A. INTRODUCTION

Chapter 11, "Air Quality," assesses the Second Avenue Subway's potential to create both beneficial and adverse impacts during its construction and operation. The purpose of this appendix is to provide more information on certain topics, including a description of the pollutants of concern, information on the current regulatory framework, and a description of the methodology that was used to assess impacts.

B. ANALYZED POLLUTANTS

Six main air pollutants are of concern in New York City: carbon monoxide (CO), particulate matter (PM_{10} and $PM_{2.5}$), nitrogen oxides (NO_x), ground-level ozone [including the precursors to ozone formation: volatile organic compounds (VOCs) and NO_x], lead, and sulfur dioxide. As detailed below and in subsequent sections of this appendix, ambient concentrations of CO, PM_{10}, $PM_{2.5}$, NO_x, and VOCs are particularly relevant to the air quality analyses conducted for the Second Avenue Subway because construction activities could result in temporary elevated levels of these pollutants, while operation of the subway could reduce long-term regional emissions of these same pollutants because of its improvement to regional traffic conditions. Lead and SO_2 are not relevant to the air quality analyses because these pollutants would not be generated in significant quantities during construction activities, due to the use of ultra low-sulfur diesel fuels, and during operation, no significant sources of these pollutants would be used.

POLLUTANTS OF CONCERN FOR THE SECOND AVENUE SUBWAY

CARBON MONOXIDE

Carbon monoxide (CO), a colorless and odorless gas, is produced by the incomplete combustion of gasoline and other fossil fuels. In New York City, approximately 80 to 90 percent of CO emissions are from motor vehicles. CO concentrations can vary greatly over relatively short distances. Elevated concentrations are usually limited to locations near crowded intersections, along heavily traveled and congested roadways, or at parking lots or garages. Consequently, CO concentrations must be predicted on a localized or microscale basis.

For the Second Avenue Subway, CO levels at critical intersections along or near the alignment were assessed to evaluate the effects of traffic diversion and truck trips that would result from construction. To assess improvements to background CO levels during the subway's operation resulting from reductions in vehicle miles traveled (VMT), a regional analysis was also conducted.

PARTICULATE MATTER—PM_{10} AND $PM_{2.5}$

Particulate matter (PM) is a group of air pollutants that exists as discrete particles, either as liquid droplets (i.e., aerosols) or as solids (which may be attached to or suspended in liquid droplets), with a wide range of sizes and chemical composition. The constituents of PM are both numerous and varied, and they are emitted by a wide variety of sources, both natural and anthropogenic. Natural sources include the condensed natural organic vapors; salt particles resulting from the evaporation of sea spray; wind-borne pollen, fungi, molds, algae, yeast, rusts, bacteria, and debris from live and decaying plant and animal life; and particles eroded from beaches, soil, and rock.

Major anthropogenic sources include fuel combustion (e.g., from power generation, home heating, wood-burning stoves and fireplaces, and vehicular exhaust), chemical and manufacturing processes, construction, and agricultural activities. Diesel-powered vehicles, especially heavy trucks and buses, and construction equipment emit particulate matter; high concentrations of particles may be found locally near roadways with high volumes of heavy diesel-powered vehicles (e.g., near bus depots, truck marshaling yards, and construction sites). In contrast, gasoline-powered engines do not emit an appreciable quantity of particles. Resuspended road dust contributes to particle concentrations as well.

Only particles that are small enough to be respirable are considered a primary concern—particles with an aerodynamic diameter (AD) less than 10 micrometers (µm)[1] are known as PM_{10} and particles with an AD less than 2.5 µm are referred to as $PM_{2.5}$. They are sometimes referred to, respectively, as "coarse-mode" and "fine-mode" particles since their sources, composition, and fate can often be defined by this distinction; the distinction between coarse and fine particles has typically been in the 1 to 3 µm range. While $PM_{2.5}$ mostly comprises fine-mode particles (depending on the definition), PM_{10} includes both.

Fine particulate matter, or $PM_{2.5}$, is mainly derived from combustion as either noncombustible material, products of incomplete combustion, or material that has volatilized and then condensed to form primary PM (before the release from an exhaust or stack) or secondary PM (when emitted gases condense in the atmosphere). Major constituents of $PM_{2.5}$ are typically sulfates, nitrates, organic and elemental carbon (products of incomplete combustion—soot), and primary inorganic particulate matter (noncombustible material—ash). Sulfates and nitrates are secondary components formed from their precursor gaseous pollutants, sulfur dioxide (SO_2) and nitrogen oxides (NO_x), at some distance from the source, due to the time needed for the physiochemical conversion within the atmosphere. Due to the influence of these "secondary" particles from distant or regional sources, ambient levels of $PM_{2.5}$ are typically more evenly distributed in an urban area than PM_{10}, which can be more highly influenced by local sources. In fact, EPA has estimated that in the eastern United States, the largest component of $PM_{2.5}$ is secondary sulfate (56 percent). Recent data from the New York State Department of Environmental Conservation (NYSDEC) monitoring sites suggest that about one-third of the $PM_{2.5}$ in the city is sulfate-based and that levels are considerably more uniform throughout New York City than for PM_{10}.

Since PM_{10} consists of all particles less than 10 µm, it includes those $PM_{2.5}$ particles discussed above as well as coarse-mode particles in the 2.5 to 10 µm size range. Typically, coarse-mode particles are formed from large solids/droplets by mechanical disruption (e.g., crushing,

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[1] A micrometer (µm) is one millionth of a meter. For comparison purposes, the width of a human hair ranges from 30 to 200 µm.

grinding, abrasion of surfaces, etc.), evaporation of sprays, and suspension of dusts. Major components include coal and oil fly ash, oxides of crustal elements, sea salt, biological material (e.g., pollen, mold spores, fungi, etc.) and resuspended road dust. In urban air, 30 to 60 percent of PM_{10} may consist of $PM_{2.5}$ particles.

For the Second Avenue Subway, three separate analyses of PM were performed to assess the potential adverse impacts from certain project-related construction activities: 1) the localized effects of PM_{10} emissions on nearby sensitive receptors from on-site construction operations, equipment, and on-street mobile sources—including spoils removal and materials delivery trucks traveling to and from the shaft sites—were examined; 2) the localized effects of potential $PM_{2.5}$ emissions from construction activities on nearby sensitive receptors were assessed using the results of the PM_{10} analysis; and 3) an assessment of the regional effects of $PM_{2.5}$ during the construction phase from all construction-related sources was conducted, based on an average concentration throughout the region. In addition, a regional analysis of the changes in PM_{10} levels during the subway's operation resulting from reductions in VMT was performed.

NITROGEN OXIDES AND OZONE

Nitrogen oxides (NO_x) are of principal concern because of their role with volatile organic compounds (VOCs) as precursors in the formation of ground-level ozone. There is a standard for average annual nitrogen dioxide (NO_2) concentrations,[1] which is normally examined only for fossil fuel energy sources. Ozone is formed through a series of reactions that take place in the atmosphere in the presence of sunlight. Because the reactions are slow and occur as the pollutants are diffusing downwind, elevated ozone levels are often found many miles from sources of the precursor pollutants.

For the Second Avenue Subway, NO_x and VOC emissions generated by trucks and barges during construction were assessed regionally. The changes in NO_x and VOC emissions resulting from changes in vehicular travel patterns throughout the New York metropolitan area during the subway's operation were also analyzed regionally.

OTHER POLLUTANTS OF CONCERN IN NEW YORK CITY

LEAD

Lead emissions are principally associated with industrial sources and motor vehicles that use gasoline containing lead additives. Most U.S. vehicles produced since 1975, and all produced after 1980, are designed to use unleaded fuel. As these newer vehicles have replaced the older ones, motor-vehicle-related lead emissions have decreased and ambient concentrations of lead have declined significantly. Nationally, the average measured atmospheric lead level in 1985 was only about one-quarter the level in 1975. In 1985, the U.S. Environmental Protection Agency (EPA) announced new rules drastically reducing the amount of lead permitted in leaded gasoline. Monitoring results indicate that this action has been effective in significantly reducing atmospheric lead levels. Even at locations in the New York City area where traffic volumes are very high, atmospheric lead concentrations are far below the national standard of 1.5 micrograms per cubic meter (3-month average).

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[1] The annual average air quality standard for NO_2 is 100 $\mu g/m^3$.

Because no significant sources of lead are associated with the Second Avenue Subway's construction or operation, no lead analysis is necessary.

SULFUR DIOXIDE

Sulfur dioxide (SO_2) emissions are primarily associated with the combustion of oil and coal. No significant quantities are emitted from mobile sources, and monitored SO_2 concentrations in Manhattan are below the national standards.

Because no significant sources of SO_2 would be used during construction or operation of the Second Avenue Subway, no SO_2 analysis is necessary.

C. AIR QUALITY STANDARDS

Like other development projects in New York City, the Second Avenue Subway must be evaluated within the context of a federal, regional, state, and local regulatory framework of standards that aim to minimize the effects of project-related air quality impacts. Those regulatory standards that are applicable to the Second Avenue Subway are discussed below.

NATIONAL AND STATE AIR QUALITY STANDARDS

As required by the Clean Air Act, primary and secondary National Ambient Air Quality Standards (NAAQS) have been established for the six major air pollutants identified in the previous section. (Hydrocarbon standards have been rescinded because these pollutants are primarily of concern only in their role as ozone precursors.) EPA has revised its standards with respect to particulate matter on two occasions. The first revision occurred in 1987, when EPA replaced total suspended particles (TSP) as the indicator for the standard with a new indicator that included only particles with an aerodynamic diameter less than or equal to 10 µm (PM_{10}). The more recent revision involved the adoption of a new additional standard for "fine particles" with an aerodynamic diameter less than or equal to 2.5 µm ($PM_{2.5}$). The standard for PM_{10} was retained, but in a slightly revised form. EPA has established the new $PM_{2.5}$ standard after extensive review of the epidemiological and risk assessment studies, which showed a correlation between increased ambient levels of particles of that size and a variety of adverse health effects. It is expected to be several years before the EPA formally provides analytical guidance to assess $PM_{2.5}$ concentrations on a microscale level.

Table I-1 shows the standards for these pollutants. These standards have also been adopted as the ambient air quality standards for New York State. The primary standards protect the public health, and represent levels at which there are no known significant effects on human health. The secondary standards are intended to protect the nation's welfare, and account for air pollutant effects on soil, water, visibility, vegetation, and other aspects of the environment. For CO, NO_2, ozone, and particulate matter, the primary and secondary standards are the same.

Table I-1
National and New York State Ambient Air Quality Standards

Pollutant	Primary		Secondary	
	PPM	Micrograms Per Cubic Meter	PPM	Micrograms Per Cubic Meter
Carbon Monoxide				
Maximum 8-Hour Concentration[1]	9		9	
Maximum 1-Hour Concentration[1]	35		35	
Lead				
Maximum Arithmetic Mean Averaged Over 3 Consecutive Months		1.5		
Nitrogen Dioxide				
Annual Arithmetic Average	0.05	100	0.05	100
Ozone[2]				
1-Hour Maximum	0.12	235	0.12	235
Particulate Matter (PM_{10})				
Annual Geometric Mean		50		50
Maximum 24-Hour Concentration[3]		150		150
Fine Particulate Matter ($PM_{2.5}$)				
Annual Arithmetic Mean		15		15
Maximum 24-Hour Concentration[4]		65		65
Sulfur Dioxide				
Annual Arithmetic Mean	0.03	80		
Maximum 24-Hour Concentration[1]	0.14	365		
Maximum 3-Hour Concentration[1]			0.50	1,300

Notes:
1 Not to be exceeded more than once a year.
2 The ozone 1-hour standard applies only to areas that were designated non-attainment when the ozone 8-hour standard was adopted in July 1997.
3 Not to be exceeded by 99th percentile of 24-hour PM_{10} concentrations in a year (averaged over 3 years).
4 Not to be exceeded by 98th percentile of 24-hour $PM_{2.5}$ concentrations in a year (averaged over 3 years).
PPM = parts per million.
Sources:
40 CFR Part 50 "National Primary and Secondary Ambient Air Quality Standards"
40 CFR 50.12 "National Primary and Secondary Standard for Lead."

STATE IMPLEMENTATION PLAN (SIP)

The Clean Air Act requires each state to submit a SIP to the EPA demonstrating attainment of NAAQS. Amendments to the Act in 1977 and 1990 require comprehensive plan revisions for areas where one or more of the standards have yet to be attained. In the New York City metropolitan area, the standard for ozone continues to be exceeded. Consequently, as part of the SIP, New York City is implementing measures to reduce levels of hydrocarbons and nitrogen oxides as part of its effort to attain the NAAQS ozone standard. In addition, Manhattan is designated as a moderate non-attainment area[1] for PM_{10}.

As discussed later in this appendix, New York State and the EPA have not yet determined whether New York City is within attainment of the $PM_{2.5}$ NAAQS. Existing monitoring data indicate that the region is well within the 24-hour $PM_{2.5}$ standard but the 3-year annual average $PM_{2.5}$ concentrations in New York City range from just below to just above the standard of 15 $\mu g/m^3$. States are required to submit proposed $PM_{2.5}$ NAAQS attainment/non-attainment designations to EPA within 1 year after receipt of 3 years of monitoring data.

EPA has recently redesignated New York City as an area in attainment for CO. The Clean Air Act Amendments (CAAA) described above require that a maintenance plan be established to ensure continued compliance of the CO NAAQS for former non-attainment areas. In addition, for ozone, the CAAA requires a series of SIP revisions. These revisions include air quality control measures for target years, emission reductions of ozone precursor emissions (VOCs and NO_x), and an ozone attainment demonstration by 2007. In June 1997, the NYSDEC submitted an ozone SIP revision that addressed these requirements.

SIGNIFICANT ADVERSE IMPACT CRITERIA

A significant impact generally results if the NAAQS for any of the six major pollutants is exceeded. In addition to the NAAQS, New York City has developed criteria to assess the significance of the incremental increase in CO concentrations that would result from proposed projects or actions, as set forth in the *City Environmental Quality Review (CEQR) Technical Manual* (City of New York, 1993). These criteria (known as *de minimus* criteria) set the minimum change in CO concentration that defines a significant environmental impact. Significant increases of CO concentrations in New York City are defined as: 1) an increase of 0.5 parts per million (ppm) or more in the maximum 8-hour average CO concentration at a location where the predicted No Build Alternative 8-hour concentration is equal to or between 8 and 9 ppm; or 2) an increase of more than half the difference between baseline concentrations and the 8-hour standard, when No Build Alternative concentrations are below 8.0 ppm.

Although the $PM_{2.5}$ monitoring data collected by New York State Department of Environmental Conservation (NYSDEC) are still under review by NYSDEC, average annual concentrations in some areas of New York City are expected to be slightly higher than the annual average NAAQS. The 3-year annual mean and the official 24-hour 98th percentile background levels are yet to be determined. NYSDEC has published a policy to provide interim direction for evaluating $PM_{2.5}$ impacts, until such time as NYSDEC adopts a SIP covering $PM_{2.5}$. This policy applies to facilities applying for permits or major permit modification from NYSDEC under State Environmental Quality Review Act (SEQRA) that emit 15 tons of PM_{10} or more annually. The interim policy states that such a project will be deemed to have a potentially significant adverse impact if the project's maximum predicted impacts are predicted to increase $PM_{2.5}$ concentrations by more than 0.3 $\mu g/m^3$ averaged annually, or more than 5 $\mu g/m^3$ on a 24-hour basis. Projects that exceed either the annual or 24-hour threshold will be required to prepare an Environmental Impact Statement (EIS) to assess the severity of the impacts, to evaluate

[1] A non-attainment area is any area that does not meet, or that contributes to ambient air quality in a nearby area that does not meet, the national primary or secondary ambient air quality standard for the pollutant area.

alternatives, and to employ reasonable and necessary mitigation measures to minimize the $PM_{2.5}$ impacts of the source to the maximum extent practicable.

Additionally, the New York City Department of Environmental Protection (NYCDEP) is currently recommending interim guidance criteria for evaluating the potential $PM_{2.5}$ impacts from NYCDEP projects under City Environmental Quality Review (CEQR). The interim guidance criteria NYCDEP is currently employing for determination of significant adverse impacts from $PM_{2.5}$ are: 1) predicted 24-hour (daily) average increase in $PM_{2.5}$ concentrations greater than 5 $\mu g/m^3$ at a discrete location of public access, either at ground or elevated levels (microscale analysis); and 2) a predicted annual average increase in ground-level $PM_{2.5}$ greater than 0.1 $\mu g/m^3$ on a neighborhood scale (i.e., the annual increase in concentration representing the average over an area of approximately 1 square kilometer, centered on the location where the maximum impact is predicted for stationary sources; or for mobile sources, at a distance from a roadway corridor similar to the minimum distance defined for location background monitoring stations).

D. EXISTING CONDITIONS AND TRENDS

EXISTING MONITORED AIR QUALITY CONDITIONS (2000)

Based on the most recent NYSDEC monitoring criteria, there are no exceedances of the NAAQS for CO, NO_x, PM_{10}, or SO_2 at any location in East Harlem, the Upper East Side, East Midtown, Gramercy Park/Union Square, the East Village/Lower East Side/Chinatown, and Lower Manhattan. $PM_{2.5}$ has been monitored in New York since 2000. Although determination of compliance by EPA, based on three annual averages, is yet to be made, the data indicate that annual averages in New York City range from slightly lower to slightly higher than the 15 $\mu g/m^3$ NAAQS. Monitored concentrations of CO, SO_2, PM, NO_2, lead, and ozone ambient air quality data for representative locations[1], including sites near the Second Avenue alignment, are shown in Table I-2. These values are the 2000 monitored data available for these locations (NYSDEC, 2000).[1]

CURRENT AIR QUALITY TRENDS

In the past two decades, air quality in New York City has improved significantly. Ambient concentrations of most key ("criteria") pollutants have decreased to their lowest levels in 25 years, and exceedances of the standard for a few pollutants are infrequent. The current trend is reflected by the monitored concentrations of criteria pollutants, including CO, NO_x, PM, SO_2, ozone, and lead, which are consistently lower throughout the city.

Both long- and short-term CO concentrations have improved considerably in the past 10 years in the city, resulting from the continuing improvement in emissions controls on motor vehicles and their inspection and maintenance. NO_x levels continue to remain well below the air quality

[1] The monitoring locations are part of NYSDEC's Bureau of Air Quality Surveillance's ambient air quality monitoring network. The information obtained from this continuous and manual monitoring network is used by the state to determine the attainment status of the criteria pollutants and to determine the ambient air quality so that programs can be developed to target the appropriate source categories for emission reductions.

Table I-2
Representative Monitored Ambient Air Quality Data

Pollutant	Location	Units	Period	Concentrations			Number of Exceedances of Federal Standard	
				Mean	Highest	Second Highest	Primary	Secondary
CO	Bloomingdale's 59th-60th St Lexington-Third Ave	ppm	8-hour 1-hour	— —	4.1 6.0	3.9 6.0	0 0	0 0
	P.S. 59 228 East 59th St	ppm	8-hour 1-hour	— —	2.9 4.7	2.8 4.1	0 0	0 0
	225 East 34th St	ppm	8-hour 1-hour	— —	3.7 5.5	3.3 4.9	0 0	0 0
	350 Canal St	ppm	8-hour 1-hour	— —	4.6 6.4	4.2 5.6	0 0	0 0
SO_2	P.S. 59	ppm	Annual 24-hour 3-hour	0.013 — —	— 0.053 0.073	— 0.046 0.073	0 0 —	— — 0
	Mabel Dean Bacon Station 240 Second Ave. between 14th and 15th Sts	ppm	Annual 24-hour 3-hour	0.013 — —	— 0.053 0.086	— 0.045 0.081	0 0 —	— — 0
PM_{10}	Mabel Dean Bacon Station.	µg/m²	Annual 24-hour	24 —	— 61	— 49	0 0	0 0
$PM_{2.5}$	P.S. 59	µg/m²	Annual 24-Hour	18.4 —	— 66.2	— 41.7[1]	NA[2]	NA
	Mabel Dean Bacon Station	µg/m²	Annual 24-Hour	16.8 —	— 63.8	— 42.9[1]	NA[2]	NA
	350 Canal St	µg/m²	Annual 24-Hour	17.5 —	— 63.6	— 45.0[1]	NA[2]	NA
NO_2	P.S. 59	ppm	Annual	0.038	—	—	0	0
	Mabel Dean Bacon Station	ppm	Annual	0.036	—	—	0	0
Lead	Susan Wagner H.S., Staten Island	µg/m²	3-month	—	0.02	0.02	0	0
O_3	Mabel Dean Bacon Station.	ppm	1-hour	—	0.087	0.072	0	0

Notes:
1 98th percentile concentration (1999-2000)
2 Based on two year's data and is insufficient for determining compliance with NAAQS.
Source: *New York State Air Quality Report, Ambient Air Monitoring Systems*, Annual 2000 NYSDEC DAR-02-1.

standards, and PM_{10} emissions have exhibited a sustained downward trend in the last decade due to the implementation of New York State and federal regulations on emissions from incinerators, various fossil fuel combustion sources, and diesel-fueled motor vehicles. Although no data are available to definitively prove that $PM_{2.5}$ levels have also been reduced, levels of this pollutant are likely decreasing as well, as use of cleaner-burning fuels and regulations on stationary sources and diesel-powered vehicles are implemented throughout the state and region. Ambient SO_2 concentrations in the city have decreased as well, as a result of the continued lowering of the sulfur content of coal and residual oil via implementation of the New York State fuel sulfur regulations.

The continuing implementation of more stringent VOC controls has contributed significantly to the reduction in ambient ozone concentrations in the city during the last decade. Also, lead concentrations are in compliance with all standards in New York City and have been unchanged or decreased marginally following two decades of steady decline. Based on the current and projected air quality trends for New York City, the region should experience continued reductions of ambient concentrations and improving air quality.

Based on the current and projected air quality trends for New York City, the region should experience continued reductions of ambient concentrations and improving air quality. Air quality in the region should continue to improve due to the effects of federally mandated emission control programs scheduled to be implemented over the next several years. Many of these programs were part of the 1990 CAAA or are included as part of each state's SIP to meet the ozone NAAQS. These programs cover a wide range of sources, both mobile and stationary, and will affect emissions of NO_x, SO_2, CO, PM, and VOCs. The more relevant programs with respect to the project are discussed below.

As part of the 1990 CAAA, EPA set new emission standards for heavy-duty diesel trucks and buses that began to take effect in the 1990s. In October 2000, it published a final rule for the Control of Emissions of Air Pollution from 2004 and Later Model Year Heavy-Duty Highway Engines and Vehicles. On December 21, 2000, a final rule was signed by the Administrator for additional emission reductions for the model year 2007 with a reduction in the sulfur content of diesel fuel to take effect by mid-2006.

Furthermore, as directed in the 1990 CAAA, EPA has taken measures to reduce emissions from non-road (e.g., construction equipment, etc.) diesel engines in two past regulatory actions. A 1994 final rule set initial emission standards for new non-road diesel engines greater than 50 hp. These standards ("Tier 1") gained modest reductions in NO_x emissions. In 1998, EPA adopted more stringent Tier 2 and Tier 3 standards for these engines, as well as standards for engines under 50 hp. As these standards are implemented, emissions of particulate matter from non-road diesel engines are projected to decrease.

In addition, New York State is committed to obtaining compliance with the ozone standard by 2007. However, as noted earlier, New York State and the EPA have not yet determined whether New York City is within attainment of the $PM_{2.5}$ standards. If New York City (or portions thereof) is ultimately determined to be in non-attainment of the $PM_{2.5}$ standards, then a SIP will eventually be required to develop and commit to programs that will need to demonstrate attainment with the $PM_{2.5}$ standards. EPA is required to promulgate an official attainment/non-attainment designation by the earlier of these two time frames: either 1 year after a state's initial designation, or December 31, 2005 (i.e., no later than December 31, 2005). Once EPA makes a designation, a state will have up to three years to develop and submit a $PM_{2.5}$ SIP to the EPA, and up to 10 years from the designation of non-attainment to attain the $PM_{2.5}$ standards, with the possibility of two 1-year extensions.

E. METHODOLOGY FOR PREDICTING POLLUTANT CONCENTRATIONS

The specific methodology for how potential impacts from these pollutants are assessed is presented below, including a discussion of analysis methods that relate to the Second Avenue Subway's construction activities.

As detailed below, four different air quality analyses were conducted to assess potential impacts from the Second Avenue Subway project's construction and operation:

- *Carbon monoxide analysis*—to estimate increases in CO levels resulting from construction-related traffic diversions and congestion;
- *Particulate matter concentrations analysis*—to determine potential increases in PM_{10} and $PM_{2.5}$ near the construction sites and on local streets resulting from construction activities and the use of diesel-powered equipment;
- *Regional construction impact analysis*—to estimate potential regional increases in NO_x, VOC, and $PM_{2.5}$ emissions due to construction transportation activities; and
- *Regional operational impact analysis*—to evaluate the potential improvements in regional air quality (i.e., decreases in CO, VOCs, NO_x, and PM_{10}) when the Second Avenue Subway is operating.

In this section, the air quality models used, sites selected for analysis, and other factors are described. Detailed information on the analysis methodologies (including modeling assumptions, worst-case meteorological conditions, and emission rates) is presented as well.

METHODOLOGY FOR PERFORMING CARBON MONOXIDE ANALYSIS

To compare estimated CO against the national and state ambient air quality standards for CO (which are based on 1- and 8-hour averages of CO concentrations), maximum concentrations for these same periods must be estimated. Since exceedances of the 1-hour CO standard are extremely rare in New York City, the CO analysis for the Second Avenue Subway focuses on determining the maximum predicted 8-hour CO concentrations for the project alternatives. The CO analysis for the Second Avenue Subway project's construction uses a modeling approach approved by EPA for modeling the dispersion of CO along roadway segments, which has been widely used for evaluating air quality impacts from projects in New York City, New York State, and throughout the country. To conduct the Second Avenue Subway analysis, several worst-case assumptions relating to meteorology, traffic, and background concentration levels were employed. In addition, all air pollution dispersion models were designed conservatively, resulting in higher predicted CO concentrations.

DISPERSION MODELS FOR MICROSCALE ANALYSES

At all sites selected for analysis, maximum 8-hour average CO concentrations were first determined using EPA's CAL3QHC model (EPA, 1995b). The CAL3QHC model employs normally distributed dispersion of line source emissions, with algorithms for estimating vehicle queue lengths at signalized intersections and the ensuing emissions from the idling vehicles. The queuing algorithm requires additional input for site-specific traffic parameters, such as signal timing, and performs delay calculations from the *Highway Capacity Manual* traffic forecasting model (Transportation Research Board, 1985 and 1994) to predict the number of idling vehicles. Next, a more refined model, the CAL3QHCR (EPA, 1995c), was used to determine maximum concentrations at locations where maximum predicted CO concentrations exceeded the applicable ambient air quality standard. CAL3QHCR is an enhanced but separate version of CAL3QHC that allows for the incorporation of actual local meteorological data into the modeling, instead of worst-case assumptions regarding meteorological parameters. Under the Tier I simulation scenario, CAL3QHCR utilizes peak hour traffic data and corresponding CO emission rates with an extensive meteorological database. The CAL3QHCR model also allows for varying traffic volumes of peak hour conditions (i.e., Tier II simulation scenario), which generally results in maximum predicted CO levels lower than those calculated under Tier I (because off-peak traffic volumes are much lower than those in corresponding peak hours).

WORST-CASE METEOROLOGICAL CONDITIONS

In general, the transport and concentration of pollutants from vehicular sources are influenced by three principal meteorological factors: wind direction, wind speed, and atmospheric stability, which accounts for the effects of dispersion or mixing in the atmosphere.

Wind direction, which influences the accumulation of pollutants at a particular receptor location, was chosen to maximize pollutant concentrations at each of the prediction sites. In applying the CAL3QHC modeling, the wind angle was varied to determine the worst-case wind direction resulting in the maximum concentrations.

Following the recommendations of EPA and the NYCDEP for the CAL3QHC model (City of New York, 2001), CO computations were performed using a wind speed of 1 meter/second, and stability class D, representative of neutral conditions. A persistence factor of either 0.77 or 0.70 was selected for the East Midtown and remaining study areas, respectively, for the 8-hour period. The persistence factor takes account of the fact that over 8 hours, traffic parameters will fluctuate downward from the peak and meteorological conditions will change, as compared with the 1-hour values. A surface roughness of 3.21 meters was chosen, and a 50° F ambient temperature was assumed for the emissions computations. At each receptor location, the wind angle that maximized the pollutant concentrations was used in the analysis regardless of frequency of occurrence.

For the refined analysis using the CAL3QHCR model, the latest 5 years of meteorological data with surface data from LaGuardia Airport (1997-2001) and concurrent upper air data from Brookhaven, New York, were used in the simulation program. Upper air data from this Long Island station was used since it is the nearest location in the New York region with complete 24-hour data necessary for dispersion modeling.

VEHICLE EMISSIONS DATA

To predict ambient concentrations of pollutants generated by vehicular traffic, emissions from vehicle exhaust systems must be estimated. Vehicular emissions of CO were computed using the EPA-developed Mobile Source Emissions Model, MOBILE5B (EPA, September 1996). The model uses the vehicle speeds (predicted speeds for No Build and lower speeds for Build due to congestion). Emissions for five classes of motor vehicles were estimated: light-duty, gasoline-powered automobiles; light-duty, gasoline-powered taxis; light-duty, gasoline-powered trucks; heavy-duty, gasoline-powered trucks; and heavy-duty, diesel-powered trucks. No light-duty diesel-powered vehicles (automobiles and taxis), light-duty diesel-powered trucks, or motorcycles were assumed. In the case of motorcycles, the number of such vehicles on any street is generally small. In the case of diesel-powered vehicles, emissions from a comparable class of gasoline-powered vehicles were included. CO emissions from the gasoline-powered vehicles are higher than the comparable diesel-powered vehicle emissions, and thus yield conservative estimates of total composite CO emissions and concentrations.

In addition, based on the latest guidance from NYSDEC and NYCDEP (NYCDEP, 2000), sport-utility vehicles (SUVs) should be classified as light-duty gas trucks to properly model their emissions. NYSDEC has also officially removed the oxygenated fuels program and has replaced it with the Federal Reformulated Gasoline (RFG) program. Therefore, the MOBILE5B CO emission estimates were prepared accounting for this change in fuel programs.

Emission estimates were based on implementation of the New York State auto and light-duty gasoline-powered truck inspection and maintenance (I&M) program begun in January 1982 and the taxi I&M program begun in October 1977. The I&M program requires annual inspections of automobiles and light trucks to determine if CO and hydrocarbon emissions from the vehicles' exhaust systems are below emission standards. Vehicles failing the emissions test must undergo maintenance and pass a re-test to be registered in New York State.

Heavy-duty vehicle emission estimates reflect local engine displacement and vehicle loading characteristics. These data were obtained from the NYCDEP and are based on vehicle registration data.

VEHICLE OPERATING CONDITIONS

Auto operating conditions used in the future conditions CO emission calculations were obtained from *Bureau of Science and Technology Report No. 34 (Revised)*. Since light-duty gasoline-powered trucks now include SUVs, the worst-case thermal conditions used for autos were assumed, as a conservative estimate. Table I-3 summarizes these thermal state conditions used in the analysis.

Table I-3
Vehicle Operating Conditions Assumed in the Air Quality Analysis

Vehicle	Analysis Period	
	AM	PM
Local Autos (Uptown)		
Percentage Cold (Non Catalytic)	22.5	19.8
Percentage Cold (Catalytic)	22.8	26.3
Percentage Hot (Catalytic)	0.6	4.2
Local Autos (Midtown)		
Percentage Cold (Non Catalytic)	5.9	21.6
Percentage Cold (Catalytic)	6.1	27.6
Percentage Hot (Catalytic)	1.4	3.9
Light-Duty Gasoline Trucks (Uptown)		
Percentage Cold (Non Catalytic)	19.8	19.8
Percentage Cold (Catalytic)	26.3	26.3
Percentage Hot (Catalytic)	4.2	4.2
Light-Duty Gasoline Trucks (Midtown)		
Percentage Cold (Non Catalytic)	21.6	21.6
Percentage Cold (Catalytic)	27.6	27.6
Percentage Hot (Catalytic)	3.9	3.9

TRAFFIC DATA

Traffic data for the Second Avenue Subway's construction phase air quality analysis were derived from traffic counts and other information developed for the traffic analysis described in Chapter 5D, "Transportation—Vehicular Traffic." For the air quality analysis, a screening was conducted to determine the worst-case time periods for analysis at critical intersections. The screening analysis was also used to determine the weekday peak period that would be subjected to full-scale microscale analysis, based both on traffic volumes and approach delays, as well as the corresponding levels of service for the construction phase. The time periods selected for the mobile source analysis predict the greatest significant traffic impacts due to diversions resulting from the proposed construction activities and represent generally constrained study area traffic conditions.

The peak 8-hour concentrations were determined by applying a conservative persistence factor of 0.70 or 0.77 to the maximum predicted 1-hour local impact values (see above). This persistence factor accounts for the fact that over 8 hours, vehicle volumes will fluctuate downward from the peak, speeds may vary, and wind directions and speeds will change somewhat, compared with the conservative assumptions used for the single highest hour.

BACKGROUND CONCENTRATIONS

Background concentrations are those pollutant concentrations not directly accounted for through the modeling analysis (which directly accounts for vehicular-generated emissions on the streets within 1,000 to 1,600 feet and line-of-sight of the receptor location). Background concentrations must be added to modeling results to obtain total pollutant concentrations at a prediction site.

The 8-hour average CO background concentrations used in the future (2010) analysis were 2.9 and 2.0 ppm, for the East Midtown and other study areas, respectively (see Table I-4 for modeling locations). These values, obtained from NYCDEP (The City of New York, 1998), are based on CO concentrations measured at NYSDEC monitoring stations and are adjusted to reflect the reduced vehicular emissions expected in the analysis year. This decrease reflects the increasing numbers of federally mandated lower-emission vehicles that are projected to enter the vehicle fleet as older, higher-polluting vehicles are retired (i.e., vehicle turnover), and the continuing benefits of the New York I&M program.

MOBILE SOURCE RECEPTOR LOCATIONS

To determine the most significant air quality impacts that could occur at any location along the entire Second Avenue Subway alignment as a result of construction, five representative receptor sites in the three most congested neighborhood zones—East Harlem, the Upper East Side, and East Midtown—were selected for quantified microscale analysis (see Table I-4 and Figure I-1). These sites are the locations where the greatest construction-related air quality impacts and maximum changes in CO concentrations are expected. EPA's transportation conformity regulations require analyses of CO for individual sites that would be affected by construction activities for more than 5 years. Based on the project's current phasing plan, construction activities would last longer than 5 years at four locations: near the 125th Street Station (including construction of the station and mined tunnels), in the 96th Street vicinity, in the 34th Street vicinity, and at the Hanover Square Station area in conjunction with Pier 6. The project's effects on CO at each of those locations were analyzed. Quantitative CO analyses were conducted for the 96th Street and 34th Street areas, which represent the worst-case conditions, and the results of those quantitative analyses were used to qualitatively assess the project's effects on CO at 125th Street and near the Hanover Square Station.

Table I-4
Mobile Source Receptor Locations

Receptor Site	Study Area	Location	Time Period Analyzed
1	East Harlem	124th Street and Park Avenue	AM
2	East Harlem/ Upper East Side	96th Street and Lexington Avenue	AM
3	East Harlem/ Upper East Side	96th Street and Second Avenue	AM/PM
4	East Midtown	34th Street and Lexington Avenue	AM
5	East Midtown	34th Street and Second Avenue	AM/PM

The five receptor sites were selected based on the results of the vehicular transportation analysis (see Chapter 5D), and represent either locations with the worst existing traffic conditions in the East Side study area or locations that would experience the greatest increases in traffic due to diversions and increased traffic from construction activities along the Second Avenue Subway alignment. The intersection that would be most severely affected by traffic during construction—34th Street and Second Avenue—was specifically chosen for analysis because it would be representative of other major study area cross streets (e.g., Second Avenue and 125th, 66th, 57th, and 42nd Streets) that would have potential CO impacts.

Because of the relatively lower levels of traffic congestion and the less intense traffic effects resulting from the construction activities in the Gramercy Park/Union Square, East Village/Lower East Side/Chinatown, and Lower Manhattan study areas, no receptor sites were selected for analysis in these areas. Changes to CO levels at all intersections throughout these areas would be proportionally smaller than at the five selected receptor sites, and would thus not represent "worst-case" conditions necessary for analysis purposes.

Multiple receptor sites were modeled at each of these intersections (i.e., receptors were placed at spaced intervals along the approach and departure links). Candidate intersections (intersections analyzed as part of the transportation chapter) were ranked based on the methodology developed by the EPA (November 1992) and the New York State Department of Transportation (NYSDOT) to evaluate critical locations.

Following EPA's procedure, the busiest study area intersections were selected by taking into account their traffic volumes and level of service (LOS), a measure of combined traffic volume, signal timing, and related congestion and delay. Traffic that would be diverted to specific intersections as a result of construction was also considered in ranking the study area intersections.

METHODOLOGY FOR ANALYZING PM_{10} PARTICULATE MATTER CONCENTRATIONS

The analyses discussed below consider the effects of Second Avenue Subway construction on PM_{10} concentrations. The analyses include both an on-street analysis consisting of detailed microscale intersection modeling, and a construction activity analysis consisting of detailed stationary, non-road and off-road source modeling. The study was performed using EPA-developed models and emission factors. Maximum PM_{10} concentrations near the construction sites were estimated and compared against the national and state air quality standards. Detailed modeling procedures using EPA-developed models and emission factors were employed to analyze impacts from the on-street emissions and on-site operations during the construction phase.

DISPERSION MODELING

To estimate the cumulative impact of PM_{10} emissions from all local sources—including on-street emissions from vehicles (both project-related and others) and emissions from construction activity within the construction sites—multiple source modeling was conducted using EPA's Industrial Source Complex Short Term version 3 (ISCST3) dispersion model, described in *User's Guide for the ISCST3 Dispersion Models* (EPA, 2002).

The ISCST3 model calculates pollutant concentrations from one or more sources based on hourly meteorological data. The meteorological data set consisted of the latest 5 years of concurrent meteorological data available (1997-2001), with surface data from LaGuardia Airport and concurrent upper air data from Brookhaven, New York. Computations with the ISCST3 model were made assuming stack tip downwash, buoyancy-induced dispersion, gradual plume rise, urban dispersion coefficients and wind profile exponents, no collapsing of stable stability classes, no building downwash, and elimination of calms. The potential air quality impacts were modeled without the building downwash algorithm enabled, since the sources of PM_{10} and $PM_{2.5}$ associated with construction of the subway would be low-level sources and the maximum impacts from low-level PM_{10} and $PM_{2.5}$ emission sources generally occur at or near ground level (within the first few stories of the emission source). Building wake effects would therefore not significantly impact maximum predicted concentrations for this analysis. The model was used to predict the fourth-highest daily and highest annual concentrations, defined by the EPA as a standard method for predicting PM_{10} concentrations, and added to highest daily and annual background concentrations.

ON-STREET EMISSIONS

EPA's transportation conformity regulations require analyses of PM_{10} for individual sites that would be affected by construction activities for more than 5 years. The project's effects on PM_{10} concentrations at the four locations where construction would last longer than 5 years in the current phasing plan were analyzed. A quantitative analysis was conducted for the three worst-case locations for PM (96th Street vicinity, 34th Street vicinity, and Pier 6 barge site), and the results of those quantitative analyses were used to qualitatively assess the project's effects on PM_{10} at 125th Street.

The intersections at 96th Street and Second Avenue and 34th Street and Second Avenue were selected for detailed on-street analysis, since these sites, adjacent to long-term construction sites, would experience a large increase in diesel truck traffic generated by construction activities required to excavate and build the 96th and 34th Street Stations and staging areas/shaft sites/spoils removal areas. This analysis is considered conservative because increases in PM_{10} levels from construction traffic at other locations along the Second Avenue Subway alignment would either be comparable or proportionally smaller than increases at 96th Street and 34th Street, since the extent of construction would either be similar or reduced at those locations. In addition, both locations have a concentration of nearby residential and other sensitive uses, including schools, a public park and a hospital near 96th Street and a public park and religious institution near 34th Street.

In addition, a barge facility was also assessed because the construction operations at the potential barge site would differ from those along the subway alignment. The methodology used for assessing potential particulate matter effects from barging activities involved identifying a "worst case" assumption for the barge operation. The SDEIS described two possible barge sites that might be used during construction: one in East Harlem at 129th Street and the Harlem River, and the other in Lower Manhattan at Pier 6 and the East River. The air quality analysis in the SDEIS was conducted for the barge site that was identified as worst-case in terms of potential air quality effects, the 129th Street barge site. Both barge sites would have had similar loading and unloading operations using the same type and number of construction equipment. At both sites, it was assumed that the same numbers of trucks would travel between the barging operations and the project's construction sites. Both barge sites were located adjacent to a multi-lane, limited access highway (the Harlem River Drive at 129th Street and the FDR Drive at Pier 6). The 129th Street barge site is located directly across the street from a large public park, Harlem River Drive Park and Crack is Wack Playground. Because the sites were otherwise equivalent, the 129th Street barge site was selected as the worst-case barge site because it had a sensitive receptor (the park) in close proximity. Since completion of the SDEIS, the 129th Street barge site has been eliminated from further consideration, but the air quality analysis at this site can still be used to represent the reasonable worst-case air quality effects of barging operations for the project.

A detailed analysis of hour-by-hour traffic volumes over a 24-hour period was conducted to determine the diurnal change in on-street emissions. The 24-hour distribution of baseline traffic was determined from data collected at the both intersections. The 24-hour distribution of construction phase trucks was estimated by Eng-Wong, Taub & Associates for this analysis.

EPA's mobile source particulate model, PART5 (EPA, 1995a), was used to compute PM_{10} emission factors for on-street vehicles. Based on data collected in New York City, a paved road silt loading factor of 0.16 grams per square meter was employed. Other inputs utilized in the model include: 1) no precipitation—this is a worst-case emission for 24 hours during a dry period (an annual average would consist of 140 days of precipitation, which is the number of days in the year with more than 0.01 inches of rain, reducing the emission factor proportionally by 38.3 percent); a standard fleet average vehicle weight of 6,000 pounds; and a fleet average number of four wheels per vehicle. Vehicle classifications for on-street traffic were obtained from collected traffic data for Second Avenue. PM_{10} emission factors used for the models were 1.05 g/VMT and 0.04 g/vehicles per hour (vph) idling on Second Avenue, 1.03 g/VMT and 0.07 g/vph idling on the main streets (96th and 34th) and 1.45 g/VMT and 1.107 g/vph idling for trucks.

The section of the Harlem River Drive included in the modeling of the 129th Street barge site was modeled as a line source represented as discrete volume sources, as defined by the EPA's ISCST3 line source definition procedure. Because of the close proximity of residences to the on-road emissions at the 30s and 90s sites (see below), these roads were modeled as line sources represented as area sources with initial vertical dispersion. This procedure enables a more homogenous emission throughout each link and the placement of receptors close to the source. Initial vertical dispersion was calculated according to the procedure described for CAL3QHC line source modeling, based on a constant wind speed of 0.3 meters per second. This procedure produces more accurate results during the periods when the highest concentrations are expected; these concentrations have the greatest impact on the average annual or daily results.

CONSTRUCTION EMISSIONS

Second Avenue Subway construction activities would take place at many locations along the proposed alignment. To determine which activities and locations should be used for the model, the following factors were considered: intensity and duration of construction activities; proximity to sensitive uses; ability to represent activities that would occur in other places along the alignment; and amount of existing traffic. Based on these criteria, the area between 97th and 92nd Streets ("the 90s"), a corresponding area in the 30s concentrated near 36th Street ("the 30s"), and site that was proposed to be used for barging at the Harlem River Drive and 129th Street were selected for analysis. (The barge operation at 129th Street is no longer proposed, but this analysis is representative of the air quality effects of a barging operation at Pier 6 in Lower Manhattan that is still under consideration.) Within the 90s and 30s, two separate construction activities were modeled: the open-cut station excavation process and the spoils removal process for the tunnel boring machine.

These activities were identified because they would each require the largest number of construction vehicles and machinery over a multi-year period and because they would also occur at all locations where stations would be constructed. An analysis of each of these activities at these locations was performed separately[1] to assess potential impacts on PM_{10} concentrations from construction activity. This is considered to be a worst-case approach, because although construction could occur at a number of locations along the subway alignment, and although a variety of construction techniques could be used to build a particular project element, the methods that would result in the worst impacts are the two that have been selected for this analysis at these locations. Hence, the results of the analysis for each activity can be used to extrapolate conclusions about other portions of the subway alignment.

The following describes the methodology used to evaluate possible impacts from these construction activities.

Source Simulation

On-site sources for Second Avenue Subway construction activities include emissions from the following:

- Truck and equipment movements on unpaved and paved surfaces;
- Transfer of spoils from cranes to trucks or barges;
- Transfer of materials from barges to storage areas and trucks;
- Transfer of spoils from trucks to temporary storage areas and vice versa; and
- Diesel emissions from construction equipment.

The specific construction activities, and corresponding locations, emissions sources, models or guidance used for emission rate calculations, and ISCST3 source types are shown in Tables I-5

[1] As described in Chapter 3, it is not anticipated that the open-cut excavation process and the spoils removal process for the TBM would occur simultaneously in any location along the Second Avenue corridor. In the 90s construction zone, slurry wall construction and TBM operations could occur simultaneously for approximately one year during Phase 1. For air quality, the cut-and-cover operations at this location would be the worst-case condition (with greater effects to air quality than the year of simultaneous TBM and slurry wall operations), and therefore can be used to determine the worst-case conditions here.

Table I-5
Open-Cut Station Excavation Construction Activity (90s and 30s)

Modeled Activity and Location	Sources (Fugitive Dust or Combustion from Equipment)	Source of Emission Data	ISCST3 Modeling Source Type
Open Station Excavation Area • 96th to 95th Streets • 36th to 35th Streets	*Fugitive Emissions* Unpaved Road (Two Front-End Loaders and Bulldozer)	*AP-42 Section 13.2.2*	Area
	Diesel Emissions Two Front-End Loaders Bulldozer Cherry Picker	NONROAD Model	
Crane to Truck Transfer of Spoils • 96th to 95th Streets • 36th to 35th Streets	*Diesel Emissions* Crane	NONROAD Model	Point
	Fugitive Emissions Spoils Transfer	*AP-42 Section 13.2.4*	Area
Park Staging Area • 97th to 96th Streets • 36th to 35th Streets	*Fugitive Emissions* Muck Bin[1]	*AP-42 Section 13.2.4*	Area
	Diesel and Fugitive Emissions Materials Loading Trucks	PART5 Model	Area
	Diesel Emissions Two Diesel Generators[2]	NONROAD Model	Point
	Diesel Emissions Air Compressor[2]	NONROAD Model	Point
Spoils Loading Area • 96th Street • 36th Street	*Diesel and Fugitive Emissions* Spoils Trucks	PART5 Model	Area

Notes:
Unless noted, all operations occur 16 hours per day, 6 days a week.
Types and locations of construction equipment and activities were developed based on preliminary planning for modeling purposes only.
[1] 2 hours per day, 6 days a week
[2] 24 hours per day, 6 days a week

and I-6 for the construction activities analyzed—open-cut station excavation and TBM spoils removal, respectively. The parameters used to model activities at the 129th Street barge site are shown in Table I-7. It was assumed that two separate areas would be modeled for the transfer operations at the barge site. These areas are defined as Area 1 and Area 2 in Table I-7. The ISCST3 model requires sources of emissions to be modeled as point, area, or volume sources. For the purposes of this air quality analysis, most emissions were modeled as either point or area sources. Although not part of the project, the traffic on the Harlem River Drive near the barge site was modeled due to the significance of the PM_{10} levels in the area and because such emissions would not be reflected in the monitored background levels. The road was simulated as a line source, represented in the model as discrete volume sources according to the EPA's ISCST3 modeling guidance. Emissions were calculated based on a daily traffic volume of 103,700 vehicles, with a daily maximum (capacity) peak of 6,320 vph (NYSDOT, 1999).

Table I-6
TBM Spoils Removal Construction Activity (90s and 30s)

Modeled Activity and Location	Sources (Equipment or Fugitive Dust)	Source of Emission Data	ISCST3 Modeling Source Type
Crane to Truck Transfer of Spoils • 96th to 95th Streets • 36th to 35th Streets	*Fugitive Emissions* Unpaved Road Emissions (Front-End Loader and Bulldozer)	*AP-42 Section 13.2.2*	Area
	Diesel Emissions Cherry Picker Front-End Loader Bulldozer	NONROAD Model	
	Fugitive Emissions Spoils Transfer Emissions	*AP-42 Section 13.2.4*	
	Diesel Emissions Crane	NONROAD Model	Point
Deck Opening Transfer of Spoils • 93rd to 92nd Streets • 36th to 35th Streets	*Fugitive Emissions* Spoils Transfer	*AP-42 Section 13.2.4*	Area
Park Staging Area • 97th to 96th Streets • 36th to 35th Streets	*Fugitive Emissions* Muck Bin[1]	*AP-42 Section 13.2.4*	Area
	Diesel and Fugitive Emissions Materials Loading Trucks	PART5 Model	Area
	Diesel Emissions Two Diesel Generators	NONROAD Model	Point
	Diesel Emissions Air Compressor	NONROAD Model	Point
Spoils Loading Area • 96th Street • 36th Street	*Diesel and Fugitive Emissions* Spoils Trucks	PART5 Model	Area

Notes:
Unless noted, all operations occur 24 hours per day, 6 days a week.
Types and locations of construction equipment and activities were developed based on preliminary planning for modeling purposes only.
[1] 2 hours per day, 6 days a week

Table I-7
Barge Site Activity

Modeled Activity and/or Location	Sources (Fugitive Dust or Combustion from Equipment)	Source of Emission Data	ISCST3 Modeling Source Type
Area 1 (identical assumptions were made for Area 2)[1]	*Fugitive Emissions* Unpaved Road emissions (Front-End Loader and Bulldozer)	*AP-42 Section 13.2.2*	Area
	Diesel Emissions Front-End Loader Bulldozer	NONROAD Model	
Truck to Crane Transfer of Spoils (identical assumptions were made for Area 2)	*Diesel Emissions* Crane	NONROAD Model	Point
	Fugitive Emissions Spoils Transfer	*AP-42 Section 13.2.4*	Area
Crane to Barge Transfer of Spoils (identical assumptions were made for Area 2)	*Diesel Emissions* Barge Crane	NONROAD Model	Point
	Fugitive Emissions Spoils Transfer	*AP-42 Section 13.2.4*	Area
Staging Area	*Diesel Emissions* Diesel Generator	NONROAD Model	Point
	Diesel Emissions Air Compressor	NONROAD Model	Point
	Diesel Emissions Two Barge Cranes	NONROAD Model	Point
	Diesel Emissions Tug Boat Auxiliary Engine	See Below[2]	Point
Materials Delivery Area	*Diesel Emissions* Materials Loading Trucks	PART5 Model	Area
	Fugitive Emissions Materials Loading Trucks	*AP-42 Section 13.2.2*	
Spoils Loading Area	*Diesel Emissions* Spoils Trucks	PART5 Model	Area
	Fugitive Emissions Spoils Trucks	*AP-42 Section 13.2.2*	
FDR Mobile Emissions	*Diesel Emissions* Traffic	*AP-42 Section 13.2.1*	Line

Note: Unless noted, all operations occur 24 hours per day, 6 days a week.
Types and locations of construction equipment and activities were developed based on preliminary planning for modeling purposes only.
[1] The barge site includes 2 identical loading facilities, identified here as Areas 1 and 2.
[2] EPA, 1999 and PANYNJ, 2001.

The following is an overview of the assumptions made regarding equipment used for the stationary source modeling for the construction site activities for Second Avenue Subway.

- At each site, four to five pieces of heavy equipment would be operating on-site simultaneously either for 16 hours per day or 24 hours per day, depending on the construction activity.
- The generators and air compressor would be continuously operating 24 hours per day, six days per week at the park staging area.
- Conveyors could be used for spoils removal and transfer operations. However, this equipment was not considered to be a significant emission source requiring air quality modeling because the conveyors would be covered to control dust and noise or because they would be located below-ground.
- Assorted other pieces of smaller construction equipment were not included in the modeling because it was assumed that these pieces of equipment would be powered by a combination of generators and electric power. Smaller pieces of equipment include drills, forklifts, cement mixers, saw-cutters, etc.
- For the purposes of this analysis, all equipment and fugitive dust-generating activities were conservatively assumed to be located at-grade in unenclosed areas, although typically, many construction activities would occur below-grade. For example, truck hoists would likely be employed to allow trucks to be loaded below-ground. Also, much of the excavation work would occur beneath temporary panels placed over the excavated areas to maintain traffic flow and minimize surface disruptions.

Additionally, the following assumptions were made for the 129th Street barge facility:

- Spoils from three open station excavation areas and two areas that would involve both open station excavation and TBM activities were assumed to be transported simultaneously to the barge facility;
- Two identical areas were assumed to be utilized on the upland area near the barge site to the transfer of spoils. Three pieces of heavy equipment would be operating in each area for 24 hours per day, 6 days per week.
- The generator, air compressor, crane, and tug auxiliary engine were assumed to also be continuously operating 24 hours per day, six days per week.

Estimates of Emission Rates

The emission estimates used to model the various sources were derived from three sources: PART5 model for fugitive dust sources from paved roads (EPA, 1995a); *EPA's AP-42, Compilation of Air Pollutant Emission Factors* (EPA, 1995-2000 and 1995-2002) for fugitive dust sources from unpaved roads and materials transfer; and EPA's Draft NONROAD Emissions Inventory Model for off road diesel-fueled equipment. Additionally, emissions from barge auxiliary engines were derived from EPA emission factors (EPA, 1999).

Emission estimates for PM_{10} were developed based on the processing rates identified for spoils that would be excavated. Spoils removed as part of the open station excavation construction activity were assumed to have a density of 2,700 lbs. per cubic yard. This value is given as the density of wet excavated earth (O'Brien, 1996), which most closely resembles the material to be excavated in this area. Additionally, the spoils to be excavated during the TBM construction activity were given a density of 3,400 lbs./cubic yard, wet gravel from 1/2 inch to 2 inches in size (O'Brien, 1996). This is considered to be a conservative approach because aggregate materials to be excavated during the TBM activity would be close to hand-sized, which would mean a lower density and overall processing rate, and would thus result in lower emission factors.

Total emissions were varied throughout operating hours. Open-cut station excavation was assumed to take place 16 hours a day and was therefore modeled at a constant rate from 6 AM to 10 PM. TBM spoils removal emissions were based on a 24-hour workday.

Tables I-8 through I-10 show the general assumptions that were used to determine the emission factors for all potential emission sources.

PART5 Emission Rates. Vehicular emissions for PM were computed using the previously discussed particulate matter emissions model, PART5. PART5 calculates PM emission factors, in grams per mile, from such on-road mobile sources as automobiles, trucks, and buses for particle sizes in the range of 1 to 10 µm. PART5 also calculates fugitive dust releases for paved and unpaved roads, based on algorithms developed by the Office of Air Quality Planning and Standards, and idle emissions (in grams per hour) developed from manufacturers' data.

PART5 was used to model emissions from paved road surfaces, including emissions from vehicle exhaust and the resuspension of road dust. Second Avenue Subway activities that have the potential to release fugitive dust from paved road surface travel include movements from spoils removal trucks and materials loading trucks. These emissions were assumed to occur with open station excavation, TBM spoils removal, and on-road spoils transport activities. As for on-road fugitive dust calculations, worst-case daily values were used, including no precipitation.

AP-42 Estimates of PM_{10} Emission Rates. Estimates of PM_{10} emission rates from construction activities at the site were based on the anticipated operations and EPA emission factors and procedures (EPA, 1995-2000 and 1995-2002).

EPA's AP-42 sections 13.2.2 and 13.2.4, Unpaved Roads, and Aggregate Handling and Storage Piles, were used to estimate emission factors for vehicular travel on unpaved roads, and the on-site material transfer operations, respectively. These sections use empirical expressions to calculate estimated PM emission factors.

Unpaved road emissions are those that result from movements of vehicles on unpaved surfaces. This is a potential emission source because vehicle tire movements cause the resuspension of particles to the air. Various construction vehicles that were assumed to have frequent unpaved surface movements include front-end loader, cherry picker, and bulldozer, as well as truck movements transporting spoils and materials. Parameters used to determine the emission factor of these sources include particle size, silt content, and moisture content of the unpaved surfaces, regional precipitation, vehicle weight, and VMT per day.

Where site-specific information regarding silt content for the unpaved road was not available, typical values listed in AP-42 were used. Conversely, the worst-case dry conditions default value of 0.2 percent was assumed for the unpaved surface moisture content. This is a conservative assumption. A typical silt content of 8.5 percent taken from AP-42 Table 13.2.2-1 was assumed. The AP-42 empirical expression directly relates silt content to emissions—i.e., a high amount of silt in the unpaved surface increases the emission factor. Alternatively, moisture content is inversely correlated to emission factors.

Table I-8
Open-Cut Station Excavation Construction Activity Input Parameters (90s and 30s)

Sources (Equipment or Fugitive Dust)	Assumptions
Unpaved Road Movement Emissions ▪ 96th to 95th Streets ▪ 36th to 35th Streets	160 trips per day for front-end loader 80 trips per day for bulldozer 70-foot travel distance 8.5 percent silt content 0.2 percent moisture content 140 days of precipitation per year (no reduction for daily model) 30-ton front-end loader 8-ton bulldozer 80 percent reduction for dust suppression program
Diesel-Fueled Equipment ▪ 96th to 95th Streets ▪ 36th to 35th Streets	Diesel emissions from two front-end loaders, a bulldozer, and cherry picker were added to the emissions from equipment movements on unpaved roads. 85 percent ULSD reduction
Crane ▪ 96th to 95th Streets ▪ 36th to 35th Streets	15-foot stack height 0.5-foot stack diameter exhaust at ambient temperature 0.003'/sec exhaust velocity
Crane to Truck Transfer of Spoils ▪ 96th to 95th Streets ▪ 36th to 35th Streets	169 tons/hr processing rate (based on 2,000 cy/day excavated and a soil density of 2,700 lbs/cy[1]) 11 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Muck Bin, Park Staging Area ▪ 97th to 96th Streets ▪ 36th to 35th Streets	10 percent of total processing rate 2 hours of operation per day 11 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Materials Loading Trucks	45 trucks per day 2 trucks idling on-site at all times
Diesel Generators	3-foot stack height 0-foot stack diameter exhaust at ambient temperature 0.003'/sec exhaust velocity
Air Compressor	3-foot stack height 0-foot stack diameter exhaust at ambient temperature 0.003'/sec exhaust velocity
Spoils Removal Trucks	200 trucks per day 2 trucks idling on-site at all times

Sources:
EPA's AP-42, Compilation of Air Pollutant Emission Factors
Preliminary planning information based on Preliminary Engineering.
[1] O'Brien, 1996

Table I-9
TBM Spoils Removal Construction Activity Input Parameters (90s and 30s)

Sources (Equipment or Fugitive Dust)	Assumptions
Unpaved Road Movement Emissions ▪ 96th to 95th Streets ▪ 36th to 35th Streets	40 trips per day for front-end loader 20 trips per day for bulldozer 70-foot travel distance 8.5 percent silt content 0.2 percent moisture content 140 days of precipitation per year (no reduction for daily model) 30-ton front-end loader 8-ton bulldozer 80 percent reduction for dust suppression program
Diesel-Fueled Equipment ▪ 96th to 95th Streets ▪ 36th to 35th Streets	Diesel emissions from two front-end loaders, a bulldozer, and cherry picker were added to the emissions from equipment movements on unpaved roads. 85 percent ULSD reduction
Crane to Truck Transfer of Spoils ▪ 96th to 95th Streets ▪ 36th to 35th Streets	163 tons/hr processing rate (based on 2,300 cubic yards (cy) per day excavated and a gravel density of 3,400 lbs/cy[1]) 2.1 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Crane ▪ 96th to 95th Streets ▪ 36th to 35th Streets	15-foot stack height 0.5-foot stack diameter exhaust at ambient temperature 0.003'/sec exhaust velocity
Deck Opening Transfer of Spoils ▪ 93rd to 92nd Streets ▪ 36th to 35th Streets	20 percent of total processing rate 2.1 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Muck Bin, Park Staging Area ▪ 97th to 96th Streets ▪ 36th to 35th Streets	10 percent of total processing rate 2 hrs of operation per day 2.1 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Materials Loading Trucks	45 trucks per day 2 trucks idling on-site at all times
Diesel Generators	3-foot stack height 0-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity
Air Compressor	3-foot stack height 0-foot stack diameter exhaust at ambient temperature 0.003'/sec exhaust velocity
Spoils Removal Trucks	230 trucks per day 2 trucks idling on-site at all times

Sources:
EPA's AP-42, Compilation of Air Pollutant Emission Factors
Preliminary planning information based on Preliminary Engineering.
[1] O'Brien, 1996

Table I-10
Barge Site Activity

Sources (Equipment or Fugitive Dust)	Assumptions
Unpaved Road Construction Equipment Movement Emissions for Area 1 (identical assumptions were made for Area 2)[1]	160 trips per day for front-end loader 80 trips per day for bulldozer 70-foot travel distance 8.5 percent silt content 0.2 percent moisture content 140 days of precipitation per year (no reduction for daily model) 30 ton front-end loader 8 ton bulldozer 80 percent reduction for dust suppression program
Diesel-Fueled Equipment	Diesel emissions from front-end loader and bulldozer were added to the emissions from equipment movements on unpaved roads. 85 percent ULSD reduction
Truck to Crane Transfer of Spoils for Area 1 (identical assumptions were made for Area 2)	419.5 tons/hr processing rate 9.22 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Crane to Barge Transfer of Spoils for Area 1 (identical assumptions were made for Area 2)	419.5 tons/hr processing rate 9.22 percent moisture content 4.9 meters/sec mean wind speed 80 percent reduction for dust suppression program
Crane	15-foot stack height 0.5-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity
Diesel Generator	3-foot stack height 0-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity
Air Compressor	3-foot stack height 0-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity
Tug Boat Auxiliary Engine	15-foot stack height 0.5-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity
Barge Cranes	15-foot stack height 0.5-foot stack diameter 293K exhaust temperature 0.003'/sec exhaust velocity

Table I-10 (cont'd)
Barge Site Activity

Sources (Equipment or Fugitive Dust)	Assumptions
Unpaved Road Truck Movement Emissions for Area 1 (identical assumptions were made for Area 2)	*Materials Delivery Trucks* 10 trips per day 100-foot travel distance 8.5 percent silt content 0.2 percent moisture content 140 days of precipitation per year (none for daily model) 34-ton truck 80 percent reduction for dust suppression program
	Spoils Trucks 820 trips per day 100-foot travel distance 8.5 percent silt content 0.2 percent moisture content 140 days of precipitation per year (none for daily model) 34-ton truck 80 percent reduction for dust suppression program
Materials Loading Trucks	10 truck trips per day 2 trucks idling on-site at all times
Spoils Removal Trucks	820 truck trips per day 3 trucks idling on-site at all times
FDR Mobile Emissions	Traffic Data from NYS Highway Sufficiency Ratings NYSDOT 1999

Note:
[1] The barge site includes two identical loading facilities identified here as Areas 1 and 2.
Source:
EPA's AP-42, Compilation of Air Pollutant Emission Factors
Preliminary planning information based on Preliminary Engineering.

The emission factors related to spoils transfer operations, derived from AP-42 *Aggregate Handling and Storage Piles*, take into account particle size, moisture content of materials handled, and wind speed. A moisture content of 11.0 and 2.1 percent was used for the open-cut station excavation and TBM spoils removal, respectively. Moreover, a moisture content of 9.22 percent was used for the transfer of spoils at the barge facility to account for the different spoils coming from open station excavation and TBM activity. The higher moisture content was assumed for the open-cut station activity because the material to be excavated is soil that will be significantly watered, whereas the material to be excavated with the TBM would be rock-sized material, which generally has lower moisture content.

An 80 percent control factor[1] was applied to the AP-42 unpaved and materials transfer emissions calculations. This control factor accounts for watering and chemical applications that are

[1] According to AP42 13.2.4, "Continuous chemical treating of material loaded onto piles, coupled with watering treatment of roadways, can reduce total particulate emissions from aggregate storage operations by up to 90 percent." Suppression of unpaved road dust, according to AP42 13.2.2 (Draft version) can reduce up to 95 percent of PM emissions.

planned to be used as part of the Second Avenue Subway dust-suppression program, which would be developed and monitored by New York City Transit (NYCT). The program would include the use of dust covers for trucks, (water) spray misting exposed areas, and using safe chemical dust suppressants to treat and control spoils at construction areas that could otherwise be a source of substantial fugitive dust emissions. The construction dust-suppression program would be included in the project's Construction Environmental Protection Program (CEPP). As explained in other chapters of this FEIS, the CEPP will be the document in which all project commitments and requirements related to construction will be incorporated. NYCT will incorporate relevant portions of the CEPP in all construction contracts, and contractors will be obligated to follow these provisions. NYCT will ensure that the CEPP and all related individual plans established by its contractors are implemented and coordinated.

NONROAD Model. PM_{10} emissions from non-road construction equipment were computed using EPA's Draft NONROAD Emissions Inventory Model (EPA, June 8, 2000). NONROAD calculates emissions in grams per brake-horsepower-hour from such non-road diesel equipment sources as front-end loaders, cranes, bulldozers, and generators. The NONROAD model was developed by EPA to assist state and local air pollution control agencies in creating and projecting inventories of emissions from non-road mobile sources. Emissions of hydrocarbons (HC), NO_x, CO, carbon dioxide (CO_2), SO_x, and PM are included in this model.

The model estimates emissions for each specific type of equipment by multiplying the population for the base or a future projected year, the average load factor (which is an estimate of the fraction of available power which is used), activity use in hours per year, and an emission factor. Projections are made using projected growth rates and scrappage rates to quantify the population of equipment at different times. Emission factors take into account engine deterioration factors and future lower emission levels based on regulation. The model can estimate non-road emission inventories from different geographical areas ranging from the national level to the sub-county level, as well as make projections for a single month to multiple years. It incorporates geographical information, population statistics, and equipment information.

Specific emission factors for the construction equipment that would be used in the project, presented in Table I-11, were taken from the NONROAD data tables. Horsepower data was derived from the Preliminary Engineering team and various other sources, including the following websites: Caterpillar Equipment, Toyota Industrial Equipment, Harrington Hoists and Cranes, Honda Industrial Generators, Komatsu Equipment Company, and Manitowoc Cranes.

Table I-11
NONROAD PM_{10} Emission Factors for Diesel Combustions Engine Sources

	NONROAD Emission Factor (g/hp-hr)	Horsepower	Emission Factor (g/hr)	Emission Factor (g/s)	NONROAD Load Factor	Actual Emission Factor (g/s)
Crane	0.2544	300	76.32	0.0212	0.43	0.0091
Cherry Picker	0.2470	300	74.10	0.0206	0.43	0.0089
Front-End Loader	0.2436	175	42.63	0.0118	0.55	0.0065
Air Compressor	0.3816	200	76.32	0.0212	0.48	0.0102
Bulldozer	0.2340	70	16.38	0.0046	0.59	0.0020
Portable Generator	0.5088	50	25.44	0.0071	0.62	0.0030
Tug Boat Auxiliary Engine[1]	0.5361	50	26.81	0.0074	0.40	0.0030

Notes:
[1] EPA, 1999 and PANYNJ, 2001
Emission factors are without implementation of ultra-low sulfur diesel (ULSD) fuel and diesel particulate filters.
Source: EPA's Draft NONROAD Emissions Inventory Model, Office of Transportation and Air Quality, June 8, 2000.

For the air quality analysis, the stationary diesel-fueled equipment was modeled as point sources (crane, generator, air compressor, and auxiliary engine), and the mobile diesel-fueled equipment was modeled as area sources (front-end loader, bulldozer, and cherry picker), to account for equipment movements on the unpaved surfaces.

To reduce emissions from construction equipment, NYCT has directed that all future contracts for capital construction projects include requirements for using ultra-low sulfur diesel (ULSD) fuel and diesel particulate filters in all heavy non-road equipment. This policy is recommended by the NYSDEC and other environmental organizations attempting to minimize emissions. ULSD fuel, with a maximum sulfur content of 15 parts per million, not only reduces emissions, but it also permits the use of advanced pollution control technologies. Implementation of these measures can reduce the emission of particles from combustion by approximately 85 percent.[1] The emission rates, presented below in Tables I-12 through I-16, account for this reduction. This reduction was not used for on-road vehicles, as they could not be controlled under this program.

Table I-12
Emission Rates for Area Sources for Open-Cut Station Excavation

Source		PM_{10} Emission Rate[1] ($g/sec/m^2$)		Total (kg/year)
Description	**Area (m^2)**	**24 Hour**	**Annual**	
Open Station Excavation[2]	836	1.53E-5	9.44E-6	146.8
Crane to Truck Transfer of Spoils (Fugitive Dust)	167	3.7E-5	3.7E-5	111.9
Muck Bin (Fugitive Dust)	111	5.6E-6	5.6E-6	11.2
Spoils Removal Truck Loading[3]	232	2.9E-6	2.9E-6	0.0327
Materials Delivery Truck Unloading[3]	232	2.7E-6	2.7E-6	0.0309

Notes:
Emissions based on 16 hours per day and 6 days per week of operation
1 With 80 percent reduction on fugitive dust emissions from paved and unpaved surfaces due to dust-suppression program and 85 percent reduction on off-road diesel combustion emissions due to ULSD requirements. Emission rates were calculated over entire area of activity. Annual includes natural precipitation.
2 Unpaved road movements and diesel emissions
3 Paved road movements and diesel emissions
Source: AP-42 and PART5

Receptor Locations

A comprehensive receptor grid, including discrete receptors (i.e., off-site locations providing continuous public access) that represent nearby sensitive uses, was developed for the modeling analysis. Discrete receptors were placed at residential windows surrounding each construction site perimeter, at various elevations. In addition, ground-level receptors were located at other locations with continuous public access. Receptors modeled included nearby parks, schools, and hospitals.

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1 The reduction of 85 percent is based on the Northeast States for Coordinated Air Use Management (NESCAUM), Memorandum: Diesel Emissions Resulting from Ground Zero Activity, April 8, 2002; *The Impact Of Retrofit Exhaust Control Technologies On Emissions From Heavy-Duty Diesel Construction Equipment*, SAE 199-01-0110, Environment Canada, NESCAUM, Manufacturer of Emission Controls Association.

Table I-13
Emission Rates for Area Sources for TBM Spoils Removal

Source		PM_{10} Emission Rate[1] ($g/sec/m^2$)		Total (kg/year)
Description	Area (m^2)	24 Hour	Annual	
Crane to Truck Transfer of Spoils[2]	167	1.10E-4	8.73E-5	36.7
Muck Bin (Fugitive Dust)	111	1.09E-5	9.33E-6	107.9
93rd/92nd Street Deck Opening Transfer of Spoils (Fugitive Dust)	111	2.18E-5	1.87E-5	10.8
Spoils Removal Truck Loading[3]	232	2.81E-6	2.81E-6	0.0483
Materials Delivery Truck Unloading[3]	232	2.68E-6	2.68E-6	0.0461

Notes:
Emissions based on 24 hours per day and 6 days per week of operation
1 With 80 percent reduction on non-combustion (fugitive dust) emissions due to dust-suppression program and 85 percent reduction on off-road diesel combustion emissions due to ULSD requirements. Emission rates were calculated over entire area of activity.
2 Unpaved road movements and diesel emissions
3 Paved road movements and diesel emissions
Source: AP-42 and PART5

Table I-14
Parameter and Emission Rate Data for Construction Equipment Point Sources

Parameter	Crane	Compressor	Generator
Height, meters	4.6	0.9	0.9
Exhaust Diameter, meters	0.15	0.0	0.0
Exit Velocity, m/sec	0.001	0.001	0.001
Exit Temperature, K	Ambient	Ambient	Ambient
PM_{10} Emissions, grams/second			
PM_{10}—24-hour average	1.37E-03	1.53E-03	6.57E-04
PM_{10}—Annual average	1.17E-03	1.30E-03	5.62E-04

Notes:
Emission rates for TBM Spoils Removal, assumed to be 24 hours per day, 6 days per week. Emissions for Open-Cut Station Excavation would be 16 hours per day and factored to zero for non-active hours.
With 85 percent reduction on off-road diesel combustion emissions.
Source of emissions: EPA's Draft NONROAD Emissions Inventory Model, Office of Transportation and Air Quality, June 8, 2000.

Table I-15
Emission Rates for Area Sources for Barge Activities

Source		PM_{10} Emission Rate[1] ($g/sec/m^2$)	
Description	Area (m^2)	24 Hour	Annual
Construction Equipment in Area 1 (Assumed the same for Area 2)[2]	334	4.69E-05	2.60E-05
Truck to Pile Transfer of Spoils in Area 1 (Assumed the same for Area 2)	334	1.18E-05	1.01E-05
Crane to Barge Transfer of Spoils in Area 1 (Assumed the same for Area 2)	1,208	3.27E-06	2.79E-06
Spoils Removal Truck Loading[3]	232	3.73E-04	1.99E-04
Materials Delivery Truck Unloading[3]	232	1.11E-05	8.01E-06

Notes:
Emissions based on 24 hours per day and 6 days per week of operation
1 With 80 percent reduction on non-combustion (fugitive dust) emissions due to dust-suppression program and 85 percent reduction on off-road diesel combustion emissions due to ULSD requirements. Emission rates were calculated over entire area of activity.
2 Unpaved road movements and diesel emissions for front-end loader and bulldozer
3 Unpaved road movements and diesel emissions
Source: AP-42 and PART5

Table I-16
Parameter and Emission Rate Data for Barge Activities

Parameter	Crane	Compressor	Generator	Barge Crane	Tug Boat Auxiliary Engine
Height, meters	4.6	0.9	0.9	4.6	4.6
Exhaust Diameter, meters	0.15	0.0	0.0	0.15	0.0
Exit Velocity, m/sec	0.001	0.001	0.001	0.001	0.001
Exit Temperature, K	293	293	293	293	293
PM_{10} Emissions, grams/second					
PM_{10}—24-hour average	1.37E-03	1.53E-03	6.57E-04	1.37E-03	4.47E-04
PM_{10}—Annual average	1.17E-03	1.30E-03	5.62E-04	1.17E-03	3.82E-04

Notes:
1. Emission rates for Barge Site, assumed to be 24 hours per day, 6 days per week.
2. Includes 85 percent reduction on off-road diesel combustion emissions.

Sources of emissions:
EPA's Draft NONROAD Emissions Inventory Model, Office of Transportation and Air Quality, June 8, 2000.
Marine and Land-Based Mobile Source Emission Estimates for 50 Foot Deepening Project-Draft, July 29, 2001

Background

To estimate the maximum expected total PM_{10} concentrations at a given receptor, the predicted levels must be added to corresponding background concentrations. Background levels of PM_{10} are based on concentrations measured at the nearest representative ambient air monitoring station at Mabel Dean Bacon station (NYSDEC, 2002 and 1998-2001 data summary available from NYSDEC online). Background levels of $PM_{2.5}$ for the region have not yet been established by the regulatory agencies. Measured $PM_{2.5}$ levels in New York City are discussed earlier in this appendix.

PM_{10} Concentrations Predicted

Detailed results of the PM_{10} modeling are presented in Table I-17.

Table I-17
PM_{10} Concentrations During Construction by Site and Construction Phase

	34th St. Open Station	34th St. Tunneling Phase	96th St. Open Station	96th St. Tunneling Phase	129th St. Barge Site
Maximum 24-Hour Concentration (μg/m³)					
No Build	98.877	98.877	88.035	88.035	102.445
Build, Near Access Roadways	102.652	102.652	88.106	88.106	102.445
Build, Near Construction Site	107.191	107.013	96.010	93.974	112.096
Max Project Contribution	14.195	17.655	14.195	17.655	26.051
Max Roadway Contribution	3.775	3.775	0.071	0.071	0.000
Maximum 5-Year Annual Average Concentration (μg/m³)					
No Build Roadways	37.933	37.933	34.443	34.443	36.424
Build, Near Access Roadways	38.907	38.907	34.465	34.465	36.424
Build, Near Construction Site	40.480	40.257	36.419	36.105	38.871
Max Project Contribution	3.914	4.229	3.914	4.229	3.822
Max Roadway Contribution	0.974	0.974	0.022	0.022	0.000

Note: Total concentrations include background levels of 61 μg/m³ for the 24-hour and 24 μg/m³ for the annual average.
Source: ISCST3 modeling.

METHODOLOGY FOR ANALYZING $PM_{2.5}$ PARTICULATE MATTER CONCENTRATIONS

Because no federal or state analysis guidance methods and data are available, and because of the regional nature of $PM_{2.5}$, the analyses of this pollutant are conservatively based on the results of the PM_{10} modeling analysis and a proportionate comparison of the estimated amount of emissions between the two types of particulate matter.

New York State and the EPA have not yet determined whether New York City is within attainment of the $PM_{2.5}$ NAAQS. Early monitoring data indicate that the region is well within the 24-hour $PM_{2.5}$ standard, but the 3-year annual average $PM_{2.5}$ concentrations in New York City will range from just below to just above the standard of 15 μg/m³. Based on current data, the 24-hour average concentrations should be well below the standard of 65 μg/m³. Furthermore, a preliminary examination of both the annual average and 24-hour average $PM_{2.5}$ data for New York City indicates that measured concentrations are significantly more uniform (i.e., differing by a few micrograms per cubic meter) across geographical areas than concentrations of PM_{10}. This is consistent with the scientific theory that secondary particles from distant sources are a major contributor to $PM_{2.5}$ concentrations in the city, and that $PM_{2.5}$ is a regional pollutant similar to ozone in its spatial distribution. Because of its regional nature, spatial averaging over an area provides a more accurate assessment of public health risk than examining peak concentrations. This is reflected in EPA's procedures for determining compliance with the new standard. As shown in Table I-18, secondary sulfates comprise nearly 60 percent of the ambient $PM_{2.5}$ in the eastern United States. Therefore, as EPA recommends, chemical speciation of the ambient air data will be necessary as a second step to focus on the most appropriate sources of $PM_{2.5}$, such as regional sulfate formation.

Table I-18
$PM_{2.5}$ Component Contribution

Pollutant Component	Eastern U.S. (%)	Western U.S. (%)
Sulfate	56	33
Elemental Carbon	5	6
Organic Carbon	27	36
Nitrate	5	8
Crustal Material	7	17

Source: *EPA National Air Quality and Emissions Trends Report, 1998*, EPA 454/R-00-003, March 2000.

Due to the importance of secondary particle formation and the long atmospheric persistence of fine particles, $PM_{2.5}$ is a regional pollutant, much like ozone, where the non-attainment area encompasses three states. Therefore, any control strategies necessary to achieve or maintain attainment of the new standard are expected to be regional in their focus.

Currently, EPA, NYSDEC, and NYCDEP do not have approved models or analytical procedures to be used for project-specific $PM_{2.5}$ studies. However, it is possible to estimate a potential maximum increase in $PM_{2.5}$ concentrations due to combustion sources that would be generated by the types and numbers of construction equipment that are expected to be used for the Second Avenue Subway using techniques originally developed for PM_{10} impact assessment.

As discussed above, most of the particulate matter (PM_{10} and $PM_{2.5}$) from the Second Avenue Subway's on-street construction trucks, as estimated by EPA's PART5 model, would be almost entirely resuspended dust. However, measured data indicate that the model greatly overestimates the road dust contribution to ambient levels. In the 1995 Draft PM_{10} SIP for New York County (NYSDEC, 1995), NYSDEC and NYCDEP expressed their concerns to EPA regarding the fugitive dust estimates in the PART5 model. Measurements at NYCDEP's Midtown Manhattan monitoring site on Madison Avenue indicated that only 8.5 percent of the particulate matter (as PM_{10}) was road dust, while the PART5 model predicted dust percentages from 13 to 86 percent. The potential for the PART5 model to overpredict resuspended dust from paved roads is an important element in any assessment of $PM_{2.5}$ from mobile sources since the projected increase in PM_{10} concentration from mobile sources mostly comprises road dust. In fact, the increases in PM_{10} concentrations due to the proposed project discussed above were approximately 90 percent road dust and 10 percent tailpipe exhaust. Therefore, any estimate of $PM_{2.5}$ increases from mobile sources using PART5 would be primarily related to road dust, and thereby tends to overestimate concentrations. EPA estimates that only 7 percent of ambient $PM_{2.5}$ in the eastern United States is related to crustal material, which includes road dust. Estimates from the PART5 model would lead to much higher percentages in ambient air.

METHODOLOGY FOR REGIONAL ANALYSIS OF CONSTRUCTION ACTIVITY

Because of the Second Avenue Subway's large scale and extended construction duration, NO_x, VOCs, and $PM_{2.5}$ would increase in the region during construction. The localized sources of potential air pollutants during the construction period would include on-site construction activity, as well as combustion emissions from fuel consumed by construction equipment and vehicles. Potential regional airborne emissions could result from trucks and barges transporting construction materials to various construction sites in Manhattan, and likewise, spoils from the removal sites to destinations outside of Manhattan. Because of the large scale and extended duration of the construction required for the Second Avenue Subway, the construction would increase regional concentrations of ozone precursors—NO_x and VOCs—as well as fine particulate matter ($PM_{2.5}$), all of which are pollutants of concern on a regional basis. The regional effects of the project's construction were assessed in two ways: 1) the total amount of these pollutants throughout the region that would result from transportation of spoils was calculated; and 2) the concentrations of $PM_{2.5}$ that would result from the project's trucking and construction site activities were computed on a regional basis. The concentrations of ozone precursors (NO_x and VOCs) that would result from construction were not predicted on a regional basis, since these pollutants are of concern because of their role in the formation of ozone, but that process is very complex and there is no reliable way to predict a project's effects on ozone.

The maximum and average annual regional emissions from supply materials and spoils removal transportation were calculated by first estimating the number of vehicles that would be required for each transport activity and the emissions from trucks and barge tugs. These emissions estimates from each mode of transport were then multiplied by the total number of estimated trips, and by the estimated total distance of travel of each transport mode for each year of construction, to yield the total estimated regional pollution burden estimates by the various alternative disposal methods.

EMISSION FACTORS

NO_x and VOCs emission factors for supply and disposal trucks were generated with MOBILE5b. $PM_{2.5}$ emission factors were obtained using PART5. All trucks were assumed to be heavy-duty diesel vehicles, traveling at a speed of 35 mph. Based on the temperatures employed for emission estimates of NO_x and VOCs in the New York State demonstration of attainment with the ozone 1-hour standard (NYSDEC, 1998 Appendix M), an average summer temperature of 78.3ºF was employed in the MOBILE5b modeling.

Emissions were also calculated for possible barging operations associated with construction. Emission factors for the transport of barged material, including auxiliary engine emissions, were calculated using procedures published by the EPA (EPA, 1999), based on an estimated capacity of 4,075 cubic yards per scow, and a travel speed of 6.4 knots per hour (PANYNJ, 2001). $PM_{2.5}$ emissions for barges were estimated to be 88 percent of PM_{10}.

Emission factors from trucks, as produced using the PART5 and MOBILE5b models, are presented in Table I-19. Emissions from barge tugs (The Port Authority of New York & New Jersey, "Marine and Land-Based Mobile Source Emission—Estimates for 50-Foot Deepening Project," NY 2001) were assumed to remain constant over the years, at 1.48E-07, 1.97E-05 and 4.73E-07 tons per hp-hour of VOCs, NO_x and PM. The barge was assumed to have a 4075 cubic yard capacity, with a 1970 hp tug moving at average speed of 6.4 knots, load factor = 0.6. Auxiliary engines were added, 4.14E-07, 1.48E-05 and 5.91E-07 tons per hp-hour of VOCs, NO_x and PM, 50hp LF=0.4.

Table I-19
HDD Emissions by Year at 35 mph [g/mi][1]

Year	VOC	NO_X	$PM_{2.5}$
2004	1.32	7.78	0.527
2005	1.32	7.15	0.497
2006	1.31	6.46	0.474
2007	1.31	5.95	0.457
2008	1.31	5.52	0.444
2009	1.31	5.18	0.435
2010	1.3	4.91	0.426
2011	1.3	4.64	0.419
2012	1.3	4.43	0.406
2013	1.3	4.22	0.403
2014	1.3	3.95	0.4
2015	1.3	3.77	0.392
2016	1.3	3.66	0.39
2017	1.3	3.59	0.39
2018	1.3	3.55	0.383
2019	1.3	3.51	0.383
2020	1.3	3.46	0.383

Note: This table is new for the FEIS.
Source: [1] EPA models—PART5, MOBILE5b

ESTIMATES OF TRUCK AND BARGE TRIPS

Truck trips were estimated by assuming a capacity of 10 cubic yards of supply or disposal material per truck. The number of daily truck and barge trips was calculated for each year of construction, using an estimate of materials and spoils associated with the various construction options based on preliminary planning and scheduling data.

ESTIMATES OF DISTANCES TRAVELED

Since the actual spoils destinations cannot be finalized at this time, three possible distances were assessed—25, 50, and 100 miles per truck. These distances would include the distance traveled within Manhattan. Supply materials were assumed to travel an average of 100 miles to each construction site. Emissions estimates accounted for the potential total round-trip distance.

METHODOLOGY FOR ANALYSIS OF PERMANENT IMPACTS OF THE SECOND AVENUE SUBWAY

To determine the benefits that the Second Avenue Subway would have on air quality by reducing vehicular traffic once it is operating, pollutant burdens—which represent total expected quantities of regional pollutant emissions for a defined time and provide an indication of the general change in air quality—were computed. Criteria pollutant and precursor emissions measured include CO, NO_x, VOCs, and PM_{10}. After completion of the SDEIS, the air quality analyses were refined to use updated speed summary data from the 1999 NYMTC conformity analysis, with the most recently predicted speeds for year 2020 (this is the latest year for which predicted speeds are available). In addition, the modeling inputs were updated to reflect the NYSDEC modeling inputs used to develop the state's emission budget in the 1998 Ozone SIP. The reduction in annual pollutant emissions due to the proposed Second Avenue Subway were based on the EPA's mobile source emissions model (MOBILE5b) in conjunction with the VMT reduction estimates due to the project. The modeling assumptions used in the analysis are described below.

ANALYSIS YEAR

The regional analysis is based on the overall reduction in pollutant emissions once the Second Avenue Subway is operational. Therefore, the analysis year for this analysis was 2025.

VMT

Based on the Second Avenue Subway ridership model (see Appendix D.1), the analysis assumes a reduction of approximately 28.4 million vehicle miles per year.

VEHICLE CLASSIFICATIONS

Emission estimates were made for two classes of motor vehicles:

- Light-duty, gasoline-powered automobiles (LDGV); and
- Light-duty, gasoline-powered trucks (LDGT).

No light-duty diesel-powered vehicles (automobiles and taxis), light-duty diesel-powered trucks, or motorcycles were assumed. In the case of motorcycles, the number of such vehicles on any street is generally small. The analysis assumes a vehicle distribution of 75 percent light-duty gasoline-powered automobiles and 25 percent light-duty gasoline-powered trucks. Within the LDGT category, a split of 75 percent LDGT1 and 25 percent LDGT2 was assumed.

EMISSIONS MODELS

Vehicular emissions for CO, NO_x and VOCs were computed using the EPA-developed Mobile Source Emissions Model, MOBILE5b. The NYSDEC modeling inputs used to develop New York States' emission budgets in the 1998 Ozone SIP were used in the analysis. This included using a Reid Vapor Pressure (RVP) of 8.6psi for emissions estimates of NO_x and VOCs.

Emissions estimates for PM_{10} were estimated using EPA's PART5, a program for calculating particle emissions from motor vehicles. The emissions estimates for PM_{10} are based on modeling runs with PART5 for the year 2020, since the PART5 model is not valid for years beyond 2020. However, the PM emissions from light-duty gasoline-powered automobiles and light-duty gasoline-powered trucks change insignificantly from 2004 through 2005, and therefore it is expected that these values would remain consistent through 2025.

VEHICLE OPERATING MODES

For automobiles and light-duty gasoline-powered trucks, emission estimates account for three possible vehicle operating conditions: cold-start, hot-start, and hot-stabilized operation. It is important to distinguish between these three operating categories, because vehicle engines emit CO at different rates depending on whether they are cold or warmed up. All reduced project-related vehicles were conservatively assumed to be operating in a hot-stabilized mode.

TEMPERATURE

Emissions estimates for CO were calculated for the winter season, at a temperature of 50ºF. Summer season emissions for NO_x and VOCs were calculated at a temperature of 78.3ºF

VEHICLE SPEEDS

Regional traffic speeds used in the MOBILE5b model were based on year 2020 Manhattan speeds from the New York Metropolitan Transportation Council's 1999 TIP and Plan/SIP conformity analysis. For CO, emission factors were calculated for a local winter Manhattan speed of 6.5 miles per hour and an arterial winter Manhattan speed of 15.2 miles per hour. For NO_x and VOCs, emission factors were calculated for a local summer Manhattan speed of 6.3 miles per hour and an arterial summer Manhattan speed of 12.5 miles per hour. The resultant emission factors were then averaged to reflect an average speed. ✷