Let's look at some success stories.

PLANTS COOL SUBURBS

The suburb of Village Homes in the city of Davis, California is 6 degrees cooler than the adjoining suburbs in summer. This is because the village contains 23 acres of greenbelts, orchards, vineyards, vegetable gardens, and edible landscapes: so the tree canopy regulates the natural temperatures. Since 1978 the village has grown over 24 per cent of its food in the streets and gardens. (For more information see http://www.villagehomesdavis.org.)

One study analysed the costs and benefits of increasing numbers of street trees. By doubling the number of street trees they believe the city's temperature can be reduced by 1.2°F (.7°C). Planting the street trees would cost an estimated $625 million, with annual savings of $98.4 million, for a payback period of just over six years. (See Kerr and Yao, quoted in Rosenthal, Crauderueff and Carter.)

Chicago: reducing pale road costs

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When the Green Alley Program began in 2006, the city paid about $145 per cubic yard of permeable concrete. By 2007 the cost of permeable concrete had dropped to only $45 per cubic yard. (Ordinary concrete was $50 per cubic yard, so permeable concrete may have seemed out of reach.) But the city came up with a solution. They invested in the local permeable concrete market, so the product cost came down. Permeable concrete became a more affordable option for consumers. More and more people now use permeable concrete.

(See 'Managing Wet Weather with Green Infrastructure', Municipal Handbook Green Streets, http://www.scribd.com/doc/34621945/Green-Infrastructure-Handbook-Green-Streets.)

Permeable Pavers and Permeable Concrete Chicago Alleys
(Source: Abby Hall, US EPA, p 17)

RESTORING RIVERS

In 1998 the South Korea city of Seoul removed a 12-lane freeway in the city centre and opened up a built over river. The reinstatement of the river led to an average reduction in summer temperatures of 3 degrees. Property values rose dramatically, and the river and its banks became a magnet for pedestrians, tourists, businesses and biodiversity. Traffic was reduced as were travel times. The city integrated a broad range of travel solutions, for example, varying opening and closing hours of shops and businesses and improving public transport options.

Resurfacing New York City's roadways with asphalt containing a white aggregate, taking into account an estimated cost of $59 million, saves energy consumers $57.2 million annually, a payback period of just over one year.

(Rosenthal, Crauderueff and Carter)

HEALTHIER SUBURBS AND MORE JOBS: GREENING THE GHETTO

The Sustainable South Bronx project in New York is working to reduce the Urban Heat Island effect partly by greening the roads and creating parks. Their research confirms the damage done to human health by the combination of heat, road traffic and lack of vegetation to clean and cool the air. Analysis of the impact of air pollution from vehicles suggests that potent environmental pollutants "at levels recently encountered in New York City air may adversely affect children's cognitive development … with implications for school performance": 'Effect of prenatal exposure to airborne Polycyclic Aromatic Hydrocarbons on neurodevelopment in the first 3 years of life among inner-city children' (see http://www.medscape.com/viewarticle/542481). With 1 in 4 children suffering asthma greening one of the most polluted parts of New York was seen as a necessity.

South Bronx also had the highest unemployment rate in the city of 24 per cent so Sustainable South Bronx set about training people and creating green jobs. "Greening our neighborhood increases the focus on green jobs and brings more parks and green industry to the South Bronx", says Miquela Craytor, Executive Director, Sustainable South Bronx (www.ssbx.org/ssbxblog/).

GREEN ROOFS

More than half of the sunlight reaching the earth is invisible to the human eye, and this invisible sunlight heats the roof. A colored surface that reflects much of the invisible sunlight is a called a cool dark color, or cool color. A cool dark color reflects more sunlight than a similar-looking conventional dark color, but less than a light-colored surface. For example, a conventional dark colored surface might reflect 20% of incoming sunlight, a cool dark colored surface, 40%; and a light-colored surface, 80%.

US Department of Energy, 'Guidelines for selecting cool roofs', page 6

http://www.fs.fed.us/psw/programs/uesd/uep/products/12/psw_cufr701_Gill_Adapting_Cities.pdf

A study in urban heat mitigation using green roofing shows that savings can be substantial. One study estimated that cool roofs could reduce New York City's heat island by 1°F (.6°C). They estimated savings of $105 million per year – $23 million in direct energy savings and $82 million in indirect savings – if cool roofs were constructed on every roof in New York City (calculated at an average additional cost of $.68 per square foot, compared to traditional roofing techniques). Under certain assumptions the cool roof payback period was about six years. (See Kerr and Yao, quoted in Rosenthal, Crauderueff and Carter.)

"The increased planting of street trees produced the greatest cooling potential per unit area and the greatest overall benefits, while the use of light surfaces was found to offer the greatest overall cooling potential"

"The use of higher albedo surfaces offered the most favorable cost/benefit ratio in this analysis. The maximum peak electric demand reductions were estimated as 74.29 MW from planting street trees in 50% of available space citywide; and 200.99 MW through 50% implementation of light surfaces throughout New York City."

Rosenthal, Crauderueff and Carter

Economic and environmental benefits of trees

Reducing the urban heat island effect is not the only benefit of trees. As research from Portland's urban forest demonstrates, the benefits are wide and far ranging:

"Portland's street and park trees provide $980,000 (US) worth of air cleaning and carbon fixing services annually, removing 25 million pounds of pollution from Portland's air supply each year. The entire urban forest canopy provides more than $3 million worth of annual air cleaning and carbon fixing services by removing almost 2 million pounds of pollutants and nearly 53 million pounds of carbon. Portland's urban tree infrastructure stores roughly 1.5 billion pounds of carbon.

Portland's street and park trees save the city over $11 million in stormwater processing by intercepting nearly half a billion gallons of stormwater annually. Citywide, the urban forest canopy intercepts 1.3 billion gallons of stormwater each year, saving almost $36 million in processing costs.

Portland's street trees are responsible for almost $750,000 in avoided energy costs, and over $13 million in property resale value is attributable to the presence of street trees.

Annual environmental benefits provided by the entire urban forest canopy exceed $38 million and will exceed $43 million when the goal of 7% more land covered by tree canopy (25% increase) is met." (p 2).

Research and references for these calculations include:

"Urban trees improve air quality passively and actively. Shade provided by trees over paved surfaces and cars reduces evaporative hydrocarbon emissions and ozone formation (Scott et al 1999). The reduction in VOC emissions extends the lifetime of paved surfaces, resulting in lower maintenance and repair costs. In addition, trees physically and chemically remove gaseous and particulate pollutants from the atmosphere (McPherson et al 2000). Small particulate matter adheres to plant surfaces, and gaseous pollutants are absorbed and may be incorporated into plant tissue.

Trees improve ambient air quality by absorbing atmospheric pollutants and lower atmospheric CO2 levels by transforming atmospheric carbon into plant tissues. Trees intercept and calm winds channelized by the urban landscape, and their transpiration and shading mitigate the urban heat island effect. Reduced demand for heating and cooling results in a net decrease in CO2 and other pollutants introduced into the atmosphere as a result of avoided emissions. In addition, trees act as carbon reservoirs by removing CO2 from the atmosphere, releasing the O2 and retaining carbon in their tissues." (p 5)

BENEFITS OF MITIGATION

If we change the colour of our roads and roofs from black to pale colours and plant trees we save money, increase bird and insect life, and increase tree and plant growth. And we cut our electricity bills. Not to mention significantly reducing our environmental footprint via less pollution.

Mitigation of the heat island effect is a major part of the Chippendale plan, and will be demonstrated throughout this Plan. But it is only one side of one story. First we'll look at the comprehensive plan for our streets.

Studies by the New York City's Office of Sustainable Design, Department of Design and Construction, have found that for every 1°F (.6°C) increase above 68°F (20°C), citywide energy consumption increased by 3300 MWh/degree/day. They concluded that potential energy savings in New York City of urban heat island mitigation strategies, including green and cool roofs, higher albedo pavement and increased tree vegetation were significant (Kerr and Yao, 2004 in Rosenthal, Crauderueff and Carter, 'Urban Heat Island mitigation can improve New York City's environment: Research on the impacts of mitigation strategies on the urban environment'

http://csud.ei.columbia.edu/sitefiles/file/SSBx_UHI_Mit_Can_Improve_NYC_Enviro%5B1%5D.pdf

New York research and solutions on green roofs

Our review of the literature, though not exhaustive, provides strong evidence that urban heat island mitigation strategies such as cool roofs, living green roofs and urban vegetation can play a role in reducing urban electricity demand, improving air quality, cooling the urban environment and diminishing stormwater runoff pollution. Though these roof projects are just a small part of emerging green building technologies, they can help to offset the carbon footprint of existing and new buildings, while providing additional value and environmental improvement.

We conclude with three recommendations for New York City with regards to the two main approaches discussed in this report, cool and green roofs: the city must support further research with community-based organizations for effective place and neighborhood-based heat island mitigation strategies; the city must continue to expand efforts to address summertime heat as a public health issue; and the city must develop and phase-in additional mechanisms and policies to support climate adaptive strategies in the built environment, and ensure they are adopted in major development projects.

New York City has taken several meaningful steps to provide incentives for the implementation of green and cool roofs, to encourage market transformation and save municipal dollars. Heat island mitigation strategies have been incorporated into the Mayor's PlaNYC 2030 long-term strategic plan. The city's new building code, effective July 2008, was amended to enable green roofs through inclusion in the code and to require all flat or low-sloped roofs to be covered by a white or Energy Star reflective roofs for at least 75 per cent of the area of the roof or setback surface, along with other green building provisions.

A green roof incentive was also incorporated into PLaNYC. The City supported a one-year property tax credit of $4.50 per square foot of roof area converted to green roof, when at least 50 percent of the available roof is greened. SSBx advocated, along with partners in the Storm Water Infrastructure Matters (S.W.I.M.) coalition, for passage through the New York State legislature of the bill that enabled this tax abatement to take effect in June 2008.

According to S.W.I.M., this incentive can potentially cover approximately 25 percent of the costs associated with the materials, labor, installation and design of a green roof. The City will need to develop a transparent and expeditious process to effectively encourage private building owners and developers to use the incentive. Plans should be further developed and dates confirmed to phase these incentives into place and to evaluate their effect, on both the environment and the creation of green-collar jobs, to support the greening and cooling of New York City's neighborhoods.

Extract from Joyce Klein Rosenthal, Rob Crauderueff and Majora Carter, 'Urban Heat Island mitigation can improve New York City's environment: Research on the impacts of mitigation strategies on the urban environment' http://csud.ei.columbia.edu/sitefiles/file/SSBx_UHI_Mit_Can_Improve_NYC_Enviro%5B1%5D.pdf, pp 34–35. For more information see Appendix A.