Note on the 2006 Inventory

The 2006 GHG and CAP Inventory was completed and published in February 2009. Many of the assumptions and methodologies in the inventory have been updated or changed since then. SC&A updated the 2006 estimate in 2018 in order to reflect a more like-to-like comparison with later inventories. The 2018 memo discussing the changes made to the 2006 estimate are included as an addendum starting on page 110 at the end of this file.

Revised 5.26.2023

GREENHOUSE GAS EMISSION INVENTORY FOR THE PORT AUTHORITY OF NEW YORK & NEW JERSEY

Calendar Year 2006 (Revised)

Prepared for:

The Port Authority of New York & New Jersey
New York, NY

Prepared by:

Southern Research Institute
Durham, NC

and

E.H. Pechan & Associates, Inc.
Springfield, VA

February 2009

(This page intentionally left blank)

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

ACRONYMS AND ABBREVIATIONS

CAP	criteria air pollutant
CH_4	methane
CHE	cargo-handling equipment
CMV	Commercial Marine Vessels
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DOE	U.S. Department of Energy
EDMS	Emission Dispersion Modeling System
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EIS	economic impact study
EPA	U.S. Environmental Protection Agency
EWR	Newark Liberty International Airport
GHG	greenhouse gas
GSE	ground support equipment
GVWR	gross vehicle weight rating
GWBBS	George Washington Bridge Bus Station
GWP	global warming potential
HDDVs	heavy-duty diesel vehicles
HFCs	hydrofluorocarbons
I/M	inspection maintenance
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
JFK	John F. Kennedy International Airport
kg	kilogram
KIAC	Kennedy International Airport Cogeneration
kWh	kilowatt hour
LDGT-1 and 2	light-duty gasoline trucks below 6,000 pounds
LDGT-3 and 4	light-duty gasoline trucks between 6,001 and 8,500 pounds
LDGV	light-duty gasoline vehicles
LGA	LaGuardia Airport
LPG	liquid petroleum gas
LTO	landing and takeoff
MMBtu	million British thermal units

mpg	miles per gallon
MSW	municipal solid waste
N_2O	nitrous oxide
NERC	North American Electric Reliability Council
NO_x	oxides of nitrogen
NYNJHS	New York New Jersey Harbor System
NYNJLINA	New York Northern New Jersey Long Island Ozone Nonattainment Area
OGV	ocean-going vessels
PABT	Port Authority Bus Terminal
PANYNJ	Port Authority of New York and New Jersey
PATH	Port Authority Trans-Hudson
Pechan	E.H. Pechan & Associates, Inc.
PFCs	perfluorocarbons
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
$PM_{2.5}$	particulate matter with an aerodynamic diameter of 2.5 microns or less
SAR	Second Assessment Report
SF_6	sulfur hexafluoride
SO_2	sulfur dioxide
Southern	Southern Research Institute
TAR	Third Assessment Report
TJ	terajoule
UTV	Utility Track Vehicle
VMT	vehicle-miles traveled
VOC	volatile organic compound
WBCSD	World Business Council on Sustainable Development
WIP	work in progress
WRI	World Resources Institute

(This page intentionally left blank)

1.0 EXECUTIVE SUMMARY

1.1. BACKGROUND

The Port Authority of New York and New Jersey (PANYNJ) manages and maintains the bridges, tunnels, bus terminals, airports, Port Authority Trans-Hudson (PATH) commuter rail system and marine terminals that are critical to the metropolitan New York and New Jersey region's trade and transportation capabilities. Major facilities owned, managed, operated, or maintained by the PANYNJ include John F. Kennedy International, Newark Liberty International, and LaGuardia airports; the George Washington Bridge and Lincoln and Holland tunnels; Port Newark, the Howland Hook Marine Terminal; the Port Authority Bus Terminal and the 16-acre World Trade Center site in Lower Manhattan.

As a cornerstone in its broader sustainability program, PANYNJ is implementing a program to reduce its greenhouse gas (GHG) emissions by 80 percent, from 2006 levels, by the year 2050. To establish an initial baseline required to monitor progress toward this goal, PANYNJ utilized the services of Southern Research Institute (Southern) and E.H. Pechan & Associates, Inc. (Pechan) to conduct a GHG emissions inventory of Port Authority facilities and operations. The inventory includes the emissions of PANYNJ tenants (e.g., airlines and container terminals) and patrons (e.g., airport passengers and PATH riders). As part of the project, Southern and Pechan were also to develop procedures and implement systems that allow for annual tracking and reporting of GHG emissions.

1.1.1. Objectives

The GHG emission inventory described in this report was developed for calendar year 2006. This was the most recent year of available data, and was a generally representative year in terms of climate, traffic, and operational characteristics. The following objectives were set for this GHG emission inventory effort:

1. Account for all six GHGs identified by the Intergovernmental Panel on Climate Change (IPCC): carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydroflurocarbons (HFCs); perfluorocarbons (PFCs); and sulfur hexafluoride (SF_6)
2. Include direct and indirect emissions
3. Maximize flexibility to prepare for future regulatory regimes (e.g., track emissions by department, facility, type of emission, expressing emissions in absolute and normalized terms)
4. Ensure transparency
5. Estimate emissions rather than rely on direct measurement
6. Establish a system that allows for annual reporting

7. Adhere to the IPCC guidelines for conducting national GHG emission inventories and incorporate expert techniques in the inventory of corporate emissions, as well as of airports, marine terminals, and other transportation facilities. This includes the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
8. Express emissions in tons of CO_2 equivalent units (CO_2e) as well as separately for each of the individual gases

For non-CO_2 GHGs, the mass estimates of these gases were converted to CO_2e by multiplying the non-CO_2 GHG emissions in units of mass by their global warming potentials (GWPs). GWPs were developed by the IPCC to quantify the globally averaged relative radiative forcing effects of a given GHG, using CO_2 as the reference gas. In 1996, the IPCC published a set of GWPs for the most commonly measured GHGs in its Second Assessment Report (SAR). In 2001, the IPCC published its Third Assessment Report (TAR), which adjusted the GWPs to reflect new information on atmospheric lifetimes and an improved calculation of the radiative forcing of CO_2. However, SAR GWPs are still used by international convention and the United States to maintain the value of the CO_2 currency. Therefore, the SAR GWP values are used in this analysis. Table 1-1 provides a comparison of the SAR and TAR GWPs.

Table 1-1. Comparison of Global Warming Potentials from the IPCC's Second and Third Assessment Reports

Greenhouse Gas	GWP (SAR, 1996)	GWP (TAR, 2001)
CO_2	1	1
CH_4	21	23
N_2O	310	296
HFC-23	11,700	12,000
HFC-125	2,800	3,400
HFC-134a	1,300	1,300
HFC-143a	3,800	4,300
HFC-152a	140	120
HFC-227ea	2,900	3,500
HFC-236fa	6,300	9,400
HFC-43-10mee	1,300	1,500
CF_4	6,500	5,700
C_2F_6	9,200	11,900
C_3F_8	7,000	8,600
C_4F_{10}	7,000	8,600
C_5F_{12}	7,500	8,900
C_6F_{14}	7,400	9,000
SF_6	23,900	22,000

1.1.2. Inventory Boundary

One of the first steps in the development of this, and any other, GHG emission inventory is determining the organizational boundary for reporting emissions. The organizational boundary decisions that were made during this project were done so that all methods for data collection were applied consistently across all operations, facilities, and sources of the PANYNJ. The objective of this exercise was to develop a GHG inventory that meets the criteria for submittal to the California Climate Action Registry (or the equivalent Registry for New York and New Jersey). The California Climate Action Registry is based on the requirements of the accepted guidelines and principles in the World Resources Institute (WRI) GHG protocol.

The California Climate Action Registry and WRI GHG Protocol have two main options for determining the GHG emissions that should be reported: management control or equity share. Under the management control option, 100 percent of the emissions from operations, facilities, and sources that the organization controls are reported. Under the equity share option, an organization reports emissions based on its share of financial ownership of an entity, operation, or source. Management control is more appropriate than equity share for an entity like the PANYNJ because it is a public organization. Equity share reporting is most common for profit-making corporations. An important reason for choosing to report emissions based on management control is that when the PANYNJ controls how an operation or a facility is managed, the organization is able to control factors such as capital investment and technology choice, how energy is used, and the level of emissions generated. Thus, reporting emissions under the management control approach reflects the ability of the PANYNJ to implement actions that could reduce GHG emissions.

Within the management control option, financial or operational criteria can be used to define GHG reporting. Operational control is the authority to develop and carry out the operating or health, safety, and environmental policies of an operation or at a facility (GHG Protocol, 2004). Financial control is the ability to dictate or direct the financial policies of an operation, or facility, with the ability to gain the economic rewards from activities of the operation or the facility. It was decided that operational criteria would be used for this inventory.

Table 1-2 summarizes the boundaries that were applied in this study for the departments and facilities included in the 2006 PANYNJ GHG emission inventory. This organizational boundary reflects the PANYNJ's interest in quantifying both direct and indirect GHG emissions for the facilities for which it has operational control. Therefore, there are a number of facilities included in this inventory that are leased by tenants because the PANYNJ may ultimately be able to implement actions that could reduce the GHG emissions at these tenant run properties. In addition, the PANYNJ opted to account for indirect emissions from its patrons, within certain geographic boundaries that vary by PANYNJ department. The rationale for including these emissions was that the PANYNJ may be able to influence its patrons in ways that reduce GHG emissions.

Table 1-2. Boundaries for each Department in the GHG Emissions Inventory

Department	Boundary
Aviation	• Civil and commercial use of airplanes, up to 3,000 feet • Aircraft ground support equipment • Vehicle trips attracted by the airport, including those of private vehicles, taxis, and buses
Port Commerce	• All vessels that call on Port Authority facilities within the three-mile demarcation line off the eastern coast of the United States • Cargo handling equipment/Automotive shipping/On-dock locomotive switchers • Drayage trucks/rail freight to the first point of rest, to the limits of the New York Northern New Jersey Long Island Ozone Nonattainment Area (NYNJLINA)
Tunnels, Bridges, & Terminals	• Emissions based on vehicle volume, the roadway length of each facility, and the average length of toll lane queues • Terminals include all vehicle travel within the terminal property
PATH	• Traction power • Commuters' vehicle trips to PATH stations • Fuel consumption of Utility Track Vehicles and other equipment
Real Estate & Development	• Office space leased by the Port Authority • Buildings leased to tenants (operating and capital leases) • Excludes real estate projects that the Port Authority does not manage or operate
Construction	• Construction equipment used in Port Authority capital projects
Vehicle Fleet	• Fuel consumption
Employee Commuting	• Vehicle trips to and from work by Port Authority employees

Table 1-3 lists the PANYNJ facilities that are included in this GHG emission inventory. The table is organized by department first, then by facility. The report sections follow this organization.

Table 1-3. Port Authority Facilities Included in the 2006 GHG Emission Inventory

AVIATION
- John F. Kennedy International Airport
- LaGuardia Airport
- Newark Liberty International Airport
- Teterboro Airport
- Downtown Manhattan Heliport
- AirTrain JFK / AirTrain Newark
- Kennedy International Airport Cogeneration (KIAC) Cogeneration

REAL ESTATE & DEVELOPMENT
- Bathgate Industrial Park
- The Teleport
- The Legal Center
- World Trade Center
- Essex County Resource Recovery Facility
- PA leased space:
  - 225/233 Park Avenue South
  - One Madison Avenue
  - 115 Broadway
  - Gateway Plaza I, II, III
  - 5 Marine View
  - 777 Jersey Avenue
  - Port Authority Technical Center
  - KAL Building at JFK

TUNNELS, BRIDGES, & TERMINALS
- George Washington Bridge
- Bayonne Bridge
- Goethals Bridge
- Outerbridge Crossing
- Lincoln Tunnel
- Holland Tunnel
- George Washington Bridge Bus Station
- Port Authority Bus Terminal

PORT COMMERCE
- Port Newark / Elizabeth PA Marine Terminal
- Howland Hook Marine Terminal and Port Ivory
- Brooklyn PA Marine Terminal
- Auto Marine Terminal and Greenville Yard
- Elizabeth Landfill

PATH
- PATH Rapid Transit System
  - 13.8 route miles
  - 13 stations
  - Journal Square Transportation Center
  - Harrison Car Maintenance Facility
  - Waldo Yard Buildings

1.2. RESULTS SUMMARIES

This section of the report summarizes the key results of the GHG emission estimates in CO_2e terms. The GHG emissions inventory for calendar year 2006 estimates that PANYNJ GHG direct and indirect emissions total approximately 5.77 million metric tons of CO_2e. Table 1-4 and Figure 1-1 show the 2006 CO_2e emissions by department. The Aviation Department has the highest 2006 GHG emissions (62.4 percent), followed by Port Commerce (15.5 percent), and Real Estate and Development (12.2 percent). Tunnels, bridges and terminals, PATH and mobile sources contribute the remaining 10 percent of 2006 GHG emissions.

Table 1-4. PANYNJ CO_2 Equivalent Emissions in 2006

Department	CO_2 Equivalent Emissions (metric tons)
Aviation	3,598,949
Port Commerce	891,129
Real Estate & Development	703,518
Tunnels, Bridges & Terminals	410,702
Mobile Sources	81,691
PATH	81,834
Totals	5,767,823

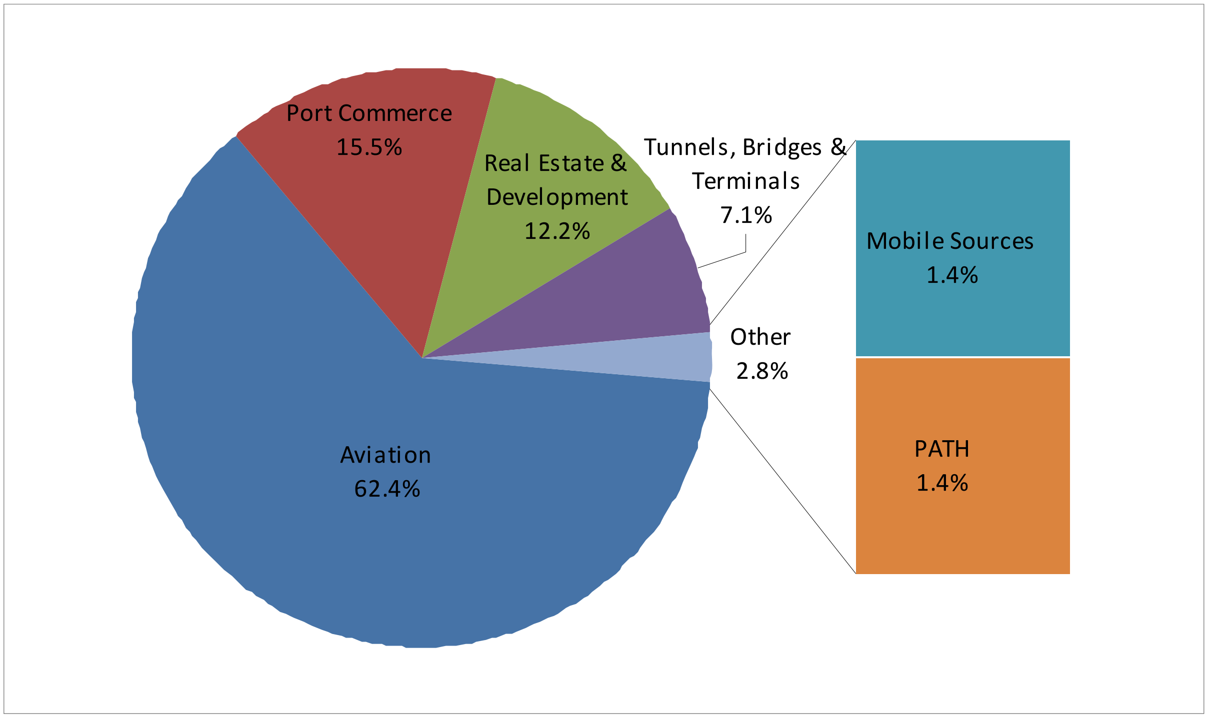

Figure 1-1. CO_2 Equivalent Emissions by Department

Figures 1-2 and 1-3 show how the department-level emissions break down when sorted according to whether they are direct GHG emissions, indirect electricity emissions, or other indirect GHG emissions. These types of breakdowns are important because several years ago, the World Resources Institute and the World Business Council on Sustainable Development (WRI/WBCSD) collaborated on a stakeholder process to develop a standardized protocol for voluntary corporate GHG inventories. The resulting WRI/WBCSD GHG protocol has been widely accepted by the GHG community and identifies three potential scopes for a corporate GHG inventory. Scope 1 encompasses an organization’s direct GHG emissions, whether from on-site energy production or other industrial activities. Scope 2 accounts for energy that is purchased off-site (primarily electricity, but can also include energy such as steam). Scope 3 is much broader and can include anything from employee travel, to upstream emissions imbedded in products purchased or processed by the firm, to downstream emissions associated with transporting and disposing of products sold by the organization, or activities operated by third parties.

The WRI/WBCSD GHG protocol considers quantification of Scope 3 emissions optional when preparing an overall corporate GHG inventory, as do similar protocols such as the U.S. Environmental Protection Agency’s (EPA’s) Climate Leaders Program and the California Climate Action Registry. One reason for this is that one organization’s Scope 3 emissions are usually another organization’s Scope 1 and 2 emissions.

Figure 1-2 shows the relative contributions of the different departments to Scope 1 and Scope 2 GHG emissions. This figure shows that the Aviation Department produced 59.4 percent of the PANYNJ’s Scope 1 and 2 GHG emissions, which is largely electricity and steam usage in airport buildings. The next largest Scope 1 and Scope 2 GHG emitter within the Port Authority was Mobile Sources, which is comprised of fleet vehicles and construction equipment (approximately 15.1 percent). PATH produces 15 percent of the PANYNJ’s Scope 1 and 2 emissions. This is primarily due to the electricity purchased to run the PATH trains. Other departments contributing three percent or more to the PANYNJ Scope 1 and Scope 2 emission totals include Tunnels, Bridges, and Terminals; and Real Estate and Development.

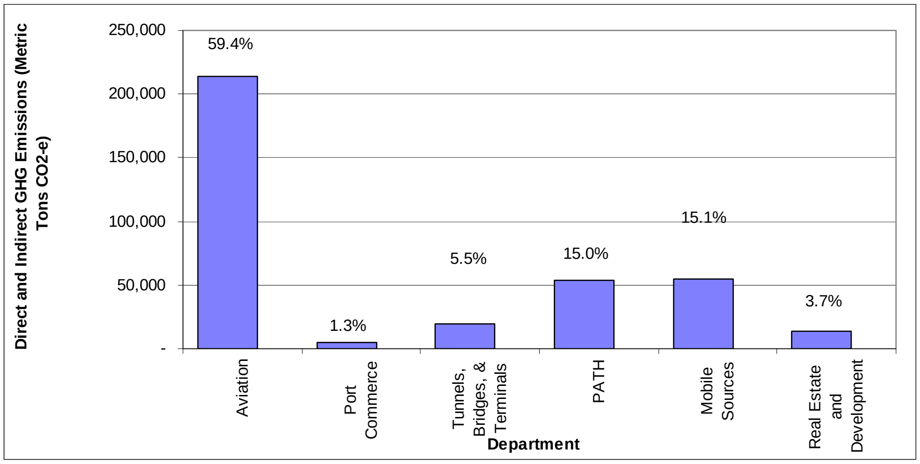

Figure 1-2. CO_2 Equivalent Direct GHG (Scope 1) and Indirect Electricity (Scope 2) Emissions, by Department

Figure 1-3 displays the Port Authority's Scope 3 GHG emission estimates by department. The Scope 3 emissions are dominated by the following departments: Aviation (62.6 percent); Port Commerce (16.4 percent); and Real Estate and Development (12.8 percent). Aviation GHG emissions result predominantly from aircraft landing and takeoffs (LTO), as well as the attracted vehicle travel to the airports. Aircraft ground support equipment is only a minor contributor to the aviation department's GHG emissions. Within Port Commerce, commercial marine vessels, cargo handling equipment, and attracted vehicle travel are all important contributors to the GHG emissions.

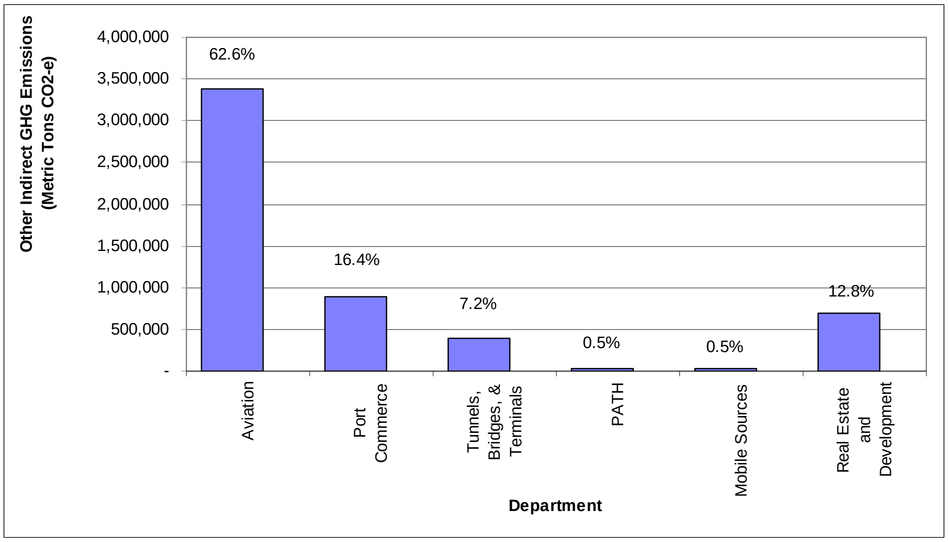

Figure 1-3. CO_2 Equivalent Other Indirect (Scope 3) GHG Emissions, by Department

Figure 1-4 provides a breakdown of the sources of Scope 1 and 2 GHG emissions (under the direct management control of the Port Authority), irrespective of department. The figure shows that the Scope 1 and 2 GHG emissions are dominated by indirect electricity use (approximately 76 percent of total Scope 1 and 2 emissions; 15 percent of which is from PATH trains). The second most important Scope 1 and 2 emissions source is Construction Equipment operated at PANYNJ funded projects (approximately 13.4 percent). Most of this construction equipment is diesel-powered. Other GHG sources under the Port Authority's management control that contribute between 1 and 5 percent of the GHG emissions include (in order of importance): Natural Gas, Fleet Vehicles and the Elizabeth Landfill.

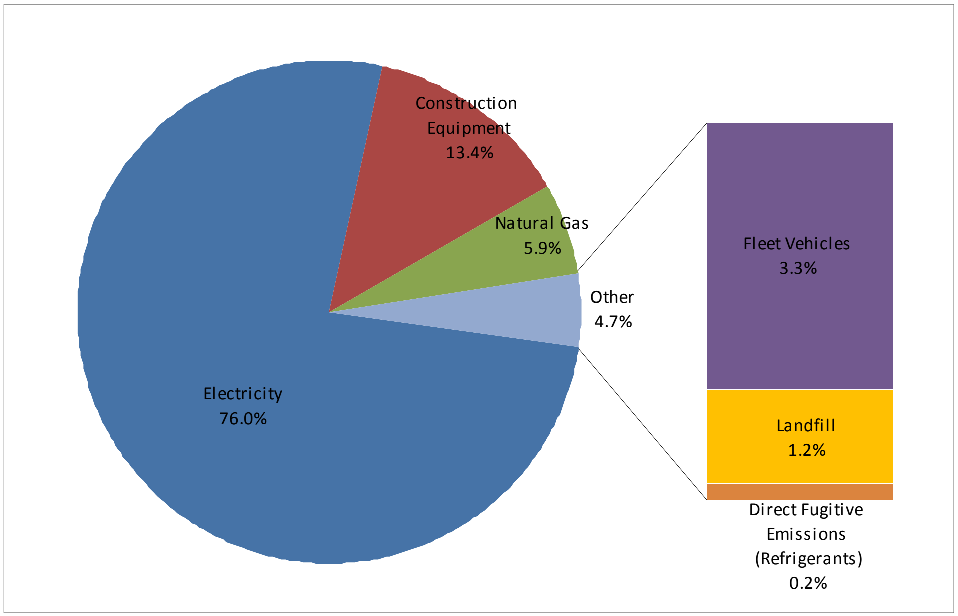

Figure 1-4. GHG Emissions under Direct Management Control

Figure 1-5 summarizes the GHG emissions by source for Scope 3 emissions (those outside PANYNJ's direct management control). Aircraft emissions account for approximately 36.8 percent and attracted vehicle travel to PANYNJ facilities accounts for approximately 38.4 percent of Scope 3 emissions. The remaining 24.8 percent of these emissions are fairly evenly spread among indirect electricity use in buildings, the Essex County Resource Recovery facility, commercial marine vessels, and cargo handling equipment.

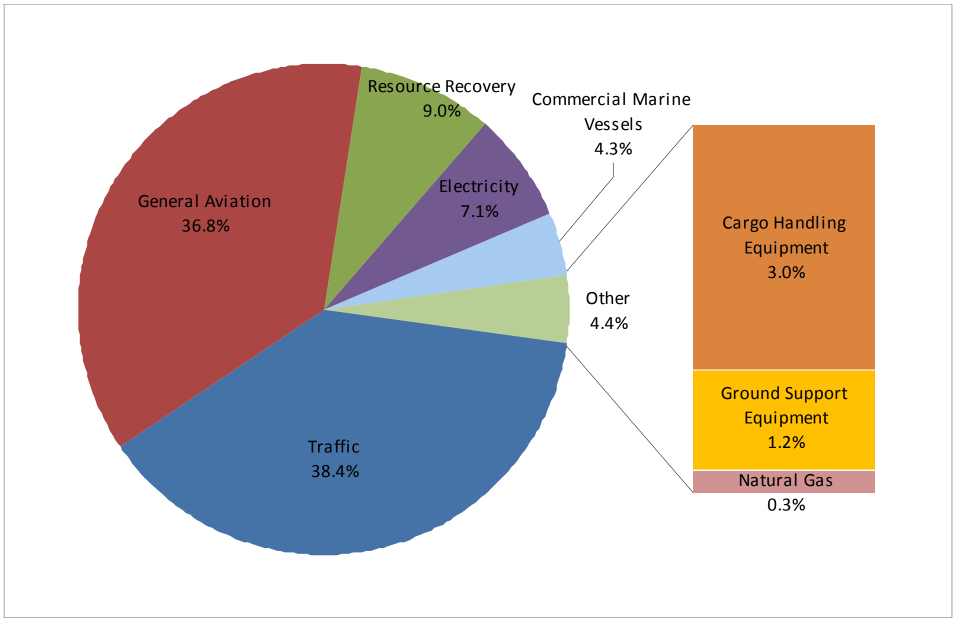

Figure 1-5. GHG Emissions outside Management Control

Table 1-5 provides Scope 1, 2, and 3 GHG emissions reported by department and broken down by sector. The table also shows how the GHG emissions from energy use in buildings is allocated among direct energy use in PANYNJ-occupied space (Scope 1 emissions), indirect electricity usage in PANYNJ-occupied space (Scope 2 emissions) and direct energy and indirect electricity usage in tenant-occupied space (Scope 3 emissions). The table shows that Scope 3 GHG emissions comprise 94 percent of the total organizational emissions. Scope 3 emissions are generated by tenants operating on PANYNJ properties. Figure 1-6 displays the information in Table 1-5 graphically. The figure shows the importance of aircraft, aviation-attracted travel in the overall Scope 1, 2, and 3 GHG emissions for the Port Authority.

Table 1-5. PANYNJ CO_2 Equivalent Emissions in 2006 (metric tons)

Department	Direct GHG Emissions Scope 1	Indirect Electricity GHG Emissions Scope 2	Other Indirect GHG Emissions Scope 3	Totals
Aviation				
Aircraft	-	-	1,963,359	1,963,359
Air Train	-	26,919	-	26,919
Ground Support Equipment	-	-	63,575	63,575
Attracted Travel	-	-	1,169,468	1,169,468
Buildings	18,316	166,136	116,853	301,305
JFK Cogeneration Plant	-	-	71,360	71,360
Fleet Vehicles	2,963	-	-	2,963
Port Commerce				
Commercial Marine Vessels	-	-	227,735	227,735
Cargo Handling Equipment	-	-	158,404	158,404
Attracted Travel	-	-	449,871	449,871
Buildings	-	-	50,569	50,569
Direct Fugitive Emissions (Refrigerants)	18	-	-	18
Landfill	4,221	-	-	4,221
Fleet Vehicles	311	-	-	311
Tunnels and Bridges				
Attracted Travel	-	-	344,281	344,281
Queuing	-	-	24,050	24,050
Buildings	662	17,537	-	18,199
Direct Fugitive Emissions (Refrigerants)	35	-	-	35
Fleet Vehicles	1,491	-	-	1,491
Bus Terminals				
Attracted Travel	-	-	6,345	6,345
Buildings	-	-	16,289	16,289
Fleet Vehicles	12	-	-	12
PATH				
Trains	-	40,828	-	40,828
Attracted Travel	-	-	27,805	27,805
Buildings	-	12,743	-	12,743
Direct Fugitive Emissions (Refrigerants)	18	-	-	18
Diesel Equipment including Utility Track Vehicles and Generators	284	-	-	284

Department	Direct GHG Emissions Scope 1	Indirect Electricity GHG Emissions Scope 2	Other Indirect GHG Emissions Scope 3	Totals
Fleet Vehicles	156	-	-	156
Mobile Sources				
Fleet Vehicles	364	-	-	364
Public Safety Department Fleet Vehicles	5,252	-	-	5,252
Direct Fugitive Emissions (Refrigerants)	708	-	-	708
Construction Equipment	48,287	-	-	48,287
Employee Commuting	-	-	27,080	27,080
Total Real Estate & Development				
Buildings	2,245	9,660	210,170	222,075
Resource Recovery Facility	-	-	480,073	480,073
Fleet Vehicles	1,370	-	-	1,370
Total	**86,713**	**273,823**	**5,407,287**	**5,767,823**

1.3. REPORT ORGANIZATION

The report is organized by department and sector, with each of the following sections providing information about the boundaries used to calculate GHG emissions, the facilities included, GHG emission estimation methods, resulting GHG emission estimates, and comparisons with GHG emission estimates from any existing studies of that sector. The conclusion of each chapter contains a summary of the GHG emission estimates for the department, showing all sources within the department.

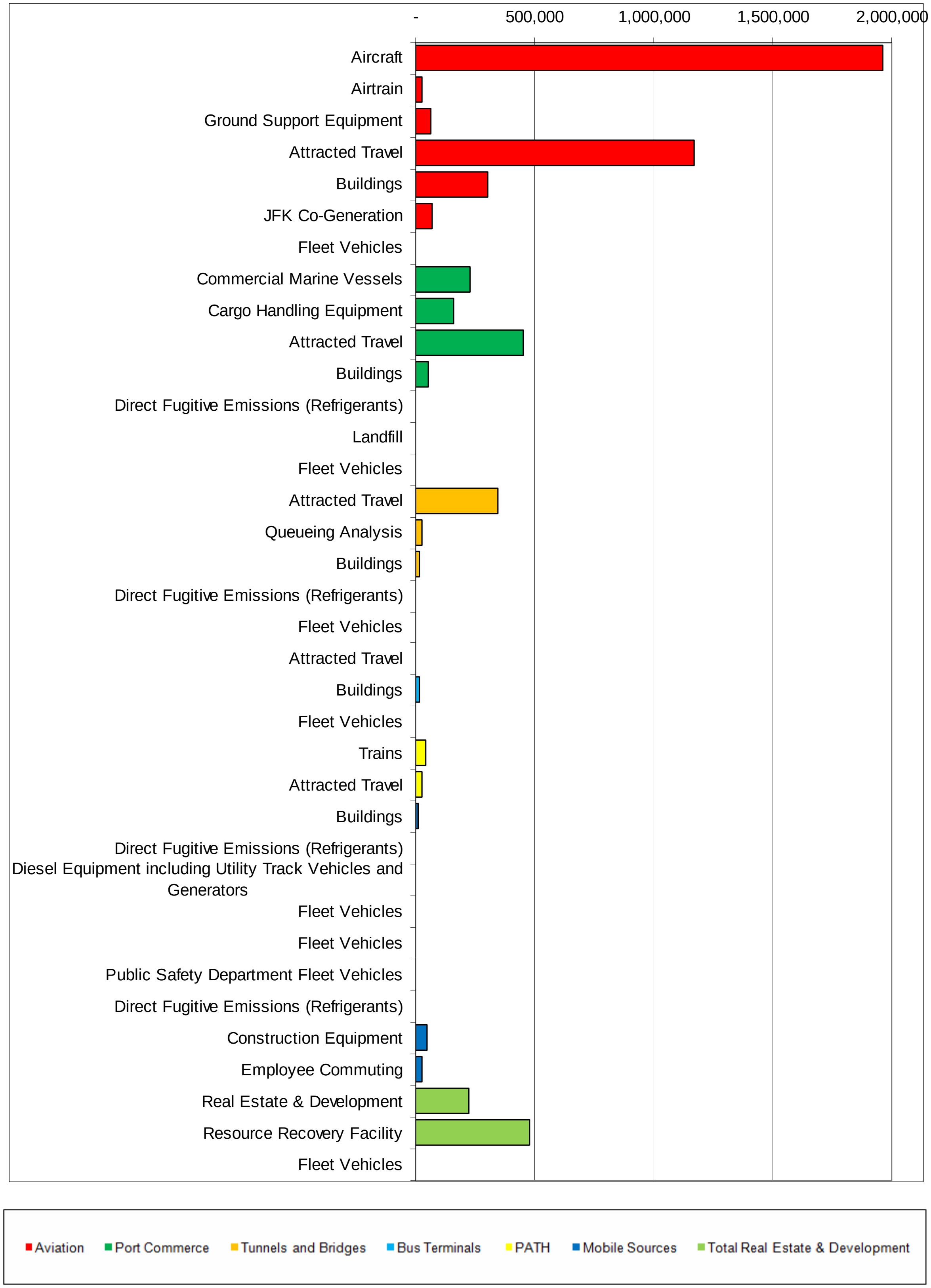

Figure 1-6. GHG Emissions (Metric Tons of CO_2e) by Activity Type

(This page intentionally left blank.)

2.0 AVIATION

2.1. AIRCRAFT

2.1.1. Boundary

The boundary for aircraft includes civil-commercial use of airplanes up to 3,000 feet.

Emissions from aircraft cruising in the upper atmosphere are not within the boundaries of this emissions inventory for a number of reasons. Including only local emissions makes the inventory more relevant to its purpose because it constrains the emissions to better represent the Port Authority's area of influence. In order to be consistent with the methodology used for taking inventory of criteria air pollutants, only emissions within the mixing zone are included in the inventory. The mixing zone is the layer of the earth's atmosphere where chemical reactions of pollutants can ultimately affect ground level pollutant concentrations. This is consistent with how the boundary would be defined for an ozone or $PM_{2.5}$ non-attainment area inventory.

For these reasons, only emissions stemming from LTO procedures are accounted for in this inventory. The boundary where cruising ends and approach begins, or where climb out ends and cruising begins is determined by the distance above the ground. Emissions only fall within the boundary of the airport when they are below the mixing height. For this greenhouse gas inventory, the boundary used was the U.S. Environmental Protection Agency's default mixing height for commercial aircraft, 3000 feet. (ICF, 1999).

2.1.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. John F. Kennedy International Airport (JFK);
b. LaGuardia Airport (LGA);
c. Newark Liberty International Airport (EWR);
d. Teterboro Airport; and
e. Downtown Manhattan Heliport.

Four airports and one heliport controlled by the Port Authority are included in the 2006 GHG inventory (NYC, 2007). In New Jersey, Teterboro Airport and Newark Liberty International Airport are accounted for. In New York, LaGuardia Airport and John F. Kennedy International Airport are included. Stewart International Airport is not included in the inventory for this baseline year because it did not come under Port Authority control until November

2007. The Downtown Manhattan Heliport is also included, although beginning in 2008 it will no longer be under Port Authority control.

2.1.3. Methods

Activity data in the form of LTO cycles along with emission factors from representative aircraft were used to estimate the total quantity of the pollutants. A complete LTO cycle consists of five parts: approach; taxi/idle in; taxi/idle out; takeoff; and climb out. The IPCC Guidelines for National Greenhouse Gas Inventories Table 3.6.9: LTO Emission Factors by Typical Aircraft were used as the source for the emission factors of all jet, turboprop, and propeller planes. Table 3.6.3: Correspondence between Representative Aircraft and Other Aircraft Types, from the same document, lists some other aircraft designations that have the same emissions as those in Table 3.6.9. (IPCC, 2006). The Port Authority provided activity data in the form of a table listing the number of arrivals and departures from each airport by aircraft model. The aircraft models were identified by four character abbreviations. Nearly three-quarters of the yearly operations were from aircraft with the exact model type as those found in one of the IPCC tables.

Remaining aircraft types were compared with those in the table on a number of properties in order to find the closest match and substitute emission factors. Additional information about both the unknown aircraft types and the aircraft types in the IPCC tables was taken from the Emission Dispersion Modeling System (EDMS). The EDMS model included more correspondence information than was available from the IPCC guidelines. This additional information made it possible to assign emission factors to all aircraft types.

A small percentage of the total aircraft operations were aircraft types without four character designations, or aircraft types with four character designations that were unrecognizable. These aircraft types had such a small number of operations that researching them would have been inefficient. These unknown operations were accounted for by applying the average of the known emission factors weighted by the number of operations by airport.

Helicopter emissions from the Downtown Manhattan Heliport were estimated based on 2006 operations at this facility. Emissions were calculated using the number of trips and emission factors from a representative model type. Activity data for this sector was in the form of the number of complete trips which originated and terminated at the heliport. Emission factors (based on fuel consumed per hour) calculated for a typical model, the Bell 427 helicopter, were used for all operations. Due to the small number of operations compared to the airports, and considering that this property will no longer be under Port Authority control in the future, a more detailed analysis, breaking down flights by helicopter model, was not performed.

Once emission factors for CO_2, CH_4, and N_2O were assigned to all operations, the number of arrivals and departures by aircraft type and airport were averaged to convert into LTOs, since the cycle includes both operations. The LTO activity data was multiplied by the emission factors, and then summed. The CH_4 and N_2O emission totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents. Finally, activity data on total domestic and international flights from the 2006 Annual Airport Traffic Report (Parsons Brinckerhoff et al., 2006) was used to divide the CO_2e proportionally by activity data into domestic and international.

2.1.4. Results

Table 2-1 summarizes the aircraft GHG emission estimates for the facilities included in the inventory. Aircraft GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O species being much less important. CO_2 emissions account for 99 percent of the CO_2e emissions. Table 2-1 also provides an estimate of the split between domestic and international travel, which indicates that 80 percent of the aircraft GHG emissions are from domestic flights. This distinction is only important in international reporting conventions for comparing one country's GHG emission estimates with another's.

Table 2-1. Aircraft Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)				**CO_2e Domestic (metric tons)**	**CO_2e International (metric tons)**
Airport	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**		
Newark	588,762	39	19	595,538	485,270	110,268
Teterboro	118,568	20	4	120,198	120,198	-
LaGuardia	420,740	16	15	425,601	402,214	23,387
JFK	786,533	33	26	795,296	528,278	267,018
Downtown Manhattan Heliport	26,492	-	1	26,725	26,725	-
Totals	**1,941,095**	**108**	**65**	**1,963,359**	**1,562,685**	**400,674**

As an airport operator, the Port Authority has limited policy options for reducing the GHG emissions of aircraft. Moreover, exercising those options would be most effective within the 3,000-foot boundary used for this source of emissions. Therefore, the Port Authority used IPCC guideline, Tier 2 methods (IPCC, 2006) to account for aircraft activity as explained above.

The International Council for Local Environmental Initiatives (ICLEI) provides a different methodology for GHG emissions inventories that is better suited for municipalities. ICLEI's methodology calls for the accounting of emissions that aircraft generate over their entire flight routes. The City of New York used ICLEI's methodology in reporting the emissions of aircraft at JFK International Airport and LaGuardia Airport in 2005. Following this methodology, the emissions associated with all of the fuel loaded onto planes at Port Authority in 2006 were as follows: JFK – 13.3 million metric tons; LGA – 2.5 million metric tons; Newark -7.6 million metric tons; Teterboro – 0.43 million metric tons. The Port Authority will work with its partners in both the public and private sectors to reduce these emissions.

2.1.5. Comparison with Estimates in Previous Studies

The 2005 New York City GHG inventory estimates that aviation is responsible for 10.5 million metric tons of CO_2e emissions. This estimate includes both LTO and cruise emissions (based on fuel performance) for JFK and LaGuardia airports. This inventory calculates the total CO_2e emissions from these two airports at approximately 1.2 million metric tons. Because the LTO emissions comprise approximately 10 percent of the total flight emissions, the totals are in reasonable agreement.

2.2. GROUND SUPPORT EQUIPMENT (GSE)

2.2.1. Boundary

The boundary for aircraft GSE is the airport property (tarmac) where aircraft are serviced, loaded, and towed. The types of equipment are consistent with the definitions used by EPA in its NONROAD model.

2.2.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. John F. Kennedy International Airport;
b. LaGuardia Airport;
c. Newark Liberty International Airport;
d. Teterboro Airport; and
e. Downtown Manhattan Heliport.

Four airports and one heliport controlled by the Port Authority are included in the GHG inventory for the year 2006. Stewart International Airport is not included in the inventory for this baseline year because it did not come under Port Authority control until November 2007.

2.2.3. Methods

The primary method used to estimate airport GSE GHG emissions was to multiply reported fuel use (gasoline, diesel, and propane) by the CO_2, CH_4, and N_2O emission factors for those fuels.

To collect data about the GSE fuel use at each airport, the Port Authority distributed a survey to all airport tenants. The responses to this survey were incomplete, so some gap filling was required in order to complete the GHG-related activity information for this sector. This analysis was performed on an airport-by-airport basis. As an additional data source, the EPA's NONROAD model was run to estimate 2006 emissions for aircraft GSE. This data source provides an additional data point that can be used either as a check on the completeness of data provided by airport tenants, or as an alternative data source for estimating GHG emissions by airport.

While the Federal Aviation Administration's EDMS was an option that was considered for use in estimating airport GSE emissions, it was decided to use EPA's NONROAD model instead. The primary reason for not using EDMS is that its input requirements are much more extensive than those for NONROAD. For example, EDMS requires collecting and inputting gate-by-gate aircraft activity information. If EDMS was also being used to estimate aircraft GHG emissions, it would have made sense to use it to estimate GSE emissions. However, since EDMS was not used to estimate aircraft emissions, it was inefficient to use this model for airport GSE emission estimates.

Estimates of GSE activity at LaGuardia and JFK airports were based largely on fuel usage reporting from tenants and fuel suppliers.

For Newark airport, only a small number of tenants responded to the tenant survey, and those that responded mostly provided information about the types of equipment they operated, rather than fuel use. Therefore, Newark airport GSE fuel consumption and emission estimates were initially developed from EPA's NONROAD model. To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. NONROAD uses a national average engine activity estimate. Geographic allocation factors are used to distribute national equipment populations to counties or states. These factors are based on surrogate indicators of equipment populations. In 2007, actual fuel use data was collected for Newark airport. To make the 2006 emissions more consistent with the 2007 methodology, 2007 fuel use was recalculated using LTO data obtained from FAA's Air Traffic Activity System (FAA, 2009). A ratio of 2006/2007 LTO data was applied to the 2007 fuel use to estimate 2006 fuel use. The GHG emissions were then estimated by applying the fuel use data to emission factors.

The information for Teterboro airport GSE was in the form of equipment populations, so Teterboro airport GSE fuel consumption and emissions were also initially estimated using EPA's NONROAD model. Actual fuel use data was collected for Teterboro airport in2007. Teterboro emissions were recalculated using the same methods described above for Newark airport.

2.2.4. Results

Table 2-2 summarizes the airport GSE GHG emission estimates for the facilities included in the inventory. Airport GSE GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O species being much less important. CO_2 emissions account for 92 percent of the CO_2e emissions.

Table 2-2. Airport GSE Emissions by Gas and CO_2 Equivalent

Airport	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
LaGuardia	11,065	8.3	2.6	12,056
JFK	32,198	42.7	3.6	34,218
Newark	15,386	15.9	2.7	16,568
Teterboro	677	0.6	0.1	733
State				
New Jersey	16,062	16.5	2.9	17,301
New York	43,263	51.0	6.2	46,274
Port Authority Totals	**59,325**	**67.5**	**9.1**	**63,575**

2.2.5. Comparison with Estimates in Previous Studies

EPA's NONROAD model was used to estimate airport GSE emissions for the New York and New Jersey counties in the New York City metropolitan area. These 2006 NONROAD model estimates can be used to compare with the estimates developed from fuel supplier data. NONROAD simulations provide county-level emissions and fuel consumption estimates. LaGuardia and JFK airport are both in Queens County, NY, so NONROAD provides estimates that include both of these airports (combined). The NONROAD model estimates that airport GSE used 4.15 million gallons of fuel during 2006, while the PANYNJ surveys found that 4.5 million gallons were consumed. These estimates are in reasonable agreement.

There is significant uncertainty in the airport GSE GHG emission estimates because of related uncertainties in relevant fuel use reporting. For example, the EPA NONROAD model reports a higher percentage of diesel usage in airport GSE than was reported by LaGuardia and JFK tenants and fuel suppliers. In addition, the GHG emission estimates for Newark airport are lower than those for JFK despite similar aircraft activity and types.

2.3. ATTRACTED TRAVEL

2.3.1. Boundary

For attracted travel related to airport facilities (excluding buses and cargo-related vehicles), the established boundary includes areas within a 100-mile radius of the facilities. This boundary was developed based on the county of origin data received from Port Authority's Aviation Department (Fushan, 2008). The information received showed that some of the passengers surveyed traveled as far as Nassau, NY; New London, CT; and Philadelphia, PA. For buses servicing the airport facilities, the boundaries vary according to the routes taken by each bus line. The established boundary for cargo-related vehicles at John F. Kennedy International airport includes routes used to access and egress the facility. This is consistent with the cargo information available for this facility.

2.3.2. Facilities Included in the Inventory

The facilities included in this inventory include:

a. John F. Kennedy International Airport;
b. Newark International Airport;
c. LaGuardia Airport; and
d. Teterboro Airport.

2.3.3. Methods

This portion of the GHG inventory includes emissions associated with vehicle trips that are attracted by airport facilities. Vehicle types (also referred to as travel mode) include privately-owned vehicles, taxis, buses, rental cars, limousines, vans, shuttle buses, and light- and heavy-duty goods vehicles. Vehicle miles traveled (VMT) for the airport facilities were calculated by mode and for the roundtrip to and from the airport.

In estimating VMT, trip origin, traveled distance, trip distributions, and transport mode were utilized. Table 2-3 summarizes trip origin and estimated one way travel distances by airport. Distances reported in the table were estimated using Google Maps. Percentages of trip distributions for each airport facility, as well as mode by trip origin are documented in the 2007 emissions inventory procedures document (Pechan, 2008). Table 2-4 lists average travel party size by travel mode for all airport facilities. Data presented in Tables 2-3 and 2-4 along with trip distributions data were applied in allocating number of passengers to number of vehicles. The methodology applied for estimating VMT is consistent for all vehicle types listed in Table 2-4. Different methods (data sources) were used to estimate taxi, rental cars, bus, shuttle bus, and cargo transport vehicle travel. These methods are summarized by vehicle type in the following subsections.

Table 2-3. Origin and Estimated Distance to Each Airport Facility

State/City	Trip Origin	Estimated Distance to (one way) JFK	LGA	EWR
New York City	Manhattan	17.60	8.90	16.80
	Bronx	19.40	8.40	25.50
	Brooklyn	14.10	11.50	16.30
	Queens	6.80	6.90	26.50
	Staten Island	27.80	25.60	13.90
	Westchester	40.00	9.70	47.70
	Long Island	17.90	9.20	16.60
	Rockland	46.00	34.90	41.30
	Dutchess	N/A	82.80	N/A
	Putnam County	63.10	55.60	70.80
	Orange	74.80	63.80	70.30
	Sullivan	N/A	N/A	N/A

State/City	**Trip Origin**	**Estimated Distance to (one way)**		
		JFK	**LGA**	**EWR**
Other New York	Albany	100.00	100.00	100.00
	Columbia	100.00	N/A	100.00
	Delaware	N/A	N/A	N/A
	Dutchess	96.40	N/A	98.90
	Monroe	66.80	55.70	62.20
	Montgomery	N/A	N/A	N/A
	Rensselaer	100.00	N/A	N/A
	Suffolk	N/A	76.30	95.8
	Sullivan	N/A	N/A	N/A
	Ulster	100.00	N/A	100.00
	All Other Counties	100.00	100.00	100.00
New Jersey	Atlantic	100.00	N/A	N/A
	Bergen	33.60	22.40	27.50
	Burlington	87.30	N/A	62.70
	Camden	100.00	N/A	N/A
	Essex	37.90	35.60	17.60
	Gloucester	100.00	N/A	83.80
	Hudson	25.90	16.70	9.30
	Hunterdon	N/A	N/A	50.00
	Mercer	69.80	N/A	45.30
	Middlesex	53.00	50.60	30.10
	Monmouth	58.80	56.40	34.30
	Morris	57.70	46.50	22.40
	Ocean	69.70	N/A	45.20
	Passaic	30.70	27.40	14.70
	Somerset	54.80	N/A	30.30
	Sussex	75.00	N/A	58.80
	Union	38.30	N/A	9.40
	Warren	N/A	N/A	23.10
Connecticut	Fairfield	56.90	50.00	71.10
	Hartford	100.00	N/A	100.00
	Litchfield	100.00	100.00	N/A
	Middlesex	100.00	N/A	N/A
	New Haven	80.90	74.00	95.10
	New London	100.00	N/A	N/A
	Tolland	100.00	N/A	N/A
Pennsylvania	Bucks	100.00	N/A	93.70
	Lehigh	100.00	N/A	89.50
	Monroe	N/A	N/A	78.10
	Montgomery	100.00	N/A	98.80
	Northampton	N/A	98.20	77.40
	Philadelphia	100.00	100.00	80.50
	Pike	100.00	N/A	85.70
	All Other Counties	100.00	100.00	100.00
Others	Other US	100.00	100.00	100.00

Table 2-4. Average Travel Party Size by Travel Mode and Airport Facility

Travel Mode	Average Travel Party Size by Facility		
	JFK	**LGA**	**EWR**
Private Cars, Limousine/Town Car[1]	2.42	2.77	2.06
Rental Cars (applied to SWF only)[1]	2.42	2.77	2.06
Chartered/Tour Bus[2]	45.86	45.86	45.86
Shared-Ride/Van Service, Hotel/Motel/Off-Airport Parking Shuttle/Van [3]	10.80	10.80	10.80

[1] Parsons Brinckerhoff, et al., 2006.
[2] Excellent, et al., 2008.
[3] Airlink, et al., 2008.

2.3.3.1. Limousines, Private Cars, Chartered Buses Hotel/Motel Shuttles, Off-Airport Parking Shuttles, and Vans VMT

VMT for limousines, private cars, chartered buses, hotel/motel shuttles, off-parking airport shuttles, and vans were estimated using the number of passengers arriving at each airport as a surrogate (PANYNJ, 2006a). -The estimated numbers of passengers did not include taxi passengers, rental car passengers, public bus passengers, and Amtrak/LIRR/Subway/Air Train passengers (if applicable). For each facility (except Teterboro airport, for which no attracted travel information was available), the number of passengers was allocated by mode, trip origin, and average travel party size using the data in Tables 2-3 and 2-4. Trip distributions by mode are reported in the 2007 emissions inventory procedures document (Pechan, 2008). This provided an estimate of the number of vehicles. The estimated number of vehicles by mode and trip origin was then multiplied by the appropriate trip length listed in Table 2-3. For example, 59.8 percent of private car trips to JFK airport originated in downtown Brooklyn, with a one way distance of 14.1 miles, an average travel party size of 2.42, and the total number of passengers of 3,049,116. Therefore, VMT to and from each airport facility is estimated as follows:

*Private Car VMT = ((Number of Passengers * Percent Distribution) / Travel Party Size) * Trip Length * 2 to account for both directions) = (3,049,116 * (59.8 / 100) / 2.42) * 14.1 * 2 = 21,247,551miles (both ways)*

2.3.3.2. Rental Car VMT

VMT for rental cars servicing JFK, LGA, and EWR were estimated based on the total number of vehicle transactions during 2006 (Avis, 2006; Dollar, 2006). The number of vehicle transactions for these facilities was allocated by trip origin based on the percentage of airport passengers by trip origin (Fushan, 2008). The result for each trip origin was multiplied by the appropriate trip length reported in Table 2-3. Then, VMT was multiplied by a factor of two to account for travel to and from the airport.

2.3.3.3. Taxi VMT

VMT for taxis servicing JFK, LGA, and EWR were estimated using the number of taxis dispatched obtained from Port Authority's 2006 traffic statistics report (PANYNJ, 2006b). Like rental cars, the number of taxis dispatched was allocated by trip origin utilizing the percentage of airport passengers by trip origin (Fushan, 2008). VMT were calculated by multiplying the resulting number of taxis dispatched by trip origin by the trip length. Trip length by origin is summarized in Table 2-3. The resulting VMT by trip origin was multiplied by a factor of two to account for travel to and from the airport.

2.3.3.4. Public Bus VMT

VMT for buses were based on the estimated number of buses, number of bus trips, and trip origin/destination. Information on buses servicing the airports was obtained from Port Authority's website and the New York City Online Directory & Guide - Airport Transportation website (PANYNJ, 2006c; Citidex, 2008). Trip lengths for each bus line were estimated using Google Maps. All routes taken by each bus line were accounted for in estimating trip lengths. VMT were derived by multiplying the number of bus trips by the estimated trip length to and from the airport. Information on public buses included in this inventory is described in the 2007 emissions inventory procedures document (Pechan, 2008).

2.3.3.5. Shuttle Bus VMT

Data received for shuttle buses include information such as number of shuttle buses, fuel consumed, and miles traveled (Sarrinikolaou, 2007). The available information for the shuttle bus routes and typical day travel profiles for JFK airport was used to estimate a shuttle bus fuel consumption value of 121,462 gallons by dividing estimated VMT by a typical airport shuttle bus fuel economy value (Chandler, et al., 2006). The total mileage information received for LGA airport (239,825 miles) was used (Sarrinikolaou, 2007). For EWR airport, VMT data was estimated based on shuttle service within the airport (Sarrinikolaou, 2007) as well as data received from private shuttles. For the shuttle service within EWR airport, reported fuel consumption was 205,368 gallons. Olympia Trails reported a total mileage of 1,000,554 miles. Marriott Corporation reported fuel consumption of 37,000 gallons. To estimate airport shuttle bus VMT in instances where only fuel consumption was reported, the reported fuel consumption data was multiplied by the typical airport shuttle bus fuel economy value (Chandler, et al., 2006).

2.3.3.6. Cargo VMT

VMT for cargo-related travel was derived using the number of trips multiplied by the estimated trip length of the access and egress routes obtained from the Air Cargo Truck Movement Study conducted for JFK airport (URS, 2002). Because cargo-related VMT was only available for JFK airport, cargo travel for LGA and EWR airports was estimated using the ratio of cargo tons from JFK to the ratio of cargo tons at LGA and EWR airports (PANYNJ, 2006b). Trip length by origin is provided in Table 2-5 and was estimated using Google Maps.

Table 2-5. Trip Origin and Estimated Distance to JFK Airport for Cargo Travel

Trip Origin	Distance (in miles, one way)
Van Wyck	5.10
On Airport	6.70
Rockway Blvd	2.80
Belt Parkway/Southern State	8.20
Other Routes*	5.70

*Average distance based on Van Wyck, On Airport, Rockaway Blvd, and Belt Parkway/Southern State trip length.

2.3.3.7. Emission Calculations

Once VMT estimates were developed for all attracted travel, VMT estimates were totaled by facility and mode. VMT were then allocated to four vehicle types: autos; buses; small trucks; and large trucks. Auto VMT includes limousines, taxis, rental cars, private cars, pick-up trucks, and vans. Bus VMT includes chartered/tour bus, hotel/motel shuttle bus, off-airport parking shuttle bus, public bus, and New York Airport Service Bus to JFK, LGA, or Newark Liberty Airport Express Bus (i.e., Olympia Trails), After VMT were allocated to the four vehicle types, VMT were disaggregated to EPA’s vehicle types and fuel types categories, so that the appropriate emission factors could be applied (EPA, 2003). Then, VMT were distributed by vehicle age (EPA, 2003; DEC, 2007).

Cold start emission estimates for CH_4 and N_2O associated with the startup of a cooled vehicle engine were applied to all parked vehicles. Vehicle emissions for this category were calculated by multiplying the number of parked cars, based on Port Authority airport parking statistics (PANYNJ, 2006a), by the corresponding composite cold start emission factor for each vehicle type. The cold start emission factors (in mg/start) by vehicle type and technology type were obtained from the IPCC report (IPCC, 2006).

2.3.3.8. Teterboro Airport Emission Calculations

Because no vehicle travel attraction statistics were available for Teterboro airport, Teterboro emissions estimates were derived using LGA airport emissions by passenger and fuel type as a surrogate. Estimated LGA emissions (per passenger) were multiplied by Teterboro’s total number of 2006 passengers (FAA, 2006).

2.3.4. Results

This section reports GHG emissions from airport facilities. Table 2-6 summarizes the GHG emission estimates for highway vehicles for the facilities included in this inventory.

Table 2-6. Airport Facilities Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Facility Name	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	**CH_4**	**N_2O**	**CO_2 Equivalent**
John F. Kennedy (JFK)	434,151	29	32	444,651
La Guardia (LGA)	204,398	14	16	209,553
Newark (EWR)	502,708	34	37	515,014
Teterboro	244	0	0	250
Total	**1,141,501**	**76**	**85**	**1,169,468**

In 2006, airport attracted travel produced 1,169,468 metric tons of CO_2e emissions. As shown in Table 2-6, approximately 97.6 percent were emissions of CO_2. CH_4 and N_2O (both as CO_2e) only account for about 2.4 percent.

To the extent that vehicles accessing Port Authority's airports use the Port Authority's tunnels and bridges, the methods used to estimate PANYNJ-related vehicle travel in this report will overestimate GHG emissions. Vehicle trips to and from the airport facilities that use Port Authority's tunnels and bridges are also counted in the tunnels and bridges inventory.

The uncertainties in attracted travel emissions estimates come from data collection. This is because data were either not available, or did not provide all of the information necessary to complete the mobile source inventory. The primary cause of uncertainty in developing 2006 GHG emission estimates for airport facilities was due to a lack of precise input data such as activity data (VMT) and vehicle information at a level of detail in which available emission factors could be applied. To compensate for the lack of vehicle activity data, expert judgment was relied upon in assessing the value of information received. Another source of uncertainty has to do with the differences in classifying vehicle types. EPA's vehicle categories are broken down by vehicle weight and fuel types (e.g., light-duty gasoline vehicles, light-duty diesel vehicles) while Port Authority's facilities define their vehicles as autos, vans, small trucks, etc.

2.4. JOHN. F. KENNEDY INTERNATIONAL AIRPORT COGENERATION PLANT

2.4.1. Boundary

This section quantifies the direct emissions from the KIAC plant, which is located on PANYNJ property. The emissions associated with electricity and thermal energy generated by the plant and used on the premises, or that sold to the Port Authority and to metered tenants on the premises are accounted for in the Real Estate and Development – Buildings section of this report (Chapter 8). The direct KIAC emissions from energy not used at the airport are covered in this section. Energy generated by the KIAC plant that is not used on the premises is considered a Scope 3 emissions source covered by this section. Non-utilized steam (waste steam) generated by the facility is also a Scope 3 emissions source. These emissions are considered to be Scope 3 because the generation of the emissions is not under management control of the PANYNJ.

2.4.2. Facilities Included in the Inventory

The KIAC plant contains two natural gas turbine-generator sets with attached heat recovery steam generators. The plant generates electricity for the entire airport and sells the excess to Con Edison. In addition to electrical energy, the plant generates thermal energy from the capture of waste heat. The thermal energy produced is sufficient to heat and cool the Central Terminal and Light Rail Facilities. KIAC Partners operate the plant under a 25-year agreement with the Port Authority, and also manage the existing Central Heating and Refrigeration Plant and related thermal distribution systems.

2.4.3. Methods

The total number of kilowatt-hours of electricity generated during 2006 was retrieved from the Emissions & Generation Resource Integrated Database (eGRID) (eGRID, 2006). The total electricity used by the terminal and the light rail facility was provided by PANYNJ. Subtracting this from the total electricity generated provides the amount of electricity sold to Con Edison or lost in transmission. This amount of electricity is the responsibility of the cogeneration plant. Any heat input not used to generate electricity is used on site. Subtracting the steam used for electricity generation and the steam used for heating and cooling (in terms of heat input) from the total heat input leaves a small amount of waste steam (<0.12 percent of total heat input), which must also be accounted for as an emission source.

The total emissions are calculated using the heat inputs and emission factors from CCAR GRP v 2.2. (CCAR, 2007) The total emissions, divided into electricity and steam by energy, are shown in Table 2-7. These emissions are those that would be reported for registry purposes.

Table 2-7. Total KIAC Plant GHG Emissions by Gas and CO_2 Equivalent

	CO_2 (metric tons)	**CH_4 (metric tons)**	**N_2O (metric tons)**	**CO_2 Equivalent (metric tons)**
Electricity	250,090	28.0	0.5	250,824
Steam	27,668	3.1	0.1	27,749
Total	**277,758**	**31.0**	**0.5**	**278,573**

For the entire facility, the natural gas usage in terms of heat input was 5,262,560 million British thermal units (MMBtu). From the CCAR GRP, the emissions factors are 52.78 kilograms (kg)/MMBtu CO_2, 0.0059 kg/MMBtu CH_4, and 0.0001 kg/MMBtu N_2O . Therefore, for example, the total emissions from CO_2 are:

*5,262,560 BTU * 52.78 kg/Btu * 0.001 metric tons/kg = 277,758 metric tons.*

Emission factors must derived for both electricity and steam to determine the share of emissions that fall under the responsibility of the KIAC Plant (as direct emissions) and the share that fall under the responsibility of PANYNJ (as indirect emissions from purchased electricity and steam). The electricity emission factor is calculated by dividing the total plant emissions from electricity generation by the total electricity generated. The steam emission factor is the total emissions from steam divided by the total heat input not used for electricity generation. The overall total heat input and the total heat input used for electricity generation in MMBtu and the millions of cubic feet of natural gas used were retrieved from EIA (EIA, 2007). These emission factors are shown in Table 2-8.

Electricity related emissions are then calculated by multiplying the electricity that is the cogeneration plant's responsibility by the electricity emission factor. The emissions associated with the waste steam are calculated by multiplying the heat input from waste steam by the ratio of total emissions from steam generation to the heat input associated with steam generation.

Table 2-8. KIAC Plant GHG Emission Factors

	CO_2 (metric tons/kilowatt hour [kWh])	**CH_4 (metric tons/kWh)**	**N_2O (metric tons/kWh)**
Electricity	4.46E-04	4.99E-08	8.46E-10
Steam	**CO_2 (metric tons/MMBtu)**	**CH_4 (metric tons/MMBtu)**	**N_2O (metric tons/MMBtu)**
	0.05278	5.90E-06	1.00E-07

2.4.4. Results

Table 2-9 summarizes the activity data for electricity and steam which fall under the boundary of this section, and the related emissions.

Table 2-9. KIAC Plant Activity Data and GHG Emissions by Gas and CO_2 Equivalent

	Activity Data	**CO_2 (metric tons)**	**CH_4 (metric tons)**	**N_2O (metric tons)**	**CO_2 Equivalent (metric tons)**
Electricity Sold to ConEd	158,667,340 kWh	70,821	7.92	0.13	71,029
Wasted Steam	6,249 MMBtu	330	3.69E-02	6.25E-04	331
Total	**--**	**71,151**	**7.95**	**1.35E-01**	**71,360**

2.5. AVIATION DEPARTMENT EMISSIONS SUMMARY

Table 2-10 summarizes the GHG emissions from all facilities within the aviation department, specifying the source of the emissions and the amount that falls under each scope for each source. Some additional emissions from mobile sources that could not be divided by facility appear in Table 7-11.

Table 2-10. Aviation Department 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
John F. Kennedy International Airport	**16,124**	**142,323**	**1,412,371**	**1,570,818**
Aircraft	-	-	795,296	795,296
Ground Support Equipment	-	-	34,218	34,218
Attracted Travel	-	-	444,651	444,651
Buildings	14,792	124,607	66,847	206,246
Fleet Vehicles	1,332	-	-	1,332
Airtrain JFK		17,716	-	17,716
JFK Co-generation Plant	-	-	71,360	71,360
LaGuardia Airport	**2,300**	**17,773**	**670,028**	**690,101**
Aircraft	-	-	425,601	425,601
Ground Support Equipment	-	-	12,056	12,056
Attracted Travel	-	-	209,553	209,553
Buildings	1,613	17,773	22,818	42,204
Fleet Vehicles	687	-	-	687
Newark Liberty International Airport	**2,843**	**32,959**	**1,152,810**	**1,188,612**
Aircraft	-	-	595,538	595,538
Ground Support Equipment	-	-	16,568	16,568
Attracted Travel	-	-	515,014	515,014
Buildings	1,911	23,756	25,690	51,357
Fleet Vehicles	932	-	-	932
Airtrain Newark	-	9,203	-	9,203
Teterboro Airport	**6**	**-**	**122,538**	**122,544**
Aircraft	-	-	120,198	120,198
Ground Support Equipment	-	-	733	733
Attracted Travel	-	-	250	250
Buildings	-	-	1,357	1,357
Fleet Vehicles	6	-	-	6
Downtown Manhattan Heliport	**6**	**-**	**26,867**	**26,873**
Aircraft	-	-	26,725	26,725
Buildings	-	-	141	141
Fleet Vehicles	6	-	-	6
AVIATION	**21,279**	**193,055**	**3,384,614**	**3,598,948**

2.6. REFERENCES

Airlink, et al., 2008: “Shared-Ride/Van Service Passenger Capacity,” Available at Airlink Shuttle, Carmel and Limousine Service, and Classic Limousine websites, October 2008.

Avis, 2006: Avis, Budget, and Hertz, “Vehicle Transactions,” 2006.

CCAR, 2007: California Climate Action Registry. “California Climate Action Registry General Reporting Protocol,” http://www.climateregistry.org/resources/docs/protocols/grp/GRPV2March2007_web.pdf. March, 2007

Chandler, et al., 2006: K. Chandler and E. Eberts (Battelle); L. Eudy (National Renewable Energy Laboratory), “New York City Transit Hybrid and CNG Transit Buses: Interim Evaluation Results,” Technical Report NREL/TP-540-38843, prepared for National Renewable Energy Laboratory, January 2006.

Citidex, 2008: Citidex.com, “New York City Online Directory & Guide - Airport Transportation,” http://www.citidex.com/special/airporttrans/jfk_mta.html, November 2008.

DEC, 2007: New York State Department of Environmental Conservation, “2006 Enhanced I/M Program Annual Report and 2005-2006 Biennial Report: Appendix A,” (http://www.dec.ny.gov/chemical/39482.html), 2007.

Dollar, 2006: Dollar, “Vehicle Transactions,” 2006.

EIA, 2007: U.S. Department of Energy, Energy Information Administration. “EIA-906/920 Databases” http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html, 2007

EPA, 2003: U.S. Environmental Protection Agency, Office of Transportation and Air Quality. “User’s Guide to MOBILE6.1 and MOBILE6.2 - Mobile Source Emission Factor Model,” EPA420-R-03-010, August, 2003.

EPA, 2007: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,” EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

Excellent, et al., 2008 : “Chartered Bus Passenger Capacity,” Available at Excellent Bus Service Inc., Leprachaun Bus Line, and Classic Limousine websites, October 2008.

FAA, 2006: Federal Aviation Administration, “Passenger and All-Cargo Statistics,” http://www.faa.gov/airports_airtraffic/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy06_all_enplanements.xls, 2006.

FAA, 2009. Federal Aviation Administration, "2006-2008 Airport Operations Data for Newark and Teterboro Airports," Air Traffic Activity System (ATADS), http://aspm.faa.gov/opsnet/sys/Airport.asp, 2009.

Fushan, 2008: Port Authority of New York and New Jersey, CCCAS Division, Aviation Department, Passenger and Trip Distributions by Origin, “2008 O-D Pas Transportation Mode By Trip Origin.xls,” October 10, 2008.

ICF, 1999: ICF Consulting Group, “Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft,” prepared for U.S. Environmental Protection Agency, Office of Mobile Sources, Ann Arbor, MI, April 1999.

IPCC, 2006, Intergovernmental Panel on Climate Change, “2006 IPCC Guidelines for National Greenhouse Gas Inventories,” prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), published: IGES, Japan, 2006.

NYC, 2007: New York City, “Inventory of New York City Greenhouse Gas Emissions,” Mayor’s Office of Operations, Office of Long-term Planning and Sustainability, April 2007.

PANYNJ, 2006a: Port Authority of New York & New Jersey, “2006 Airport Traffic Report,” 2006.

PANYNJ, 2006b: Port Authority of New York & New Jersey, “2006 Monthly Summaries of Airport Activities,” http://www.panynj.gov/CommutingTravel/airports/html/traffic_2006.html, 2006.

PANYNJ, 2006c: Port Authority of New York & New Jersey website, http://www.panynj.gov/CommutingTravel/airport, 2006.

Parsons Brinckerhoff, et al., 2006: Brinckerhoff, Parsons, et. al., “FAA Regional Air Service Demand Study – PANYNJ Air Passenger Survey Findings Final Report,” April 19, 2006.

Pechan, 2008: E.H. Pechan & Associates, Inc., “Calendar Year 2007 Emissions Inventory Procedures Document,” prepared for Port Authority of New York and New Jersey, November 2008.

Sarrinikolaou, 2007: George Sarrinikolaou, “Airport Shuttle Bus Information,” November 30, 2007 (via email).

URS, 2002: URS Corporation, “John F. Kennedy International Airport – Air Cargo Truck Movement Study,” prepared for Port Authority of New York & New Jersey Traffic Engineering, May 2002.

(This page intentionally left blank.)

3.0 PORT COMMERCE

3.1. COMMERCIAL MARINE VESSELS

3.1.1. Boundary

The boundary for Commercial Marine Vessels (CMV) corresponds to the NYNJLINA and includes all facilities that are under the management control of the PANYNJ. Emissions out to the three mile demarcation line off the eastern coast of the United States are included under this boundary. Emissions from vessels calling on facilities that are not under the management control of the PANYNJ are not included in this emissions inventory. The jurisdictional boundary of the PANYNJ is within the New York New Jersey Harbor System (NYNJHS).

3.1.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. Auto Marine Terminal;
b. Port Newark / Elizabeth Marine Terminal;
c. Red Hook Container Terminal; and
d. Howland Hook Marine Terminal.

3.1.3. Methods

Activity data (including engine output, fuel used, and dredging volume) for each CMV category was multiplied by the relevant emission factor and load factor to estimate the total quantity of gases.

CMVs are classified into three major categories: ocean going vessels (OGV); towboats; and harbor vessels. This classification system is consistent with previous reports commissioned by the PANYNJ, including the emissions inventories conducted by Starcrest. The OGV and harbor vessel categories have been further broken down into subcategories. The classification of OGV into subcategories differed between the ship call information collected for port-wide activity vessels and the ship call information specific to PANYNJ facilities. Port wide subcategories include: bulk carriers; vehicle carriers; containerships; passenger cruise ships; roll-on/roll-off vessels; and tankers. PANYNJ categories include: bulk; auto[1]; containerships; cruise ships; and tankers. These differences in vessel categorization may lead to attributing emissions to the incorrect category. However, this is unlikely to have a significant impact on CMV emission estimates.

---

[1] Assumed to include vehicle carriers, RORO vessels, Reefer ships, and General cargo ships

Within the harbor vessel category, four sub-categories exist: assist tugs; dredging vessels; ferry/excursion vessels; and government vessels. Of these, only emissions from assist tugs and dredging vessels were considered under the management control of the PANYNJ. While the Port Authority serves as a ferry transportation clearinghouse for the New York/New Jersey metropolitan area, it was determined that the PANYNJ does not have management control over ferry/excursion operations, as these services operate from ports and landing sites not under the management control of the PANYNJ. It was also determined that government vessels did not operate from PANYNJ facilities. As such, emissions associated with both of these sub-categories were not included in this inventory. Emissions associated with OGV anchorages were also considered to be outside the management control of the PANYNJ.

There are three potential emission sources for CMVs: main engines (used to power the vessel’s propellers); auxiliary engines (used to power the vessel’s internal systems including heating and cooling requirements); and boilers (used to provide hot water and to keep the main engines warm when at port). Each CMV category has emissions from one or more of these engine categories.

The majority of CMV activity data was obtained from the 2006 calendar year Starcrest Port of New York and New Jersey emissions inventory at PANYNJ facilities (Starcrest, 2008). Details on the methods used to develop activity and emissions for these categories are included in the Starcrest report. 2006 calendar year dredging data (in cubic yards) was obtained from the Port Authority Waterways Unit. The dredging data reflects the volumes dredged from the Port Authority/U.S. Army Corps of Engineers joint Harbor Deepening Project, as well as dredging from Port Authority berths to maintain depth.

Emission factors for dredging were derived from emission factors calculated by Starcrest for dredging criteria air pollutant (CAP) emissions, in tons/million cubic yards. These CAP emission factors were translated into greenhouse gas emission factors by applying a conversion ratio calculated using the relative ratios between the main engine GHG emission factors provided by Entec and EPA. For CO_2 and N_2O, oxides of nitrogen (NO_x) was used as an emissions factor indicator. For CH_4, volatile organic carbon (VOC) was used as an indicator. The dredging emission factors were then converted from tons/million cubic yards into metric tons/cubic yards. Emissions were calculated by multiplying the volume of material removed by dredging by the appropriate emission factor for each gas. The dredging emissions are accounted for as part of the harbor vessels emissions. The rest of the harbor vessel emissions are from assist tugs.

3.1.4. Results

Table 3-1 summarizes the CMV GHG emission estimates for the different vessel types included in the inventory. CMV GHG emissions are dominated by CO_2 emissions (99 percent), with methane and nitrous oxide contributing significantly less. Table 3-1 also provides an estimate of the split between the vessel categories, which indicates that approximately 79 percent of CMV GHG emissions are from OGV, 15 percent are from harbor vessels, and 6 percent are from towboats.

Table 3-1. Commercial Marine Vessel GHG Emissions by Gas and CO_2 Equivalent

CMV Category	Greenhouse Gas Emissions Totals (metric tons)					
	CO_2	CH_4	N_2O	CH_4 CO_2e	N_2O CO_2e	Total CO_2 Equivalent
Ocean Going Vessels	177,593	16	4	334	1391	**179,318**
Towboats	13,322	5	2	97	492	**13,911**
Harbor Vessels	33,872	4	2	88	547	**34,507**
Port Authority	**224,787**	**25**	**8**	**518**	**2,430**	**227,735**

3.1.5. Comparison with Estimates in Previous Studies

In 2003, Starcrest completed a CAP emissions inventory of the New York-Northern New Jersey-Long Island Non-attainment Area for the year 2000. There are three major differences between the Starcrest report and this GHG inventory. First, the 2000 Starcrest inventory did not estimate GHG emissions, only CAP emissions. Secondly, the activities included within the non-attainment area incorporate non-PANYNJ related emissions. The 2006 Starcrest report only included activity to and from Port Authority marine terminals. Notable differences include emissions from ferry/excursion vessels, government vessels, vessels at non-PANYNJ anchorages, and activity from private terminals (e.g., Global and the Passenger Ship Terminals along with the majority of activity from tankers). Finally, the activity profile of vessels has changed over the last six years, as indicated in Table 3-2.

Table 3-2. Changes in the Port-Wide Activity Profile of Commercial Marine Vessels between 2000 and 2006

Vessel Category	Change from 2000 to 2006
Bulk	-19.9%
Car carrier	-8.4%
Container	17.0%
Cruise Ship	30.4%
Misc	14.5%
Roll-on/Roll-off	-19.0%
Tanker	11.8%
Aggregate Total Calls - All Vessels	9.3%

The 2005 New York City GHG inventory estimates that the transportation of freight by water is responsible for 6.2 million metric tons of CO_2e emissions. GHG emissions from shipping for the New York City inventory were taken from the study entitled *Estimating Transportation Related Greenhouse Gas Emissions and Energy Use in New York State* (NYC, 2007). The methodology used by the New York City inventory estimated GHG emissions based on the statewide use of residual and diesel fuel (whereas this GHG inventory uses activity based data, primarily engine output data). This fuel use was allocated to counties based on the proportion of water freight tonnage in each county. The 2005 New York City inventory notes that the methodology employed to estimate shipping emissions “confers results which may be less accurate than other sections of this inventory.” The *IPCC Climate Change 2007:*

Mitigation of Climate Change report recognizes the “substantial discrepancies” between emissions estimates derived from fuel use versus those derived from activity based data. Corbett and Koehler (2003) also recognized the discrepancy between activity-based inventories and fuel-based inventories.

3.2. CARGO HANDLING EQUIPMENT (CHE)

3.2.1. Boundary

The boundary for this category includes cargo-handling diesel equipment used in three different operations at the terminals leased by the PANYNJ:

- CHE at container terminals;
- Switch locomotives at container terminals and Line haul locomotives within the boundary of the NYNJLINA, and
- Vehicle movement at auto-marine terminals.

Privately-owned terminals (e.g., Global Terminals) were not included in the inventory.

3.2.2. Facilities Included in the Inventory

This category includes diesel engines used in off-road CHE at five of the PANYNJ leased container terminals, including:

a. American Stevedoring, Inc./Brooklyn Port Authority Marine Terminal;
b. New York Container Terminal/Howland Hook Terminal;
c. APM Terminal/Elizabeth PA Marine Terminal;
d. Maher Terminal/Elizabeth PA Marine Terminal; and
e. Port Newark Container Terminal.

The predominant types of equipment used at container terminals include: terminal tractors; straddle carriers; forklifts; and top loaders. Several other types of off-road equipment, including cranes, comprise this category. Switch locomotive activity includes all locomotive activity related to movement of cargo within the boundaries of the Port Authority's five marine terminals. Line haul locomotive activity includes all activity related to the movement of cargo from the Port Authority facilities to destinations outside the boundary of the Port Authority facilities, but within the NYNJLINA.

The auto-marine terminals include:

a. BMW;
b. Distribution Auto Service;
c. FAPS, Inc.;
d. Northeastern Auto-Marine Terminal; and
e. Toyota Logistic Services.

This category includes the movement of imported and exported vehicles and worker transport vans at auto-marine terminals.

3.2.3. Methods

A 2006 GHG and CAP emission inventory for containers terminals and switch/line haul locomotives was prepared for the New York and New Jersey Port District (Starcrest, 2008). A 2002 CAP emission inventory for automarine terminals was prepared for the five container terminals leased by the Port Authority (Starcrest, 2003b). These data formed the basis of 2006 GHG emission estimates for all four categories of port-related CHE, each of which are described below. Details on the methods used to develop activity and emissions for these categories are included in the background reports (Starcrest, 2003b; Starcrest, 2008).

3.2.3.1. Container Terminal CHE

For the 2006 CHE study, updates to equipment population and equipment hours of activity that had previously been provided by the terminal operators for the 2002 and 2004 emission inventories, was collected. The terminal operators estimated average activity levels for types of equipment. Equipment populations were derived from information obtained by the container terminal operators.

2006 CAP emissions were estimated using the NONROAD2005 model. The activity data collected replaced the default model inputs. Adjustments were made to the sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}), and 2.5 microns or less ($PM_{2.5}$) emissions for the equipment that was reported to also use on-highway fuel.

While the NONROAD model estimates CO_2 emissions, the model does not report N_2O or CH_4 emissions. The other GHG emissions were developed using EPA emission factors expressed in terms of grams/kg fuel (EPA, 2008). The amount of fuel was calculated from the CO_2 emissions obtained from the NONROAD2005 model since the emissions are directly proportional to fuel consumption, using an average fuel carbon content of 86 percent (Starcrest, 2008)

3.2.3.2. Switch and Line Haul Locomotives

2006 switch locomotive emission estimates were based on switch car activity and operating schedules compiled for the 2002 CHE study, and data on containers handled for 2002 and 2006, which includes an increase in Port Newark and Elizabeth PA Marine Terminal cargo throughputs over the 2002-2006 period (Starcrest, 2008). In 2002, six switch locomotives servicing Port Elizabeth and Port Newark operated a total of 27,144 hours per year. An adjustment to 2006 cargo throughput was made using a ratio of 2002 to 2006 container throughputs: 2.35 million containers in 2006 divided by 1.84 million in 2002. The ratio (1.28) was multiplied by the 2002 operating hours to obtain an estimate of 2006 operating hours of 34,744 hours. An annual horsepower-hours estimate was developed by applying an average in-use horsepower to the 2006 operating hours estimate. Activity in terms of horsepower-hours per year was multiplied by the emission factors (in grams/horsepower-hour) to estimate annual switch locomotive emissions.

Line haul locomotive emission estimates are based on the amount of fuel used in the transport of cargo to and from the Port Authority marine terminals. The fuel usage is estimated using the number of train trips, train weights, and distance. Emission factors were applied to the fuel use estimate to develop the total line haul locomotive GHG and CAP emissions.

Switch locomotive emission factors for most CAP pollutants (except SO_2) were obtained from an EPA report of locomotive emission factors (EPA, 1997). Line haul locomotive CAP emission factors were obtained from an EPA regulatory support document on locomotive emission standards (EPA, 1998). For both switch and line haul locomotives, SO_2 and CO_2 emission factors were developed using a mass balance approach based on the typical amounts of sulfur and carbon in diesel fuel. N_2O and CH_4 emission factors were obtained from an EPA publication on greenhouse gases (EPA, 2008).

3.2.3.3. Auto-Marine Terminals

Based on the 2002 inventory, activity at auto-marine terminals represents a relatively small fraction (less than 1 percent) of total port-related CHE fuel consumption and emissions. As such, an effort was not made to obtain 2006 fuel consumption, and the 2006 activity was instead based in part on the VMT associated with imported, exported, and worker vehicles compiled for the 2002 CHE study.

VMT were estimated for the 2002 CHE study for three categories of vehicles: light-duty gasoline vehicles (LDGVs); light-duty gasoline trucks below 6,000 pounds (LDGT-1 and -2); and light-duty gasoline trucks between 6,001 and 8,500 pounds (LDGT-3 and -4). 2002 VMT were estimated for 2006 using information provided by the PANYNJ on the number of vehicles arriving or departing PANYNJ facilities via vessel for each year (PANYNJ, 2007a). This value was reported as 634,100 in 2002 and 732,029 vehicles in 2006. Fuel consumption associated with the 2006 VMT was estimated using data from the 2007 Annual Energy Outlook, which lists the miles per gallon (mpg) of 2006 model year light-duty vehicles as 29.5 mpg and light-duty trucks as 22.0 mpg.

Fuel consumption was used in conjunction with CO_2 default emission factors from IPCC Guidelines Table 3.2.1 for Motor Gasoline, and CH_4 and N_2O emission factors from IPCC Table 3.2.2 for Motor Gasoline –Low Mileage Light Duty Vehicle Vintage 1995 or Later (IPCC, 2006). The emission factors developed by EPA and applied to the auto-marine terminal fuel consumption account for both start and running emissions. Emission factors are expressed in kg/terajoule (TJ). Gasoline fuel volumes were converted to an energy basis using a conversion factor of 1.2946 E-4 TJ per gallon of gasoline (IOR, 2007).

3.2.4. Results

Table 3-3 summarizes the GHG emission estimates for the CHE categories included in the inventory. Container terminal CHE is the predominant contributor to the CHE inventory. Information was not available to assign container terminal, switch/line haul locomotive and auto-marine terminal activity or emissions to states.

GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions are approximately 99 percent of the CO_2e emissions.

Table 3-3. Cargo Handling Equipment GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emissions Totals (metric tons)			
Category (Portwide)	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Container Terminal CHE	142,253	4	8	143,544
Switch Locomotive	4,941	0.13	0.39	4,989
Line Haul Locomotive	9,626	0.25	0.76	9,721
Auto-marine Terminal	146	8.0E-03	1.2E-02	150
Totals	**156,966**	**4**	**9**	**158,404**

3.3. ATTRACTED TRAVEL

3.3.1. Boundary

The boundary for attracted travel at the PANYNJ Port Commerce facilities includes the following activities:

- Truck idling within the marine terminal area;
- Truck travel within the marine terminal area;
- Truck trips to and from the terminal areas to deliver or pick up containers at the port terminals.

3.3.2. Facilities Included in the Inventory

The following facilities are included in this inventory:

a. Auto-Marine Terminal;
b. Port Newark / Port Elizabeth Marine Terminal;
c. Red Hook Container Terminal;
d. Howland Hook Marine Terminal.

3.3.3. Methods

Activity data for each attracted travel category was multiplied by the relevant emission factors to estimate total GHG emissions. The activity used for truck idling was the number of hours of idling and was calculated by multiplying the number of trucks entering the terminals in 2006 by an estimate of the average amount of time spent idling at the terminal per trip. The activity indicator used for truck travel within the terminal area was the VMT within the terminal area. This was calculated by multiplying the 2006 annual one-way gate count by an estimate of the average VMT per terminal trip. The activity used for truck travel to and from the terminal area was the VMT associated with the trip to deliver and the trip to pick-up the cargo or container. This was calculated by multiplying the annual one-way gate count by estimates of the average trip length.

2006 total annual HDDV trips from Starcrest emission inventory report (Starcrest, 2008b) were used for the 2006 one-way gate count. The 2006 gate counts were allocated to each marine terminal based on average daily terminal gate count data previously provided by the Port Authority for May 2006. The terminal ratios were calculated as the terminal-specific average daily May 2006 gate count to the total average May daily gate counts for all Port Authority terminals The 2006 average daily gate count data for the Auto Marine Terminal and the Red Hook Container Terminal were estimated by first multiplying the Port Authority total twenty-foot equivalent units by 0.23percent (the proportion of twenty-foot equivalent units attributable to this terminal based on information provided by the Port Authority) and then by scaling the twenty-foot equivalent units data to gate counts in the same proportion as the other terminals, based on total marine terminal activity data from the PANYNJ Annual Report (PANYNJ, 2006).

Once the 2006 proportions of gate counts by terminal were calculated, these ratios were applied to the total 2006 gate count from Starcrest (Starcrest, 2008b) to estimate the 2006 gate counts by terminal. Other data used in calculating the activity were obtained from a truck origin-destination survey (Vollmer, 2006) and a CAP emission inventory report for the ports (Starcrest, 2008). Emission factors were obtained from EPA's latest GHG emission inventory report (EPA, 2007a). Table 3-4 summarizes the activity data used to calculate emissions from attracted travel at the marine terminals.

3.3.3.1. Truck Idling Activity within the Terminal Area

As mentioned above, the activity indicators used for truck idling was the number of hours of idling. This was calculated by multiplying the annual gate count data by an estimate of the average amount of time spent idling at the terminal per trip. The emission inventory report prepared by Starcrest (Starcrest, 2008) provides a table of on-terminal operating characteristics based on 2006 survey data that summarizes annual trips, VMT, average speed, and idling hours by terminal type. The total on-terminal idling hours were divided by the total annual on-terminal trips for each terminal type to estimate the average number of idling hours per trip. The terminal types included in the Starcrest 2006 survey data are: Auto Terminals, Container Terminals, and Warehouses. The Howland Hook Marine Terminal truck trip data used idling hours from Starcrest Container Terminals, the Red Hook Container Terminal and Auto Marine Terminal used idling data from Starcrest Auto Terminals, and the Port Newark and Elizabeth terminals truck trips used idling hours from the average of all Starcrest terminal types.. The Red Hook Container Terminal and Auto Marine Terminal categories were grouped together due to a lack of gate count and travel activity data available for each, so the Starcrest Auto Terminals idling data was used for this category. Once the idling values were applied to each terminal, they were multiplied by each terminal’s estimated annual 2006 gate count to determine the total number of hours that trucks spent idling at the port terminals in 2006. Each truck was assumed to consume 0.5 gallon of diesel fuel per hour of idling (EPA, 2007b). The estimates of the total hours of idling for each terminal are shown in Table 3-4.

3.3.3.2. Truck Travel Activity within the Terminal Area

The activity used for truck travel within the terminal area was the VMT within the terminal area. This was calculated by multiplying the gate count data by an estimate of the average VMT per terminal trip by terminal type. The VMT associated with each trip within each terminal was calculated in a manner similar to the estimation of idling hours per trip. The summary data referenced above from the Starcrest report (Starcrest, 2008) were used to calculate the average on-terminal VMT per truck trip by dividing the total on-terminal VMT by terminal type by the

Table 3-4. Summary of Activity Data for Port Commerce Attracted Travel

Terminals	Estimated Annual 2006 Gate Count (1-way)	Estimated Average Miles per Trip within Terminal (miles)[a]	Estimated Total Miles Traveled within Terminal (miles)	Estimated Idling Hours per Trip in Terminal (hours)[a]	Estimated 2006 Total Truck Idling Hours in Terminal (hours)	Estimated Trip Length To or From Terminal (miles)	Total 2006 VMT for Trip to and from Terminal (miles)
Port Newark/ Port Elizabeth	2,875,996	1.08	3,111,556	1.36	3,921,438	42.7	245,589,043
Howland Hook Marine Terminal	452,178	1.13	508,957	1.4	632,492	42.7	38,612,702
Red Hook Container Terminal/Auto Marine Terminal	15,808	0.39	6,111	1.68	26,564	42.7	1,349,907

[a] Source: Estimated by Pechan from data in Starcrest, 2008

number of annual terminal truck trips by terminal type. This resulted in an average on-terminal VMT per truck trip of 1.08 miles within the Port Newark and Elizabeth terminals, 1.13 miles per trip within the Howland Hook terminal, and 0.39 miles per trip within the Red Hook and Auto Marine terminals. These values were multiplied by each terminal's estimated annual 2006 gate count to determine the total VMT that trucks drove within the port terminals during the year. The total VMT estimated within the terminals is shown in Table 3-4.

3.3.3.3. Truck Travel Activity To and From the Terminal Area

The activity used for truck travel to and from Port Commerce terminal areas was the VMT associated with the trip to deliver and the trip to pick up the cargo or containers from the terminal and was calculated by multiplying gate count data by estimates of the average trip length. The source of the average trip length data was the Vollmer terminal survey report (Vollmer, 2006). This report summarized the distribution of truck origins and destinations by county, state, or region. A weighted average trip length was estimated by multiplying the distribution percentage by the distance from the terminals (assumed to be at the centroid of Union County, NJ) to the centroid of the origin or destination county. Data on highway miles between county centroids were obtained from the Center for Transportation Analysis at the Oak Ridge National Laboratory (CTA, 2008). In cases where the origin or destination is listed as a State or region rather than a county, a surrogate county was selected in which a major metropolitan area is located. Trip lengths were capped at a maximum of 400 miles per trip (the distance a truck could travel in an eight-hour day at 50 mph). Separate analyses were performed to estimate a weighted average origin trip length and a weighted average destination trip length. Table 3-5 shows the distribution of origin and destination trips, the surrogate counties used, and the mileage from the terminals to each origin or destination. This calculation resulted in an average origin trip length of 45.0 miles and an average destination trip length of 40.4 miles. The sum of these two values (85.4 miles) was then multiplied by the annual gate counts for each terminal to estimate the 2006 VMT to and from the terminals. Table 3-4 summarizes the estimated VMT associated with the trips to and from the terminals.

3.3.3.4. Emission Factors and Emission Calculations

Emission factors for trucks were obtained from EPA's latest GHG Inventory report (EPA, 2007a). The emission factors associated with heavy-duty diesel vehicles (HDDVs) were used for CH_4 and N_2O, in terms of grams per mile, while the emission factor associated with diesel fuel consumption was used for CO_2, in terms of mass per gallon. The CH_4 and N_2O emission factors for HDDVs do not vary by model year or emission control technology. Annual VMT from truck travel, both within the terminals and on the trips to and from the terminals was converted to annual fuel consumption for estimating CO_2 emissions by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy by model year and vehicle type, were obtained from the Department of Energy's Annual Energy Outlook (DOE, 1998-2007). The diesel CO_2 emission factor was multiplied by the total fuel consumed by the trucks during idling, traveling within the terminal, and traveling to and from terminals. The HDDV CH_4 and

Table 3-5. Port Commerce Distribution of Truck Origin and Destinations--All Terminals

State/Region	County	Surrogate County Used	Truck Origins Percent of Total	Truck Destinations Percent of Total	Distance from Union County, NJ (highway miles)
NJ	Bergen		2.3%	2.4%	24.8
	Essex		23.3%	23.3%	10.8
	Hudson		21.9%	22.7%	14.4
	Mercer		0.5%	0.5%	42.4
	Middlesex		9.3%	9.8%	16.9
	Monmouth		0.7%	0.4%	35.9
	Morris		0.7%	0.9%	24.2
	Ocean		0.1%	0.1%	55.7
	Passaic		0.9%	1.1%	22.6
	Somerset		0.8%	0.9%	27.9
	Union		12.4%	14.4%	5.3
	Other	Atlantic County (Atlantic City)	2.5%	2.8%	106.3
NY	Bronx		1.1%	0.6%	33.9
	Kings		3.5%	3.0%	27.1
	New York		0.9%	0.5%	26.1
	Queens		0.8%	0.9%	32.0
	Richmond		0.9%	1.2%	12.0
	Dutchess		0.2%	0.2%	96.6
	Nassau		1.4%	1.0%	48.8
	Orange		0.3%	0.4%	72.2
	Putnam		0.0%	0.0%	82.2
	Rockland		0.1%	0.1%	41.6
	Suffolk		0.2%	0.2%	69.3
	Westchester		0.4%	0.5%	45.7
	Upstate	Onondaga County (Syracuse)	1.5%	1.4%	241.2

State/Region	**County**	**Surrogate County Used**	**Truck Origins Percent of Total**	**Truck Destinations Percent of Total**	**Distance from Union County, NJ (highway miles)**
CT	Fairfield		0.3%	0.1%	80.1
	New Haven		0.4%	0.3%	107.1
	Other		0.4%	0.2%	146.3
Western MA		Hampden County (Springfield)	0.2%	0.0%	165.6
Eastern MA & RI		Suffolk County (Boston)	1.4%	1.1%	237.0
Northern New England		Hillsborough County (Manchester, NH)	0.1%	0.1%	262.0
NE Pennsylvania		Lackawanna County (Scranton)	2.2%	1.8%	112.6
SE Pennsylvania		Philadelphia County	2.6%	2.5%	77.7
Central Pennsylvania		Dauphin County (Harrisburg)	1.5%	1.4%	151.3
Western Pennsylvania		Allegheny County (Pittsburgh)	0.4%	0.3%	358.6
DE		New Castle County (Wilmington)	0.2%	0.1%	109.7
MD and DC		Baltimore City	0.8%	0.4%	174.6
Midwest			0.9%	0.9%	400.0
Pacific Northwest			0.1%	0.0%	400.0
Pacific Southwest			0.1%	0.0%	400.0
Canada			1.6%	1.5%	400.0
Weighted Average Origin Trip Length (highway miles)					45.0
Weighted Average Destination Trip Length (highway miles)					40.4
Average Trip Length (highway miles)					***42.7***

SOURCE: Vollmer, 2006, Table VI-1; CTA, 2008

N_2O emission factors were multiplied by the total truck VMT within the terminals, and VMT to and from terminals to obtain the emissions from vehicle travel.

The resulting emissions were then summed by activity and terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

3.3.4. Results

Table 3-6 summarizes the GHG emission estimates for the Port Commerce attracted travel activities included in this inventory. A majority of the emissions are associated with the truck travel to and from the port terminals.

While the estimates of total gate counts should be fairly certain, the allocations of gate counts by terminal have a higher degree of uncertainty.

GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions account for more than 99 percent of the CO_2e emissions.

Table 3-6. Port Commerce Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

		Greenhouse Gas Emissions Totals (metric tons)			
Activity	**Facility**	**CO_2**	**CH_4**	**N_2O**	**CO_2 Equivalent**
Idling Within Terminal					
	Port Newark/Port Elizabeth	19,895	0.00	0.00	19,895
	Howland Hook Marine Terminal	3,209	0.00	0.00	3,209
	Red Hook Container Terminal/Auto Marine Terminal	135	0.00	0.00	135
	Total	*23,239*	*0.00*	*0.00*	*23,239*
Travel Within Terminal					
	Port Newark/Port Elizabeth	4,586	0.02	0.01	4,591
	Howland Hook Marine Terminal	750	0.00	0.00	751
	Red Hook Container Terminal/Auto Marine Terminal	9	0.00	0.00	9
	Total	*5,345*	*0.02*	*0.02*	*5,350*
Travel To and From Terminal					
	Port Newark/Port Elizabeth	361,932	1.25	1.18	362,324
	Howland Hook Marine Terminal	56,905	0.20	0.19	56,966
	Red Hook Container Terminal/Auto Marine Terminal	1,989	0.01	0.01	1,992
	Total	*420,826*	*1.46*	*1.37*	*421,282*
Total Attracted Travel					
	Port Newark/Port Elizabeth	386,413	1.27	1.19	386,810
	Howland Hook Marine Terminal	60,864	0.20	0.19	60,926
	Red Hook Container Terminal/Auto Marine Terminal	2,133	0.01	0.01	2,135
	Total	***449,410***	***1.47***	***1.39***	***449,871***

3.4. LANDFILL

3.4.1. Boundary

Historical aerial photography suggests that landfill dumping began in the Elizabeth landfill area sometime in the 1940's and ended in 1970.

According to the New Jersey Department of Environmental Protection records, the total acreage of the landfill area is 155 acres. The landfill's exact boundaries are not known and could not be accurately determined through aerial photography review alone due to the uncontrolled nature of filling employed at the landfill during its use. However, based on information from the New Jersey Department of Environmental Protection and a review of boring logs, it can be determined that the general boundary for the main portion of the landfill lies south of Bay Avenue between the Conrail railroad tracks and east to McLester Street. The southern boundary runs south past North Avenue to where the present day Jersey Gardens Mall is located. Moreover, the landfill is subdivided into two portions. The primary portion of the former landfill is currently owned by IKEA. The remaining portion consists of outlying portions of the landfill where fill was placed, and is owned by the Port Authority. The Port Authority property is part of the Port Commerce department, and is leased to tenants.

3.4.2. Facilities Included In The Inventory

Elizabeth Landfill

3.4.3. Methods

Activity data in the form of total solid waste deposited (metric tons) in the landfill was used to estimate the CH_4 emissions from the landfill. To estimate the depth of the landfill, the stratigraphic profile map of the landfill provided by PANYNJ was used. The profile map shows contours of the top of the organics layer, the bottom of the refuse fill, and the thickness of the refuse fill. Starting from the ground surface, the stratigraphic sequence of the landfill consists of the following units: silty sand, organic silt, dredged material, waste material/organic layer, and top layer of fill sand. The depth of the landfill was estimated by subtracting the elevation of the top of the organics layer from the bottom of the refuse fill. The refuse thickness was estimated to be between 6 to 8 feet. The density of solid waste multiplied by the volume of the landfill was used to estimate the amount of waste emplaced. Solid waste density was assumed to be 0.6 tons/cubic yard (EPA, 2005b), which resulted in an estimate solid waste-in-place of 1,091,208 metric tons.

EPA's LandGEM model was used to estimate the amount of landfill gas produced and the resultant annual emissions of methane from the landfill gas (EPA, 2005b). LandGEM is based on the gas generated from anaerobic decomposition of landfilled waste, which has a methane content between 40 and 60 percent Default pollutant concentrations used by LandGEM have already been corrected for air infiltration, as stated in AP-42. The annual waste emplacement estimate was input to LandGEM for each year of operation. The model assumptions also include: the methane generation potential of 3,204 cubic feet per ton of waste and a methane generation rate constant of 0.065 per year.

Landfill gas is a mixture of substances generated when bacteria decompose the organic materials contained in the solid waste emplaced. By volume, MSW landfill gas is about 50 percent CH_4 and 50 percent CO_2. The amount and rate of CH_4 generation depends upon the quantity and composition of the landfilled material, as well as the surrounding landfill environment. The stratigraphic profile map provided by the PANYNJ shows dredge material in the landfill, and dredge material produces very small quantities of methane. Since the contribution from this layer is minimal, the estimates show the total methane emissions from both the refuse and dredge layers within the landfill. The waste-in-place estimate was divided by the number of estimated operating years of the landfill (30 years) to estimate an average annual waste emplacement during the assumed years of operation, 1940 to 1970.

There was no detailed and accurate data available on the yearly waste deposits and the composition of waste deposited each year in the landfill. Therefore, the LandGEM model was used instead of the IPCC based waste model.

3.4.4. Results

Table 3-7 summarizes the landfill GHG emission estimates for the facility included in the inventory. Although the landfill produces emissions of both CO_2 and CH_4, only the methane emissions are reported here, since the CO_2 is considered to be of primarily biogenic origin (e.g., decomposable paper, vegetation). There is also some evidence that landfills produce N_2O emissions; however, sufficient measurements are not yet available to evaluate these emissions from U.S. landfills.

Emissions generated by the Elizabeth Landfill have been determined to be Scope 1. Neither the Californian Climate Action Registry, nor the WRI/WBCSD Greenhouse Protocol offer explicit guidance on ownership of emissions from a closed landfill in the case of leased land. In the case of the Elizabeth Landfill, the PANYNJ owns and manages most of this property and leases it to tenants. There is no landfill gas capturing system in place. For other types of leased operations (such as buildings), where the owner doesn’t exert operational control, the emissions are deemed to rest with the tenant (Scope 3 emissions for the owner). However, the case of emissions from closed landfills is slightly different, as the leasing operator is not assuming operational control of the closed landfill site. If the tenant were to move its operations away from PANYNJ owned land, the emissions from the landfill would remain.

Table 3-7. Landfill GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Elizabeth Landfill – Port Commerce Department	0	201	0	4,221

3.5. PORT COMMERCE DEPARTMENT EMISSIONS SUMMARY

Table 3-8 summarizes the GHG emissions from all facilities within the Port Commerce Department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be allocated by facility appear in Table 7-11.

Table 3-8. Port Commerce Department 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
All Port Authority Ports	**-**	**-**	**386,139**	**386,139**
Commercial Marine Vessels	-	-	227,735	227,735
Cargo Handling Equipment	-	-	158,404	158,404
Port Newark/ Elizabeth Terminal	**241**	**-**	**431,233**	**431,474**
Attracted Travel	-	-	386,810	386,810
Buildings	-	-	44,424	44,424
Fleet Vehicle	223	-	-	223
Direct Fugitive Emissions	18	-	-	18
Howland Hook Marine Terminal/Port Ivory	**11**	**-**	**63,316**	**63,327**
Attracted Travel	-	-	60,926	60,926
Buildings	-		2,390	2,390
Fleet Vehicle	11	-	-	11
Red Hook Container Terminal and Brooklyn PA Marine Terminal (Brooklyn Piers)	**77**	**-**	**2,354**	**2,431**
Attracted Travel	-	-	2,135	2,135
Buildings	-	-	219	219
Fleet Vehicle	77	-	-	77
Auto Marine Terminal and Greenville Yard	**-**	**-**	**3,537**	**3,537**
Attracted Travel	-	-	Included in Red Hook	
Buildings	-	-	3,537	3,537
Elizabeth Landfill	**4,221**	**-**	**-**	**4,221**
PORT COMMERCE DEPARTMENT	**4,550**	**-**	**886,580**	**891,129**

3.6. REFERENCES

Corbett and Koehler, 2003: Corbett, J. J. and H. W. Koehler, "Updated Emissions from Ocean Shipping," J. Geophys. Res., 108(D20), 4650, doi:10.1029/2003JD003751, 2003.

CTA, 2008: Center for Transportation Analysis, Oak Ridge National Laboratory, "County-to-County Distance Matrix," downloaded February 27, 2008 from http://cta.ornl.gov/transnet/SkimTree.htm

DOE, 2007: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007,” Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

ENTEC, 2002: ENTEC, “Quantification of Emissions from Ships Associated with Ship Movements between Ports in the European Community,” Final Report, prepared for the European Commission, July 2002.

EPA, 1997: U.S. Environmental Protection Agency, "Emission Factors for Locomotives, Technical Highlights," EPA420-F-97-051, December 1997.

EPA, 1998. U.S. Environmental Protection Agency, Office of Mobile Sources, "Locomotive Emission Standards, Regulatory Support Document," April 1998.

EPA, 2004a: U.S. Environmental Protection Agency, “Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Modeling,” EPA420-P-04-005, April 2004.

EPA, 2004b: U.S. Environmental Protection Agency, “Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling - Compression Ignition,” EPA420-P-04-009, April 2004.

EPA, 2006, U.S. Environmental Protection Agency, “Current Methodologies and Best Practices for Preparing Port Emission Inventories,” prepared by ICF Consulting, January 2006.

EPA, 2007a: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,” EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

EPA, 2007b: U.S. Environmental Protection Agency, Clean School Bus USA, National Idle-Reduction Campaign, Idle-Reduction Background, October 19, 2007, retrieved November 11, 2008 from: http://www.epa.gov/otaq/schoolbus/antiidling.htm.

EPA, 2008: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006,” EPA #430-R-08-005, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2008.

IOR, 2007: IOR Energy, “Engineering Conversion Factors,” available at (http://www.ior.com.au/ecflist.html), 2007.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," Volume 2, Energy, 2006.

IPCC, 2007: Intergovernmental Panel on Climate Change, "IPCC Climate Change 2007: Mitigation of Climate Change. Contribution of working Group III to the fourth Assessment Report of the Intergovernmental Panel on Climate Change," [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., 851pp, 2007.

Lotz, 2007: E-mail from D. Lotz entitled, "Follow-up-CSX and NS Fuel Consumption," sent to G. Sarrinikolaou on November 28, 2007.

NYC, 2007: New York City, "Inventory of New York City Greenhouse Gas Emissions," Mayor's Office of Operations, Office of Long-term Planning and Sustainability, April 2007.

PANYNJ, 2006: The Port Authority of New York & New Jersey, "Annual Report 2006, Comprehensive Annual Financial Report for the Year Ended December 31, 2006," prepared by the Public Affairs and Comptroller's Departments of the Port Authority of New York & New Jersey, available at http://www.panynj.gov/AboutthePortAuthority/InvestorRelations/AnnualReport/, 2006.

PANYNJ, 2007a: Port Authority of New York and New Jersey, Spreadsheet entitled, "Cargo data 101007.xls," 2007.

PANYNJ, 2007b: Port Authority of New York & New Jersey, Spreadsheet entitled, "2006_Port_Truck_data.xls," 2007.

Starcrest, 2003a: Starcrest Consulting Group, LLC, "New York, Northern New Jersey, Long Island Non-attainment Area Commercial Marine Vessel Emissions Inventory," prepared for The Port Authority of New York and New Jersey and the United States Army Corps of Engineers – New York District, 2003.

Starcrest, 2003b: Starcrest Consulting Group, LLC, "The Port of New York and New Jersey Emissions Inventory for Container Terminal Cargo Handling Equipment, Auto-marine Terminal Vehicles, and Associated Locomotives," prepared for the Port Authority of New York and New Jersey, June 2003.

Starcrest, 2007: Starcrest Consulting Group, LLC, *PANYNJ CHE Fuel Use by State (9 Nov 07).xls*, spreadsheet with 2002 and 2004 fuel consumption estimates, transmitted via email entitled, "Port Commerce - CHE fuel use," from G. Sarrinikolaou, PANYNJ, sent to J. Wilson, E.H. Pechan & Associates, Inc., November 13, 2007.

Starcrest, 2008: Starcrest Consulting Group, LLC, “2006 Baseline Multi-Facility Emissions Inventory of Cargo Handling Equipment, Heavy-Duty Diesel Vehicles, Railroad Locomotives and Commercial Marine Vessels,” prepared for the Port Authority of New York and New Jersey, November 2008.

USACE, 2007: United States Army Corps of Engineers - Waterborne Commerce section, Personal Communications, December 6, 2007.

Vollmer, 2006: Vollmer Associates, Eng-Wong, Taub & Associates, Stump/Hausman, New Jersey Institute of Technology, Stevens Institute of Technology, “Port Authority Marine Container Terminals Truck Origin-Destination Survey 2005,” draft report prepared for the Port Authority of New York & New Jersey, February 27, 2006.

4.0 TUNNELS AND BRIDGES

4.1. ATTRACTED TRAVEL

This chapter provides emissions estimates from vehicle travel at the Port Authority's tunnels and bridges. The vehicle emissions reflect travel through the facilities as well as queuing at these facilities.

4.1.1. Boundary

The established boundaries for vehicle travel are the length of each bridge and the average length of each tunnel (PANYNJ, 2007a). Table 4-1 provides the roadway length and traffic volume for each facility.

Table 4-1. Tunnels and Bridges Roadway Length and Traffic Volume by Facility

Facility Type	Facility Name	Roadway Length[1]		Annual Traffic Volume[2] (one way)
		Feet	Miles	
Bridges	George Washington Bridge	13,389	2.54	54,265,000
	Bayonne Bridge	9,900	1.88	4,213,000
	Goethals Bridge	8,052	1.53	13,025,000
	Outerbridge Crossing	10,824	2.05	16,219,000
Tunnels	Lincoln Tunnel	19,800	3.75	21,933,000
	Holland Tunnel	17,160	3.25	17,365,000

[1] DATA SOURCE: PANYNJ, 2007a.
[2] DATA SOURCE: PANYNJ, 2007b.

4.1.2. Facilities Included in the Inventory

Tunnel and bridge facilities included in this inventory are listed in Table 4-1.

4.1.3. Methods

This section summarizes the procedures applied for developing a GHG emissions inventory from highway vehicles traveling via the Port Authority's tunnels and bridges. Activity data were developed based on the annual traffic volume and length of the facility (see Table 4-1) obtained from Port Authority's Tunnels, Bridges, and Terminal department (PANYNJ, 2007a; PANYNJ, 2007b). CO_2 emissions estimates were calculated using a fuel-based methodology. Emissions estimates for CH_4 and N_2O were calculated using a distance-based methodology.

VMT for the tunnel and bridge facilities were derived by multiplying annual traffic volumes by the roadway length in miles. Since GHG emissions from highway vehicle sources are calculated based on vehicle types (CH_4 and N_2O) and fuel types (CO_2), VMT were allocated to these vehicle categories: auto; buses; small trucks; and large trucks.

Vehicle type distributions applied were developed based on 2006 traffic volumes (Jiji, 2007). After VMT were allocated to these four vehicle types, VMT was disaggregated to vehicle categories equivalent to EPA's vehicle types and fuel types, which were needed for proper allocation of emission factors and fuel economy data. Table 4-2 provides a summary of the fraction of VMT accrued by each of the Port Authority vehicle types. The table also shows how the total VMT for each Port Authority vehicle type was allocated among the corresponding EPA vehicle types. These allocation fractions were developed based on default data from EPA's MOBILE6 emission factor model.

Table 4-2. Vehicle Classifications and Allocation Factor

Port Authority Vehicle Type	VMT Mix Fractions by PA's Vehicle Type	EPA Vehicle Type	Allocation Factors
AUTO	0.918123	LDGV	0.441509
		LDGT1	0.378024
		LDGT2	0.129424
		HDGV	0.032171
		LDDV	0.000514
		LDDT	0.002114
		HDDV	0.010096
		MC	0.006148
SMALL TRUCKS	0.028199	HDGV	0.209174
		HDDV	0.790826
LARGE TRUCKS	0.050777	HDGV	0.000059
		HDDV	0.999941
BUSES	0.002902	HDGV	0.103739
		HDDV	0.896261

After VMT were disaggregated to vehicle categories equivalent to EPA's vehicle types and fuel types, VMT were then distributed across 25 model years, so that the appropriate emission factors could be applied as described in EPA's GHG inventory report (EPA, 2007). Vehicle age-specific distribution data were developed based on 2006 vehicle registration data for gasoline- and diesel powered light-duty and heavy-duty vehicles. Vehicle registration data were obtained from the New York State's 2006 enhanced inspection maintenance (I/M) program annual report (DEC, 2007). Vehicle age-specific distribution data (i.e., 25-year range, 1982 through 2006) were then utilized in estimating GHG emissions and were used for all facilities.

CO_2 emissions were estimated by converting VMT into fuel use by applying fuel economy factors and multiplying by emission factors expressed in grams per gallon. Fuel economy factors were derived from a combination of EPA's default values and various U.S. Department of Energy (DOE) Energy Information Administration (EIA) Annual Energy Outlook reports (EPA, 2003; DOE, 1996-2007a). Emission estimates for CO_2 were calculated by multiplying fuel used by fuel-specific emission factors. Fuel-specific emission factors were obtained from DOE's EIA's voluntary reporting of GHG program website (DOE, 2007b).

Emissions estimates for CH_4 and N_2O were developed by multiplying VMT by the corresponding weighted emission factors (in grams/mile) by vehicle category. Emission factors in units of grams/mile for CH_4 and N_2O were also derived from the EPA's GHG inventory report (EPA, 2007).

Once emission estimates were calculated by vehicle category and model year group, emissions were summed for all model years and vehicle categories for each GHG gas type. The CH_4 and N_2O emissions were converted into their respective CO_2e emissions by multiplying the CH_4 and N_2O emissions in metric tons by their corresponding 100-year GWPs.

4.1.4. Results

This section contains the results of GHG emissions for tunnels and bridges facilities. Table 4-3 summarizes the transportation-related GHG emission estimates for the facilities included in this inventory.

Table 4-3. Tunnels and Bridges GHG Emissions by Gas and CO_2 Equivalent

Facility Name	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	**CH_4**	**N_2O**	**CO_2 Equivalent**
Bridges				
George Washington Bridge	137,287	7	8	139,967
Bayonne Bridge	8,124	0	0	8,277
Goethals Bridge	20,116	1	1	20,503
Outerbridge Crossing	31,403	2	2	32,063
Tunnels				
Lincoln Tunnel	92,915	4	5	94,486
Holland Tunnel	47,830	3	4	48,985
Total	**337,675**	**18**	**20**	**344,281**

In 2006, the PANYNJ produced 344,281 metric tons of CO_2e GHG emissions associated with travel through its tunnels and bridges. Over 80 percent of emissions occurred at the George Washington Bridge, Lincoln Tunnel, and Holland Tunnel. George Washington Bridge accounted for about 41 percent of the emissions estimates while Lincoln Tunnel and Holland Tunnel accounted for about 27 percent and 14 percent, respectively. As shown in Table 4-3, approximately 98 percent were emissions of CO_2, less than 1 percent was from CH_4 (as CO_2e), and approximately 2 percent was from N_2O (as CO_2e).

4.2. QUEUING ANALYSIS

4.2.1. Boundary

The boundary for queuing on the bridges and tunnels includes the volume of queued vehicles accessing toll facilities on the bridge and tunnel crossings, as well as the outbound queues that occur at the Lincoln Tunnel.

4.2.2. Facilities Included in the Inventory

The facilities included in this analysis are:

a. George Washington Bridge;
b. Bayonne Bridge;
c. Goethals Bridge;
d. Outerbridge Crossing;
e. Lincoln Tunnel; and
f. Holland Tunnel.

4.2.3. Methods

Activity data for queuing activity on the tunnels and bridges was multiplied by fuel-specific CO_2 emission factors, in terms of mass per gallons of fuel consumed, to estimate the total GHG emissions. The activity used for queuing was the number of hours of vehicle delay. The estimated number of vehicle hours of delay was then multiplied by an estimate of idling fuel consumption (gallons per hour) to calculate the amount of fuel consumed due to queuing delays at the toll facilities.

The primary data source for estimating queuing times was based on Transcom data that was electronically collected on most of the PA bridges and tunnels (PANYNJ, 2008). The Port Authority provided data on the total number of annual vehicle hours of delay on the Lincoln Tunnel, Bayonne Bridge, Goethals Bridge, and Outerbridge Crossing. As this analysis did not include the Holland Tunnel or the George Washington Bridge, the sources of data on vehicle queuing times for these two facilities included two Skycomp studies conducted in 2006 for the PANYNJ (Skycomp, 2006a; Skycomp, 2006b). These studies presented data on volumes and queue travel times based on aerial photos of the surveyed facilities. Two spring flights and two fall flights were performed during both the morning peak hours (spanning 5:30 a.m. to 10:00 a.m.) and the afternoon/evening peak hours (spanning 3:00 p.m. to 8:00 p.m.), for a total of eight flights on weekdays. Additional flight surveys were conducted in July and August on a Saturday and two Sundays.

For each facility, season, and peak period, the Skycomp reports presented hourly volumes and the average hourly queue travel time. This information was used to estimate vehicle hours of delay for each facility by hour, season, and peak period. This was done by multiplying the hourly volume by the average hourly travel time. The vehicle hours of delay were then summed across the hours making up the peak period. Volume weighted vehicle hours of delay were then calculated for each facility and peak period to obtain a typical daily estimate of vehicle hours of delay for each facility and peak period based on the spring and fall data for weekdays. This analysis was performed for traffic heading through the toll facilities. Table 4-4 summarizes the resulting estimated daily average vehicle hours of delay at each facility on an average weekday, Saturday, and Sunday. Total annual vehicle hours of delay were calculated by multiplying the weekday estimates by 261 days and the weekend estimates by 52 days each.

Table 4-4. Estimated Daily Average Vehicle-Hours of Delay by Tunnel and Bridge Facility

	Average Daily Vehicle-Hours of Delay		
Facility	**Weekday**	**Saturday**	**Sunday**
Holland Tunnel	2,055.6	3,384.1	5,795.0
Lincoln Tunnel	7,332.0	2,840.2	2,840.2
George Washington Bridge	3,894.7	5,177.2	10,139.7
Goethals Bridge	725.8	694.3	694.3
Outerbridge Crossing	73.5	208.4	208.4
Bayonne Bridge	0.4	0.4	0.4

Since the CO_2 emission factors are fuel-specific, the annual vehicle hours of delay were allocated by vehicle type using ratios of the traffic volumes by vehicle type (derived for the Attracted Travels analysis of the bridges and tunnels) to the total facility traffic volumes. The resulting vehicle hours of delay by vehicle type were converted to fuel consumption by vehicle type, assuming 0.5 gallon of fuel is consumed per hour for all vehicle types during idling (EPA, 2008). Emission estimates for CO_2 were calculated by multiplying the vehicle type fuel consumption values by fuel-specific emission factors. Emission factors were obtained from EPA's latest GHG inventory report (EPA, 2007) and converted to units of pounds per gallon of fuel consumed. The fuel consumed by vehicle type during idling was then multiplied by the fuel-specific CO_2 emission factor.

The resulting emissions were then totaled by facility. CH_4 and N_2O emissions were not estimated, as idling emission factors are not readily available for these pollutants. The contribution of these pollutants is expected to be negligible.

4.2.4. Results

Table 4-5 summarizes the GHG emission estimates from queuing at the Port Authority tunnels and bridges. Over 94.3 percent of the queuing emissions occurred on the approaches to the George Washington Bridge, the Lincoln Tunnel, and the Holland Tunnel. The Lincoln Tunnel accounted for 41.6 percent of the total CO_2 equivalent emissions while the George Washington Bridge and the Holland Tunnel accounted for 34.0 and 18.8 percent, respectively. Emissions estimates for the Bayonne Bridge, Goethals Bridge, and Outerbridge Crossing accounted for only 5.7 percent. The estimated GHG emissions are entirely CO_2 emissions, as CH_4 and N_2O emissions were not calculated.

Table 4-5. Tunnels and Bridges 2006 Queuing GHG Emissions by Gas and CO_2 Equivalent

Facility Name	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Bridges				
George Washington Bridge	8,167	0	0	8,167
Bayonne Bridge	1	0	0	1
Goethals Bridge	1,180	0	0	1,180
Outerbridge Crossing	183	0	0	183
Tunnels				
Lincoln Tunnel	9,994	0	0	9,994
Holland Tunnel	4,525	0	0	4,525
Total	**24,050**	**0**	**0**	**24,050**

4.3. REFERENCES

DEC, 2007: New York State Department of Environmental Conservation, “2006 Enhanced I/M Program Annual Report and 2005-2006 Biennial Report: Appendix A,” (http://www.dec.ny.gov/chemical/39482.html), 2007.

DOE, 2007a: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007,” Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

DOE, 2007b: U.S. Department of Energy, Energy Information Administration, “Voluntary Reporting of Greenhouse Gases Program, Fuel and Energy Source Codes and Emission Coefficients,” http://www.eia.doe.gov/oiaf/1605/coefficients.html, 2007.

EPA, 2003: U.S. Environmental Protection Agency, Office of Transportation and Air Quality. “User’s Guide to MOBILE6.1 and MOBILE6.2 - Mobile Source Emission Factor Model,” EPA420-R-03-010, August, 2003.

EPA, 2007: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,” EPA430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

EPA, 2008: U.S. Environmental Protection Agency, “National Idle-Reduction Campaign, Idle-Reduction Background,” http://www.epa.gov/otaq/schoolbus/antiidling.htm, November 2008.

Jiji, 2007: Danny Jiji, Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminals, “Question About Traffic Analysis”, data file 2006 Veh Distribution.xls, provided to Pechan via email on December 13, 2007.

PANYNJ, 2007a: Port Authority of New York and New Jersey, “Master List of GHG Emissions Inventory Comments/Questions - Comment #23, Comments-questions - master list012208.doc,” January 22, 2008.

PANYNJ, 2007b: Port Authority's website, http://www.panynj.gov/CommutingTravel/bridges/html/, 2007.

PANYNJ, 2008: Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminals, "Summary Transcom Vehicle Hours of Delay," data file 2008-0214 Summary.xls, provided to Pechan February 14, 2008.

Skycomp, 2006a: Skycomp, Inc., "2006 Summer Weekend Traffic Congestion Survey," final report, prepared for the Port Authority of New York and New Jersey, 2006.

Skycomp, 2006b: Skycomp, Inc., "2006 Annual Report of Interstate Toll Delay," final report, prepared for the Port Authority of New York and New Jersey, 2006.

(This page intentionally left blank)

5.0 BUS TERMINALS

5.1. BOUNDARY

For the analysis of GHG emissions associated with the PANYNJ bus terminals, the boundary was defined as the property lines of the terminals, with emissions estimated based on the bus and vehicle travel within the terminals, the idling emissions that occur when the buses are parked in the facility, and the start-up emissions associated with starting a vehicle parked within the facility. Defining the boundary in this way eliminates double-counting of emissions from trips through or across the Port Authority tunnels and bridges.

5.2. FACILITIES INCLUDED IN THE INVENTORY

Two bus terminals are included in this analysis:

a. George Washington Bridge Bus Station; and
b. Port Authority Bus Terminal.

5.3. METHODS

GHG emissions were estimated from buses traveling through the Port Authority bus terminals and from personal vehicles parking in the bus terminals. The activity for the buses is the mileage traveled within the terminals and the fuel consumed while idling in the terminals during 2006. The activity for the personal vehicles is the mileage traveled within the terminals and the vehicle starts within the terminals during 2006. These activity data were multiplied by emission factors for CO_2 (in terms of mass per gallon of fuel consumed) and CH_4 and N_2O emission factors (in terms of mass per mile and mass per vehicle start) to estimate emissions within the Port Authority bus terminals.

Emissions for buses were calculated in two parts: (1) emissions that occur while traveling within the bus terminals and (2) emissions that occur while buses are idling. The activity associated with the emissions that occur while a bus is moving is VMT. This was estimated by multiplying the total number of bus movements at each terminal by the estimated distance that the bus travels within the terminal. The average distance traveled within a bus terminal was estimated to be twice the length plus the width of the dimensions of the bus terminal. Table 5-1 summarizes the total 2006 bus movements and dimensions of both bus terminals, along with the corresponding data sources. Since the CO_2 emission factor is expressed in units of mass per gallon of fuel, the total bus VMT was converted to gallons of diesel fuel consumed by dividing the total VMT by an estimate of the bus fuel economy of 4.23 miles per gallon (Larsen, 2006). In addition to the bus travel through the terminal, this analysis also accounts for the VMT accumulated due to extra circulation on city streets currently required at the George Washington Bridge Bus Station

(GWBBS) at the Lower Level as well as the extra circulation on city streets when the Port Authority Bus Terminal (PABT) congestion requires a diversion. Based on information from the Port Authority, the diversion at the GWBBS totals 1,980 feet, affecting 15 buses per hour on weekdays from 7 a.m. to 8 p.m. The PABT diversion covers a distance of 2,681 feet, with 10 buses circulating at any given time from 5 p.m. to 6:45 p.m. weekdays. This results in an additional 19,000 miles of bus travel at the GWBBS and 23,000 miles at the PABT per year.

The average time spent idling per bus was estimated from data in a PANYNJ report that surveyed and analyzed bus movements within the PABT (PANYNJ, 2007). From the data in this report, the average time each bus spends within the terminal was calculated, and then the amount of time it would take a bus to travel the specified distance through the facility at a nominal speed of 5 miles per hour was subtracted. The remaining time was assumed to be the average bus idling time. It should be noted that New York City law prohibits buses from idling for more than three minutes. However, information on enforcement of this law was not available, so idling times were not limited to three minutes. Total bus idling time was then calculated by multiplying the average per-bus idling time by the number of bus movements. To estimate the amount of fuel consumed during idling, it was assumed that one gallon of diesel fuel is consumed for each hour of idling (EPA, 2002) and this factor was multiplied by the total bus idling time.

Emission factors for buses were obtained from EPA's latest GHG Inventory report (EPA, 2007), applying emission factors from the heavy-duty diesel vehicle category. The CO_2 emission factor is expressed in units of mass per gallon of fuel consumed, while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. Thus, the CO_2 emission factor was multiplied by the total fuel consumed by the buses while traveling within the bus terminals as well as during idling. The CH_4 and N_2O emission factors were multiplied by the total bus VMT within the bus terminals. It should be noted that 60 buses fueled on compressed natural gas (CNG) belonging to New Jersey Transit enter and exit the bus terminals daily. However, based on current research, GHG emissions from CNG buses are expected to be comparable to those from diesel buses. CNG buses have lower CO_2 emissions than diesel buses, but on a total fuel cycle basis, increased emissions from CH_4 tend to offset these CO_2 reductions (Cannon, 2000).

Emissions for the vehicles parked within the terminals were also calculated in two parts: (1) emissions that occur while traveling within the bus terminals to parking spaces and (2) emissions that occur when the vehicle is started after having been parked (cold start emissions). The vehicles parked at the bus terminals were assumed to be a mix of light-duty cars, light-duty trucks, and motorcycles. The per-vehicle VMT that accrues when a vehicle is traveling through a bus terminal was estimated in the same manner as the bus VMT (twice the length plus the width of the dimensions of the bus terminal). The per-vehicle VMT was then multiplied by the total number of vehicles parked at the bus terminals during 2006, as shown in Table 5-1. The number of vehicle starts was assumed to be equal to the number of vehicles parked during 2006. Cold start emissions from buses were not calculated, as the IPCC emission factors for cold starts from diesel vehicles are all negative (IPCC, 2006).

Table 5-1. Bus Terminal Activity Data

Terminal	Terminal Length (feet)	Terminal Width (feet)	Total Bus Movements[a]	Total Vehicles Parked
George Washington Bridge Bus Station	400[b]	185[b]	309,000	36,500[c]
Port Authority Bus Terminal	1,200[d]	200[d]	2,192,000	418,500[e]

[a] SOURCE: PANYNJ, 2006.
[b] SOURCE: http://www.panynj.gov/CommutingTravel/bus/html/gabout.html.
[c] Estimated as 100 vehicles parked per day multiplied by 365 days per year.
[d] Terminal 400 by 800 feet in 1963; expanded by 50 percent in late 1980s, so original length of 800 feet was multiplied by 1.5 to obtain current length of 1,200 feet.
[e] Leased parking at PABT from Leased Parking Stats-PABT.xls (total 2006 vehicles parked), spreadsheet provided by PANYNJ to Pechan, October 20007.

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2007), while the emission factors for vehicle starts were obtained from the IPCC guidelines (IPCC, 2006). Both the running and cold start CH_4 and N_2O emission factors varied by vehicle category and emission control technology. Weighted emission factors were estimated based on the expected distribution of vehicles by control technology and vehicle category. Annual VMT from the vehicles parking at the bus terminals was converted to annual fuel consumption to estimate CO_2 emissions by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy data were obtained from DOE's Annual Energy Outlook (DOE, 1998-2007). The weighted CO_2 emission factor was multiplied by the total fuel consumed by the vehicles while traveling within the bus terminals. The weighted CH_4 and N_2O running emission factors were multiplied by the total VMT to obtain the running emissions and the weighted cold start CH_4 and N_2O emission factors were multiplied by the total number of vehicles parked to obtain the cold start emissions.

The resulting emissions from both the buses and vehicles were then totaled by bus terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

5.4. RESULTS

Table 5-2 summarizes the GHG emission estimates that occur within the PANYNJ bus terminal boundaries. These emissions are broken down by facility, as well as for buses and personal vehicles. Emissions at the PABT are nearly 10 times greater than the emissions at the GWBBS. This is reasonable, given the differences in magnitude of bus operations of the two facilities, as shown in Table 5-1. The bus terminal GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for over 99 percent of the CO_2e emissions. The amount of time the buses spend idling within the terminals and the speeds the buses travel within the terminal are relatively uncertain. Idling times were estimated based on the time buses spend within the terminals and subtracting off the amount of time it would require for them to pass through the terminal at an assumed speed of 5 mph. If this assumed speed is significantly different from the actual speeds through the terminal, or if the buses generally turn their engines off while parked in the terminal, the emissions from idling could be significantly different.

Table 5-2. Bus Terminal GHG Emissions by Gas and CO_2 Equivalent

State	Facility		Greenhouse Gas Emissions Totals (metric tons)			
			CO_2	CH_4	N_2O	CO_2 Equivalent
NY	George Washington Bridge Bus Station	Buses	607	0.001	0.001	607
		Vehicles	2	0.002	0.004	4
		Total	*609*	*0.002*	*0.004*	*611*
NY	Port Authority Bus Terminal	Buses	5,643	0.006	0.005	5,645
		Vehicles	74.186	0.025	0.047	89
		Total	*5,717*	*0.030*	*0.053*	*5,734*
	Bus Terminals	**Total**	***6,326***	***0.033***	***0.057***	***6,344***

5.5. TUNNELS, BRIDGES, AND TERMINALS EMISSIONS SUMMARY

Table 5-3 summarizes the GHG emissions from all facilities within the Tunnels, Bridges and Terminals Department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be divided by facility appear in Table 7-11.

Table 5-3. Tunnels, Bridges and Terminals Department 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
George Washington Bridge	**323**	**3,095**	**148,134**	**151,552**
Attracted Travel	-	-	139,967	139,967
Queuing	-	-	8,167	8,167
Buildings	-	3,095	-	3,095
Fleet Vehicle Emissions	323	-	-	323
Staten Island Bridges (Bayonne, Goethals, & Outerbridge Crossing)	**265**	-	-	**265**
Fleet Vehicles Emissions	265	-	-	265
Bayonne Bridge	**-**	**268**	**8,278**	**8,546**
Attracted Travel	-	-	8,277	8,277
Queuing	-	-	1	1
Buildings	-	268	-	268
Goethals Bridge	**359**	**750**	**21,683**	**22,792**
Attracted Travel	-	-	20,503	20,503
Queuing	-	-	1,180	1,180
Buildings	359	750	-	1,109
Outerbridge Crossing	**192**	**32,438**	**183**	**32,813**
Attracted Travel	-	32,063	-	32,063
Queuing	-	-	183	183
Buildings	192	375	-	567
Lincoln Tunnel	**573**	**7,543**	**104,480**	**112,596**

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Attracted Travel	-	-	94,486	94,486
Queuing	-	-	9,994	9,994
Buildings	27	7,543	-	7,570
Fleet Vehicle Emissions	511	-	-	511
Direct Fugitive Emissions	35	-	-	35
Holland Tunnel	**84**	**5,898**	**53,510**	**59,492**
Attracted Travel	-	-	48,985	48,985
Queuing	-	-	4,525	4,525
Buildings	84	5,506	-	5,590
Fleet Vehicle Emissions	-	392	-	392
George Washington Bridge Bus Station	**-**	**-**	**4,028**	**4,028**
Buildings	-	-	3,417	3,417
In Terminal Bus Emissions	-	-	607	607
In Terminal Private Vehicle Emissions	-	-	4	
Port Authority Bus Terminal	**12**	**-**	**18,606**	**18,618**
Buildings	-	-	12,872	12,872
Fleet Vehicle Emissions	12	-	-	12
In Terminal Bus Emissions	-	-	5,645	5,645
In Terminal Private Vehicle Emissions	-	-	89	89
TUNNELS, BRIDGES & TERMINALS	**1,543**	**49,992**	**359,167**	**410,702**

5.6. REFERENCES

Cannon, 2000: James S. Cannon and Chyi Sun, INFORM, Inc., “New Technologies for Cleaner Cities,” 2000.

DOE, 2007: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007,” Report # DOE/EIA-0383(2007), February, 2007, http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls.

EPA, 2007: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,” EPA #430-R-07-002, April, 2007, http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

IPCC, 2006: Intergovernmental Panel on Climate Change, “2006 IPCC Guidelines for National Greenhouse Gas Inventories,” prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), published: IGES, Japan, 2006.

Larsen, 2006: Bent Larsen, New Jersey Transit buses average about 4.23 miles per gallon; overroad buses are typically 3.70 - 4.88 miles per gallon; some older local buses are as low as 2.64 mpg, 2006.

PANYNJ, 2006: The Port Authority of New York & New Jersey, “Annual Report 2006, Comprehensive Annual Financial Report for the Year Ended December 31, 2006,” prepared by the Public Affairs and Comptroller’s

Departments of the Port Authority of New York& New Jersey, available at http://www.panynj.gov/AboutthePortAuthority/InvestorRelations/AnnualReport/, 2006.

PANYNJ, 2007: Port Authority of New York and New Jersey, Tunnels, Bridges, and Terminals, “Port Authority Bus Terminal Bus Operations – Data Collection,” Technical Memorandum, Final Draft, prepared by Port Authority of NJ and NJ Engineering Department, in association with Edwards and Kelcey, October 2, 2007.

6.0 PATH

6.1. TRAINS

6.1.1. Boundary

The boundary associated with the PATH trains consists of the traction power used to power the trains. Emissions associated with the rest of PATH facilities and stations are included in Section 8.1 Buildings. Only emissions associated with the electricity used by the trains are within this boundary. This means that the energy totals used as activity data do not account for the losses associated with generation and transmission. Only the electricity delivered to the site falls within the boundary of this inventory.

6.1.2. Facilities Included in the Inventory

The traction power of all PATH trains is included in the inventory. Therefore, all trains which ran during 2006 regardless of which stations they traveled to are included in this inventory.

6.1.3. Methods

The traction power comes from the main PSE&G account associated with PATH, (PathCorpWashSt_All) for which the Port Authority provided electricity consumption data. The account is largely a traction power account, but it also includes some non-traction power. PATH estimates that traction power accounts for 85 to 90 percent of the electricity usage. Therefore, traction power is estimated as 85 percent of the total kWh billed during 2006. GHG emission factors corresponding to electricity generation are taken from EPA's eGRID as the average emission factors associated with the power pool of the North American Electric Reliability Council (NERC) sub-region containing New Jersey. eGRID is a comprehensive source of data on the environmental characteristics of electric power generated in the United States. The emission factors for CO_2, CH_4, and N_2O were multiplied by the activity data to find the annual emissions of each gas in metric tons. The CO_2 equivalents for CH_4 and N_2O were calculated using the IPCC SAR GWPs from Table 1-1.

6.1.4. Results

Table 6-1 shows the GHG emissions associated with the traction power as well as the indirect emissions associated with all other PATH facilities. Indirect emissions from traction power make up the majority of the PATH GHG emissions. Only the traction power falls within the boundary of this section. The emissions are strongly dominated by CO_2, which comprises over 99 percent of the total GHG emissions.

Table 6-1. PATH Train GHG Emissions by Gas and CO_2 Equivalent

PATH Power Use	CO_2 (metric tons)	CH_4 (metric tons)	N_2O (metric tons)	CO_2 Equivalent (metric tons)
Traction Power	40,161	0.30	0.33	40,828
Total Non-Traction	7,087	0.05	0.06	7,106
Total	**47,248**	**0.35**	**0.38**	**47,375**

6.2. ATTRACTED TRAVEL

6.2.1. Boundary

For the analysis of GHG emissions associated with the attracted travel at PATH train stations, the boundary was defined as the vehicle trips associated with PATH commuters. These commuters are those who drive, or are driven, to access a PATH station. This captures home to station trips and returns. Bus trips to and from the Journal Square Transportation Station are also included. This includes the distance traveled from the stop to Journal Square and the distance traveled from Journal Square to the next bus stop.

6.2.2. Facilities Included in the Inventory

This analysis includes riders at any of the 13 stations on the PATH route. It also includes buses traveling to and from Journal Square Transportation Center.

6.2.3. Methods

Direct GHG emissions were estimated from vehicles traveling to or from the PATH train stations and from buses traveling to and from Journal Square Transportation Center. The activity for both modes of travel is VMT. Cold start emissions were also calculated based on vehicle trips. These activity data were multiplied by emission factors for CO_2 (in terms of mass per gallon of fuel consumed) and CH_4 and N_2O emission factors (in terms of mass per mile and mass per vehicle start) to estimate emissions associated with attracted travel at PATH train stations.

6.2.3.1. Vehicle Access to PATH Train Stations

Activity for vehicles bringing passengers to the PATH train stations was estimated based on the total number of PATH passengers in 2006 (PANYNJ, 2007a) and a 2004 PATH passenger travel study that assigned travel modes to PATH passengers (Eng-Wong, Taub & Associates, 2004). In this survey, the PATH access and egress modes associated with personal vehicles included the following: Auto: Drove; Auto: Passenger; Commuter Van; and Taxi. The total number of 2006 PATH passengers was multiplied by the fraction of PATH commuters using one of these listed modes. This was performed separately for weekdays, weekends, and holidays. Once the number of passengers using personal vehicles to travel to the PATH stations was determined, estimates of vehicle occupancy were used to determine the number of vehicles traveling to and from the PATH stations. Table 6-2 shows the number of passengers estimated by access/egress mode, the vehicle occupancy assumed for each type of vehicle mode, and the assumed one-way trip length for each mode. The five-mile auto and taxi commuting distance to PATH stations was estimated by taking the national average one-way commuting distance of 12 miles (Pisarski, 2006) and subtracting the estimated average PATH train ride distance of seven miles (from Journal Square to 33rd Street). There was insufficient information for estimating the average commuter van travel distance to PATH stations, so it was assumed to be 4 times the distance of auto travel to PATH stations. The average vehicle occupancy for auto: drove, and auto: passenger modes are estimated by summing the total number of passengers by auto and dividing by the number of passengers that drove. This estimation assumes that all passengers who arrived and departed from the PATH stations by automobile are with drivers who also rode PATH. The average taxi vehicle occupancy of 1.63 is taken from the 2001 National Household Travel Survey for all trip purposes (Hu and Reuscher, 2004). The assumption of 8 passengers per commuter van is based on an EPA report on vanpool benefits (EPA, 2005). Total VMT associated with vehicle travel for each mode was then calculated by multiplying the number of passengers by the assumed trip length and dividing by the assumed vehicle occupancy. The number of passengers accounts for both passengers entering the train stations and those leaving the stations.

Table 6-2. Activity Data for Vehicle Travel To and From PATH Train Stations

PATH Access/Egress Mode	2006 Total Passengers	Assumed Trip Length (miles)	Assumed Vehicle Occupancy	Assumed Number of Starts per Trip	2006 Total VMT (miles)
Auto:drove	6,777,365	5	1.43	1	23,635,439
Auto: Passenger	2,939,542	5	1.43	1	10,251,383
Commuter Van	950,550	20	8	1	2,376,374
Taxi	2,585,906	5	1.63	0	7,932,226
Total					**44,195,422**

Emissions for the vehicles bringing passengers to the PATH stations were calculated in two parts: (1) emissions that occur while traveling to or from the PATH stations and (2) emissions that occur when the vehicles are started after having been parked (cold start emissions). The vehicles carrying passengers to the PATH stations were assumed to be a mix of light-duty cars, light-duty trucks, and motorcycles. The number of vehicle starts by access mode is shown in Table 6-2.

Emission factors for running vehicles were obtained from EPA's latest GHG Inventory report (EPA, 2007), while the emission factors for vehicle starts were obtained from the IPCC guidelines (IPCC, 2006). Both the running and cold start CH_4 and N_2O emission factors varied by vehicle category. Weighted emission factors were estimated based on the expected distribution of vehicles by vehicle category. Annual VMT from the vehicles traveling to the PATH stations were converted to annual fuel consumption by dividing the VMT by vehicle fuel economy in miles per gallon. Fuel economy data were obtained from the Department of Energy's Annual Energy Outlook (DOE, 1998-2007). The weighted CO_2 emission factor was multiplied by the total fuel consumed by the vehicles while traveling to and from the PATH stations. The weighted CH_4 and N_2O running emission factors were multiplied by the total VMT to obtain the running emissions. The weighted cold start CH_4 and N_2O emission factors were multiplied by the total number of vehicle starts associated with the trips to and from the PATH stations to obtain the cold start emissions.

6.2.3.2. Bus Travel To and From Journal Square Transportation Center

The activity associated with the bus emissions is VMT. This was estimated by multiplying the total number of 2006 bus departures from the Journal Square Transportation Center by an estimated trip length of five miles from Journal Square. Again, the 5-mile commuting distance to Journal Square was estimated by taking the national average one-way commuting distance of 12 miles (Pisarski, 2006) and subtracting the estimated average PATH train ride distance of seven miles (from Journal Square to 33rd Street). The resulting VMT was multiplied by two to account for both the trip to and the trip from the Transportation Center. Annual bus departure data for 2006 was provided by PANYNJ (PANYNJ, 2007b). This showed that 469,900 buses departed from the Journal Square Transportation Center in 2006. Since the CO_2 emission factor is expressed in units of mass per gallon of fuel, the total bus VMT was converted to gallons of diesel fuel consumed by dividing the total VMT by an estimate of the bus fuel economy of 4.23 miles per gallon (Larsen, 2006).

Emission factors were obtained from EPA's latest GHG Inventory report (EPA, 2007), applying emission factors from the heavy-duty diesel vehicle category for buses. The CO_2 emission factor is expressed in units of mass per gallon of fuel consumed while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. Thus, the CO_2 emission factor was multiplied by the total fuel consumed by the buses while traveling within the bus terminals as well as during idling. The CH_4 and N_2O emission factors were multiplied by the total bus VMT accumulated in the immediate trip to and from Journal Square.

The resulting emissions from both the buses and vehicles were then totaled by bus terminal. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

6.2.4. Results

Table 6-3 summarizes the GHG emission estimates that occur through the attracted vehicle trips to the PATH stations as well as for the bus trips to and from the PATH Journal Square. Emissions from vehicle trips account for a majority of the PATH attracted travel emissions. The PATH attracted travel GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for over 97 percent of the CO_2e emissions.

Table 6-3. PATH Attracted Travel GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
PATH Vehicle Trips Attracted	15,910	1.41	1.89	16,526
Bus Trips at PATH Journal Square Station	11,272	0.02	0.02	11,279
PATH Attracted Travel Total	***27,182***	***1.43***	***1.91***	***27,805***

6.3. DIESEL EQUIPMENT

6.3.1. Boundary

All diesel equipment operated by PATH is included within the boundary of this inventory. There are a number of Utility Track Vehicles (UTVs) which perform track maintenance services along the PATH system in both New Jersey and New York, as well as within rail yards. The UTVs operate throughout the PATH system, which includes the following counties/municipalities: Hudson County, NJ (Jersey City, Kearny, Harrison, and Hoboken), Essex County, NJ (Newark), and New York County (Manhattan).

6.3.2. Facilities Included in the Inventory

All PATH locations where equipment is used, including all tracks and the Harrison Car Maintenance Facility are included in this inventory.

6.3.3. Methods

PATH reported their overall diesel fuel use in gallons. Emissions were calculated using the diesel fuel use as activity data, and using GHG emission factors for diesel fuel retrieved from the IPCC Guidelines (IPCC, 2006).

6.3.4. Results

Table 6-4 summarizes the emissions from diesel equipment.

Table 6-4. PATH Diesel Fuel Use GHG Emissions by Gas and CO_2 Equivalent

Equipment	Diesel Usage (gallons)	Greenhouse Gas Emissions Totals (metric tons)			
		CO_2	CH_4	N_2O	CO_2 Equivalent
Generators	1,000	11.1	6.22E-04	4.29E-03	12.4
Utility Track Vehicles	13,785	153	8.58E-03	5.91E-02	171.6
Other Diesel Equipment	8,061	90	5.01E-03	3.46E-02	100.4
Total	22,846	254	1.42E-02	9.79E-02	284.4

6.4. PATH EMISSIONS SUMMARY

Table 6-5 summarizes the GHG emissions from all facilities within the PATH Department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be divided by facility appear in Table 7-11.

Table 6-5. PATH Department 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	**Scope 2**	**Scope 3**	**Facility Emission Totals**
Attracted Travel	-	-	27,805	27,805
Buildings	-	12,743	-	12,743
Direct Fugitive Emissions	18	-	-	18
Vehicle Fleet	156	-	-	156
Indirect Emissions from Purchased Traction Power	-	-	40,828	40,828
Diesel Utility Track Vehicles	172	-	-	172
Diesel Generators	12	-	-	12
Other Diesel Equipment	100	-	-	100
PATH RAPID TRANSIT SYSTEM	**458**	**12,743**	**68,633**	**81,834**

6.5. REFERENCES

DOE, 2007: U.S. Department of Energy, Energy Information Administration, “Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007,” Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

Eng-Wong, Taub & Associates, 2004: Eng-Wong, Taub, & Associates, “2004 PATH Passenger Travel Study,” selected tables provided by PANYNJ, 2004.

EPA, 2005: U.S. Environmental Protection Agency, “Vanpool Benefits: Implementing Commuter Benefits as one of the Nation’s Best Workplaces for Commuters,” from EPA 420-S-01-003, http://www.bestworkplaces.org/pdf/vanpoolbenefits_07.pdf, October 2005.

EPA, 2007: U.S. Environmental Protection Agency, “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005,” EPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

Hu and Reuscher, 2004: Patricia S. Hu and Timothy R. Reuscher, “Summary of Travel Trends: 2001 National Household Travel Survey,” prepared for the U.S. Department of Transportation, Federal Highway Administration, http://nhts.ornl.gov/2001/pub/STT.pdf, December 2004.

IPCC, 2006: Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds), published: IGES, Japan, 2006.

Larsen, 2006: Bent Larsen, New Jersey Transit buses average about 4.23 miles per gallon; overroad buses are typically 3.70 - 4.88 miles per gallon; some older local buses are as low as 2.64 mpg, 2006.

PANYNJ, 2007a: data file provided by the Port Authority of New York & New Jersey, "PATH 2006 Totals.xls," 2007.

PANYNJ, 2007b: data file provided by the Port Authority of New York & New Jersey, BUS@PARK STATS 2006_JournalSquare.xls, 2007.

Pisarski, 2006: Alan Pisarski, "Commuting in America III: The Third National Report on Commuting Patterns and Trends," published by Transportation Research Board, Washington DC, 2006.

(This page intentionally left blank.)

7.0 MOBILE SOURCES

7.1. FLEET VEHICLES

7.1.1. Boundary

The boundary for fleet vehicles includes the mileage traveled by all on-road motor vehicles (including cars, trucks, buses, and motorcycles) owned or operated by the PANYNJ and any non-road fuel usage from non-road vehicles.

7.1.2. Facilities Included in the Inventory

The fleet vehicles included in this inventory are associated with all facilities owned or operated by PANYNJ.

7.1.3. Methods

Direct GHG emissions were estimated for all motor vehicles in PANYNJ fleets, using the fuel usage in 2006 as the primary activity data and emission factors distinguished by vehicle type and model year group. Emission estimates were based on the specific vehicles that PANYNJ operates, gallons of fuel used, and the type of fuel used. In total, 1,597 on-road fleet vehicles were identified from the data provided by PANYNJ, and 672 non-road vehicles. These vehicles were estimated to travel 13.68 million miles and consume 1.24 million gallons of fuel in 2006.

Data on individual fleet vehicles was provided by the Central Automotive Division of the PANYNJ (PANYNJ, 2007a). This data file included information on the make, model, and year of each vehicle; the state and facility to which the vehicle was registered; descriptive information on the use, classification, and gross vehicle weight rating (GVWR) class of the vehicle; the fuel type of the vehicle; the gallons of fuel consumed in 2006; and the miles traveled in 2006. This data set included both on-road vehicles and non-road engine and equipment data, for which emissions were calculated separately. The majority of the emissions were calculated based on the reported fuel usage. The data on fuel use appeared more accurate than the vehicle miles traveled, which contained a number of odometer corrections. However, in some cases where both miles and gallons were provided, the fuel economy calculated by dividing the number of miles by the number of gallons yielded values outside of what would be expected to be a reasonable range based on the vehicle type and model. In these cases, the VMT seemed to be a more accurate reflection of the actual usage. For cases with inconsistent fuel and VMT data or missing fuel data, the vehicles were assigned fuel economy values based on the model year, vehicle type, and fuel of the vehicle. These data were obtained from the Department of Energy’s Annual Energy Outlook (DOE, 1998-2007). Annual fuel consumption was then calculated for each vehicle by dividing the annual mileage by the fuel economy in miles per gallon.

For this analysis, the fuel use and fuel class data were used to estimate fleet vehicle activity during 2006. For on-road vehicles each vehicle was assigned to one of the following vehicle types, based on the reported weight or, if not reported, the vehicle make and model: light-duty vehicle; light-duty truck 1 (up to 6,000 pounds GVWR); light-duty truck 2 (greater than 6,000 pounds GVWR); heavy-duty vehicle; and motorcycle. Vehicles were also classified by the following fuel types: gasoline, hybrid, diesel, bio-diesel, bi-fuel, flex-fuel, and CNG. For each vehicle, both on-road and non-road, the gallons of fuel use reported or calculated was used as the primary activity data. For CNG and bi-fuel vehicles, vehicle-specific CNG usage was unavailable. The total annual CNG fuel consumed was thus averaged over all the dedicated CNG and bi-fuel vehicles which were in use during 2006. These average values were then assigned to all of these vehicles for their CNG usage. Bi-fuel vehicles thus accounted for both the gasoline usage and CNG usage.

CO_2, CH_4, and N_2O emission factors were assigned to each vehicle type. The CO_2 emission factors varied only by fuel type (gasoline, diesel, CNG, flex-fuel, Bi-fuel, and biodiesel). For on-road vehicles, the CH_4 and N_2O emission factors were dependent upon the vehicle type, fuel type, and model year of the vehicle. These emission factors were obtained from EPA’s latest GHG Inventory report (EPA, 2007). The CO_2 emission factors are expressed in units of mass per gallon of fuel consumed while the CH_4 and N_2O emission factors are expressed in units of mass per VMT. For non-road vehicles, CH_4 and N_2O emission factors in units of mass per gallon of fuel consumed were assigned to all vehicles, dependent only on fuel type. These emission factors came from the IPCC Guidelines. (IPCC, 2006)

Once emission factors for CO_2, CH_4, and N_2O were assigned to all fleet vehicles, emissions of each of these gases were calculated by multiplying the emission factor by the corresponding activity – gallons consumed for CO_2 and VMT for CH_4 and N_2O in the case of on-road vehicles and gallons consumed for non-road vehicles. The resulting emissions were then totaled by facility with which each vehicle was associated. All Public Safety department vehicles were totaled together, regardless of facility. The CH_4 and N_2O emissions totals were multiplied by their GWP coefficients to calculate their CO_2 equivalents.

In addition to the data provided by CAD, PANYNJ provided data for the amount of propane used in firefighting equipment at JFK. Emissions from this fuel use were calculated based entirely on fuel volume and added to the Public Safety Department emissions.

7.1.4. Results

Table 7-1 summarizes the GHG emission estimates from PANYNJ on-road fleet vehicles and Table 7-2 summarizes GHG emissions from off-road engine/vehicle fuel use reported by the Central Automotive Division. In both cases, emissions are further broken down by the facility that the vehicles are associated with. The fleet vehicle GHG emissions are dominated by CO_2 emissions, with emissions of CH_4 and N_2O contributing much less. CO_2 emissions account for nearly 98 percent of the CO_2e emissions.

Table 7-1. On-road Fleet Vehicle GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Brooklyn Piers	76	1.79E-03	2.15E-03	77
Downtown Heliport	6	3.13E-04	6.04E-04	6
George Washington Bridge	316	1.45E-02	1.65E-02	321
Holland Tunnel	363	2.54E-02	6.78E-03	365
JFK Int. Airport	1,223	2.85E-01	7.73E-02	1,253
LGA Airport	665	1.29E-01	3.31E-02	678
Lincoln Tunnel	492	2.00E-02	1.43E-02	497
Long Term Rental Pool	220	1.41E-01	2.07E-02	229
New York Marine Terminal	11	1.64E-03	4.99E-04	11
Newark Legal Center	3	0	0	3
Newark Liberty Int. Airport	911	9.48E-02	4.57E-02	927
NY Motor Pool	134	4.56E-03	4.16E-03	135
P.A. Bus Terminal	12	3.41E-04	4.92E-04	12
P.A. Technical Center	1,046	3.03E-01	4.85E-02	1,067
P.A. Technical Center Short Term Pool	147	2.13E-03	2.80E-03	148
Park Avenue Offices	134	1.89E-03	3.25E-03	135
PATH Rail Transportation	149	7.04E-02	1.68E-02	156
Port Newark Facilities	64	1.73E-03	2.80E-03	65
Port Newark Marine Terminal	154	7.18E-03	1.17E-02	158
Rehabilitation Shop at 777	2	1.28E-04	2.46E-04	2
Staten Island Bridge Facilities	258	4.76E-02	1.77E-02	265
Teterboro Airport	6	1.20E-04	2.06E-04	6
World Trade Center Building Site	6	2.67E-04	5.70E-04	6
Public Safety Department Total	4,180	3.51E-01	1.25E-01	4,226
Total	***10,577***	***1.50E+00***	***4.52E-01***	***10,749***

Table 7-2. Non-road Fleet Vehicle GHG Emissions by Gas and CO_2 Equivalent

Facility	Greenhouse Gas Emissions Totals (metric tons)			
	CO_2	CH_4	N_2O	CO_2 Equivalent
Brooklyn Piers	0.6	0	0	0.6
George Washington Bridge	2	0	0	2
Holland Tunnel Total	24	1.35E-03	9.16E-03	27
JFK Int. Airport Total	78	3.45E-03	3.00E-03	79
LGA Airport Total	8	1.84E-04	1.77E-04	8
Lincoln Tunnel Total	14	2.21E-04	2.30E-04	14
Newark Liberty Int. Airport Total	5	1.31E-04	1.09E-04	5
P.A. Technical Center Total	8.1	4.54E-04	3.13E-03	9.1
Staten Island Bridge Facilities Total	0.4	0	0	0.4
Public Safety Department Total	1020	3.45E-02	1.86E-02	1025
Nonroad Fleet Vehicles Total	***1160***	***4.03E-02***	***3.44E-02***	***1171***

7.2. CONSTRUCTION EQUIPMENT

7.2.1. Boundary

The boundary for construction equipment includes any construction equipment used during the 2006 calendar year in Port Authority capital projects.

7.2.2. Facilities Included in the Inventory

PANYNJ provided 2006 construction work in progress (WIP) spending data for its facilities (PANYNJ, 2007b). The PANYNJ WIP spending data was then assigned to counties. For PATH facilities, PANYNJ provided the county assignments. Table 7-3 lists the facilities included in this inventory by county where construction equipment operated during 2006. The assumptions used in assigning the facilities to counties were as follows:

1. For Tunnels and Bridges, the WIP construction spending for each bridge and tunnel was split evenly between the two counties that the bridge or tunnels spans.
2. For all the “multi-facilities,” the WIP construction spending was split in proportion to the total WIP spending by county for the other facilities.

In so doing, it was determined that there was no report of construction WIP spending in Bronx County, New York.

Table 7-3. PANYNJ Facilities Where Construction Occurred in 2006

Facility	County/State
AVIATION	
John F. Kennedy International Airport	Queens, NY
LaGuardia Airport	Queens, NY
Newark Liberty International Airport	Essex, NJ
Teterboro Airport	Bergen, NJ
AirTrain JFK	Queens, NY
REAL ESTATE & DEVELOPMENT	
World Trade Center	New York, NY
Port Authority Technical Center	Hudson, NJ
TUNNELS & BRIDGES	
George Washington Bridge	New York, NY & Bergen, NJ
Bayonne Bridge	Richmond, NY & Hudson, NJ
Geothals Bridge	Richmond, NY & Essex, NJ
Outerbridge Crossing	Richmond, NY & Union, NJ
Lincoln Tunnel	New York, NY & Hudson, NJ
Holland Tunnel	New York, NY & Hudson, NJ
PORT COMMERCE	
Port Newark	Essex, NJ
Elizabeth Marine Terminal	Essex, NJ
Arthur Kill	Richmond, NY
Howland Hook Marine Terminal	Richmond, NY

Facility	County/State
Brooklyn PA Marine Terminal (Brooklyn Piers)	Kings, NY
PATH	
World Trade Center	New York, NY & Hudson, NJ

7.2.3. Methods

Construction equipment emissions were estimated using information about construction spending by the PANYNJ during 2006 as a surrogate for fuel use in construction equipment. Because there is no direct link between construction spending and GHG emissions, EPA's NONROAD model was used to estimate fuel use and associated GHG emissions at the county-level for the New York and New Jersey counties where the PANYNJ had some construction activity in 2006. Then data were obtained from McGraw-Hill on the county-level construction dollars spent during 2006. The McGraw-Hill data was used to compute the ratio of PANYNJ construction spending to total county-level construction spending. The resulting county ratios were multiplied by the county-level CO_2, CH_4, and N_2O emissions obtained from the NONROAD2005 model to yield the PANYNJ GHG estimates.

EPA's NONROAD2005 Model (EPA, 2005) was run to estimate 2006 construction equipment emissions for the following counties:

- Bergen County, NJ;
- Essex County, NJ;
- Hudson County, NJ;
- Union County, NJ;
- Bronx County, NY;
- Kings County, NY;
- New York County, NY;
- Queens County, NY; and
- Richmond County, NY.

To estimate pollutant emissions, the NONROAD model multiplies equipment populations and their associated activity by the appropriate emission factors. Geographic allocation factors are used to distribute national equipment populations to counties and states. These factors are based on surrogate indicators of equipment populations. For example, the 2003 value of construction adjusted for geographic construction material cost differences is the surrogate indicator used in allocating construction equipment. A national average engine activity (i.e., load factor times annual hours of use) is used in NONROAD.

The construction equipment emissions, including fuel consumption, are reported at the equipment type and fuel type level in the NONROAD model. For this analysis, the county-level emissions were summed up to the fuel type level.

The model estimates emissions for the following fuel types: 2-stroke gasoline; 4-stroke gasoline; diesel fuel; liquid petroleum gas (LPG); and CNG.

County-level fuel consumption obtained from the NONROAD model runs were used in conjunction with CO_2, CH_4, and N_2O default emission factors from IPCC Guidelines Table 3.3.1 for Motor Gasoline and Diesel (IPCC, 2006) and Tables 3.2.1 and 3.2.2 for LPG and CNG (IPCC, 2006) to estimate GHG emissions. Emission factors are expressed in kg/TJ; therefore, gasoline fuel consumption was converted to an energy basis using a conversion factor of 1.2496E-4 TJ per gallon gasoline (IOR, 2007). Diesel fuel consumption was converted to an energy basis using a conversion factor of 1.4990E-4 TJ per gallon of diesel fuel (IOR, 2007). LPG fuel consumption was converted to an energy basis using a conversion factor of 9.58E-5 TJ per gallon LPG (IOR, 2007). CNG fuel consumption was converted to an energy basis using a conversion factor of 2.41E-5 TJ/gallon CNG (CNG, 2007). GHG emissions were estimated by multiplying the converted fuel consumption by the GHG emission factors from Tables 3.3.1, 3.2.1, and 3.2.2 of the 2006 IPCC Guidelines.

7.2.4. Results

Table 7-4 summarizes the construction equipment GHG emission estimates for the facilities included in the inventory. Diesel fueled construction equipment is the predominant contributor of emissions in all facilities, with

Aviation facilities being the predominant contributor of emissions across all fuel types. GHG emissions are dominated by CO_2 emissions, with CH_4 and N_2O contributing much less. CO_2 emissions are approximately 90 percent of the total CO_2e emissions.

Table 7-4. Construction Equipment GHG Emissions by Gas and CO_2 Equivalent

Facility	State	County	Greenhouse Gas Emissions Totals (metric tons)			
			CO_2	CH_4	N_2O	CO_2 Equivalent
Aviation						
Teterboro Airport	New Jersey	Bergen	741	0	0	829
Newark Airport	New Jersey	Essex	2,430	0	1	2,719
JFK Airport	New York	Queens	9,510	0	4	10,638
JFK Air Train	New York	Queens	1,177	0	0	1,316
LaGuardia Airport	New York	Queens	2,160	0	1	2,416
Aviation - Multi-Facility			1,864	0	1	2,085
PATH						
PATH	New Jersey	Hudson	1,032	0	0	1,155
PATH	New York	New York	71	0	0	71
Port Commerce						
Port Elizabeth	New Jersey	Essex	893	0	0	999
Port Newark	New Jersey	Essex	732	0	0	819
Brooklyn Piers	New York	Kings	138	0	0	154
PCP444171	New York	Queens	108	0	0	120
Arthur Kill	New York	Richmond	319	0	0	357
Howland Hook	New York	Richmond	6,353	0	2	7,106

Facility	State	County	Greenhouse Gas Emissions Totals (metric tons)			
			CO_2	CH_4	N_2O	CO_2 Equivalent
Port Commerce – Multi-Facility			1,825	0	1	2,041
Tunnels, Bridges, & Terminals						
George Washington Bridge			2,548	0	1	2,725
Goethals Bridge			3,443	0	1	3,851
Bayonne Bridge			1,288	0	0	1,440
Outerbridge Crossing			1,218	0	0	1,362
Holland Tunnel			789	0	0	844
Lincoln Tunnel			662	0	0	707
TB&T - Multi-Facility			719	0	0	791
World Trade Center						
World Trade Center	New York	New York	990	0	0	995
World Trade Center - Security-related work split among PATH (Journal Square Transportation Center), TB&T (G.W. Bridge) and the Public Safety Department (Port Authority Technical Center)	New Jersey	Hudson	57	0	0	63
World Trade Center – Real Estate & Development Department (FR=Ferry Terminal)	New York	New York	1,290	0	0	1,295
World Trade Center – Multi Facility	New York	New York	1,381	0	0	1,387
Total			**43,738**	**1**	**15**	**48,287**

Note that the uncertainty associated with emission estimates for construction is high. This is due to the use of a national model that relies on a surrogate indicator (dollar value of construction in 2003) to estimate activity and emissions at the county level, coupled with the use of Port Authority spending data to further allocate county-level emissions to the facility level. A more robust method would rely on actual fuel use records by construction project for the year of interest.

7.2.5. Comparison with Estimates in Previous Studies

An economic impact study (EIS) was performed for construction activity and emissions associated with redevelopment of the Lower Manhattan WTC site, including the WTC PATH Terminal (PANYNJ, 2008). The emissions reported in the EIS were developed using emission factors available from EPA's NONROAD model, applied to project-specific equipment fleets and operating schedules. CAP emissions from the EIS were compared to CAP emissions developed as part of the PANYNJ's 2006 inventory for New York County. Table 7-5 shows this comparison. Note that assumptions were made in allocating portions of the total spending and associated emissions to counties for TB&T. Therefore, the table breaks out the contribution of these facilities from the PATH and WTC facilities. These emissions are comparable, yet differences are likely resulting from the EIS's use of local activity levels associated with the construction projects being analyzed.

Table 7-5. Comparison of 2006 New York County Construction Equipment Emissions, tons per year

Pollutant	PANYNJ 2006 Inventory			EIS for New York County*
	Total New York County	TB&T	PATH and WTC	
VOC	9.3	3.0	6.2	1.6
NO_x	57.8	18.9	38.8	37.3
$PM_{2.5}$	5.2	1.7	3.5	1.5

*On-site emissions were estimated in EIS as a fraction of total construction emissions, which also included indirect emissions associated with related on-road activity.

7.3. EMPLOYEE COMMUTING BOUNDARY

The GHG emissions from PANYNJ employee commuting are associated with the employees commuting to and from work. Employee commuting in vehicles not owned or controlled by the PANYNJ, such as light rail, train, subway, buses, and employees' cars are indirect emissions categorized under Scope 3 emissions. Emissions from business travel by employees via train, commercial plane, and non-company owned cars are not included in the emissions estimate.

7.3.1. Facilities Included In the Inventory

The PANYNJ facilities shown in Table 7-6 are included in the operational boundary for estimating emissions from employee commuting.

Table 7-6. PANYNJ Facilities Included in Employee Commuting Emission Estimates

Number	Facility Name
1	115 Broadway
2	225 Park Avenue South
3	233 Park Avenue South
4	5 Marine View
5	777 Jersey Avenue
6	AirTrain JFK/ AirTrain Network
7	Auto Marine Terminal and Greenville Yard
8	Bayonne Bridge
9	Brooklyn PA Marine Terminal
10	Downtown Manhattan Heliport
11	Gateway Plaza I
12	Gateway Plaza II
13	Gateway Plaza III
14	George Washington Bridge
15	George Washington Bridge Bus Station
16	Goethals Bridge

Number	Facility Name
17	Harrison Car Maintenance Facility
18	Holland Tunnel
19	Howland Hook Marine Terminal and Port Ivory
20	John F. Kennedy International Airport
21	Journal Square Transportation Center
22	KAL Building at JFK
23	LaGuardia Airport
24	Lincoln Tunnel
25	Newark Liberty International Airport
26	One Madison Avenue
27	Outerbridge Crossing
28	PATH station
29	Port Authority Bus Terminal
30	Port Authority Technical Center
31	Port Newark/Elizabeth Marine Terminal
32	Teterboro Airport
33	The Teleport
34	Waldo Yard Buildings
35	World Trade Center

7.3.2. Methods

7.3.2.1. Activity Data for Employee Commuting

PANYNJ employee commuting emissions were estimated by activity data measured in the total distance that employees travel to and from work, the modes of transportation they use to travel, and CO_2 emission factors for each travel mode. PANYNJ is a relatively large organization with over 7,000 employees. GHG Protocol based "Working 9 to 5 on Climate Change: An Office Guide" and calculation tools based on a survey method developed by WRI were used to estimate employee commuting emissions (WRI, 2002). The survey results were adjusted for the 11 holidays observed by PANYNJ each year.

To determine employee commuting activity, a web-based survey was developed and implemented during December 2007. PANYNJ employees were queried for the following information:

- Mode of transportation (e.g., car, bus, train, walk, skateboard, others);
- Average round trip distance traveled by the employee between work and home;
- Average number of days per week the employee commutes;
- For the employees who drive to work, the fuel efficiency of the employee's vehicle, fuel type, and the number of people who travel with the employee;
- Information about commuting combinations used. For example, an employee may drive to a central location such as a train station or a bus depot and then travel the rest of the way to work by train or bus.

Distance traveled is the principal activity indicator for all modes of transportation except cars, for which fuel use is used to estimate GHG emissions.

To improve response rate, the survey was designed to be short, quick, and user friendly. To increase the accuracy of data, a high participation rate from a varied audience was targeted. The data input in the survey was checked by comparing the total number of weekdays an employee travels to work and the sum of weekdays entered by the employee for various commuting combinations.

7.3.2.2. Activity Data & Emissions – Car Travel

The methodology to estimate emissions from car use is based on fuel use approach. A three-step calculation methodology described in GHG Protocol based "Working 9 to 5 on Climate Change: An Office Guide" developed by WRI was used to estimate the total fuel use for commuting by car (WRI, 2002).

Step 1. The total distance traveled by an employee's typical commute was captured using the survey. Total distance traveled by an employee in a year was estimated using information provided on the number of days worked in the organization per year. This estimate took into consideration that the PANYNJ observes 11 holidays per year.

*Total annual distance traveled = Number of days commuted per annum * Distance traveled per day*

Step 2. Total fuel use was estimated using the total distance traveled times the fuel efficiency of the car. Each car has a different fuel economy and fuel type, so the calculations were made separately for each fuel type and employee. For survey responses where personal vehicle fuel economy values were missing, default values were obtained from DOE (DOE, 2007). Table 7-7 shows average fuel economy values.

*Fuel use = Total annual distance traveled by employee * Fuel economy of the car*

Table 7-7. Passenger Car Commuting Fuel Economy Values

Fuel Type	Miles per Gallon
Gasoline Mileage	24.7
Diesel Mileage	24.0

Step 3. Fuel use per employee was estimated by dividing the total fuel usage by the number of people sharing the car. Estimates of vehicle occupancy rates were taken from survey responses.

Fuel use per employee = Estimated fuel use / Number of people in car

Car travel emission factors based on fuel use and the corresponding emission factors from GHG Protocol's calculation tools for service-sector companies were used to estimate the emissions (WRI, 2006). Table 7-8 shows emission factors by fuel type.

Table 7-8. Passenger Car Commuting Emission Factors

Fuel Type	kg CO_2/Gallon
Gasoline	8.87
Diesel	10.15

7.3.2.3. Activity Data & Emissions – Train, Light Rail, and Bus Travel

Emissions from train, light rail, and bus travel are estimated as CO_2 per passenger mile or kilometer traveled. The emission factors from the GHG Protocol's calculation tools for service-sector companies were used to estimate the emissions (WRI, 2006) and are shown in Table 7-9.

Table 7-9. Bus and Rail Commuting Emission Factors

Train Type	kg CO_2/mile
US Intercity Rail (i.e., Amtrak)	0.314
US Transit Rail (e.g., subway, PATH)	0.169
US Commuter Rail (i.e., NJ Transit)	0.163
CNG, urban (buses)	0.228

The following assumptions were made based on the information obtained from the American Public Transportation Association (APTA, 2007).

- Subway emission factors were based on U.S. Transit Rail.
- Metro North emission factors were based on U.S. Commuter Rail.
- PATH Train emission factors were based on U.S. Transit Rail.
- NJ Transit Train emission factors were based on U.S. Commuter Rail.
- Long Island Railroad emission factors were based on U.S. Commuter Rail.
- Amtrak Train emission factors were based on U.S. Intercity Rail.
- Bus emissions were calculated using the CNG emission factor.

7.3.3. Results

The emissions from each mode of transport were added to obtain the total estimated emissions for all employees that completed the survey. The survey captured a total of 1,166 valid responses out of 1,185 responses collected. This sample is appropriate for a 7,000 employee organization according to "Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations" (EPA, 2005). The survey sample was extrapolated to the entire population using the following equation:

*Total estimated emissions = Emissions from sample group * Ratio (number of employees in organization / number of employees in sample group)*

GHG emissions estimates are summarized in Table 7-10.

Table 7-10. Employee Commuting GHG Emissions by Gas and CO_2 Equivalent

Source	**Greenhouse Gas Emission Totals (metric tons)**			
	CO_2	**CH_4**	**N_2O**	**CO_2e (metric Tons)**
Employee Commuting	27,080	N/A	N/A	27,080

Emissions from car travel accounted for 66 percent of total emissions. 20 percent of the emissions estimated were from Metro North, NJ Transit, and Long Island RR travel.

7.4. MOBILE SOURCES EMISSIONS SUMMARY

Table 7-11 summarizes the GHG emissions from mobile sources which could not be separated across departments, specifying the source of the emissions and the amount which falls under each scope for each source.

Table 7-11. Mobile Sources 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	**Scope 2**	**Scope 3**	**Facility Emission Totals**
Fleet Vehicles- NY Motor Pool & Long Term Rental Pool	364	-		364
Public Safety Department Fleet Vehicles	5,252	-		5,252
Direct Fugitive Emissions - Central Automotive Division	708	-	-	708
Construction Equipment	48,287	-		48,287
Employee Commuting	-	-	27,080	27,080
Mobile Sources: Multiple Departments	**54,611**	-	**27,080**	**81,691**

7.5. REFERENCES

APTA, 2007: American Public Transportation Association, commuter rail information was obtained from APTA and is available at http://www.apta.com/research/stats/rail/crservuse.cfm, 2007.

CNG, 2007: CNG Service of Arizona, "Compressed Natural Gas," available at (http://www.cngaz.com/forms/WhatCNG.pdf), 2007.

DOE, 2007: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual *Energy Outlook* 2007**,"** Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

DOE, 2007: U.S. Department of Energy, Energy Information Administration, "Annual Energy Outlook 2007 with Projections to 2030 - Supplemental Tables to the Annual Energy Outlook 2007**,"** Report # DOE/EIA-0383(2007), http://www.eia.doe.gov/oiaf/aeo/supplement/sup_tran.xls, February 2007.

EPA, 2002: U.S. Environmental Protection Agency, "Study of Exhaust Emissions from Idling Heavy-Duty Diesel Trucks and Commercially Available Idle Reduction Devices", EPA-420-R-02-025, Office of Transportation and Air Quality, October 2002.

EPA, 2005: U.S. Environmental Protection Agency, "Guidance for Quantifying and Using Emission Reductions from Best Workplaces for Commuter Programs in State Implementation Plans and Transportation Conformity Determinations," 2005.

EPA, 2005: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, *NONROAD2005*, [Computer software], available at (http://www.epa.gov/otaq/nonrdmdl.htm#model), December 7, 2005.

EPA, 2007: U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*, USEPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

IOR, 2007: IOR Energy, "Engineering Conversion Factors," available at (http://www.ior.com.au/ecflist.html), 2007.

IPCC, 2006. Intergovernmental Panel on Climate Change, "2006 IPCC Guidelines for National Greenhouse Gas Inventories," Volume 2, Energy, Intergovernmental Panel on Climate Change, 2006.

PANYNJ, 2007a: Port Authority of New York and New Jersey, data spreadsheet EPA Emissions Data Updated.xls, provided by Jeff Trilling, Central Automotive Division, PANYNJ, September 27, 2007.

PANYNJ, 2007b: Port Authority of New York and New Jersey, "PANYNJ_2006 construction data.xls," sent via email on October 31, 2007.

PANYNJ, 2008. *Chapter 9, Chapter 15, and Appendix D of World Trade Center Environmental Impact Analysis,* files included in emails entitled, "WTC EIS Info" from G. Sarrinikolaou, PANYNJ, sent to J. Wilson, E.H. Pechan and Associates, Inc., January 31, 2008.

WRI, 2002: World Resources Institute, "Working 9 to 5 on Climate Change: An Office Guide," prepared by Samantha Putt del Pino and Pankaj Bhatia, 2002.

WRI, 2006: World Resources Institute, “CO_2 Emissions from Employee Commuting, Version 2.0, June 2006,” June 2006.

8.0 REAL ESTATE AND DEVELOPMENT

8.1. BUILDINGS

8.1.1. Boundary

The GHG emissions inventory boundary includes all PANYNJ operated buildings; buildings leased to tenants; and office space that the PANYNJ leases from other organizations.

8.1.2. Facilities Included In the Inventory

All facilities listed in Table 1-3 of this report are included in this building energy use category.

8.1.3. Methods

Methods used to estimate GHG emissions from buildings depend on the energy source (indirect electricity; natural gas; or steam) and the availability of data for that energy source. GHG emission factors were developed and applied separately for each energy source and were mostly differentiated by state depending on the characteristics of the fuel mix providing electricity or natural gas to the PANYNJ and its tenants.

Most of the estimates of indirect electricity usage during 2006 were provided by the PANYNJ. Electricity consumption was not available by facility except in rare cases. New York State electricity is provided by the New York Power Authority. In New Jersey, electricity for large accounts is purchased from Constellation Energy and from PSE&G for all other accounts. The category of direct emissions from combustion is dominated by natural gas used for heating. Calendar year 2006 fuel consumption data were provided by PANYNJ.

Because the electricity used in New York and New Jersey is generated from different fuel mixes, the indirect emissions are different. Electricity emission factors were taken from eGRID2006 (Pechan, 2007). The factors were taken from two eGRID sub-regions: one which includes New York City and Westchester, and another which includes New Jersey. These factors are representative of the regional power pools. The electricity factors were differentiated by state, as shown in Table 8-1 below.

Table 8-1. Building Energy Use Electricity and Natural Gas Emission Factors

Indirect Electricity Emission Factors (pounds/megawatt hour)			
State	**CO_2**	**Methane**	**Nitrous Oxide**
New Jersey	1096	0.0081	0.0089
New York	922	0.0077	0.0079
Natural Gas Emission Factors (kg/million Btu)			
	CO_2	**Methane**	**Nitrous Oxide**
	52.78	0.059	0.0001

The only major exception to this was the electricity use at John F. Kennedy International Airport, which was provided by their on-site cogeneration facility. Individual emission factors for both the electricity derived from the cogeneration plant and the heating and cooling from the steam not used for electricity generation were derived as explained in Section 2.4. In addition, the Port Authority Bus Terminal reported usage of purchased steam for heating. This steam was assumed to have a total generation and delivery efficiency of 75% in accordance with The Climate Registry General Reporting Protocol. The steam was assumed to be generated by oil and natural gas. Scope 2 emissions from this purchased steam were extremely small compared to the electricity use.

There were a number of instances where electricity and natural gas usage were not available, and in these instances, estimates of building square footage were used to approximate the 2006 energy use. Where fuel usage was not available, GHG emissions for commercial building energy consumption during 2006 was estimated using emission rates for typical building types in pounds per square foot. Carbon emissions from building energy use were estimated by the average energy usage of similar building types. Energy use for the typical office building is estimated at 93 kBtu per square foot, and energy use for warehouse and storage is about one-half of that at 45 kBtu per square foot. These estimates are based on the DOE EIA's 2003 Commercial Building Energy Consumption Survey – Table C1. Total Energy Consumption by Major Fuel for Non-Mall Buildings, 2003 (EIA, 2006).

Using the Commercial Building Energy Consumption Survey table, the percentage of the energy in the form of electricity and in the form of heating fuel was calculated for both office space and warehouse space. On average, the energy use for both the typical and Energy STAR office building consists of 63 percent electricity and 37 percent natural gas. The split for warehouse and storage space was somewhat different, with a smaller share of the energy use by electricity. These percentages were applied to the energy per square foot rates to determine the electricity use per square foot and energy from natural gas use per square foot. These rates were converted into emissions per square foot factors by multiplying by unit conversion factors and the electricity and natural gas emission factors listed above.

Individual emissions factors were developed for the facilities without electricity and gas use data that have mixed space use proportional to the square footage for each usage type. This was necessary for the Bathgate Industrial Park and the George Washington Bridge Bus Terminal. Using the same Commercial Building Energy Consumption Survey table, proportions between the average electricity and gas usage of facilities used only occasionally to those used during normal hours was developed and applied to the space at I Gateway plaza, which was a rarely used conference room.

Having the activity data in the form of kWh of electricity used and therms of natural gas used is the preferred method for applying emission factors. The method of using square footage factors was developed for this inventory.

Full Scope 3 electricity usage data was unavailable for Newark Airport Terminal tenants, Port Newark Marine Terminal, and Elizabeth Marine Terminal. Rather than develop square footage estimates for these very large areas, a load analysis for Port Newark was received from PSE&G, which included the airport terminal, monorail, and Central Heating and Refrigeration Plant, as well as Port Newark/Elizabeth North and South warehouses and Car Terminal. The data received showed the kilowatt hours used on a peak day in August, when consumption was at its highest. To convert this data into annual activity data, eighteen power plants which supply electricity to four PSE&G subsidiaries in New Jersey were found using eGRID. Peak to annual electricity usage from these plants was analyzed using 2006 daily data queried from the EPA’s Clean Air Markets Division website. (EPA, 2007) On average, it was found that the annual electricity consumption was about 149 times more than the usage on a peak day. This factor was used to supply the surrogate data for the airport terminal and the two marine terminals. The accuracy of this method was demonstrated by the fact that it provided numbers in close agreement with billing kWh data received for the Central Heating and Refrigeration Plant and monorail. Scope 2 emissions at the Newark terminal were determined from bills provided by the Port Authority and were subtracted from the peak load analysis to estimate the total Scope 3 emissions at the airport.

There was no way to distinguish between the electricity used by the Port Authority and the electricity resold to tenants in the New York airports using the 2006 activity data. Therefore, the relative percentages of electricity used by metered tenants and the Port Authority was used to divide the emissions in LaGuardia between Port Authority use (55.2 percent - Scope 2) and tenant use (44.8 percent - Scope 3) using 2007 utility bills. For JFK main terminal electricity use, which is purchased from the KIAC Plant, the Port Authority accounted for 48 percent of electricity consumption in 2007 and tenants accounted for 29 percent. With a lack of better information, the remaining 23 percent was divided evenly between the Port Authority and tenants, making the final distribution 59.5 percent Scope 2 Port Authority use and 40.5 percent Scope 3 tenant use.

In addition to the other utilities reported, the Aviation department reported natural gas and heating oil use. Emissions were calculated for these sources using emission factors from the IPCC guidelines, and they were attributed to the Port Authority as Scope 1 emissions.

8.1.4. Results

Indirect emissions from electricity use made up a greater portion of the total emissions than the direct emissions from natural gas combustion. Each department's total CO_2 equivalent emissions are listed in Table 8-2. The division of emissions by scope of this inventory is included in Table 8-3, showing that the majority of emissions come from facilities not directly under PANYNJ control.

Table 8-2. Natural Gas and Indirect Electricity GHG Emissions from Facilities by Department

Department	Natural Gas Direct CO_2 Equivalent Emissions (metric tons)	Electricity Use Indirect CO_2 Equivalent Emissions (metric tons)	Total CO_2 Equivalent Emissions (metric tons)
Aviation[a]	19,702	281,602	301,304
Real Estate & Development	6,262	215,813	222,075
Tunnels, Bridges, & Terminals	1,087	33,399	34,486
Port Commerce	9,568	41,001	50,570
PATH Rapid Transit System	-	12,743	12,743
Total	**36,619**	**584,559**	**621,177**

[a] At JFK, natural gas emissions were considered indirect, as the facility was not heated with natural gas furnaces, but with purchased steam generated by the natural gas fired KIAC Plant.

Table 8-3. Natural Gas and Indirect Electricity GHG Emissions by Inventory Scope

Facility Management	Natural Gas Direct CO_2 Equivalent Emissions (metric tons)	Electricity Use Indirect CO_2 Equivalent Emissions (metric tons)	Total CO_2 Equivalent Emissions (metric tons)
PANYNJ Operated	21,221	206,074	227,295
Leased to Tenants	15,397	378,485	393,882

8.2. RESOURCE RECOVERY FACILITY

8.2.1. Boundary

The GHG emissions from the Essex County Resource Recovery facility are associated with municipal solid waste (MSW) combustion as well as combustion of fossil fuel for auxiliary usage. Emissions associated with hauling and tipping of waste is not included in the total emissions estimates from this facility, since they are considered outside of the operational boundaries of the facility.

8.2.2. Facilities Included In The Inventory

The Essex County Resource Recovery Facility.

8.2.3. Methods

8.2.3.1. Solid Waste Combustion

Activity data in the form of the amount of waste combusted were used along with emissions factors to estimate the total quantity of pollutants emitted. Total MSW combusted in 2006 was 891,117 tons. These data were provided by the facility owners. The facility does not have a reliable waste characterization study.

The method for estimating CO_2 emissions from incineration of MSW was based on an estimate of the fossil carbon content in the waste combusted multiplied by the oxidation factor, and estimating the amount of fossil carbon oxidized to CO_2. The activity data are the waste inputs into the incinerator and the emission factors are based on the oxidized carbon content of the waste that is of fossil origin. Relevant data include the amount of and composition of the waste, the dry matter content, the total carbon content, the fossil carbon fraction, and the oxidation factor.

The EPA's waste characterization data for discarded solid waste were used to define the waste composition of MSW combusted (EPA, 2005) and are given in Table 8-4. Non-combustible materials such as glass, metals, and other inert material were assumed to be separated from the waste combusted and were therefore excluded from the composition. The 2006 Annual Truckload Inspection and Ash Analysis Findings Report (PANYNJ, 2006) was analyzed to determine the waste composition of MSW received by the Essex County Resource Recovery Facility. The information on waste characteristics provided in the report was not used because there was not enough detail in the report to derive weight percentages for the different components of the solid waste stream combusted at the facility (e.g., percent by weight of plastics, metals, glass, paper, food, yard debris, etc.). That level of detail is needed in order to assess the fossil based CO_2 emissions versus the biogenic CO_2 emissions from the facility (to account for the fossil based CO_2 in the inventory). Therefore, the EPA Report on national waste characteristics (EPA, 2005a) was used as a substitute source of data. The method based on the total amount of waste combusted by waste composition is outlined in the following equation:

$$CO_2 = (MSW * \text{Dry Matter Content} * \text{Carbon Content} * \text{Fossil Carbon} * \text{Oxidation Factor} * 44/12)$$

Table 8-4. Waste Composition of MSW Combusted GHG Emissions

MSW Component	Composition (mass %)
Paper/Cardboard	30.0
Textiles	7.0
Food Waste	20.0
Wood	9.0
Garden and Park Waste	9.0
Other (Diapers)	2.0
Rubber and Leather	4.0
Plastics	19.0
Metal	-
Glass	-

MSW Component	Composition (mass %)
Other, Inert Waste	-

Dry matter, carbon content, and fossil carbon content were estimated using IPCC data. The assumed waste composition data shown in Table 8-4 was used to revise the IPCC default values based on a comparison of the U.S. and IPCC waste characteristics. The most important variable is the fossil carbon content, which could be adjusted using the plastics content from the two waste profiles. Dry matter content data provided in *Volume 5, Chapter 2, Waste Generation, Composition and Management Data* of 2006 IPCC guidelines were used (IPCC, 2006a).

CH_4 emissions from waste incineration are dependent on the continuity of the incineration process, the incineration technology, and management practices. N_2O emissions from waste incineration are determined by type of technology and combustion conditions, the technology applied for NO_x reduction, as well as the contents of the waste stream. The CH_4 and N_2O emission factors provided in *Volume 2, Chapter 2, Stationary Combustion* of 2006 IPCC guidelines were used in estimating the emissions. Emissions were estimated by multiplying tons of waste combusted by each pollutant's emission factor (IPCC, 2006b). CH_4 and N_2O emission factors are shown in Table 8-5.

Table 8-5. Waste Combustion CH_4 and N_2O Emission Factors

Type of Incineration	CH_4 Emission Factor (kg/GT)	N_2O Emissions Factor (g/T waste)
Continuous Incineration	0.2	50

8.2.3.2. Fuel Combustion

The Essex County Resource Recovery Facility also combusted Type 2 distillate fuel in plant operations in 2006. The fuel was used as auxiliary fuel in the boilers. Activity data in the form of amount of fuel combusted along with emission factors were used to estimate emissions. The facility reported that the fuel oil combusted in plant operations during 2006 was 211,618 gallons. The total emissions from fuel combustion were calculated by multiplying gallons of fuel consumed with each pollutant's emission factor.

Emission factors for CO_2 provided in *Table C.5: Carbon Dioxide Emission Factors and Oxidation Rates for Stationary Combustion* (CCAR, 2007) were used to estimate CO_2 emissions. Emission factors for CH_4 and N_2O provided in *Table C.6: Methane and Nitrous Oxide Emission Factors for Stationary Combustion by Sector and Fuel Type* (CCAR, 2007) were used to estimate the emissions. The emission factors are shown below in Table 8-6.

Table 8-6. Fuel Based Emission Factors (Diesel)

Pollutant	Emission Factor (kg/gallon)
CO_2	10.15
CH_4	0.0014
N_2O	0.0001

The CO_2 emission factor already incorporates a factor for the fraction of carbon oxidized. The CO_2 fraction reflects the fact that slightly less than 100 percent of the carbon in the fuel consumed is completely oxidized.

8.2.4. Results

Emission estimates from the facility account for combustion processes only. There are minor emissions associated with trucking and hauling of waste as well as fuel use in support equipment. Emission estimates are not adjusted for the GHGs that are avoided due to electricity generation, recovery of metals, and methane emissions from landfills. Emissions from waste combustion were 90 percent of total emissions.

Estimated emissions are summarized in Table 8-7. The IPCC GWP factors were used to convert CH_4 and N_2O into their CO_2 equivalents.

Table 8-7. Essex County Resource Recovery Facility GHG Emissions by Gas and CO_2 Equivalent

Source	Greenhouse Gas Emission Totals (metric tons)			
	CO_2	**CH_4**	**N_2O**	**CO_2e (metric Tons)**
MSW Combustion	466,379	0.16	40	477,912
Fuel Combustion	2,148	0.3	0.02	2,161
Totals	**468,527**	**0.46**	**40**	**480,073**

8.2.5. Comparison with Estimates in Previous Studies

The Essex County Resource Recovery Facility reported their 2006 anthropogenic CO_2 emissions due to combustion of MSW and fuel usage to be 298,715 metric tons. Emission estimates can differ because of differences in waste characterization data. Emission estimates in this report are potentially higher than those developed by the facility as a result of a higher percentage of plastics in EPA's waste characterization data.

8.3. REAL ESTATE AND DEVELOPMENT EMISSIONS SUMMARY

Table 8-8 summarizes the GHG emissions from all facilities within the Real Estate and Development department, specifying the source of the emissions and the amount which falls under each scope for each source. Some additional emissions from mobile sources which could not be divided by facility appear in Table 7-11.

Table 8-8. Real Estate and Development Department 2006 GHG Emissions by Facility and Scope (metric tons CO_2 equivalent)

	Scope 1	Scope 2	Scope 3	Facility Emission Totals
Bathgate Industrial Park	**-**	**-**	**7,685**	**7,685**
Buildings	-	-	7,685	7,685
The Teleport	**-**	**-**	**30,148**	**30,148**
Buildings	-	-	30,148	30,148
The Legal Center	**3**	**-**	**6,914**	**6,917**
Buildings	-	-	6,914	6,914
Fleet Vehicles	3	-	-	3
World Trade Center (including WTC ERP)	**6**	**-**	**165,423**	**165,429**
Buildings	-	-	165,423	165,423
Fleet Vehicles	6	-	-	6
PA leased office space	**3,606**	**9,660**	**-**	**13,266**
Buildings	2,245	9,660	-	11,905
Fleet Vehicles	1,361	-	-	1,361
Essex County Resource Recovery Facility	**-**	**-**	**480,073**	**480,073**
Mixed Solid Waste Combustion Emissions	-	-	477,912	477,912
Fuel Combustion Emissions	-	-	2,161	2,161
REAL ESTATE & DEVELOPMENT	**3,615**	**9,660**	**690,243**	**703,518**

8.4. REFERENCES

CCAR, 2007: California Climate Action Registry, “California Climate Action Registry General Reporting Protocol,” Reporting Entity-Wide Greenhouse Gas Emissions Version 2.2 March 2007.

EIA, 2006: Energy Information Administration, “2003 Commercial Buildings Energy Consumption Survey: Consumption and Expenditures Tables, Table C1. Total Energy Consumption by Major Fuel for Non-Mall Buildings, 2003,” December 2006.

EPA, 2005a: U.S. Environmental Protection Agency, “Municipal Solid Waste in the United States,” 2005 Facts and Figures, Office of Solid Waste, 2005.

EPA, 2005b: U.S. Environmental Protection Agency, “LandGEM - Landfill Gas Emissions Model, Version 3.02, User’s Guide,” (EPA-600/R-05/047), Office of Research and Development, Clean Air Technology Center, http://epa.gov/lmop/, May 2005.

PANYNJ, 2006: Report provided by the Port Authority of New York & New Jersey, Essex County Resource Recovery Facility, “2006 Annual Truckload Inspection and Ash Analysis Findings Report”.

EPA, 2007: U.S. Environmental Protection Agency, Clean Air Markets Division “Clean Air Markets – Data and Maps,” [Data file query] Available from http://camddataandmaps.epa.gov/gdm/index.cfm

IPCC, 2006a: Intergovernmental Panel on Climate Change, “2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 2: Waste Generation, Composition and Management Data,” prepared by the National Greenhouse Gas Inventories Programme, Riitta Pipatti (Finland), Chhemendra Sharma (India), Masato Yamada (Japan), published: IGES, Japan, 2006.

IPCC, 2006b: Intergovernmental Panel on Climate Change, “2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 5: Incineration and Open Burning of Waste,” prepared by the National Greenhouse Gas Inventories Programme, G.H. Sabin Guendehou (Benin), Matthias Koch (Germany), Leif Hockstad (USA), Riitta Pipatti (Finland), and Masato Yamada (Japan), published: IGES, Japan, 2006.

Pechan, 2007: E.H. Pechan & Associates, Inc., “Emissions & Generation Resource Integrated Database for the year 2006 (2004 data), version 2.1,” April 2007.

(This page intentionally left blank)

9.0 DIRECT FUGITIVE EMISSIONS

9.1. BOUNDARY

The boundary for reporting direct fugitive emissions is the PANYNJ operated facilities listed in the Executive Summary of this report. Fugitive emissions are intentional and unintentional releases of GHGs from joints, seals, gaskets, etc. Direct emissions are emissions from sources that are owned or controlled by the reporting organization.

9.2. FACILITIES INCLUDED IN THE INVENTORY

All PANYNJ departments and facilities that use refrigerants are included. Direct fugitive emission estimates can include SF_6 emissions, but there was no SF_6 leakage at PANYNJ facilities during 2006. The electric power industry uses about 80 percent of the SF_6 produced worldwide, with circuit breaker applications accounting for most of this amount.

9.3. METHODS

Leakage from refrigeration systems, such as air conditioners and refrigerators, is common across a wide range of entities. Only those refrigerants that contain or consist of compounds of GHGs are reported. HFCs are the primary GHG of concern for refrigeration systems, particularly for motor vehicle air conditioners. Today, HFC-134a is the standard refrigerant for mobile air conditioning systems.

HFC emissions from air conditioners are estimated by performing a mass balance calculation and then converting each HFC emission to CO_2 equivalents. The mass balance method starts with a base inventory of all HFCs in use, and adjusts the total based on purchases and sales of HFCs and changes to the total refrigerant charge remaining in the equipment. The used HFCs that cannot be accounted for are assumed to have been emitted to the atmosphere.

Due to data availability, 2006 refrigerant emissions for the PANYNJ were estimated based on purchases of HFCs during the calendar year. While this does not provide a full accounting of refrigerant losses using a mass balance method, this estimation method is common for organizations in their first year of GHG emissions accounting.

Table 9-1 summarizes the reported PANYNJ refrigerant purchases during 2006. Freon gas (R-22) is subject to phase-out as an HCFC under the Montreal protocol regulations, so it is not counted as a GHG under reporting protocols such as the California Climate Action Registry. The U.S. Clean Air Act enforcement of the Montreal Protocol includes limiting HCFC consumption to a specific level and reducing the supply of HCFCs in a step-wise fashion beginning January 1, 2004. On September 21, 2007, the Montreal Protocol agreed to accelerate the phase-out of HCFCs. By 2010, in developed countries, the accelerated schedule calls for a 75 percent reduction from baseline consumption. By 2020, HCFC production is supposed to cease with a 0.5 percent of baseline for service permitted only until 2030. Therefore, GHG emission estimates for refrigerants are based on HFC-134a purchases only.

Table 9-1. 2006 Purchased Quantities of Refrigerants

Department/Facility	**Freon Gas R22 (pounds)**	**Freon Refrigerant R134A (pounds)**
Aviation-Newark Airport	180	
Aviation-JFK Airport	120	
PATH	180	30
Port Commerce-NJ Marine Terminals	30	30
TBT-George Washington Bridge	120	
TBT-Lincoln Tunnel	90	60
Operations Services Department-Central Automotive Division	30	1,200
Total	**750**	**1,320**
NOTE: The purchased quantities are recorded in 30-pound cylinders.		

9.4. RESULTS

GHG emission estimates for refrigerants purchased by the PANYNJ during calendar year 2006 are shown in Table 9-2. These estimates are based on Freon amounts that were ordered during 2006 and may not reflect what was used during the year. Future estimates should account for balances on hand at the beginning and end of the year.

Table 9-2. Direct Fugitive Loss GHG Emissions by Gas and CO_2 Equivalent

	Greenhouse Gas Emission Totals (metric tons)	
Department/Facility	**HFC-134a**	**CO_2e**
Aviation-Newark Airport	0	0
Aviation-JFK Airport	0	0
PATH	0.0136	17.7
Port Commerce-NJ Marine Terminals	0.0136	17.7
TBT-George Washington Bridge	0	0
TBT-Lincoln Tunnel	0.0272	35.4
Operation Services Department-Central Automotive Division	0.5442	707.5
Totals	**0.5986**	**778.3**

ADDENDUM

Revisions to the 2006 Base Year

Prepared by SC&A, Inc

July 5, 2017

Executive Summary of Revisions to the 2006 Base Year

Objective:

Enable a like-to-like comparison of GHG emissions across the temporal series, and more importantly, against the 2006 base year.

Methodology

Fugitive Emissions, Refrigerants

The initial base year only had a partial assessment and many data points were incongruent with later inventories known to have higher quality activity data. From EY2010 to EY2014, the inventory program made a strong push to have a full picture of refrigerant emissions by inventorying air conditioning (AC) equipment and their key characteristics, such as refrigerant type, charge, and cooling capacity. So, for the revised base year, we backcast the value from the 2012 to 2014 period that met the following two conditions: a) value was derived from a refrigerant survey, and b) the utilization coefficient was less than a full year, since AC equipment only runs in the warm season.

Application of this method resulted in the revision of all entries in the Scopes Table associated with the “Refrigerant and Fire Suppressants” activity, except for Ports NJMT, for which the original estimate was in line with subsequent years.

Energy Production, Essex County Resource Recovery Facility

The initial base year was calculated as a function of waste tonnage and a national profile of waste composition, yielding a low confidence assessment. For the revised base year, we tapped on GHG data collected by EPA per 40 CFR Part 98 since 2010, and supplemented that information with GHG and CAP data as retrieved from eGRID for 2007 to recreate an 8-year data series; note the eGRID library does not have 2006 data. SC&A performed a trend analysis and observed that plant emissions fell within a band. To fill in for 2006, SC&A assigned the median value of the 8-year period for each pollutant. For instance, biogenic CO_2 ranged from 368 kilotons to 530 kilotons, of which the median value was 381 kilotons.

Application of this method resulted in the revision of Energy Production emissions in the Scopes Table associated with the “Essex County Resource Recovery facility” short facility name.

Biogenic Emissions - Central Automotive Division, Employee Commuting, Elizabeth Landfill

The 2006 GHG inventory did not estimate biogenic emissions. For all three of these categories, biogenic emissions are estimated based on the 2006 estimate of anthropogenic emissions. For all three categories, the first year where biogenic emissions were estimated was used to establish a ratio of biogenic emissions to anthropogenic emissions for each category. For the Central Automotive division, 2010 was used for the ratio, and for Employee Commuting and Elizabeth

Landfill, 2013. This ratio was then applied to the 2006 estimate of anthropogenic emissions to estimate biogenic emissions in 2006.

Aircraft Emissions – Aircraft Movements

2006 Aircraft emissions were initially estimated using IPCC emission factors, which are very conservative and may potentially overestimate emissions. This analysis instead re-estimates these aircraft using the FAA's EDMS model (version 5.1.3), which was the standard tool for estimating aircraft emissions until it was replaced by the AEDT model. The 2006 aircraft list was converted into EDMS inputs using each aircraft's IPCC aircraft code. These aircraft totals were then normalized to match the FAA's ATADS database of total flights occurring at each airport in 2006 (as is done in all aircraft inventories from 2011 forward). EDMS then provides an emissions estimate of CO_2 and the CAPs. CH_4 and N_2O emissions were estimated in post processing based on the IPCC kg/LTO emission factors. For aircraft with no IPCC emission factors available, a weighted emission factor of kg/LTO was applied for each airport.

Aircraft Emissions – Ground Support Equipment

Ground Support Equipment (GSE) was not estimated in the initial 2006 inventory. There is no GSE equipment inventory available for 2006, so instead emissions are estimated based on the default assignment of GSE based on aircraft type in EDMS. This provides an estimate of CAP emissions from GSE, but not GHGs. To estimate CO_2 emissions, first we calculated a ratio of diesel and gasoline GSE for each airport from EDMS. Then CO_2 emissions from gasoline and diesel were estimated based on stoichiometry (that is the ratio between gasoline/diesel SO2 and gasoline/diesel CO_2 emissions). Then CH4 and N2O emissions were estimated using the ratio of CO_2 to CH4/N2O emissions seen in aircraft emissions.

Aircraft Emissions – APUs

Auxiliary Power Units (APUs) were not estimated in the initial 2006 inventory. There is no available information on APU units in 2006, so instead emissions are estimated based on the default assignment of APUs based on aircraft type in EDMS. This provides an estimate of CAP emissions from APUs, but not GHGs. To estimate CO_2 emissions, we use the ratio of SO2 to CO_2 emissions seen in aircraft emissions multiplied by the SO2 emissions from APUs. Then CH4 and N2O emissions were estimated using the ratio of CO_2 to CH4/N2O emissions seen in aircraft emissions. No adjustments were made for Ground Power Units or Pre conditioned air at any of the airports, because we do not have information about when these units were installed at each airport.

Filling in Missing Data from the 2006 Dataset

Many emissions categories were omitted from the 2006 inventory that need to be included. In many cases, there is not sufficient data to re-estimate emissions for these categories, so instead a later analysis year is used to fill in these missing emissions. Table 1 below shows the emissions categories that were filled in with the first available analysis year.

Table 1. Emissions Categories Where a Later Estimate Year Was Used to Fill in Missing 2006 Emissions

Scope	Department	PA Emission Category	Activity	Facility Short Name
1	Aviation	Stationary Combustion	Buildings	Teterboro Airport
1	Central Administration	Mobile Combustion	Executive Fleet	Fleet Vehicles
1	Multi-Department	Stationary Combustion	Emergency Generators and Fire Pumps	Emergency Generators and Fire Pumps
1	Multi-Department	Stationary Combustion	Welding	Multi-Facility
1	PATH	Stationary Combustion	Buildings	PATH Buildings
1	PATH	Fugitive Emissions	Refrigeration/Fire Suppression	PATH Trains
1	Real Estate	Stationary Combustion	Buildings	Real Estate NY
1	Tunnels, Bridges & Bus Terminals	Stationary Combustion	Buildings	Bus Terminals
1	Tunnels, Bridges & Bus Terminals	Fugitive Emissions	Refrigeration/Fire Suppression	Bus Terminals
1	Port	Stationary Combustion	Buildings	NJ Marine Terminals
1	Port	Stationary Combustion	Buildings	NY Marine Terminals
1	Port	Fugitive Emissions	Refrigeration/Fire Suppression	NY Marine Terminals
2	Aviation	Purchased Electricity	Buildings	Teterboro Airport
2	Real Estate	Purchased Electricity	Buildings	Real Estate NY
2	Tunnels, Bridges & Bus Terminals	Purchased Steam	Buildings	Bus Terminals
2	Tunnels, Bridges & Bus Terminals	Purchased Electricity	Buildings	Bus Terminals
2	Port	Purchased Electricity	Buildings	NJ Marine Terminals
2	Port	Purchased Electricity	Buildings	NY Marine Terminals
3	Aviation	Stationary Combustion	Buildings	AirTrain JFK
3	Aviation	Stationary Combustion	Buildings	John F. Kennedy International Airport
3	Planning	Stationary Combustion	Buildings	World Financial Center Terminal
3	Planning	Purchased Electricity	Buildings	World Financial Center Terminal
3	Real Estate	Purchased Electricity	Buildings	Industrial Park at Elizabeth
3	Real Estate	Purchased Electricity	Buildings	Queens West Waterfront Development
3	Real Estate	Purchased Electricity	Buildings	The South Waterfront
3	Real Estate	Stationary Combustion	Buildings	Industrial Park at Elizabeth
3	Real Estate	Stationary Combustion	Buildings	Queens West Waterfront Development
3	Real Estate	Stationary Combustion	Buildings	The South Waterfront

Filling in Questionable Data from the 2006 Dataset

There were also some emissions categories that had an emissions estimate in 2006 that is not in line with later estimates. We believe these estimates are not accurate and are most likely the result of incomplete data or different assumptions in the 2006 analysis. The first historical estimate where emissions are in line with later estimates was used to fill in the 2006 estimate. Table 2 shows the emissions categories where the 2006 estimate was replaced with an estimate from a later year.

Table 2. Emissions Categories Where a Later Estimate Year Was Used to Replace Questionable 2006 Emissions Estimates

Scope	Department	PA Emission Category	Activity	Facility Short Name
1	Aviation	Stationary Combustion	Buildings	Newark Liberty International Airport
2	Aviation	Purchased Electricity	Buildings	John F. Kennedy International Airport
3	Aviation	Purchased Electricity	Buildings	John F. Kennedy International Airport
3	Aviation	Stationary Combustion	Buildings	Newark Liberty International Airport
3	Aviation	Purchased Electricity	Buildings	Newark Liberty International Airport
3	Aviation	Stationary Combustion	Buildings	Teterboro Airport
3	Aviation	Purchased Electricity	Buildings	Teterboro Airport

Mobile Combustion – Ferry Movements

Mr. Amit Bhowmick, General Manager for the Ferry Transportation Program, confirmed that the World Financial Center (WFC) Terminal was operational in 2006. Furthermore, Mr. Bhowmick provided 2006 route information as well as schedule information on each active route. Combined, these data served as input to the 2006 revision.

SC&A reused the 2014 ferry movements analysis spreadsheet, with the following adjustments:

a. Replaced 2014 with 2006 route and schedule information
b. Maintained the same average engine age as in the 2014 analysis, namely 10.8 years
c. Kept all other engine specifications the same as in 2014.

A comparison between 2014 and 2006 show that routes and schedules were virtually identical, except that the Belford-WFC route was not operational in 2006. This is the main reason why 2006 emissions were lower by 5.4% from 2014.

Attracted Travel – 2006 Revisions

For this reanalysis, emissions were calculated in a manner as consistent as possible with the most recent methodology used. For most attracted travel categories, the most recent inventory year was 2012, although aviation attracted travel was calculated in the 2016 inventory. These more recent inventories have included the use of MOVES2014a emission factors for all attracted travel categories and pollutants. Unlike the predecessor MOBILE emission factor models, MOVES can provide emission factors for all pollutants of interest as well as emission factors for all activities of interest including vehicle travel, short term idling, extended idling, and starts.

MOVES inputs for this 2006 reanalysis were developed starting with activity data gathered for the original 2006 attracted travel emissions analysis. These data were reformatted as needed for input to MOVES. MOVES inputs that were not available from the original 2006 analysis used MOVES default data specific to the New York metropolitan area. Updated emission factors were calculated for a 2006 calendar year in a manner consistent with the latest attracted travel estimates. Also, where possible, the emission calculation templates from the most recent attracted travel analyses were used as the starting point for the updated 2006 analyses.

For several of the attracted travel categories, additional revisions were necessary to make the 2006 estimates more consistent with the latest estimates. These revisions are described by category below. For attracted travel categories not included here, the only revisions included the change to MOVES-based emission factors.

Attracted Travel – Aviation

Several significant changes were made to the 2006 activity used in the aviation attracted travel calculations.

- Through passengers (i.e., those continuing on to another flight) were excluded from the passenger counts used in calculating attracted travel emissions.
- The attracted travel trips for most travel modes were calculated as round-trip distances in the original 2006 analysis. This was changed such that only the Personal Car Dropped Off At Airport mode of travel included a round trip distance and all others were calculated as one way trips.
- The 2006 travel data did not include a breakdown of the personal car travel mode by dropped off at airport or parked at airport. Therefore, the 2016 share of these two modes was applied to break out the 2006 personal car travel mode into these two categories, using data specific to each airport.
- Starts from parked cars were no longer calculated separately, as these trip starts are accounted for in the trip starts from personal vehicles parked at the airport.

Attracted Travel – PATH

- The PATH Passenger Travel Study used to estimate the modes of travel by PATH passengers by station was updated from the 2004 study to the 2007 study.
- Bus travel to and from Journal Square was added to the 2006 PATH attracted travel estimate, consistent with the 2012 calculations.

Attracted Travel – Tunnels and Bridges

- Consistent with later year estimates, the number days of queueing was revised from 260 (weekdays only) to 365 (weekdays and weekends) days per year.

- Outbound queueing delays were added for the Holland Tunnel, as these were included in the 2012 analysis but were not in the original 2006 analysis.

Attracted Travel – Ports, Drayage Trucks

The key changes made in the port commerce attracted travel include:

- Updating to MOVES-based emission factors;
- Updating to the improved estimate of the average trip length for drayage trucks; and
- Simplifying the emissions calculation methodology to account for strictly the onroad emissions that occur outside of the NYNJLINA nonattainment area.

The Port Authority commissions two drayage truck emission assessments, one conducted by Starcrest Consulting for the Ports department, and the other conducted by SC&A for OEEP. To ensure consistency between these two independent assessments, SC&A uses the Starcrest-derived emissions total for drayage trucks. Therefore, estimates for truck travel on the port terminals, truck idling, and travel from the terminals up to the point of the nonattainment border (the boundary of the Starcrest emissions inventory) were obtained from the 2006 Starcrest report. SC&A builds upon this estimate to assess drayage truck emissions from the nonattainment area boundary to the first point of rest (as is typical in GHG inventories), up to a maximum of 400 miles.

Thus, in revising the 2006 Ports attracted travel emissions to account for MOVES-based emission factors and to maintain a consistent analysis approach across analysis years, SC&A updated the estimates of onroad drayage truck emissions from the nonattainment area boundary to the first point of rest. We accounted for these emissions using data and assumptions consistent with those used in the Starcrest drayage truck emission inventory calculations.

Emissions from the portion of the drayage truck trips that extend from the nonattainment area boundary to the first point of rest are calculated as the product of three data components. These are: 1) the number of drayage truck trips to the container terminals, 2) the average drayage truck trip distance outside of the nonattainment area to the first point of rest, and 3) a MOVES-based CO_2e emission factor representative of onroad drayage truck travel.

Drayage Truck Trips to Container Terminals. The number of 2006 drayage truck trips to container terminals is provided in the 2006 Starcrest report.

Drayage Truck Trip Distance Outside of Nonattainment Area. For the 2012 GHG inventory report, SC&A had estimated the total trip length of port drayage trucks to be 46.4 miles one way, using a methodology that made improvements upon the estimate originally used in the 2006 GHG inventory. We use Starcrest data to determine the portion of this average trip distance that occurs within the nonattainment area. The Starcrest reports do not separately itemize the average onroad trip length traveled by drayage trucks servicing the container terminals. However, these reports provide the number of drayage truck trips to the container terminals and the total off-terminal VMT of these trucks within the nonattainment area. We estimated the average VMT per container truck trip by dividing the total VMT of these trucks by the total number of the drayage truck trips to the container terminals which resulted in an average per-trip estimate of

32.7 miles (roundtrip) in 2006 within the nonattainment area. Thus, the total average mileage traveled by a truck servicing the container terminals from the nonattainment area boundary to the first point of rest would be 60.1 miles (46.4 miles/one-way $_{\text{to First Point of Rest}}$ * 2 one-way/roundtrip – 32.7 miles/roundtrip $_{\text{Non-Attainment Area}}$ = 60.1 miles/roundtrip $_{\text{Incremental from Non-Attainment Area}}$) in 2006. Both the SC&A trip distance and the data underlying Starcrest's VMT estimate were based on data from the Port Authority Marine Container Terminals Truck Origin/Destination Survey 2005 prepared by Vollmer which has not been updated since that time. Total VMT outside the nonattainment area to the first point of rest was calculated by multiplying the trip length outside the nonattainment area by the number of container truck trips.

MOVES CO_2e Emission Factor. The 2006 Starcrest report used MOBILE6 emission factors in calculating drayage truck emissions. As with the other attracted travel categories, SC&A used the latest version of the MOVES model to estimate a 2006 CO_2e emission factor applicable to drayage trucks.

Table 3 summarizes the resulting data components in 2006. This table also shows the emissions for the portion of drayage truck trips between the nonattainment area boundary and the first point of rest, calculated as the product of the three data components listed in Table 3. These emissions should then be added to the port commerce truck emissions reported in the 2006 Starcrest report to obtain the total port commerce attracted travel emissions from heavy-duty trucks.

Table 3. Data Components of GHG Emission Estimate for Drayage Trucks from Nonattainment Area Boundary to First Point of Rest

Data Component	2006
Number of Truck Trips to Container Terminals	3,062,660
VMT by Container Trucks Outside of Nonattainment Area (mi)	60.1
MOVES-based CO_2e Onroad Emission Factor for Drayage Trucks (g/mi)	2,176
Drayage Truck CO_2e Emissions from Nonattainment Area to First Point of Rest (metric tons)	400,173

It should be noted that the 2006 inventory does not include emissions associated with drayage truck travel to the Global Marine Terminal, as the Port Authority did not own that terminal in 2006. Emissions associated with this terminal are included in other analysis years.