2005 Inventory of Seattle Greenhouse Gas Emissions: Community & Corporate

City of Seattle
Office of Sustainability and Environment[a]

REVISED VERSION

March 2008

[a] The community and corporate inventories were completed by Roel Hammerschlag, consultant to the City of Seattle Office of Sustainability of Environment. Michael Lazarus of the Stockholm Environment Institute served as a technical advisor. The inventories were audited by Envirometrics, Inc. of Seattle, Washington.

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Methodology

Corporate vs. Geographic Inventories

There are two main approaches to large-scale greenhouse gas inventories: geographic and corporate.

Geographic inventories measure greenhouse gas emissions that originate within a defined geographic boundary. A standard protocol for geographic inventories for nations has been developed as part of the United Nations Framework Convention on Climate Change, but no such standard protocol exists for geographic inventories for cities. Following the national protocol in developing local geographic inventories is difficult. It is more challenging to assess the carbon footprint for a city because the area is much smaller (Seattle's 84 square miles compared with the United States' roughly 4 million), and because cities function within regional and national economies. Some activities that have significant greenhouse gas emissions associated with them, such as seaports, airports, freeways, and industrial plants, exist in cities but serve a much larger area and population. Conversely, the climate pollution associated with many in-city activities, such as electricity generation and solid waste disposal, occurs outside of the city's boundaries.

Corporate inventories measure the greenhouse gas emissions of an organization, drawing the boundary around the organizations facilities and operations, regardless of their geographic location. Protocols for corporate inventories were developed by the World Business Council for Sustainable Development, the World Resources Institute and the California Climate Action Registry. In contrast to geographic inventories, corporate inventories almost always include at least some indirect emissions induced by the organization's activities, such as electricity and steam purchases, employee commuting and travel, outsourced activities, waste disposal, or any number of other activities. Indirect emissions are included to bring into focus the entire reach of an organization's affect on greenhouse gas emissions.

Neither of these two standard approaches—one designed for nations and the other designed for corporate entities—is a perfect fit for assessing a local communities' carbon footprint. A standard methodology for carbon footprint assessments on the local level is being developed, through a partnership among the International Council for Local Environmental Initiatives (ICLEI), the Clinton Climate Initiative, and the California Climate Action Registry. The City's Office of Sustainability & Environment is actively engaged in the protocol development process, which is slated for completion in 2008.

Although there is not yet a standard approach, this document uses the best available data and practice to report two Seattle inventories:

(1) a community-wide inventory for the geographic area of the City of Seattle, which for the most part follows a geographic approach, but augments the inventory with reports of indirect emissions ascribable to citizens of Seattle in several areas.

(2) a corporate inventory of the City of Seattle's government operations, which follows the standard approach for corporate inventories.

Inventory Protocol

While there is a standard protocol for corporate inventories, there is no standard protocol for local community greenhouse gas inventories. Therefore, both community and corporate inventories presented here are guided by protocols developed for national and corporate inventories, specifically the *Greenhouse Gas (GHG) Protocol, Revised Edition* (2004) and the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (*IPCC Guideline*). The *GHG Protocol* was developed with a multi-stakeholder, consensus-based process by the World Business Council for Sustainable Development and World Resources Institute. The *IPCC Guideline* was developed in the early to mid-1990s by the Intergovernmental Panel on Climate Change (IPCC).

In most cases, the *GHG Protocol* and the *IPCC Guideline* provide the necessary methodology for estimating Seattle's community and corporate emissions inventories. Where there was in sufficient guidance in these above sources, the inventories follows the best available science and methodologies in the published literature.

Greenhouse Gases Inventoried

The City of Seattle inventories all six greenhouse gases identified in the IPCC Guidelines, which are listed in Table 1.

gas	chemical formula	GWP
carbon dioxide	CO_2	1
methane	CH_4	21
nitrous oxide	N_2O	310
hydrofluorocarbons	$C_xH_yF_z$	various
perfluorocarbons	C_xF_y	various
sulfur hexafluoride	SF_6	23,900

Table 1 – greenhouse gases inventoried

The table lists the global warming potential (GWP) of each gas. The GWP indicates the mass units of carbon dioxide (CO_2) that affect the same amount of global warming as one mass unit of the gas. For instance, the GWP of methane is 21, so it requires 21 kilograms of carbon dioxide to produce the same global warming as just one kilogram of methane. The higher the GWP, the more potent the greenhouse gas. The City of Seattle uses the GWPs printed in the IPCC's Second Assessment Report, released in 1996. IPCC released a Third Assessment Report in 2001 that includes slightly modified GWPs of 23 for methane and 296 for nitrous oxide. The City continues to use the Second Assessment values for consistency with countries under the UNFCCC (of which the U.S. is one), and with the U.S. Inventory. The UNFCCC countries do not plan to change the GWPs used for GHG accounting until after 2012, since the national baselines and corresponding Kyoto Protocol commitments through 2012 were created before the Third Assessment was published.

Of the six gases listed, CO_2 dominates both the U.S. Inventory and the City inventories. It is the principal combustion product of fossil fuels, which provide the vast majority of energy and energy products in the United States. Methane (CH_4) and nitrous oxide (N_2O) are both associated principally (but not only) with agricultural processes and play only a small role in most municipal inventories. Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are usually used as refrigerants and have various, very high GWPs ranging from the low 100's to over 10,000. Sulfur hexafluoride (SF_6) is a gaseous insulator used in electrical switchgear; though used in small quantities it is also inventoried due to its abnormally high GWP of 23,900.

Units

Because greenhouse gases are a pollutant of international concern, common practice is to account their quantities in metric units. In this document, all values of GHG emissions and sequestration are reported in metric tons of carbon dioxide equivalent, or $MgCO_2e$. "Mg" is shorthand for "megagram" or one million grams, the definition of a metric ton. A metric ton weighs 2,205 U.S. pounds. "CO_2e" is shorthand for CO_2-equivalent, or carbon dioxide-equivalent. The "equivalent" means that any non-CO_2 gases included in the total were weighted by their GWPs, as described in *Greenhouse Gases Inventoried* above.

Most energy values – quantities of fuel or electricity – are reported in the metric unit TJ. "TJ" is shorthand for "terajoule," a unit of 10^{12} joules. One TJ equals about 278 MWh, 9,490 therms, 949 mmBtu or 7,330 gallons of gasoline equivalent.

All numbers reported in this document are rounded to three significant digits.[b] For example, the number 21.2748 is printed as 21.3, and the number 832,491 is printed as 832,000. Four or more significant digits would misleadingly imply accuracies beyond those achievable in a GHG inventory. The spreadsheets that support this document carry out their calculations with unlimited precision; the rounding is carried out as a final step prior to printing in this document. As a result, sums of line items in the printed tables may differ slightly from the printed totals.

Organizational Boundaries

The *GHG Protocol* offers a choice to define an entity's organizational boundaries with an equity share approach or a control approach. In the equity share approach, an entity accounts emissions from facilities in which it has a financial stake; in the cases where facility ownership is shared the entity prorates emissions according to its equity share in the facility. In the control approach, the entity accounts for all emissions from facilities over which it exerts either financial or organizational control.

The corporate inventory follows the equity share approach, principally because this allows the most responsible accounting of past and future partial ownership of electric generating facilities, a major contributor to the City's emissions.

The geographic inventory does not declare an organizational boundary approach, since the boundary is defined simply as the city's geographic border.

Operational Boundaries

Even with the boundaries of the community and City government well-defined, operational boundaries still need to be set. Toward this end, the community and corporate inventories are divided into three scopes defined by the *GHG Protocol*:

Scope 1 – Direct Emissions includes emissions that originate from within the defined boundary. For the Seattle's corporate inventory, this means equipment and materials owned by the City government; on-site natural gas heating and vehicle fleets are examples. For the community inventory, Scope 1 includes all emissions that originate from within the Seattle city limits.

[b] Except for emissions factors reported in the source notes.

Scope 2 – Energy Imports includes emissions from facilities outside the defined boundary that generate electricity or steam imported into the boundary. The corporate inventory includes substantial Scope 2 emissions because a great deal of the City's energy is purchased through long-term contracts. The 1990 geographic inventory also includes Scope 2 emissions, but the 2005 geographic inventory does not include emissions from imported electricity because of Seattle City Light's policy to purchase offsets for all emissions from its electricity generation.

Scope 3 – Other Emissions includes emissions originating outside the organizational boundary, except emissions from electricity or steam generators, when those emissions are induced by activities within the organizational boundary. In the corporate inventory, this includes employee commuting, business travel and the manufacture of concrete and asphalt used in city operations. In the geographic inventory, Scope 3 include emissions from Seattle's air travel at SeaTac and the emission from King County airport, a portion of which is within Seattle's geographic boundary.

The *GHG Protocol* also offers a fourth category for the emissions inventory:

Optional Information includes notes regarding emissions from special sources not included in the three formal scopes, estimates of effects of special projects on the inventory, and background operating data for the city. Unlike Scope 3 emissions sources, items listed in Optional Information do not need to remain identical from year to year, since they are not designed to reflect trends. The corporate inventory reports emissions and emissions reductions attributable to offset purchases, forestry, and waste disposal operations as Optional Information. The community inventory reports emissions and emissions reductions attributable to urban forests, municipal solid waste and wastewater treatment as Optional Information. In addition, the community inventory reports a baseline adjustment for cement production that returns emissions to historic levels to control for a temporary closure of one of Seattle's two cement plants, which are substantial contributors to Seattle's community footprint.

Time Basis

The corporate and geographic inventories are each reported for two distinct periods: calendar year 1990 and calendar year 2005. In each case the 1990 inventory reflects emissions that occurred from January 1 to December 31, 1990 and the 2005 inventory reflects emissions that occurred from January 1 to December 31, 2005. In those cases where GHG emissions calculations are based on purchases of liquid or solid fossil fuels, the emissions reported here occurred in a period slightly later than the calendar year, since these fuels are typically stored for short periods prior to use.

The 1990 inventories are calculated for the purpose of measuring progress toward Kyoto-like targets. At the this inventory document was compiled, 1990 emissions had occurred 16 years earlier, while 2005 emissions had occurred in the immediately prior year. In many cases where accurate emissions data were available for 2005, similar 1990 data was unavailable and alternative, lower-quality sources had to be used. In other cases, activity and fuel tracking systems had changed in structure during the intervening 14 years, such that relatively accurate 1990 data were available but the data reflected a different definition of the emission source. For these reasons, great caution should be taken when comparing 1990 emissions with 2005 emissions.

Audit Trail

The formal inventory is a dataset consisting of approximately 150 electronic files and several dozen paper files. The electronic data files are available on the Office of Sustainability and Environment (OSE) electronic file system.

There are four categories of data files:

Index file – A single index file, <dataset index 05.xls>, lists names and sources of all other files, electronic and paper alike, in the inventory.

Source files – These files are numbered 05-001 through 05-149. Most are internal, city reports of energy or chemical usage that serve as the basis for greenhouse gas emissions estimates documented in the calculation files. Some source files originate from outside the city; these are clearly marked as such in the index file. Electronic source files may have any one of extensions:

.doc	Microsoft Word document
.mht	Microsoft Internet Explorer archive
.pdf	Adobe Portable Document Format
.txt	Unformatted text document
.xls	Microsoft Excel workbook

Reference files – These files are numbered 05-801 through 05-813. Each is a copy of a formally published work that is used as a reference source for universal emissions factors or other constants. Filename extensions may be any one of the same set allowed for source files.

Calculation files – These files are numbered 05-901 through 05-912. All calculation files are Microsoft Excel workbooks. The calculation files document the translation of source and reference data found in files 05-001 through 05-899 into the final GHG emissions estimates published in this document. Files <05-901.xls> and <05-902.xls> are the master calculation files for the geographic and government inventories respectively, and include at least the highest-level calculations for every datum reported in this document. Every table describing the geographic inventory in this document is duplicated from <05-901.xls>, and every table describing the corporate inventory in this document is duplicated from <05-902.xls>. Calculation file numbers 05-903 and higher document detailed calculations necessary to process some of the more complex data sources, with the results summarized in either 05-901 or 05-902.

Every single datum in the calculation files is traceable to one of the source files through the 05-nnn number provided in the “call no.” column of most of the calculation files, or in a few instances to notes below the calculations. A few data are derived from source files described with a call number in the format 00-nnn, these are files of the reconstructed 2000 inventory, available on the OSE electronic file system.

Throughout this inventory, grey boxes with the heading *source notes* report technical notes on the data sources used to generate the inventory, and in some cases on methods used for calculating emissions. The *source notes* will be of little interest to most readers, but they will assist future GHG accountants assembling subsequent inventories, and provide convenient entryways for inventory auditors.

The first *source notes* box appears here:

Source Motes

Data Sources

Data sources cited in the *source notes* boxes appear as boldface, five-digit call numbers, *e.g.* **05-086**. Such citations are simply shorthand for the corresponding file in the dataset; for example the citation above refers to file <05-086.mht>.

Emission Factors

Emission factors associated with fossil fuel consumption are used throughout the inventory, and are summarized here:

fuel	emission factor
gasoline	
1990	2,326 gCO_2/L
2005	2,317 gCO_2/L
diesel	2,651 gCO_2/L
natural gas	50.0 gCO_2/MJ
LPG	1,508 gCO_2/L
jet fuel	2,501 gCO_2/L

Only CO_2 emissions directly due to combustion of the fuels are included; higher-order emissions from fuel extraction, processing and transportation are excluded, as are CH_4 and N_2O emissions at combustion (which are at least an order of magnitude smaller and much less precisely known than CO_2 emissions). The emission factors in the table above are derived from the U.S. Inventory **05-802** and are documented in the master spreadsheet **05-901**.

Emission factors required for sources other than fossil fuel combustion are documented in the respective inventory chapters and sections.

Populations

In several cases it was necessary to estimate 1990 emissions by scaling 2005 emissions by population; or to estimate Seattle emissions by scaling a larger region's emissions by population. The population figures used for this purpose, and their sources, are:

	1990 population	source	2005 population	source
Seattle				
residents	516,259	05-011	573,911	05-051
commercial employees	-	-	381,237	05-907
industrial employees	-	-	28,129	05-907
King County				
residents	1,507,305	05-025	1,793,583	05-026
commercial employees	-	-	918,224	05-907
industrial employees	-	-	101,354	05-907
Washington				
commercial employees	-	-	2,119,139	05-907
industrial employees	-	-	254,437	05-907
U.S. residents	248,709,873	05-090	296,410,404	05-090

The commercial and industrial employee counts aggregated in **05-907** originate from the Washington State Employment Security department. County- and state-level counts come directly from the department in source **05-045**, but city-level employment data are from **05-046** compiled by Jennifer Pettyjohn of the Seattle Department of Planning and Development. The city-level data are compiled from state data that is first sorted and geocoded by the Puget Sound Regional Council. Resident populations were all acquired from the U.S. Bureau of the Census.

City Contacts

Jennifer Pettyjohn
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Partner Contacts

Washington State Employment Security *Workforce Explorer*
www.workforceexplorer.com

Chris Thomas
Washington State Employment Security

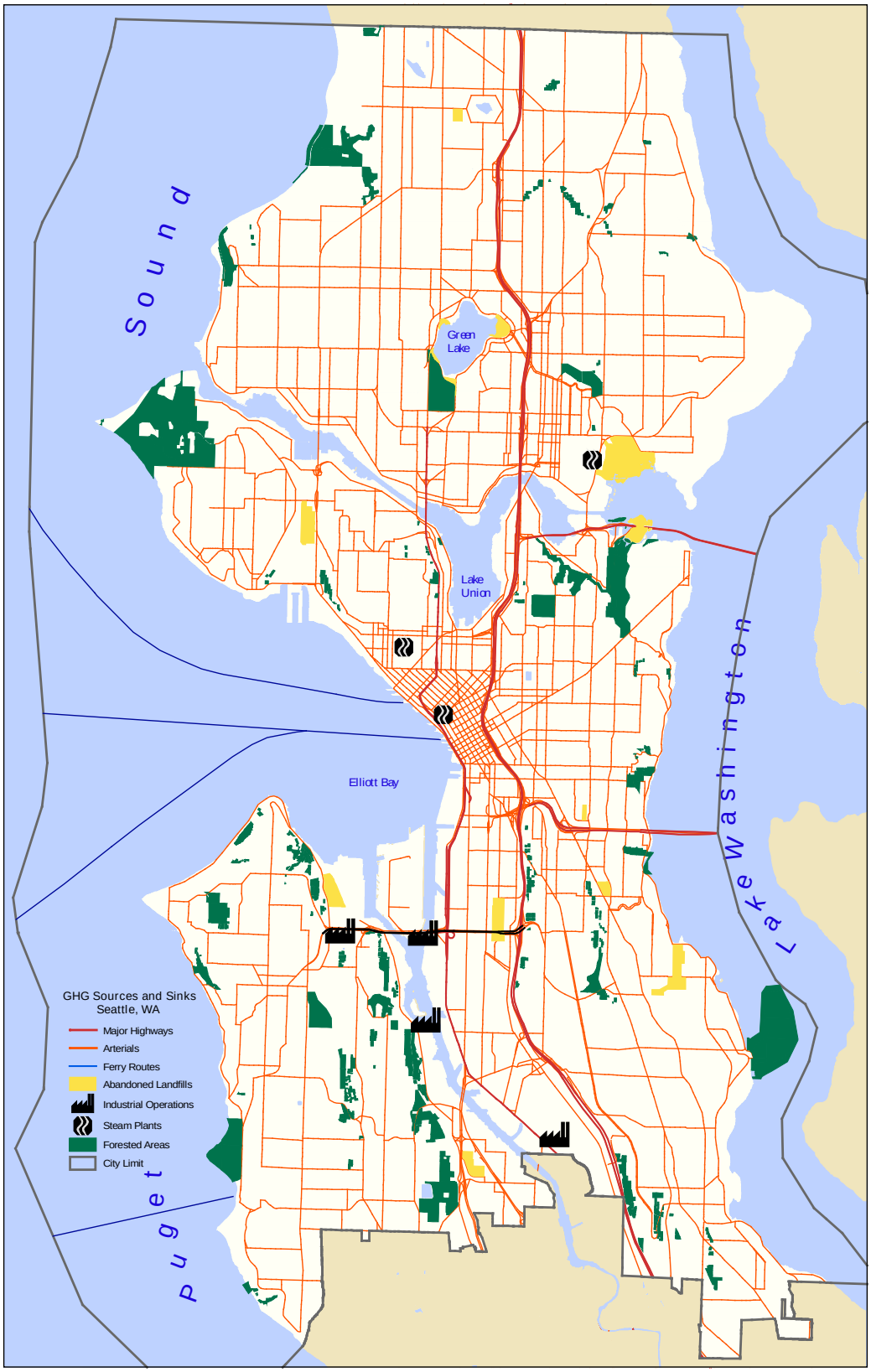
U.S. Bureau of the Census *Population Estimates Program*
www.census.gov/popest/

Community Inventory

The Geographic Boundary

The geographic boundary used in the community inventory is shown in Figure 1 on the next page. The city's east and west limits are chosen to follow the approximate midlines of Lake Washington and the Puget Sound, respectively, per the traditional definition embodied in the city charter until 1999. This ensures that maritime activity associated with the city is captured in the inventory. Scope 1 of the community inventory includes emissions originating from within the Seattle city limits.

Figure 1: Seattle city limits, selected Scope 1 greenhouse gas sources, and selected greenhouse gas sinks.



Community Inventory Overview

An overview of the entire inventory, organized by scopes, is shown below in Table 2. The summary document "Seattle's Community Carbon Footprint," summarizes the same data by emissions sectors rather than scopes. The sums in the table below may not equal totals due to rounding.

Table 2 – Overview of the Community Inventory

	emissions, $MgCO_2e$ 1990	2005
Scope 1 - direct emissions		
transportation		
road traffic	2,440,000	2,570,000
marine	219,000	234,000
rail	59,400	64,700
aircraft (King County Int'l)	184,000	129,000
total	2,900,000	2,990,000
residential		
heating & hot water	582,000	522,000
garden & rec equipment	19,700	16,600
total	602,000	538,000
commercial		
heating & hot water	572,000	567,000
miscellaneous equipment	133,000	135,000
total	705,000	703,000
industrial		
coal consumption	209,000	335,000
other fuels in stationary facilities	314,000	291,000
process emissions	208,000	487,000
fugitive gases	10,000	5,300
construction & small equipment	149,000	171,000
total	890,000	1,490,000
waste		
closed landfills	174,000	93,600
wastewater treatment	2,920	3,250
total	177,000	96,800
all Scope 1 sources	5,270,000	5,620,000
Scope 2 - energy imports		
SCL electricity	406,000	-
Scope 3 - other emissions		
MSW collection & hauling	11,700	20,400
MSW decay commitment	110,000	103,000
all Scope 3 sources	122,000	124,000
grand totals	5,801,000	5,745,000
Optional Information		
citizen air travel	1,050,000	1,070,000
industrial baseline correction	561,000	-
MSW-related sequestration	(208,000)	(146,000)
recycling emissions	(439,000)	(481,000)
urban forest sequestration	(50,600)	(47,500)

Sums may not equal totals due to rounding.

In Table 2 and all following tables, "-" indicates that a value was calculated, but is less than 0.5. "n.d." indicates no data available. Where "n.d." appears, accompanying text or source notes may describe a method by which a value was substituted for the absent data in order to calculate table totals. Values in parentheses are negative values associated with greenhouse gas sinks. All data presented in this document are rounded to three significant digits, both in order to improve readability and to avoid implying unrealistic accuracies in the emissions estimates.

Scope 1 – Direct Emissions

Scope 1 emissions, or direct emissions, originate from within the Seattle city limits, and are the majority of each year's inventory.

TRANSPORTATION

Transportation emissions, shown in Table 3 below, include those from Seattle's road, marine, rail and air traffic. The largest single emissions source in the geographic inventory is road traffic. Private vehicles are the single largest line-item in the Inventory, contributing about 1.4 million $MgCO_2e$ of the 6.8 $MgCO_2e$ gross city inventory. Commercial vehicles are a close second, contributing about 1.1 million $MgCO_2e$. Transit in the form of buses and commuter vans is a minor contributor in comparison.

Table 3 – Emissions from road traffic in Seattle

	vehicle travel, 10^6 km		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
cars & light trucks	4,580	5,190	1,330,000	1,430,000
vans	1	2	434	491
buses	29	33	46,600	52,800
commercial trucks	1,020	1,150	1,060,000	1,080,000
totals			2,440,000	2,570,000

Marine traffic is also an important contributor to Seattle's greenhouse gas emissions. Emissions from Washington State ferries include half of the cross-Sound emissions attributable to the Seattle-Bainbridge, Seattle-Bremerton, Fauntleroy-Vashon-Southworth and Vashon passenger ferries. Hotelling emissions result from the use of shipboard systems on ocean-going vessels, while they are moored within the inventory boundary. The large contribution from other ship & boat traffic is dominated by commercial activity, *e.g.* tug boats. Emissions arising from marine traffic on Puget Sound within city limits (as defined extending into the Puget Sound centerline) are summarized in Table 4.

Table 4 – Maritime emissions within Seattle geographic boundary

	fuel consumption, ML		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
pleasure craft, diesel	-	-	843	906
pleasure craft, gasoline	2	2	5,330	4,850
Washington State ferries	n.d.	16	40,700	41,400
other ship & boat traffic	n.d.	n.d.	125,000	137,000
hotelling	n.d.	n.d.	46,400	50,600
totals			219,000	234,000

ML = millions of liters

Table 5 estimates emissions from rail activity in the City of Seattle. Only emissions related to Port of Seattle activity are included, but these will constitute the great majority of all rail emissions.

Table 5 – Rail emissions originating in Seattle

	fuel consumption, ML		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
PoS on-terminal	n.d.	n.d.	15,000	16,400
PoS off-terminal	n.d.	n.d.	18,600	20,200
other freight	n.d.	n.d.	25,797	28,107
passenger	n.d.	n.d.	n.d.	n.d.
totals			59,400	64,700

King County International Airport (Boeing Field) is located partially within and partially outside the Seattle city limits. There is no reasonable method for estimating the fraction of aircraft fuel burned in or above the Seattle city limits, so the geographic inventory reports all landing and take-off (LTO) emissions associated with the airport. Emissions from each landing are defined to begin when the aircraft is under 3,000 feet elevation with respect to the runway; emissions from each takeoff end when the aircraft rises over 3,000 feet. The results are shown in Table 6.

Table 6 – Fuel consumption and emissions from activity at King County Airport

	fuel consumption, ML		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
King County International Airport	n.d.	n.d.	184,000	129,000

Transportation Source Notes

Daily average vehicle miles traveled (DVMT) in the City of Seattle in calendar year 2000 were provided by SDOT traffic modeler John Donahue in **05-063** and **05-123** for five vehicle types. **05-123** also included estimates of 1990 and 2005 gross DVMT; in **05-901** the gross DVMT estimates are used to scale the 2000 modeled DVMT by vehicle type to each of the inventory years. The five vehicle types modeled (SOV, HOV2, HOV3, van pool and truck) are grouped to three (car, van and truck) in **05-901**. The grouped DVMT were multiplied by 365 to deduce gross annual travel, and finally the DVMT for each vehicle type were multiplied by emissions factors as follows:

	emission factor	
vehicle	**1990**	**2005**
car	290 gCO_2/km	276 gCO_2/km
van	340 gCO_2/km	308 gCO_2/km
truck	1,045 gCO_2/km	936 gCO_2/km

The emissions factors are derived from fuel emissions factors described in the *Audit Trail* source note, divided by vehicle fuel efficiencies reported by the federal government in the Transportation Energy Data Book **05-808**. These emissions factors are calculated from national average data; the unique vehicle age and type mix in Seattle mean that actual emissions factors for Seattle may be different. Estimates for vehicle emissions would also be raised slightly by inclusion of nitrous oxide and methane emissions, which are not included in this inventory due to their highly uncertain emission factors.

The SDOT traffic model does not estimate DVMT for the transit system. Jim Boon of Metro King County provided 2005 Metro and Sound Transit bus mileage and fuel use in **05-056**, and 2005 bus emissions were calculated directly from fuel consumption in **05-901**. 1990 bus emissions were scaled from the 2005 emissions using the ratio of gross DVMT in 1990 vs. 2005 reported by John in **05-063**.

Fuel use by pleasure craft in King County was estimated by Kwame Agyei at Puget Sound Clean Air Agency using the NONROAD2005 model (re **05-125)**. Results for calendar years 1990 and 2005 were supplied in files **05-097** and **05-023**, respectively, which were sorted by emissions source in workbook **05-903**. The King County fuel totals in **05-903** were scaled to Seattle by population in **05-901**, and then converted to emissions using the standard fuel-related emissions factors.

2005 emissions from Washington State ferries were calculated from ferry fuel consumption and route assignments provided by Lucy Fullerton of WSDOT in **05-052** and **05-072**, respectively. The fuel consumption and routes were sorted in workbook **05-908**. Final values for emissions (including prorating to the Seattle portion of each route) were calculated in **05-901**. 1990 emissions from Washington State ferries were calculated by scaling 2005 emissions according to the relative number of departures on each route in 1990 vs. 2005, according to historical ferry schedules **05-145**, **05-146** and **05-147**.

2005 emissions from hotelling, ocean-going vessel traffic, and other commercial traffic were extracted from Port of Seattle estimates included in **05-151**, the *Puget Sound Maritime Air Emissions Inventory*, Tables 3.58 and 4.16. 1990 emissions in these categories were estimated by scaling 2005 emissions using Army Corps of Engineers freight tonnage records **05-119**.

2005 emissions from rail traffic were extracted from Port of Seattle estimates included in **05-151**, the *Puget Sound Maritime Air Emissions Inventory*, Tables 6.4, 6.6, 6.11 and 6.12. 1990 emissions in these categories were estimated by scaling 2005 emissions using Army Corps of Engineers freight tonnage records **05-119**.

2005 emissions from King County International Airport were calculated by Kwame Agyei at the Puget Sound Clean Air Agency, and reported to the City of Seattle by the inventory auditor in **05-156**. The 2005 emissions were backcast to 1990 using gross airport operations records reported in the airport's Master Plan environmental assessment **05-138**.

City Contacts

City Traffic Modeling
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Partner Contacts

Jim Boon (transit bus operating data)
Metro King County

Kwame Agyei (ACE freight tonnage records and aircraft LTO fuel use)
Puget Sound Clean Air Agency

Lucy Fullerton (state ferry fuel use)
Washington State Department of Transportation

Barbara Cole (Puget Sound Maritime Air Forum)
Port of Seattle

RESIDENTIAL BUILDINGS

Table 7 shows energy consumption and greenhouse gas emissions from single-family homes, apartment buildings and other residential buildings in the City of Seattle. The vast majority of these emissions are generated by home heating and hot water heating, although emissions also generated from the use of landscaping equipment. For economic reasons, natural gas has gained favor over oil for space heating since 1990. The shift from oil to natural gas also has a greenhouse gas benefit because natural gas is a lower emissions fuel source.

Table 7 – Emissions from single-family homes and other residential buildings

		fuel consumption		emissions, $MgCO_2e$	
		1990	2005	1990	2005
natural gas	TJ	5,170	7,380	259,000	370,000
oil	ML	122	57	323,000	152,000
totals				582,000	522,000

Table 8 displays fuel use and greenhouse gas emissions from garden and recreational equipment associated with residential homes. The emissions are dominated by lawnmowers and lawn tractors; of the 7.1 million liters of gasoline consumed in 2005, some 5.9 million were used in lawnmowers and lawn tractors.[c] The remainder of the emissions are from a wide variety of equipment including chain saws, leaf blowers, and trimmers.

Table 8 – Emissions from garden and recreational equipment

	fuel consumption, L		emissions, $MgCO_2e$	
	1990	2005	1990	2005
diesel	20,800	22,300	55	59
gasoline	8,430,000	7,120,000	19,600	16,500
LPG	2,450	2,360	4	4
totals			19,700	16,600

Residential Buildings Source Notes

Calendar year 2005 natural gas use by City of Seattle residences was provided by Bill Hopkins of Puget Sound Energy in spreadsheet **05-049**, with explanatory comments in emails **05-050** and **05-128**. Calendar year 1990 natural gas use of 5,170 TJ was estimated by prorating 1990 King County residential consumption of 22,058 TJ by 0.234, the ratio of Seattle to King County residential natural gas use in 2003 (the earliest year for which this value could be calculated with available data in **05-049** and **05-080**).

Residential oil use in the state of Washington for 2004 (the most recent available year) was reported as 215 million liters by the U.S. Energy Information Administration (EIA) in **05-028**. Data from the U.S. Census **05-027** indicates

[c] This is not shown in the table. See sheet 'scratchpad' in **05-901** for documentation.

that of 127,000 Washington homes with oil heat, 33,900 are located in Seattle. This ratio is used to prorate the state-level figure to the Seattle usage estimate of 57 million liters in **05-901**. Residential oil use in 1990 was reported as 439 million liters by the EIA in **05-086**; U.S. Census data **05-087** indicates that of the 186,000 Washington homes having oil heat in 1990, 51,600 were located in Seattle. This ratio is used to prorate the state-level figure to the Seattle usage estimate of 122 million liters in **05-901**.

For small equipment in 2005, Kwame Agyei of the Puget Sound Clean Air Agency calculated King County fuel use **05-023** as NONROAD model output, which was grouped by sector and fuel in worksheet **05-903**. County-level, residential fuel use calculated in **05-903** was prorated to the City of Seattle in **05-901** using the residential population figures documented in the source note on page 9. 1990 emissions from small equipment were calculated similarly, but beginning with NONROAD output **05-097** instead of **05-023**.

Partner Contacts

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Puget Sound Clean Air Agency

COMMERCIAL BUILDINGS

Table 9 shows energy consumption and greenhouse gas emissions from commercial buildings in Seattle. In the community inventory, the "commercial sector" includes all office-like facilities, government and educational as well as businesses. Like residential building emissions, the majority of these emissions are generated by space heating and hot water heating. However, the City of Seattle includes two major steam plants (Seattle Steam and the University of Washington steam plant) that combust natural gas at central locations and distribute the energy to multiple facilities via steam pipes.[d] The two steam plants account for nearly 40 percent of Seattle's commercial-sector gas use.

Table 9 – Emissions from commercial buildings

		fuel consumption		emissions, $MgCO_2e$	
		1990	2005	1990	2005
steam plants					
natural gas	TJ	2,730	3,190	137,000	159,000
oil	ML	5	-	15,600	1,530
other businesses and institutions					
natural gas	TJ	5,620	7,000	281,000	350,000
oil	ML	52	21	139,000	56,400
totals				572,000	567,000

Table 10 displays fuel use and greenhouse gas emissions from small equipment associated with commercial operations. This includes roughly equal contributions from landscaping equipment and from other commercial machinery like air compressors and generator sets.

Table 10 – Emissions from small equipment in the commercial sector.

[d] A third steam plant supports Seattle Center, but is much smaller and is included among "other businesses and institutions" in Table 7.

		fuel consumption		emissions, $MgCO_2e$	
		1990	2005	1990	2005
diesel	ML	11	13	28,700	34,700
gasoline	ML	39	36	89,800	84,000
LPG	ML	2	3	2,710	3,790
CNG	TJ	236	256	11,800	12,800
totals				133,000	135,000

Commercial Buildings Source Notes

Kwame Agyei of PSCAA provided natural gas and back-up oil use at Seattle Steam and the UW steam plant in **05-030** for calendar year 2005, and in **05-095** for calendar year 1990. Data from both sources were aggregated in worksheet **05-904**.

Bill Hopkins of Puget Sound Energy (PSE) provided calendar year 2005, commercial-sector gross natural gas use in the City of Seattle in spreadsheet **05-049**, with explanatory comments in emails **05-050** and **05-128**. Small source gas use was calculated in **05-901** by subtracting steam plant consumption compiled in **05-904** and CNG vehicle use calculated in **05-903** from the gross reported by PSE. Calendar year 1990 natural gas use was estimated by prorating 1990 King County commercial consumption of 17,100 TJ reported in **05-080** by 0.503, the ratio of Seattle to King County industrial natural gas use calculated from **05-049** and **05-080**. The final 1990 value of 5,620 TJ was calculated by subtracting point source consumption compiled in **05-904** and CNG vehicle use calculated in **05-903** from the prorated county-wide emissions

Commercial oil use in the state of Washington for 2004 (the most recent available year) was reported as 118 million liters by the EIA in **05-028**, and prorated by .180, the ratio of Seattle commercial employees to Washington State commercial employees derived from the figures in the page 9 source note. For 1990, EIA document **05-088** indicated commercial oil use of 306 million liters, which was prorated using the same ratio and then discounted by the 2.7 million liters attributed to steam plants in that year. (Table 7 shows 5.4 million liters attributed to steam plants in 1990 because another 2.7 million liters of residual fuel oil was burned at one of the steam plants, but residual fuel is not included in EIA document **05-088**.)

For small equipment in 2005, Kwame Agyei of the Puget Sound Clean Air Agency calculated King County fuel use **05-023** as NONROAD model output, which was grouped by sector and fuel in worksheet **05-903**. County-level, commercial fuel use calculated in **05-903** was prorated to the City of Seattle in **05-901** using the commercial employment figures documented in the source note on page 9. 1990 emissions from small equipment were calculated similarly, but beginning with NONROAD output **05-097** instead of **05-023**. Worksheet **05-903** is also the source of 1990 and 2005 values for vehicle CNG use that are subtracted from gross commercial natural gas use to calculate the values for building and water heating in Table 7.

partner contacts

Bill Hopkins (natural gas consumption)
Puget Sound Energy

Energy Information Administration
http://www.eia.doe.gov

Kwame Agyei (small equipment)
Puget Sound Clean Air Agency

INDUSTRIAL SECTOR

Table 11 shows energy consumption and greenhouse gas emissions from industrial facilities located in the City of Seattle. Unlike residential and commercial emissions, these are dominated by emissions from energy used to fuel manufacturing or other industrial processes, rather than space heating and hot water.

Title V of the U.S. Clean Air Act requires certain industrial emitters to report activity levels and associated emissions; in most cases these industries report their fuel use to the Puget Sound Clean Air Agency (PSCAA), so detailed information about their fuel consumption can be gathered with a "bottom-up" approach. The totals of these individual emissions reports appear in the "industrial sites monitored by PSCAA" section of Table 9. The balance of industrial fuel consumption appears in the "other industrial sites" section. Typically only large industrial facilities consume coal, so all of Seattle's coal emissions originate at Title V-regulated facilities.

Table 11 – Energy-related emissions from industrial facilities

		fuel consumption		emissions, $MgCO_2e$	
		1990	2005	1990	2005
industrial sites monitored by PSCAA					
natural gas	TJ	3,450	512	173,000	25,600
oil	ML	2	-	5,700	312
coal	Mg	72,800	117,000	209,000	335,000
tire-derived fuel	Mg	-	8,360	-	25,700
other industrial sites					
natural gas	TJ	1,850	4,390	92,700	220,000
oil	ML	16	7	42,500	19,300
totals				523,000	626,000

In addition to emissions from fuel use, a few industrial processes emit greenhouse gases directly. The only industrial process of this nature with a significant presence in Seattle is cement manufacturing. Table 12 summarizes industrial process emissions in 1990 and 2005. These sources of emissions were inadvertently left out of Seattle's 2002 inventory.

The significant increase in cement-related emissions from 1990 to 2005 is because one of Seattle's two long-standing cement plants was temporarily closed from 1988-1992. When the plant reopened in 1992, it was the first Energy Star certified cement plant in the country, and emission levels per ton continue to be some of the lowest in the country. Because 1990 was a very abnormal year for Seattle's cement production and because cement production is roughly 13 percent of Seattle's inventory, a meaningful comparison of the emission reduction activities from 1990 and 2005 benefits from adjusting Seattle's 1990 cement emissions to be more in line with its historical average. The Optional Information section of this report includes an estimate of what1990 cement production levels would have been had the plant not been temporarily closed.

Table 12 – Industrial process emissions

	emissions, $MgCO_2e$	
	1990	2005
cement manufacture	206,000	484,000
other industrial processes	1,820	3,220
totals	208,000	487,000

Direct emissions of greenhouse gases also arise from *fugitive* gases that leak or otherwise escape from distributed equipment, which are shown in Table 13. The fugitive gases reported here are from electric switchgear. Electrical switchgear operated by Seattle City Light is

insulated in part by the gaseous insulator sulfur hexafluoride, which has an unusually high GWP.

Table 13 – Fugitive gases

	emissions, $MgCO_2e$	
	1990	**2005**
switchgear insulation (SF_6)	10,000	5,320
totals	10,000	5,320

Table 14 displays fuel use and greenhouse gas emissions from construction equipment and other off-road machinery associated with industrial operations. Construction equipment dominates both the diesel and gasoline fuel use and therefore the total emissions. The balance of sources reported in this table includes material handling and HVAC equipment.

Table 14 – Emissions from construction and other industrial equipment.

		fuel consumption		emissions, $MgCO_2e$	
		1990	**2005**	**1990**	**2005**
diesel (L)	ML	42	48	112,000	129,000
gasoline (L)	ML	3	2	6,070	4,280
LPG (L)	ML	13	17	20,100	25,700
CNG (TJ)	TJ	213	252	10,700	12,600
totals				149,000	171,000

Industrial Sector Source Notes

Kwame Agyei of PSCAA provided industrial point source natural gas, oil and coal use in **05-030** for calendar year 2005, and in **05-095** for calendar year 1990. Data from both sources were aggregated in worksheet **05-904**. Travis Weide of Lafarge provided coal and tire-derived fuel consumption data (which were unavailable from PSCAA) directly in **05-139**. Gerald Brown of Ash Grove provided tire-derived fuel consumption data directly in **05-129**. The data from all of these sources were finally combined in **05-901** to generate the "industrial sites monitored by PSCAA" section of.

Bill Hopkins of PSE provided calendar year 2005, industrial-sector gross natural gas use in the City of Seattle in spreadsheet **05-049**, with explanatory comments in emails **05-050** and **05-128**. Small source gas use was calculated in **05-901** by subtracting point source consumption compiled in **05-904** and CNG vehicle use calculated in **05-903** from the gross reported by PSE. Calendar year 1990 natural gas use was estimated by prorating 1990 King County industrial consumption of 12,800 TJ reported in **05-080** by 0.432, the ratio of Seattle to King County industrial natural gas use calculated from **05-049** and **05-080**. The final 1990 value of 1,850 TJ was calculated by subtracting point source consumption compiled in **05-904** and CNG vehicle use calculated in **05-903** from the prorated county-wide emissions.

Industrial oil use in the state of Washington for 2004 (the most recent available year) was reported as 66.8 million liters by the EIA in **05-028**. This figure was prorated by .111, the ratio of Seattle industrial employees to Washington State industrial employees derived from the figures in the page 9 source note, and then discounted by the industrial point source consumption tabulated in **05-904**. For 1990, EIA document **05-089** indicated statewide, industrial oil use of 163 million liters, which was prorated using the same ratio and then discounted by the 2.0 million liters attributed in **05-904** to PSCAA-monitored sources.

2005 emissions from cement manufacture were calculated in **05-901** by multiplying the tons of clinker produced at each plant (from **05-100** and **05-904**) by calcination factors provided by the cement plants in **05-100** and **05-134**. 1990 process emissions were calculated similarly using 1990 clinker production data from **05-098**.

Other industrial emissions originated from two steel manufacturers. Production data available at the Puget Sound Clean Air Agency (**05-102** and **05-157**) was multiplied by the nominal IPCC emission factor associated with electric arc furnaces, 1.25 $kgCO_2/Mg$ steel. The manufacturers use entirely recycled stock so there are no emissions associated with carbon lost from pig iron (see **05-127**).

Fugitive ODS substitutes in 1990 and 2005 were both estimated by prorating the U.S. inventory of ODS substitutes **05-802** by resident populations. Fugitive SF_6 in 1990 and 2005 was estimated by Seattle City Light in source document **05-013**.

For construction and other small equipment in 2005, Kwame Agyei of PSCAA calculated King County fuel use **05-023** as NONROAD model output, which was grouped by sector and fuel in worksheet **05-903**. County-level, commercial fuel use calculated in **05-903** was prorated to the City of Seattle in **05-901** using the industrial employment figures documented in the source note on page 9. 1990 emissions from small equipment were calculated similarly, but beginning with NONROAD output **05-097** instead of **05-023**.

Partner Contacts

Kwame Agyei (small equipment and steel manufacturing data)
Puget Sound Clean Air Agency

Travis Weide (concrete manufacturing data)
Lafarge

Gerald Brown (concrete manufacturing data)
Ash Grove

Bart Kale (steel manufacturing data)
Nucor

Bill Hopkins (natural gas consumption)
Puget Sound Energy

Energy Information Administration
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WASTE

Disposal of municipal solid waste in Seattle's early history was poorly controlled and poorly documented, and as a result the exact locations and sizes of most closed landfills and garbage dumps are unknown. The Abandoned Landfill Study of 1984 identified one dozen closed landfills for intensive study, while being careful to note that these twelve were only a sample of what existed and that "[the] historical study of abandoned landfills presents a picture of 'probably anything' located 'most anyplace.'"[e] A complete list of landfill sites for which the 1984 researchers were able to find documentation appears in Appendix C.

Table 15 lists emissions from six of the largest closed landfills in the City of Seattle.

[e] Seattle-King County Department of Public Health, *Abandoned Landfill Study in the City of Seattle*. July 30, 1984. p. 3.

Table 15 – Emissions from closed landfills inside the City of Seattle

	emissions, $MgCO_2e$	
	1990	**2005**
Interbay	68,000	31,600
Genesee	64,600	30,000
Montlake	-	12,800
Judkins Park	11,600	5,380
South Park	24,700	11,500
West Seattle	4,810	2,240
totals	174,000	93,600

One of these landfills, Interbay, is partially monitored for methane emissions. Seattle Public Utilities has evaluated the Interbay, Genesee, Judkins Park and South Park landfills through historical and contemporary topographic information to estimate their volumes; hence emissions estimates for the unmonitored landfills can be estimated from volume ratios. Emissions from the Montlake landfill were estimated separately from independent estimates of landfill volume, and emissions from the West Seattle landfill are monitored directly. 1990 emissions from Montlake are reported as zero because they were flared at the time.

King County operates a large wastewater treatment plant, West Point, located adjacent to Discovery Park within the Seattle city limits. Wastewater treatment emits methane and nitrous oxide; King County inventories these emissions and reported calendar year 2003 emissions of 3,250 $MgCO_2e$; this value is used as a 2005 estimate in Table 16. 1990 emissions are slightly lower, reflecting growth in Seattle population from 1990 to 2005.

Table 16 – Emissions from wastewater treatment inside the City of Seattle.

	emissions, $MgCO_2e$	
	1990	**2005**
emissions	2,920	3,250

Waste Source Notes

Interbay monitoring data in **05-058** supplied by Min-Soon Yim indicated 4,390 $MgCO_2e$ of methane emissions from the portion of the landfill that is under vacuum. Emissions for the entire landfill are estimated by multiplying the monitored value by 7.2, the ratio of total landfill surface area to surface area over the extraction system (also documented in **05-058**).

Ratios of other landfill volumes to Interbay's volume are listed in **05-066** provided by Jeff Neuner. Emissions estimates for Genessee, Judkins Park and South Park are all generated by multiplying Interbay's emissions by the respective volume ratios. Emissions from the Montlake landfill are those estimated in the University of Washington greenhouse gas inventory **05-158**. Emissions from the West Seattle landfill are calculated from Port of Seattle monitoring data in **05-174**.

The 2005 wastewater treatment emissions are taken directly from the King County 2003 greenhouse gas inventory, **05-806**; the 1990 estimate prorates the 2005 value by Seattle city population growth.

City Contacts

Min-Soon Yim
Seattle Public Utilities / Solid Waste Field Operations

Jeff Neuner
Seattle Public Utilities / Performance Management

Partner Contacts

Kathy Bahnick (West Seattle landfill monitoring data)
Port of Seattle

John Chapman (Montlake landfill methane estimates)
University of Washington / Facilities Services

Scope 2 – Energy Imports

ELECTRICITY

Electricity consumption in the city of Seattle has grown between 1990 and 2005, from 7.40 million megawatt-hours (MWh) to 7.68 million MWh. However, population has been growing faster, so per-capita electric use declined in the same period.

In 1990, Seattle City Light (SCL) was a partial owner of the Centralia coal-fired power plant, which was the major source of greenhouse gas emissions in that year. By 2005, SCL had divested its interest in the Centralia plant, but several long-term purchase contracts still had associated GHG emissions.

In any given year, only a portion of the electricity generated by SCL or purchased on long-term contracts is delivered to SCL customers. In 1990, 76 percent of the electricity generated or purchased by SCL served its customers; the rest was sold to other utilities. In 2005, 77 percent of the electricity generated by SCL served Seattle customers.

In 2005, SCL implemented its policy to purchase emission reductions in other projects—transitioning King County buses to hybrid and biodiesel, for example—to offset the annual emissions from generating the electricity delivered to its customers. SCL's "zero net emissions" policy is driven by City of Seattle Resolution 30144. Accordingly, Table 17 shows no Scope 2 emissions in 2005.

Table 17 – Electricity consumption within Seattle city limits and related emissions.

	consumption, MWh		emissions, $MgCO_2e$	
	1990	2005	1990	2005
SCL electricity	7,400,000	7,680,000	406,000	-

SCL's service area is slightly larger than the city's geographic boundary, so both the consumption and emissions figures in Table 17 are prorated from the utility's gross figures to reflect only the data associated with electricity delivered inside the city limits.

The 364,000 $MgCO_2e$ shown for 1990 is due principally to the Centralia coal plant, and in a much smaller part to a few long-term contracts. Greater detail on emissions from electric

generation, and on emission reduction purchases, are in the Corporate inventory beginning on page 27.

Electricity Source Notes

Corinne Grande provided Seattle City Light (SCL) emissions data in spreadsheet **05-013**. 1990 generation at Centralia was provided by Mike Ruby of Envirometrics in **05-154**, multiplied by 8% to represent the equity share documented in **05-155**, and multiplied by the appropriate emission factor from **05-013**. All other emissions from generation were taken directly from **05-013**. Emissions from SCL site fuel use and sewage treatment were calculated from separate SCL data **05-132**. In **05-901** the SCL service area emissions are discounted 17% in 1990 per **05-142**, and 16% in 2005 per **05-141**, to account for electricity delivered outside the city limits.

For 2005, emissions are zero due to the offset program; see the discussion in Section *ELECTRIC UTILITY EXPORTS & OFFSETS* on page 40.

City Contacts

Corinne Grande
Seattle City Light / Science Policy Unit

Scope 3 – Other

MUNICIPAL SOLID WASTE DISPOSAL

Emissions from municipal solid waste disposal are included in Scope 3 of both the corporate inventory and the geographic inventory. See the corporate inventory for the discussion and source notes.

Optional Information

AIR TRAFFIC

Seattle residents departing on or returning from air travel usually use Seattle-Tacoma International Airport (Sea-Tac) as their departure and arrival point. Survey data from the airport operator, Port of Seattle, indicate that 29% of passenger traffic at the airport consists of residents. Though emissions from the flights taken by these passengers do not occur within the city limits, the air traffic is the result of activities by Seattle's population and hence is accounted in Scope 3.

Table 18 lists passenger fuel use and associated emissions from Seattle citizens' domestic jet travel flowing through Sea-Tac airport. The estimate was limited to domestic flights for consistency with the U.S. GHG inventory and prior City of Seattle inventories.

The science regarding global warming impact of CO_2 released in the stratosphere by aircraft (rather than at ground level by most other sources) is still in development, but indications are that stratospheric CO_2 releases may have a much higher impact. In this inventory aircraft emissions are calculated conservatively, using the same GWP as for ground-level releases; when scientific consensus settles on a GWP for stratospheric CO_2 these values may need to be retrospectively increased.

Table 18 – Fuel use and emissions ascribable to Seattle citizens' use of SeaTac airport

	fuel consumption, ML		emissions, $MgCO_2e$	
	1990	2005	1990	2005
Sea-Tac jet fuel	418	427	1,050,000	1,070,000

Air Traffic Source Notes

Russ Simonson of the Port of Seattle provided 2005 Sea-Tac jet fuel consumption (1.65 billion liters), percentage of domestic flights (91.5%), percentage of passenger flights (97.6%), and percentage of passengers from Seattle (29%) via email communication **05-040**. The three percentages were multiplied together to prorate the fuel usage to Seattle passengers taking domestic flights. Equivalent values for 1990 were taken from data sheets **05-093** and **05-094** in the OSE archives.

Partner Contacts

Russ Simonson
Port of Seattle, Aviation Division

CEMENT ADJUSTMENT

Seattle's industrial sector includes two cement plants, which have operated in the city for many decades. One of Seattle's cement plants was temporarily closed from 1988 to 1992, meaning that 1990's cement production was significantly out of step with Seattle's historical emissions. Because cement production is roughly 13 percent of the community greenhouse gas inventory and because cement production is driven by regional—even national—demand, a meaningful comparison of community-wide progress in emission reductions from 1990 to 2005 would benefit from either excluding cement from the community footprint or adjusting the 1990 baseline based on an estimate of what Seattle's cement production levels would have been had both plants been operating at the time.

A similar baseline adjustment is often used in corporate inventories to account for emissions from acquisitions and divestitures of facilities and operations that add or subtract at least 10 percent of the corporation's total footprint. Although the situation is not entirely analogous in the community footprint context, because there is no standard protocol for local communities, it is our best guide for how to control for atypical emission levels in the baseline year.

It is unclear whether the standard protocol for cities, which is currently under development, will call for exclusion of large point source emissions like cement or whether it will adopt the baseline adjustment approach. This inventory uses historical operating data to estimate the average emissions of the second cement plant: approximately 592,000 $MgCO_2e$/year. To protect proprietary data of the cement plant operator, source data for the baseline adjustment are not tabulated in this document.

Cement Adjustment Source Notes

John Anderson of the Puget Sound Clean Air Agency provided historical records of clinker production in **05-150**. In **05-901** a steady state value for clinker production was estimated as an average of the values occurring during a stable, multi-year segment of the plant's operating history. The steady-state clinker production was divided by the

2005 clinker production to produce a scaling factor; this scaling factor was multiplied by 2005 emissions from the same plant to create a 1990 counterfactual.

Partner Contacts

John Anderson
Puget Sound Clean Air Agency

MSW-RELATED SEQUESTRATION

Sequestration associated with landfilled municipal solid waste is included in Optional Information of both the corporate inventory and the geographic inventory. See the corporate inventory for the discussion and source notes.

RECYCLING EMISSIONS

Emissions savings associated with recycling are included in Optional Information of both the corporate inventory and the geographic inventory. See the corporate inventory for the discussion and source notes.

URBAN FOREST SEQUESTRATION

About half of the dry mass of a typical tree consists of carbon that was separated from CO_2 by photosynthesis. As a tree grows, it destroys CO_2, releasing the oxygen but sequestering the carbon in the mass of its roots, trunk, branches and leaves. Table 18 estimates that during the calendar year 2005 trees growing within the City of Seattle stored about 13,000 metric tons of carbon, destroying about 48,000 metric tons of CO_2 in the process. This inventory does not attempt to account the CO_2 releases associated with felled urban forest, so the gross sequestration values reported in Table 19 should be treated as maximum values of net sequestration, which is likely to be much smaller. There is no data for urban forest sequestration in 1990.

Table 19 – Annual carbon uptake (sequestration) in Seattle's urban forest

Carbon sequestration, $MgCO_2e$	1990	2005
Downtown	n.d.	363
Major Institutions	n.d.	544
Manufacturing/Industrial	n.d.	2,360
Multi-Family	n.d.	3,540
Neighborhood/Commercial	n.d.	1,720
Single Family	n.d.	16,300
Parks -Natural Area	n.d.	19,600
Parks - Developed Sites	n.d.	3,080
total	50,600	47,500

Urban Forest Sequestration Source Notes

Data for 2005 urban forest sequestration was provided by Tracy Morgenstern in **05-075**. The source document calculates sequestration using a single estimate of sequestration rate per tree (9,410 gC/tree-yr) multiplied by tree counts, so the estimate should be considered crude.

Mark Mead provided an estimate that 6% of the Seattle tree canopy was lost from 1990 to 2005 (**05-082**); this estimate was used to scale the 2005 total to create an estimated 1990 total.

City Contacts

Mark Mead
Parks & Recreation / Urban Forestry Unit

Tracy Morgenstern
Office of Sustainability and Environment

ELECTRICITY CONSERVATION

Seattle City Light has administered an aggressive electric conservation program since the 1970s, which reduces the demand for electricity and hence reduces Scope 2 emissions. In 1990, the conservation program avoided approximately 225,000 MWh of electricity use, and hence was responsible for reducing the greenhouse gas inventory about 9,170 $MgCO_2e$ below its gross value otherwise. In 2005, the conservation program avoided approximately 973,000 MWh electric consumption, significantly reducing the need for purchase of GHG offsets.

Electricity Conservation Source Notes

Conservation program performance is reported in **05-159**. The 1990 conservation program performance is converted to GHG savings in **05-901** using a 1990 SCL electricity emission factor of 0.049 $MgCO_2e$ inferred from **05-013**, and prorated to in-city electric service according to data from **05-142**.

City Contacts

"**Energy Conservation Accomplishments: 1977-2005**," available online at http://www.seattle.gov/light/Conserve/cv5_pub.htm.

Corporate Inventory

The Corporate Boundary

For the purposes of conducting a greenhouse gas inventory, City of Seattle government operations can be allocated among nine different departments that are assigned jurisdiction over the City's various facilities:

1. **City Light** – Electric generating, transmission and distribution facilities;
2. **Fleets & Facilities** – Administration buildings, vehicles, police & fire;
3. **Housing** – Low-income housing sites;
4. **Neighborhoods** – 13 Neighborhood Service Centers and over 50 P-Patches;
5. **Parks & Recreation** – Over 400 parks, community centers and pools;
6. **Public Library** – Central Library and 28 branches;
7. **Public Utilities** – Two large watersheds and various pipelines, pipeline rights-of-way, reservoirs and pumps, sewers, and two transfer stations;
8. **Seattle Center**; and
9. **Transportation** – miscellaneous rights-of-way, parking lots and pedestrian corridors.

Some of the facilities over which these departments have jurisdiction are leased rather than owned; the inventory compiles only the emissions associated with the owned facilities. In addition to the facilities represented by the nine jurisdictional departments, Public Utilities contracts out most municipal solid waste handling and disposal, and emissions of these operations are included in Scope 3 of the corporate inventory.

Table 20 – Overview of the City of Seattle corporate inventory

	$MgCO_2e$	
	1990	**2005**
Scope 1 - direct emissions		
electric utility		
owned generation	594,000	-
switchgear insulation	10,000	5,320
resource site emissions	n.d.	398
total	604,000	5,720
buildings		
natural gas heating	20,900	14,900
refrigerant loss	2,000	13
total	22,900	14,900
vehicles		
motor pool	18,700	19,500
other	3,500	2,280
total	22,200	21,800
landfills	351,000	73,400
all sources	1,000,000	116,000
Scope 2 - energy imports		
electric utility		
contracts & treaties	93,200	335,000
net market purchases	-	-
other electric purchases	n.d.	4,230
steam	740	111
all sources	93,900	340,000
Scope 3 - other emissions		
employee commuting	17,000	15,900
business air travel	1,540	709
concrete & asphalt manufacture	4,610	4,240
MSW collection & hauling	11,700	20,400
MSW decay commitment	110,000	103,000
all sources	145,000	145,000
grand totals	1,240,000	600,000
Optional Information		
exported electricity emissions	(151,000)	(78,100)
electric utility offsets	(547,000)	(266,000)
corporate electric use (MWh)	n.d.	191,000
upstream biofuel emissions	-	447
forest sequestration	-	(394,000)
MSW-related sequestration	(208,000)	(146,000)
recycling emissions	(439,000)	(481,000)

Sums may not equal totals due to rounding

For the corporate inventory, several 1990 emissions data are adopted directly from the 1990 baseline reported in the 2000 inventory, rather than entirely recalculated as they are for the geographic inventory.

Scope 1 – Direct Emissions

Scope 1 emissions, or direct emissions, originate from *equipment and facilities owned by the City of Seattle*. Scope 1 emissions made up the majority of the 1990 inventory; in 2005 Scope 2 emissions dominated the inventory.

ELECTRIC UTILITY

Direct emissions form SCL operations in 1990 and 2005 are summarized below in Table 21 below.

In 1990 Seattle had partial ownership in the Centralia coal plant, which generated all of the 528,000 $MgCO_2e$ of emissions tabulated for 1990. The plant was sold mid-2000, so in 2005 all remaining generation facilities owned by SCL were hydroelectric and there are zero emissions from owned generation.

Sulfur hexafluoride is used as a gaseous insulator in electrical switchgear, and each year a certain quantity must be replaced due to leakage. SF_6 has an extremely high GWP of 23,900, so even the small, leaked quantity makes a measurable contribution to greenhouse gas emissions.

SCL operates three large dams in the Skagit River Hydroelectric Project, and the Boundary Dam on the Pend Oreille river. Operations at both sites induce small amounts of local fossil fuel consumption, and load sewage treatment facilities serving the staff. Emissions associated with these sites are listed in the last two rows of Table 21.

Table 21 – Direct emissions from Seattle City Light

		consumption		emissions, $MgCO_2e$	
		1990	**2005**	**1990**	**2005**
owned generation	MWh	8,230,000	5,540,000	528,000	-
SF_6 loss	kg	n.d.	n.d.	10,000	5,320
site fuel use				n.d.	384
site sewage treatment				n.d.	15
totals				538,000	5,720

Electric Utility Source Notes

Seattle City Light completes an independent greenhouse gas inventory each year; data from the 2005 inventory were provided by Corinne Grande in spreadsheet **05-013**. Corinne also supplied data on Skagit and Boundary site fuel use and employee populations in **05-132**. CH_4 and N_2O emissions associated with site sewage treatment were calculated from the 2005 employee populations in **05-902** using national average rates derived from the U.S. GHG inventory **05-802**.

City Contacts

Corinne Grande – see geographic inventory Scope 2.

BUILDINGS

Greenhouse Gas emissions from buildings owned by the City of Seattle consist principally of CO_2 from combustion of natural gas for building heating and hot water. A small quantity of HFCs and PFCs are also attributable to the city's buildings, entering the atmosphere as leakage from HVAC equipment in which they are used as refrigerants. Emissions from buildings are summarized in Table 22 below.

The Fleets and Facilities Department (FFD) manages several central administration buildings as well as the police and fire department buildings. A substantive fraction of the natural gas consumption in Parks & Recreation is due to heating swimming pools. Seattle Center's natural gas is consumed primarily at a single, central steam plant that serves the entire campus.

Table 22 – GHG emissions from city-owned buildings

				emissions, $MgCO_2e$	
		1990	2005	1990	2005
natural gas heating					
City Light	TJ	n.d.	n.d.	n.d.	265
FFD (includes police & fire)	TJ	75	99	4,370	4,960
Neighborhoods	TJ	-	-	16	-
Parks & Recreation	TJ	164	118	9,500	5,910
Public Library	TJ	9	10	497	490
Public Utilities	TJ	44	10	2,530	492
Seattle Center	TJ	69	52	3,980	2,580
unknown depts.	TJ	n.d.	4	n.d.	180
totals	TJ	361	292	20,900	14,900
refrigerant loss	kg	n.d.	n.d.	2,000	13
totals				22,900	14,900

Emissions from "unknown departments" are due to natural gas accounts identified by the city's natural gas supplier but uncorrelated to any internal billing records discovered during this inventory. Refrigerant loss is tracked by a central HVAC shop so cannot be disaggregated by department.

Buildings Source Notes

1990 values for natural gas consumption and refrigerant loss are adapted from the original inventory and documented in **00-901**.

Natural gas consumption through most of the City of Seattle's PSE accounts was supplied by Kellie Kuhlman of PSE in two separate data sets **05-069** and **05-143**. Consumption for Parks & Recreation was supplied by David Broustis in **05-121**. Consumption for the Public Library system was provided by Daniel Baer in **05-103**. Emissions associated with Seattle City Light were included in the Seattle City Light inventory **05-013** supplied by Corinne Grande; the PSE account numbers associated with the City Light emissions are documented by Corinne for reference in **05-135**. All natural gas consumption is summarized in **05-911**, and converted to emissions in **05-902**.

Refrigerant loss in 2005 was reported by Kelly Bills of Fleets & Facilities in **05-148**.

City Contacts

David Broustis
Seattle Public Utilities / Sustainability Strategies

Daniel Baer
Seattle Public Library / Administrative Services Division

Corinne Grande – see geographic inventory Scope 2

Kelly Bills
Fleets & Facilities / Heating, Ventilation, Air Conditioning

partner contacts

Kellie Kuhlman (City of Seattle account data)
Puget Sound Energy / Business Account Services

George Pohndorf (supervisor)
Puget Sound Energy / Business Account Services

VEHICLES

Emissions from vehicles controlled by Fleets & Facilities are detailed in Table 23. Though diesel fuel use has increased 35% from 1990 to 2005 (from 2.3 million liters to 3.1 million liters), emissions have increased only 18% (from 6,060 $MgCO_2e$ to 7,160 $MgCO_2e$). The reason is that an increasingly large fraction of the diesel purchased is B20, a mix of 20% biodiesel and 80% fossil diesel. CO_2 emissions from burning biofuels are not counted in the inventory, because the biofuel feedstock crops absorb an equal amount of CO_2 when they grow.

Table 23 – Fuel consumption by and emissions from vehicles controlled by the Fleets & Facilities Department

		fuel consumption		emissions, $MgCO_2e$	
		1990	2005	1990	2005
FFD-managed fleet					
gasoline	L	5,310,000	5,250,000	12,400	12,200
diesel	L	2,290,000	3,100,000	6,060	7,160
CNG	TJ	4	2	217	117
LPG	L	53,500	29,400	81	44
other vehicles		n.d.	n.d.	3,500	2,280
totals				22,200	21,800

Vehicles Source Notes

2005 fuel consumption by fleet vehicles was provided by Pat Eaton of the Fleets and Facilities Department in spreadsheet **05-006**. Calendar year 1990 fuel quantities were taken from OSE archive **00-011**. Fuel quantities were converted to greenhouse gas emissions using emissions factors as described in the source note for section *Audit Trail*.

City Contacts

Pat Eaton
Fleets and Facilities Department / Fleet Administration

CLOSED LANDFILLS

Table 24 lists 1990 and 2005 emissions of methane escaping from the City of Seattle's closed landfills. These emissions include all of the landfills inside the city limits tabulated in Scope 1 of the geographic inventory, plus two additional landfills located in Kent, WA: Midway Landfill

which accepted garbage from 1966 to 1983 and Kent Highlands which accepted garbage from 1968 to 1986.

By 1990 the Midway Landfill was fully capped and all methane was flared, but Kent Highlands was only partially capped and approximately 190,000 $MgCO_2e$ of methane escaped to the atmosphere during the calendar year. By 2005 both Kent landfills were fully capped and flared, and contributed no GHGs to the corporate inventory.

Table 24 – Fugitive methane emissions from closed landfills

	emissions, $MgCO_2e$	
	1990	**2005**
fugitive methane, Kent Highlands	193,000	-
fugitive methane, all others	158,000	73,400
totals	351,000	73,400

Closed Landfills Source Notes

Sources for landfills within the city limits are documented in Scope 1 of the geographic inventory, above.

1990 emissions from Kent Highlands were provided by Jeff Neuner in **05-058**. The decision to report zero fugitive methane emissions for the two Kent landfills was made in a meeting documented in **05-061**, based on ambient CH_4 levels above the landfill equal to the background level, and on negative pressure differentials induced by the vacuum system across and beyond the surface areas of the landfills.

City Contacts

Jeff Neuner – see geographic inventory, Scope 1

Scope 2 – Energy Imports

For the corporate inventory, Scope 2 emissions are induced by wholesale energy imports into the city-owned electric system, as well as by retail energy purchases by other city-owned facilities.

CONTRACTS AND TREATIES

Seattle City Light is engaged in a number of long-term contracts and treaties committing the City to purchases or exchanges of electricity with other generators or electric systems.[f] Table 25 itemizes the three contracts that include fossil-fueled generation, and also includes a fourth line-item listing the balance of contracted generation.

High Ross is a treaty in which SCL committed to purchase 35 average megawatts of electricity from the BC Hydro system through 2065, in exchange for not raising the height of High Ross dam.[g] The BC Hydro electric system consists principally of hydro resources but also includes

[f] "Long-term" contracts are those committing the parties for a term of 1½ years or longer.

[g] Raising the height of High Ross dam would have flooded a portion of the Canadian segment of the Skagit Valley. The High Ross treaty compensates Seattle City Light for not raising the dam height by providing a guaranteed, price-regulated source of electricity.

some natural gas combustion, which is reflected in the small but nonzero emission factor of 0.042 $MgCO_2e$/MWh.

BPA Block purchases are system-average electricity from the Bonneville Power Administration, which includes some long-term contracts with fossil-fired generators. In 1990 these fossil-fired resources saddled Block electricity with an emission factor of .018 $MgCO_2e$, but in 2005 the quantity of fossil-fueled resources had increased and BPA's Block emission factor was up to 0.107 $MgCO_2e$, yielding greater Scope 2 emissions than in 1990 even though Seattle purchased less Block product.

Klamath Falls CT is a contract to purchase electricity generated with a natural gas-fired, combined-cycle combustion turbine, with an associated emission factor of 0.377 $MgCO_2e$/MWh. The contract was entered into in 2001 so Klamath Falls does not contribute to the 1990 inventory.

All other long-term contracts are for hydro resources that do not produce GHGs.

Table 25 – Emissions associated with SCL contracts and treaties

	contract generation, MWh		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
High Ross	335,000	310,000	14,100	13,000
BPA Block	1,760,000	959,000	31,700	103,000
Klamath Falls CT	-	581,000	-	219,000
non-fossil contracts	1,330,000	4,530,000	-	-
totals	3,430,000	6,380,000	45,700	335,000

Contracts & Treaties Source Notes

All data are from the 2005 inventory provided by Corinne Grande in spreadsheet **05-013**.

City Contacts

Corinne Grande – see geographic inventory Scope 2

NET MARKET PURCHASES

Each year, City Light engages in wholesale market trading, purchasing and selling electricity on the spot market as well as committing to a variety of short-term contracts. If, in a given inventory year, market purchases exceed market sales then the City of Seattle accounts for emissions from the net purchases at a market-average emissions factor. In both calendar years 1990 and 2005 sales exceeded purchases so the associated Scope 2 emissions are zero.

Net Market Purchases Source Notes

All data are from the 2005 inventory provided by Corinne Grande in spreadsheet **05-013**.

City Contacts

Corinne Grande – see geographic inventory Scope 2

RETAIL ELECTRIC PURCHASES

Most city government facilities are located within the city limits and therefore consume electricity from Seattle City Light. Since the emissions due to SCL are already accounted elsewhere in the inventory, city facility use of SCL electricity is not counted.[h] However, a few facilities lie outside city limits and purchase electricity from Puget Sound Energy (PSE). Table 26 lists the consumption and associated emissions from facilities served by PSE.

In 2005, some 36% of PSE generation was coal-fired, so PSE electricity carried a relatively high (for the Pacific Northwest) emission factor of 0.386 $MgCO_2e/MWh$. The majority of PSE electric consumption in 2005 was at the Cedar Water Treatment Facility at Lake Youngs – Seattle's largest drinking water reservoir.

Table 26 – Electricity consumed by facilities outside the SCL service territory, and the associated GHG emissions

	consumption, MWh		emissions, $MgCO_2e$	
	1990	2005	1990	2005
PSE electricity	n.d.	11,000	n.d.	4,230

Retail Electric Purchases Source Notes

2005 consumption on PSE electric accounts billed to the City of Seattle is documented in spreadsheets **05-069** and **05-143** provided by Kellie Kuhlman of PSE. The 2005 PSE emission factor of 0.386 $MgCO_2e/MWh$ was adopted from the University Washington GHG emissions inventory **05-020**.

Partner Contacts

Kellie Kuhlman
Puget Sound Energy / Business Account Services

Stephanie Harrington (UW emissions inventory)
University of Washington / Earth Initiative

RETAIL STEAM PURCHASES

In 2005 the City of Seattle owned three buildings that receive steam energy: the Arctic Building, Fire Station #10 and the Central Library. Steam used and the associated emissions are listed in Table 26.

[h] It is nevertheless valuable to track city electric consumption for the sake of encouraging wise energy use; this is done in Optional Information section below.

The Arctic Building was sold in May, 2005 and the steam use and emissions reported in Table 27 represent only those occurring prior to sale. The Dexter-Horton building was sold in 2000, so contributed to the 1990 total emissions associated with steam.

Table 27 – Steam consumption in city-owned buildings and associated emissions. "klb" are thousand-pounds

	consumption, klb		emissions, $MgCO_2e$	
	1990	**2005**	**1990**	**2005**
Arctic Building	n.d.	690	n.d.	64
Dexter-Horton Building	n.d.	-	n.d.	-
Fire Department	n.d.	751	n.d.	69
Seattle Public Library	n.d.	451	n.d.	42
totals			740	111

Retail Steam Purchases Source Notes

2005 steam sales records were provided by Ann Wedeking of Seattle Steam in file **05-043**; the Seattle Steam emission factor is duplicated from the King County 2003 greenhouse gas inventory **05-806**. The Arctic Building sale date is documented by the Puget Sound Business Journal in **05-042**.

1990 steam sales are from the 2000 Seattle inventory **05-812**.

Partner Contacts

Ann Wedeking
Seattle Steam

Scope 3 – Other

EMPLOYEE COMMUTING

Washington State's Commute Trip Reduction (CTR) law requires employers with facilities housing 100 or more employees to survey commuting behavior biannually. The survey results are reported to King County, which archives the data in a standard format and forwards it to the Washington State Department of Transportation (WSDOT); WSDOT then processes the data to provide the city with commuting travel statistics for each qualifying facility. Table 28 lists the passenger-kilometers traveled in each fossil-fueled mode by City of Seattle employees.

For 1990, a breakdown by mode is not available, but gross 1990 emissions due to commuting were calculated in the 2000 inventory at 17,000 $MgCO_2e$, 7 percent higher than 2005's total of 15,900 $MgCO_2e$.

Table 28 – City of Seattle employee commuting and associated emissions

	travel, psgr-km		emissions, $MgCO_2e$	
	1990	2005	1990	2005
car	n.d.	45,500,000	n.d.	9,030
van	n.d.	660,000	n.d.	31
bus	n.d.	32,500,000	n.d.	6,300
rail	n.d.	4,030,000	n.d.	499
total	n.d.	82,700,000	17,000	15,900

Employee Commuting Source Notes

Compiled 2005 survey data were provided by Rick Cranford of King County in **05-083** and **05-084** for the eight business sites listed below:

CTR code	site name	emp.
E83949	CBD Site	5500
E83956	Charles Street Complex	260
E83964	Haller Lake	122
E83972	Seattle Center	246
E83980	Utilities Field Operation	190
E83998	City Light/N Service Ctr	357
E85100	City Light/S Service Ctr	490
E89284	Parks and Recreation	185

In workbook **05-909** the survey mode shares, site populations and average trip lengths are converted to passenger-miles traveled in each mode, and also into vehicle-miles traveled for automobiles, carpools and vanpools. In workbook **05-902** car and van vehicle-miles, and rail passenger-miles, are converted to fuel consumption using fuel intensity data from the U.S. DOE Transportation Energy Data Book **05-808**. Bus passenger-miles were converted to fuel consumption using passenger energy intensity calculated specifically for King County Metro Transit in **05-902** from National Transit Database documents **05-018** and **05-019**.

Partner Contacts

Rick Cranford
King County / Metro Transit

Anne Ward-Ryan
King County / Metro Transit

BUSINESS AIR TRAVEL

City of Seattle employees occasionally travel by air to attend meetings and conferences. Emissions from such travel are summarized below.

Table 29 – Emissions from employee air travel on business

	emissions, $MgCO_2e$	
	1990	**2005**
employee business travel	1,540	709

source notes

1990 business travel emissions are from the prior inventory **05-812**. City government no longer tracks employee air travel (see **05-131**), so 2005 emissions were estimated in **05-902** from the last available year of travel data, 2000, as documented in the 2000 inventory in source file **00-013**.

CONCRETE & ASPHALT MANUFACTURE

The Seattle Department of Transportation utilizes substantial quantities of asphalt and concrete in road repair and construction. Asphalt and concrete production are both GHG-intensive, so the City of Seattle accounts the upstream emissions due to manufacture of the asphalt and concrete consumed by SDOT.

Table 30 – Emissions associated with SDOT road repair and construction

		SDOT use		emissions, $MgCO_2e$	
		1990	**2005**	**1990**	**2005**
asphalt	Mg	n.d.	9,980	n.d.	1,630
concrete	m^3	n.d.	7,490	n.d.	2,620
totals				4,610	4,240

Note: Upstream emissions from concrete and asphalt manufacture are not intended to fully represent emissions from the City's construction activities, which are much greater in scope and prohibitively complex to estimate.

Concrete & Asphalt Source Notes

Consumed quantities of asphalt and concrete were extracted from the SDOT Street Maintenance group's Maintenance Management System for the period September 2005 through August 2006 by Charles Bookman and reported in **05-114**. The Maintenance Management System cannot report records older than one year, so the September 2005 - August 2006 period serves as a proxy for 2005 in this inventory. The Maintenance Management System is likely to underreport quantities, so Charles also provided financial data on purchases from concrete and asphalt suppliers, in order to place upper bounds on the quantities consumed (see **05-114**).

In **05-902** the consumed quantities are multiplied by emissions factors **05-115** developed for the 2000 Inventory, to generate the emissions reported in Table 29.

City Contact

Charles Bookman
SDOT / Street Maintenance

MUNICIPAL SOLID WASTE DISPOSAL

The City of Seattle contracts out municipal sold waste (MSW) disposal to a third-party supplier, so emissions from garbage collection, transport and disposal do not fall in Scope 1 of the corporate inventory. Instead, they are tracked here in Scope 3 and presented in Table 31.

Emissions from MSW disposal arise from three different sources: in-city collection, transfer & long-haul, and landfill emissions commitment. In-city collection is simply the tailpipe emissions of the fleet of garbage trucks collecting Seattle garbage. Seattle's MSW contractor disposes of the garbage in the Arlington landfill in eastern Oregon, so significant emissions are also induced by hauling Seattle's trash by rail to the landfill – these are the transfer & long-haul emissions. In Table 31, transfer & long-haul emissions have increased substantially, from 3,410 $MgCO_2e$ in 1990 to 12,100 $MgCO_2e$ in 2005. This is because in 1990 the City of Seattle was disposing of its garbage in the King County Cedar Hills landfill, which is much nearer than the Arlington landfill.

"Landfill emissions commitment" is the total quantity of fugitive methane expected from the garbage disposed of in the inventory year, throughout its entire decay process in the landfill. The decay process takes many years, so the landfill emissions commitment is actually emitted only partly during the inventory year, and partly in future years. This line-item of the inventory is unique in this way, but recording emissions commitment associated with the waste reflects the global warming impact of the inventory year's policy choices much more accurately than the actual emissions of the landfill during that same year. This is especially true because the garbage in the landfill comes from other sources besides the City of Seattle as well.

Table 31 – Emissions associated with City of Seattle waste management

	emissions, $MgCO_2e$	
	1990	**2005**
in-city collection	8,280	8,290
transfer & long haul	3,410	12,100
landfill emissions commitment	110,000	103,000
totals	122,000	124,000

MSW Source Notes

All waste management emissions data were supplied by Jeff Morris in **05-099**.

City Contact

Jenny Bagby
Seattle Public Utilities / Strategic Asset Management

Optional Information

ELECTRIC UTILITY EXPORTS & OFFSETS

In some years the total quantity of electricity generated by SCL and purchased by SCL on long-term contracts ("resources") exceeds the quantity of electricity consumed by SCL's customers ("load"). This was the case in both 1990 and 2005, and Table 32 details the differences.

Table 32 – SCL resources, load and exports; and the emissions associated with them.

	1990	2005
resources (MWh)	11,700,000	11,900,000
load (MWh)	8,910,000	9,150,000
exported (MWh)	2,740,000	2,780,000
exported fraction	24%	23%
resource emissions ($MgCO_2e$)	573,000	335,000
exported emissions ($MgCO_2e$)	135,000	78,100

Exported = resources - load; *exported fraction = exported / resources*; and *exported emissions = resource emissions* x *exported fraction*. *Exported emissions* appears as a positive number in this table but appears as a negative number (a credit to the inventory) Table 19.

In Scope 1 and Scope 2 of the inventory, the City takes responsibility for emissions associated with all of SCL's resources, even when they are not used to supply SCL's customers. It may be appropriate to discount the portion of these emissions that does not serve SCL's customers. Table 32 calculates the fraction of each year's resources that are exported, and uses this fraction to calculate an associated emissions discount by prorating the emissions due to gross resources.

As of 2005, SCL purchases GHG offsets equal to emissions from the fraction of resources serving its own load, plus all emissions from corporate and service area operations. Table 33 details the calculation. 257,000 $MgCO_2e$ of resource emissions are serving SCL load, and SCL's total non-resource emissions are 8,410 $MgCO_2e$; these two numbers sum to make 266,000 $MgCO_2e$ of emissions to offset.

SCL's contracts include an agreement to purchase Stateline wind facility output that assigns ownership of environmental benefits associated with the electricity to SCL. Because Stateline displaces grid electricity, GHG reductions are associated with its generation and some of these are sold by SCL as transferable emission reductions. In 2005, 27,500 $MgCO_2e$ of the Stateline emission reductions were unsold and these are applied against the 266,000 $MgCO_2e$ of emissions, leaving 238,000 $MgCO_2e$ to be offset with additional offset purchases.

As of September 2006, SCL owns over 600,000 $MgCO_2e$ of transferable emissions reductions; the 238,000 $MgCO_2e$ of offsets required for 2005 will be debited from this account.

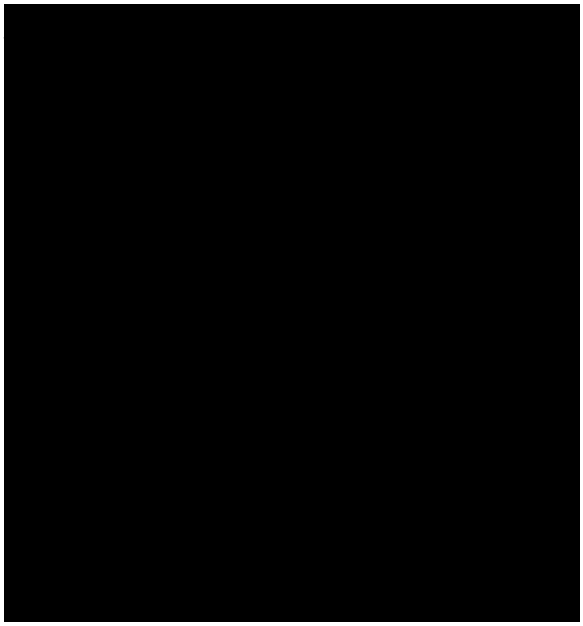

Table 33 – Calculation of offsets required to deliver GHG-neutral electricity to SCL customers. All values in $MgCO_2e$ except *fraction serving load* in percent.

Electric Utility Exports & Offsets Source Notes

Table 31 is developed in tab 'tables' of **05-902**, using the various original data sources cited elsewhere in this corporate inventory, principally the 2005 SCL GHG inventory **05-013** supplied by Corinne Grande. The value of owned transferable emission reductions ("over 600,000 $MgCO_2e$") is from **05-132**, also supplied by Corinne Grande.

city contacts

Corinne Grande – see geographic inventory Scope 2

CORPORATE ELECTRICITY USE

Seattle City Light favors conservation over acquiring generating resources wherever possible, so tracking electric use by the City allows an assessment of conservation efforts, independent of the GHG emissions or reductions associated with SCL electricity. Corporate electric use in 2005 is shown in Table 34; this datum was not compiled in the 2000 greenhouse gas inventory so 1990 data are unavailable.

Table 34 – City of Seattle corporate electricity consumption

	electric consumption, MWh	
	1990	**2005**
Seattle City Light	n.d.	n.d.
Fleets & Facilities	n.d.	48,200
Housing	n.d.	n.d.
Neighborhoods	n.d.	126
Parks & Recreation	n.d.	22,900
Public Library	n.d.	8,600
Public Utilities	n.d.	13,400
Seattle Center	n.d.	12,300
Transportation	n.d.	3,020
streetlighting	n.d.	79,300
traffic signals	n.d.	3,560
totals	n.d.	191,000

Corporate Electricity Source Notes

2005 corporate electricity consumption for the nine departments was provided by Leighton Stewart of SCL in **05-053**. Consumption in the streetlighting and traffic signals flat-rate accounts was provided by Leighton separately in **05-074** and **05-144**, respectively.

City Contact

Leighton Stewart
Seattle City Light / Account Executives

UPSTREAM BIOFUEL EMISSIONS

In the abstract, biofuels are GHG-neutral because the tailpipe emissions are completely recycled by the next crop of biofuel feedstock. In practice, substantial quantities of fossil fuels are consumed during the farming of the feedstocks and refining of the biofuels, while additional GHGs are generated in the agricultural process. The 1.98 million liters of B20 biodiesel consumed by the City of Seattle were responsible for approximately 447 $MgCO_2e$ of such upstream emissions, beyond those that would have been produced by consuming an equal amount fossil diesel fuel.

Biofuel Source Notes

Life-cycle emission reduction factors associated with biofuels were extracted from **05-152**, *Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts* published in 2007 by the California Energy Commission. These were multiplied by the biodiesel quantities supplied by Pat Eaton in **05-006**.

City Contact

Pat Eaton – see Scope 1 above.

FOREST SEQUESTRATION

GHG sequestration in urban forest is calculated in the geographic inventory, Optional Information on page 24. However, the City of Seattle also owns forested land outside the city limits, most notably in the watersheds of the Cedar River and Tolt River. The Cedar River watershed, 90,500 acres in size, was harvested for timber throughout the 20th century until 1997; there have been no harvests since that time. As a result, the re-growing forest is sequestering carbon at a high rate. Table 35 shows the net sequestration in 1990 and 2005.

The net annual sequestration is believed to be approximately zero in 1990, but is increasing as the forest matures. As of 2005, the net annual sequestration was 394,000 $MgCO_2e$, consisting of 473,000 $MgCO_2e$ of on-site sequestration in the forest, discounted by 78,400 $MgCO_2e$ of emissions associated with decaying wood products from prior years' harvests. Since no more wood products are being manufactured from Cedar River watershed harvests, the emissions associated with decay will decrease in future years, as on-site sequestration increases.

Sequestration on the Tolt River watershed has not yet been evaluated.

Table 35 – Sequestration associated with the Cedar River watershed.

	1990	2005
Cedar River Watershed		
on-site sequestration	n.d.	473,000
off-site wood product decay	n.d.	(78,400)
net sequestration	-	394,000

In this table positive values represent sequestration and negative values represent emissions, opposite to most other tables in the document.

Forest Sequestration Source Notes

All data on Cedar River watershed sequestration are from memorandum **05-079** written by Gordon Smith of Environmental Resources Trust. The memo was delivered to Corinne Grande of SCL on June 28, 2004.

City Contact

Corinne Grande – see geographic inventory Scope 2

MSW-RELATED SEQUESTRATION

The majority of MSW consists of organic matter. When organic waste is buried in a landfill, a portion decays anaerobically to methane and carbon dioxide, but the remaining portion remains buried in the landfill indefinitely. The remaining portion represents CO_2 sequestration, since the carbon in the waste was originally extracted from the atmosphere for instance by a food plant, by garden vegetation, or by a tree harvested for forest product. Table 36 lists the sequestration associated with waste disposed of in the Cedar Hills landfill in 1990, and in the Arlington landfill in 2005.

Similarly to the methane commitment described in Scope 3 above, the values in Table 36 are calculated for the waste disposed in the listed calendar year, but represent the sequestration enduring only after that waste's decay is complete, many years in the future.

Table 36 – Sequestration associated with landfilling of Seattle's municipal solid waste

	1990	2005
final anticipated sequestration	208,000	146,000

In this table positive values represent sequestration and negative values represent emissions, opposite to most other tables in the document.

MSW Sequestration Source Notes

All waste management emissions data were supplied by Jeff Morris in **05-099**.

city contact

Jenny Bagby
Seattle Public Utilities / Strategic Asset Management

RECYCLING EMISSIONS

Seattle Public Utilities' recycling program induces emissions from its operations, but also avoids emissions associated with disposal of MSW and manufacturing of new materials and products, as shown in.

In the table, emissions from collection and processing of recycled waste (4,510 $MgCO_2e$ and 21,500 $MgCO_2e$ in 2005, respectively) are straightforward. Foregone sequestration (205,000 $MgCO_2e$ in 2005) refers to the lost GHG benefit of landfilling described in the *MSW-Related Sequestration* section above: the waste that is being recycled is not being sequestered, so the associated GHG benefit is foregone. Conversely, the avoided MSW disposal emissions (126,000 $MgCO_2e$) represent the avoided methane emissions coming from the same landfill. Finally, recycling avoids the need to manufacture new materials, which is a GHG-intensive process: in 2005, Seattle's recycling program avoided some 586,000 $MgCO_2e$ of emissions from materials manufacturing.

The benefit of avoided materials manufacture overwhelms the other line-items in Table 37 so the recycling program yields a net GHG benefit, some 481,000 $MgCO_2e$ of avoided emissions in calendar year 2005. This value represents the benefit of the entire recycling program, serving the entire city population.

Table 37 – Emissions associated with Seattle's recycling program

	1990	2005
emissions		
collection	4,160	4,510
processing	17,800	21,200
foregone sequestration	197,000	205,000
avoided emissions		
disposal as MSW	(110,000)	(126,000)
manufacturing of new materials	(549,000)	(586,000)
emissions totals	(439,000)	(481,000)

Recycling Source Notes

All waste management emissions data were supplied by Jeff Morris in **05-099**.

City Contact

Jenny Bagby
Seattle Public Utilities / Strategic Asset Management

Appendix A:
Standard Factors Used in GHG Calculations

molecular mass ratios

CO_2/C	3.664	[unitless]
CO_2/CH_4	2.743	[unitless]

100-year global warming potentials (from Second Assessment Report)

CO_2	1	[unitless]
CH_4	21	[unitless]
N_2O	310	[unitless]
SF_6	23,900	[unitless]

higher heating values of fuels (from U.S. GHG Inventory 2004)

gasoline	34.8	MJ/L	
distillate fuel oil (“diesel”)	38.6	MJ/L	
residual fuel oil	41.7	MJ/L	
natural gas	0.0382	MJ/L	at 1 atmosphere, 15 degC
LPG (“propane”)	25.4	MJ/L	
coal	32.5	MJ/kg	U.S. industrial sector avg.
jet fuel	37.6	MJ/L	

carbon content of fuels (from U.S. GHG Inventory 2004)

gasoline	18.3	g/MJ
distillate fuel oil (“diesel”)	18.9	g/MJ
residual fuel oil	20.4	g/MJ
natural gas	13.7	g/MJ
LPG (“propane”)	16.3	g/MJ
coal	24.3	g/MJ
jet fuel	18.3	g/MJ

energy equivalents

gallon gasoline equivalent	132	MJ
kWh	3.60	MJ
mmBtu	1,054	MJ
therm	105	MJ

Appendix B:
Documented Historical Landfill Sites (See following page)

From Seattle-King County Department of Public Health, *Abandoned Landfill Study in the City of Seattle*, 1984.

TABLE I

DOCUMENTED HISTORICAL LANDFILL SITES

1910 ff

Tideflat area south of Jackson Street and west of Beacon Hill
Vicinity of 6th South and south of Spokane
West of Sick's Rainier Brewery

1911

East Ward Street and 29th Avenue North - Washington Park
Gilman Avenue and 16th Avenue West
27th Avenue South and Massachusetts Street
26th Avenue Northeast and the railroads - This ran back into Ravenna Park and the University Village area
35th Avenue Southwest and West Lander Street
22nd Avenue West and West Garfield Street
Foot of Wallingford Avenue at Lake Union
Along Salmon Bay at Ewing Street
Along north side of Salmon Bay Waterway at about 20th Avenue West

1920

Terry Avenue, south shore of Lake Union - Private property and street
South end of Wallingford Avenue - City property (since 1911)
Market Street and 28th Avenue Northwest - Private property and street
North of East Madison, vicinity of 30th Avenue North - Park property
26th Avenue North and East Miller Street - Park property
West Garfield and 22nd Avenue West - Street (since 1911)
Foot of 26th Avenue Northeast - City property
Puget Mill property - one-half mile south of Youngstown
First Avenue South and West Dakota Street - Railroad property
Oregon Street between 42nd and 44th Avenues South - Street
Crockett Street between Nob Hill and Third Avenue North

1920 (cont'd)

Block bounded by Dexter Avenue, Valley Street, 8th Avenue and Aloha Street in Block 9, Eden Addition
Southeast corner of 4th Avenue South and Spokane Street - Park property
The Columbia City Branch Library grounds
Green Lake field house and playfield area

September 1942

Ravenna Dump - on University of Washington property near Montlake
Interbay Dump - in vicinity of 17th Avenue West and West Barrett Street
22nd Avenue South dump - 22nd Avenue South and Norman Street
Industrial District Dump - 6th Avenue South and Lander South
Rainier Valley Dump - 43rd Avenue South and Dakota Street
West Seattle Dump - West Hanford STreet and Harbor Avenue Southwest

1945

University Dump - 25th Northeast and East 45th
Interbay Dump - 16th Avenue West and Ray Street
Judkins Street Dump - 25th Avenue South and Charles Street
6th Avenue South Dump - 6th Avenue South and Stevens
West Seattle Dump - Harbor Avenue Southwest and West Hanford
Genesee Dump - 44th Avenue South and Genesee

Appendix C:
Dataset Index

data sources

call#	ext.	**document title** and/or **<filename as received>**	**source** (person or URL)	**received**
05-001		*deleted*		
05-002	.doc	Vehicle Miles Traveled (VMT): Value as Measure of Progress and Predictive Potential for Modeling; <VMT.doc>	John Mauro	06/13/06
05-003	.xls	<psrc-data-base.xls>	John Mauro	06/13/06
05-004	.doc	<Re Table of Results.doc>	John Mauro	06/13/06
05-005	.xls	<Inventory Landfill.xls>	Kim Drury	06/13/06
05-006	.xls	<fuel use data 05.xls>	Pat Eaton	?
05-007	.xls	<VanHolde.xls>	Kim Drury	06/16/06
05-008	.xls	<Gas-DieselEmissions12-21-05.xls>	John Mauro	06/19/06
05-009	.xls	<CompileForJohnMauro11-04-05.xls>	John Mauro	06/19/06
05-010	.doc	supporting data (?)	John Mauro	06/19/06
05-011	.pdf	Decennial Population, City of Seattle, 1900-2000	<http://www.ci.seattle.wa.us/dclu/demographics/files/trndchng/histtrnd.pdf>	06/21/06
05-012	.xls	<RealFinalVersion.xls>	<G:/Climate Change/Climate Action Plan/Inventory folder/RealFinalVersion.xls>	06/26/06
05-013	.xls	<SCL's GHG Inventory for UW - Feb 2006.xls>	Corinne Grande	04/06/06
05-014	.doc	Re: my Seattle coordinates	Jeff Neuner	06/22/06
05-015	.doc	HISTORIC LANDFILL PROFILES IN THE CITY OF SEATTLE, <HISTORIC LANDFILL PROFILES.doc>	Phil Woodhouse	06/23/06
05-016	.xls	<Pma_Juris_Dept_CO2_study_refined.xls>	Alysoun Bond	06/28/06
05-017	.xls	<04.10 diesel use for UW study.xls>	Jim Boon, **King County Metro**	04/12/06
05-018	.pdf	Table 17:Energy Consumption : Details by Transit Agency (2004)	http://www.ntdprogram.com/NTD/NTDData.nsf/DataTableInformation?OpenForm&2004	04/21/06
05-019	.pdf	National Transit Database Metro Transit Profile 2004	http://www.ntdprogram.com/NTD/ntdhome.nsf/Docs/NTDPublications?OpenDocument	04/21/06
05-020	.xls	<05-914.xls>	Roel Hammerschlag	06/30/06
05-021	.doc	*phone call*	Pat Eaton	07/05/06
05-022	.xls	<SeattleGasSalesFcsts.xls>	David Van Holde	07/06/06
05-023	.xls	<kg nrd eqp pop 05.xls>	Kwame Agyei, **PSCAA**	07/10/06
05-024	.doc	<GHG Nov Report Final.doc>	Leslie Stanton, **PSCAA**	07/07/06
05-025	.mht	intercensal estimates	<http://www.census.gov/popest/archives/2000s/vintage_2001/CO-EST2001-12/CO-EST2001-12-53.html>	07/12/06
05-026	.xls	Table 1: Annual Estimates of the Population for Counties of Washington: April 1, 2000 to July 1, 2005	<http://www.census.gov/popest/counties/tables/CO-EST2005-01-53.xls>	07/12/06
05-027	.mht	QT-H8. Rooms, Bedrooms, and House Heating Fuel: 2000	<http://factfinder.census.gov/servlet/QTTable?_bm=y&-state=qt&-context=qt&-qr_name=DEC_2000_SF3_U_QTH8&-ds_name=DEC_2000_SF3_U&-CONTEXT=qt&-tree_id=403&-	07/12/06

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05-028	.mht	Distillate Fuel Oil and Kerosene Sales by End Use	<http://tonto.eia.doe.gov/dnav/pet/pet_cons_821use_dcu_SWA_a.htm>	07/13/06
05-029	.xls	<Seattle Point Sc Fuel Use.xls>	Kwame Agyei, **PSCAA**	07/10/06
05-030	.xls	<Seattle Point Sc Activity Lvl 05.xls>	Kwame Agyei, **PSCAA**	07/11/06
05-031	.doc	RE: questions on data files	Kwame Agyei, **PSCAA**	07/11/06
05-032	.doc	<NRD Generic 2005.DOC>	Kwame Agyei, **PSCAA**	07/11/06
05-033	.xls	<SAS Petroleum Fuel 05.xls>	Kwame Agyei, **PSCAA**	07/11/06
05-034	.doc	RE: Re: Coal, Oil, and Propane Consumption in Seattle	Kwame Agyei, **PSCAA**	07/14/06
05-035	FLD	RE: Nonroad Fuel Use in Seattle	Kwame Agyei, **PSCAA**	07/13/06
05-036	.mht	1999 Seattle Election - General Election Voters' Guide - Complete Text - Clist Title 2	<http://www.ci.seattle.wa.us/ethics/el99a/report/vpg/prop03ct.htm>	07/14/06
05-037	.doc	*phone call*	Scott Cline	07/14/06
05-038	.doc	RE: Boeing Field Aviation Fuel	Kwame Agyei, **PSCAA**	07/17/06
05-039	.doc	*phone call*	Jennifer Pettyjohn	07/17/06
05-040	.doc	RE: data request	Russ Simonson, **Port of Seattle**	07/17/06
05-041	FLD	Seattle Steam	Kwame Agyei, **PSCAA**	07/17/06
05-042	.mht	Seattle sells Arctic Building for $5M	Puget Sound Business Journal 6/30/05	07/20/06
05-043	.pdf	<SDOC2594.pdf>	Ann Wedeking, **Seattle Steam**	07/19/06
05-044	.doc	Seattle Steam History	Ann Wedeking, **Seattle Steam**	07/19/06
05-045	.xls	<5585_Pub_2004_AA.xls>	<http://www.workforceexplorer.com/admin/uploadedPublications/5585_Pub_2004_AA.xls>	07/21/06
05-046	.xls	<0602 UCUV Seattle Emp.xls>	Jennifer Pettyjohn (via Tom Kirn)	07/21/06
05-047	.xls	<Aircraft LTO Fuel 05.xls>	Kwame Agyei, **PSCAA**	07/18/06
05-048	.xls	<Fuel use for crew chief meeting 7-24-06.xls>	Corey Myers (via Adam Cole)	07/24/06
05-049	.xls	<05-022A.xls>	Bill Hopkins, **PSE**	07/25/06
05-050	.doc	Natural Gas Consumption	Bill Hopkins, **PSE**	07/25/06
05-051	.xls	Table 1: Annual Estimates of the Population for Incorporated Places Over 100,000, Ranked by July 1, 2005 Population: April 1, 2000 to July 1, 2005, <SUB-EST2005-01.xls>	<http://www.census.gov/popest/cities/tables/SUB-EST2005-01.xls>	07/25/06
05-052	.xls	WSF VESSEL MAINTENANCE DEPARTMENT - YEARLY FUEL REPORT FOR 2005, <CY2005 Fuel Consumption.xls>	Lucy Fullerton, **WSDOT**	07/27/06
05-053	.xls	<City Of Seattle Use 2005.xls>	Leighton Stewart	07/28/06
05-054	.doc	RE: Seattle Steam History.doc	Ann Wedeking, **Seattle Steam**	07/26/06
05-055	.doc	Carbon Sequestration through Urban Forestry - Project Report: Espresso Vivace Carbon Offsets for Coffee Bean Roasting, <Vivace Coffee Final Report_.doc>	Tracy Morgenstern	07/26/06
05-056	.xls	<CityofSeattleMetroEmissions8-2-06.xls>	Jim Boon, **King County Metro**	08/14/06
05-057	.doc	FW: City of Seattle emissions	Jim Boon, **King County Metro**	08/14/06
05-058	.xls	Global warming gas calculation for	Jeff Neuner	08/14/06

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		Interbay landfill, <co2cal for inter-2006.xls>		
05-059	.xls	Global warming gas calculation for Kent-Highlands Landfill for ch4, <co2cal for kent main-2006.xls>	Jeff Neuner	08/14/06
05-060	.doc	LANDFILL EMISSIONS	Jeff Neuner	04/27/06
05-061	.doc	*meeting*	Jeff Neuner, Phil Woodhouse, Paul Fleming, Min-Soon Yim	06/27/06
05-062	.pdf	2006 Electric Utility Fuel Mix Reports (2005 actual electricity production data)	<http://qa.cted.wa.gov/_CTED/documents/ID_3185_Publications.pdf>	08/15/06
05-063	.doc	<aug 15 2006 vmt memo to office of sustainability.doc>	John Donahue	08/15/06
05-064	.doc	Re: jurisdiction	Debbie Brooks	08/15/06
05-065	.doc	Re: 2005 VMT estimate	John Donahue	08/15/06
05-066	.doc	<City Owned Landfill Property.doc>	Jeff Neuner	08/15/06
05-067	.doc	City Owned Landfill Property.doc	Jeff Neuner	08/15/06
05-068	.xls	<2005 SPU GHG Inventory.xls>	Jeff Morris	08/17/06
05-069	.xls	<City of seattle Product Assignments.xls>	Kellie Kuhlman, **PSE**	08/21/06
05-070	.doc	Re: annexations/cesedings	Scott Cline	08/21/06
05-071	.doc	Re: data request	Jeff Morris	08/22/06
05-072	.xls	<seattle vessel assignments.xls>	Lucy Fullerton, **WSDOT**	08/21/06
05-073	.doc	Fwd: Re: Presentation by Waste Recovery Seattle International	Jeff Morris	08/23/06
05-074	.xls	<Seattle Street Lights.xls>	Leighton Stewart	08/22/06
05-075	.xls	<Tracys messing with file.xls>	Tracy Morgenstern	08/23/06
05-076	.doc	*phone call*	Mark Mead	08/24/06
05-077	.doc	RE: Re: FW: 2005 Ferry Fuel	Lucy Fullerton, **WSDOT**	08/24/06
05-078	.doc	Public Review Draft - Urban Forest Management Plan, <ew1c8_17.UFMP.doc>	Tracy Morgenstern	08/24/06
05-079	--	Projected Carbon Sequestration on the Cedar River Watershed, 1990-2040	Corinne Grande	08/21/06
05-080	.xls	<Nat Gas_1990-2003_From_Kwame_of_PSCAA_DVH MOD11-22-05.xls>	David Van Holde	07/06/06
05-081	.xls	<PSE Nat Gas.XLS>	David Van Holde	07/06/06
05-082	.doc	Re: WashingtonTreeGuide.pdf	Mark Mead	08/25/06
05-083	.xls	<QS_CityofSeattle_Roel_2005_fossilModes.xls>	Rick Cranford, **King County**	08/25/06
05-084	.xls	<QS_CityofSeattle_Roel_2005_q12.xls>	Rick Cranford, **King County**	08/25/06
05-085	.pdf	<Sample Survey - 2005 Cycle.pdf>	Rick Cranford, **King County**	08/25/06
05-086	.mht	Washington Total Distillate Sales/Deliveries to Residential Consumers (Mgal)	<http://tonto.eia.doe.gov/dnav/pet/hist/kd0vrsswa1a.htm>	08/29/06
05-087	.mht	H030. HOUSE HEATING FUEL - Universe: Occupied housing units	<http://factfinder.census.gov/servlet/DTTable?_bm=y&-state=dt&-context=dt&-ds_name=DEC_1990_STF3_&-mt_name=DEC_1990_STF3_H030&-tree_id=101&-redoLog=false&-all_geo_types=N&-_caller=geoselect&-geo_id=04000US53&-geo_id=16000US531140&-search_results=16000US531140&-format=&-_lang=en>	08/29/06
05-088	.mht	Washington Total Distillate Sales-Deliveries to Commercial Consumers	<http://tonto.eia.doe.gov/dnav/pet/hist/kd0vcsswa1a.htm>	08/29/06

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05-089	.mht	Washington Total Distillate Sales-Deliveries to Industrial Consumers (Mgal)	<http://tonto.eia.doe.gov/dnav/pet/hist/kd0visswa1a.htm>	08/29/06
05-090	.mht	United States - Population Finder - American FactFinder	<http://factfinder.census.gov/servlet/SAFFPopulation?_event=&geo_id=01000US&_geoContext=01000US%7C04000US53&_street=&_county=&_cityTown=&_state=04000US53&_zip=&_lang=en&_sse=on&ActiveGeoDiv=&_useEV=&pctxt=fph&pgsl=040&_submenuId=population_0&ds_name=null&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=>	09/06/06
05-091	.doc	<Misc Nonroad Proc 05.doc>	Kwame Agyei, **PSCAA**	08/30/06
05-092	.doc	<Aircraft Proc 05.doc>	Kwame Agyei, **PSCAA**	08/30/06
05-093	--	SUMMARY OF CALCULATIONS FOR CITY-WIDE AIRPLANE CO2	OSE archives hardcopy	--
05-094	--	Summary Report - 2001 Air Passenger Survey	Michael Drollinger, **Port of Seattle**	11/09/01
05-095	.xls	<1990 Seattle Point Sc Fuel Activity Level.xls>	Kwame Agyei, **PSCAA**	09/11/06
05-096	.xls	<CMV GHG 05.xls>	Kwame Agyei, **PSCAA**	09/11/06
05-097	.xls	<kgnr1990.xls>	Kwame Agyei, **PSCAA**	09/11/06
05-098	.xls	<1990 Seattle Point Sc Activity Level.xls>	Kwame Agyei, **PSCAA**	09/11/06
05-099	.xls	<2005 SPU MSW GHG Inventory.xls>	Jeff Morris	09/15/06
05-100	.doc	RE: Ash Grove greenhouse gas data	Jerry Brown, **Ash Grove**	09/14/06
05-101	.doc	SPD facilities	Heather Marx	09/13/06
05-102	.xls	<10281 Nucor Steel Seattle Inc 2005.xls>	Fred Austin, **PSCAA**	09/13/06
05-103	.xls	<2005NaturalGasHistory.xls>	Daniel Baer	09/12/06
05-104	.doc	Fwd: Re: 2005 natural gas use	Daniel Baer	09/12/06
05-105	.doc	Fwd: Re: 2005 natural gas use	Daniel Baer	09/14/06
05-106	.pdf	<SC PSE Accounts.pdf>	Edwin Paraiso	09/14/06
05-107	.doc	Zip codesindustrial zones	Jeanie Boawn	09/12/06
05-108	.xls	<PSE WORKSHEET 2000.xls>	Peter Haney	09/12/06
05-109	.doc	Re: data request	Heather Marx	09/11/06
05-110	.doc	1990 King County Nonroad Equipment Pop	Kwame Agyei, **PSCAA**	09/11/06
05-111	.doc	Fwd: Re: Natural gas	Kim Drury	09/08/06
05-112	.xls	<Charles Street Natural Gas usage.xls>	Kim Drury	09/08/06
05-113	.xls	<PSE-Coding-revised04-10-06.xls>	Cheri Brown	09/15/06
05-114	.doc	Re: asphalt and concrete	Charles Bookman	09/01/06
05-115	--	Year 2000 Seatran street paving with concrete	OSE archives hardcopy	--
05-116	.doc	Re: natural gas	Mary Laski	08/30/06
05-117	.doc	natural gas	Mary Laski	08/30/06
05-118	.doc	RE: recompiling 1990	Kwame Agyei, **PSCAA**	08/30/06
05-119	--	[no title]	Kwame Agyei, **PSCAA**	09/15/06
05-120	.pdf	<SPD RCM Grant Agreement.pdf>	David Broustis	09/18/06
05-121	.pdf	<2005 consumption.pdf>	David Broustis	09/18/06
05-122	.doc	*phone call*	Josephine Wong	09/18/06
05-123	.doc	<sep 18 2006 vmt memo to office of sustainability.doc>	John Donahue	09/18/06
05-124	.doc	GHG inventory - DVMT revision	John Donahue	09/19/06
05-125	.doc	RE: recompiling 1990	Kwame Agyei, **PSCAA**	08/31/06
05-126	.doc	<PSE Accounts.doc>	Heather Marx	09/19/06
05-127	.doc	*phone call*	Bart Kale, **Nucor**	09/25/06
05-128	.doc	*phone call*	Bill Hopkins, **PSE**	09/14/06

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05-129	.doc	RE: Ash Grove greenhouse gas data	Jerry Brown, **Ash Grove**	09/18/06
05-130	.doc	*phone call*	Fred Austin, **PSCAA**	09/26/06
05-131	.doc	Fwd: 2005 air travel	Victoria Galinato	07/25/06
05-132	.xls	<SCL Data for 2005 - sent 9-25-06.xls>	Corinne Grande	09/25/06
05-133	.doc	Re: SCL Data for 2005 - sent 9-25-06.xls	Corinne Grande	09/25/06
05-134	.doc	*phone call*	Travis Weide, **Lafarge**	09/29/06
05-135	.doc	Re: SCL Data for 2005 - sent 9-25-06.xls	Corinne Grande	09/25/06
05-136	.xls	<Natural gas usage.xls>	Heather Marx	09/25/06
05-137	.xls	<Natural gas usage number 2.xls>	Heather Marx	09/25/06
05-138	--	King County International Airport Master Plan, Draft SEPA EIS/NEPA EA	Kwame Agyei, **PSCAA**	?
05-139	.xls	<1990 vs 2005 data.xls	Travis Weide, **Lafarge**	09/29/06
05-140	.mht	Voluntary Reporting of Greenhouse Gases Program - Fuel and Energy Source Codes and Emission Coefficients	<http://www.eia.doe.gov/oiaf/1605/factors.html>	10/04/06
05-141	.txt	load outside Seattle City limits	Corinne Grande	09/26/06
05-142	.txt	Re: load outside Seattle City limits	Corinne Grande	10/02/06
05-143	.xls	<City of Seattle 2nd request..xls>	Kellie Kuhlman, **PSE**	10/09/06
05-144	.doc	*phone call*	Leighton Stewart	10/11/06
05-145	--	*1990 WSF schedules*	Marie Vanderberg	10/12/06
05-146	.pdf	<Winter06Schedule.pdf>	Marie Vanderberg	10/06/06
05-147	.pdf	<Fall06Schedule.pdf>	Marie Vanderberg	10/06/06
05-148	.xls	<Refrigerant-2005.xls>	Kelly Bills	10/13/06
05-149	FLD	TI06020 - City of Seattle September 22, 2006	Gail Findell, **WA Department of Revenue**	09/26/06
05-150	.xls	Cement Plant Data 1989-2006.xls	John Anderson, **PSCAA**	07/18/07
05-151	.pdf	Puget Sound Maritime Air Emissions Inventory	http://www.maritimeairforum.org/emissions.shtml	07/18/07
05-152	.pdf	Full Fuel Cycle Assessment: Well-to-Wheels Energy Inputs, Emissions, and Water Impacts	http://www.energy.ca.gov/2007publications/CEC-600-2007-004/CEC-600-2007-004-F.PDF	07/24/07
05-153	.pdf	Puget Sound Trends No. T2: Vehicle Miles Traveled	<http://www.psrc.org/publications/pubs/trends/t2aug07.pdf>	12/11/07
05-154	.xls	<Centralia generation.xls>	Mike Ruby, Envirometrics	01/07/08
05-155	.txt	Re: Centralia 1990	Corinne Grande	12/11/07
05-156	.pdf	<Audit Report.pdf>	Mike Ruby, Envirometrics	10/15/07
05-157	.xls	<Historical Steel Production.xls>	Kwame Agyei, PSCAA	01/09/08
05-158	.pdf	2005 Inventory of Greenhouse Gas Emissions ascribable to the University of Washington	Roel Hammerschlag, Stockholm Environment Institute	01/10/08
05-159	.pdf	Energy Conservation Accomplishments: 1977-2005	<http://www.seattle.gov/light/Conserve/cv5_pub.htm>	01/14/08
05-160	.xls	Forecasts of Households, Population and Employment	<www.psrc.org/data/forecasts>	01/18/08
05-161	.pdf	Washington State Greenhouse Gas Inventory and Reference Case Projections, 1990-2020	<http://www.ecy.wa.gov/climatechange/cat_documents.htm>	01/20/08
05-162	.xls	Table 9. Energy Consumption by Sector and Source (Pacific)	<http://www.eia.doe.gov/oiaf/aeo/supplement/supref.html>	01/20/08
05-163	FLD	Puget Sound Energy 2007 Integrated Resource Plan		01/20/08
05-164	--	Seattle City Light 2006 Annual Report	Roel Hammerschlag, Stockholm Environment Institute	01/24/08
05-165	.pdf	Puget Sound Trends No. T4: Ferry Ridership in the Central Puget Sound Region	<http://www.psrc.org/publications/pubs/trends/t4apr07.pdf>	01/28/08
05-166	.mht	The New Cafe Standards: Fuel standards will likely be achievable but won't encourage innovation.	<http://www.technologyreview.com/printer_friendly_article.aspx?id=20067>	01/28/08

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05-167	.txt	Re: FW: Seattle Steam feedstock	Amanda Eichel	01/29/08
05-168	.doc	phone call	Jeff Neuner	02/01/08
05-169	.pdf	Washington Port Forecasts 2004	<http://www.washingtonports.org/downloads/default.asp>	02/04/08
05-170	.pdf	2006 Integrated Resource Plan	<http://www.seattle.gov/light/news/issues/irp/>	02/04/08
05-171	.xls	<seavmt.xls>	Kris Overby, PSRC	02/08/08
05-172	.pdf	Port of Seattle Port-wide Shore Power: Long-term Electric Power & Utility Planning Study	Danielle Mills, Port of Seattle	02/14/08
05-173	.doc	phone call	Kathy Bahnick, Port of Seattle	03/03/08
05-174	.pdf	Terminal 5 Landfill Gas Collection and Treatment System Monthly Monitoring Results - Fourth Quarter 2007	Kathy Bahnick, Port of Seattle	03/03/08

references

call#	ext.	title	author	publisher or journal	year
05-801	--	Pocket Ref, 3rd ed.	Glover, Thomas J.	Sequoia Publishing, Inc.	2003
05-802	FLD	Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2004.	U.S. EPA	U.S. EPA	2006
05-803		*deleted*			
05-804	FLD	Seattle, a Climate of Change: Meeting the Kyoto Challenge. Report and Recommendations.	City of Seattle, Green Ribbon Commission On Climate Protection	City of Seattle	2006
05-805	.pdf	The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard, 2nd Edition.	World Business Council for Sustainable Development / World Resources Council	WBCSD/WRI	2004
05-806	.pdf	2003 Inventory of King County Air Emissions	King County	King County	2004
05-807	.pdf	Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery	Morris, Jeffrey	Int. J. LCA 10(4) pp. 273-284	2005
05-808	.pdf	Transportation Energy Data Book: Edition 25	Davis, Stacy C. & Diegel, Susan W.	U.S. DOE	2006
05-809	--	2003 Inventory of King County Air Emissions	King County	King County	2004
05-810	.pdf	Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting	McPherson, E. Gregory; Maco, Scott E.; Simpson, James R.; Peper, Paula J.; Xiao, Qingfu; VanDerZanden, Ann Marie; Bell, Neil	Center for Urban Forest Research, USDA Forest Service, Pacific Southwest Research Station	2002
05-811	.pdf	Emissions and Dispersion Modeling System (EDMS) User's Manual	CSSI, Inc.	FAA Office of Environment and Energy	2004
05-812	.pdf	Inventory and Report: Seattle's Greenhouse Gas Emissions	City of Seattle, Office of Sustainability and Environment	City of Seattle	2002
05-813	--	Good Practice Guidance and Uncertainty management in National Greenhouse Gas Inventories	Intergovernmental Panel on Climate Change	IPCC Secretariat	2000
05-814	.mht	Emission Facts: Average Carbon	U.S. EPA	U.S. EPA	2005

call#	ext.	title	author	publisher or journal	year
05-815	.pdf	Dioxide Emissions Resulting from Gasoline and Diesel Fuel Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels	ICF Consulting	U.S. EPA Emission Inventory Improvement Program	2004
05-816	--	Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories - Reference Manual (Volume 3)	Intergovernmental Panel on Climate Change	IPCC Secretariat	1996

workbooks

call#	description	source files
05-901	master workbook, geographic inventory	many
05-902	master workbook, corporate inventory	many
05-903	PSCAA NONROAD output sort	05-023
05-904	PSCAA point source files reconciliation	05-029, 05-030, 05-095
05-905	FFD Real Estate Services inventory sort	05-016
05-906	Seattle Steam data consolidation	05-044
05-907	NAICS code industrial/commercial ratios	05-045, 05-046
05-908	WA State Ferry data consolidation	05-052, 05-072
05-909	CTR data consolidation	05-083, 05-084
05-910	Maritime Air Forum data sort	05-096
05-911	PSE account numbers	many
05-912	2012 projections	05-901

Appendix D:
Audit and Responses

Text in Italics **are excerpts from the Envirometrics, Inc. audit dated October 15, 2007.**

No statements of the public policy of the City regarding the development of an inventory or the use to which the inventory data is to be put is included in the current report. An updated section similar to that presented in the Introduction to the 2002 Seattle Greenhouse Gas Inventory would be useful. (p.4 ¶6)

[OSE response]

The report describes the organizational boundary basis selected for the corporate inventory as the "equity share" approach, in which the emissions are assigned in proportion to the degree of ownership of the source . . . . However, that is not what was done in computing the emissions from Centralia in 1990 for the corporate inventory, the only case where the City had partial ownership in a GHG source. In this case the emissions liability was calculated from actual consumption by City Light of Centralia generation, which was 89% of its ownership share. (p.5 ¶2)

This has been corrected; the corporate inventory now accounts for 8% (Seattle's ownership share) of 1990 gross emissions from the Centralia coal plant.

Scope 3 is identified throughout the 2005 Inventory document as "other emissions". It would be more consistent with the protocols to identify it as "indirect emissions." (p.6 ¶1)

The phrase "indirect emissions" is often used in the literature to describe Scope 2 emissions, not Scope 3 emissions. (See, *e.g.*, U.S. EPA, Climate Leaders Program, "Indirect Emissions from Purchases/Sales of Electricity and Steam," 2004.) We feel that the terminology recommended does not clarify the inventory. No change.

The explanation [of Scope 3] *offered on page 6 is overbroad in stating that it includes "any sources of emissions . . . for which the city wishes to take responsibility."* (p.6 ¶1)

The text has been modified to be more consistent with the GHG Protocol definition of Scope 3.

A note at the bottom of Table 2 in the 2005 Geographic Inventory applies to both that and the 2005 Corporate Inventory. It describes the use of "-" to mean less than 0.5 MgCO2e/yr. In fact, it is used throughout the tables to mean less than 0.5 of other units also. It might be reasonable to move this note to the end of the Methodology section and rewrite it. (p.6 ¶3)

The note has been rewritten, but remains under Table 2 to ensure that it is available to casual readers of the document.

[I]*t might be useful to clarify that "n.d." may suggest that in addition to "no data" it may also mean that in the absence of the particular type of data that is not being reported an alternative calculation method was used to obtain useful emissions information, which is seen in the total.* (p.6 ¶3)

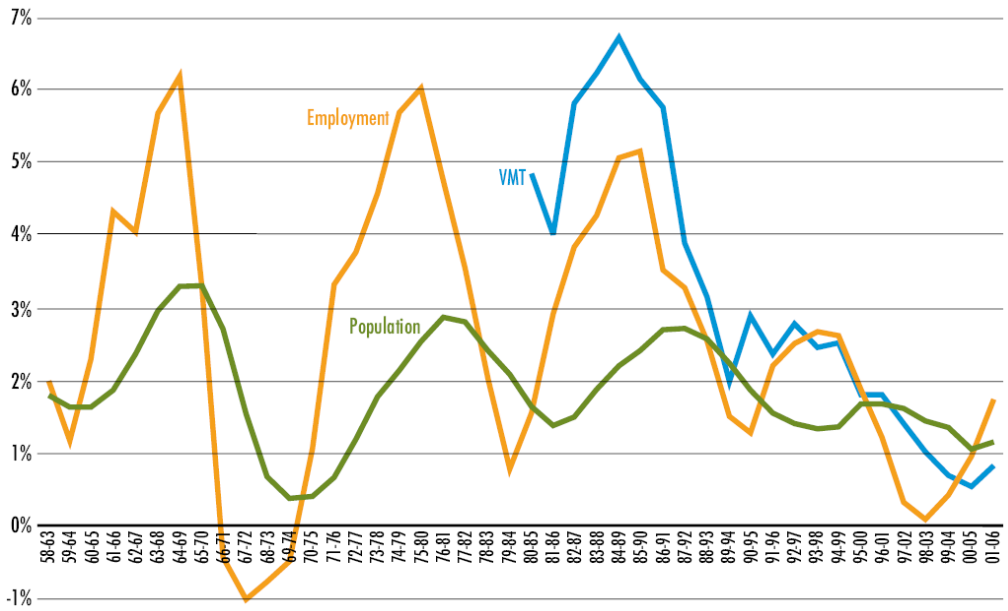
Text to this effect has been added.

Generally the source notes do adequately call attention to the often differing sources of data for the 1990 estimates and the 2005 estimates. However it may be useful to add a note in the Methodology section noting this and pointing out the potential uncertainty that can be created in the resulting numbers when there is a different basis or scaling factors that are less than ideal. (p.6 ¶4)

A new subsection **Time Basis** has been added to the **Methodology** section that covers this and related issues.

[R]*oad traffic . . . source numbers were supplied by the Seattle Dept. of Transportation (SDOT) from a model with detailed data only for the year 2000. It was necessary to use the change in actual roadway traffic counts at about 200 locations in Seattle to scale these year 2000 values to 1990. A similarly careful explanation was not given by SDOT for the 2000 to 2005 scale value, which was remarkably small and, thus, deserving of more justification than was provided.* (p.7 ¶3)

SDOT did provide an equally strong justification for the 2000 to 2005 scale value, in source document **05-123**, but **05-123** was not cited in the inventory source notes. A citation has been added. The notable reduction in growth rate between 1990-2000 and 2000-2005 is consistent with regional VMT trends tracked by the Puget Sound Regional Council, as visible in the following figure:



Five-year annual growth rates in the Puget Sound. Regional VMT hover around a 2%-3% annual growth rate in the 1990s, but then dip toward 1% in the 2000s. From **05-153**.

The inventory source note should more clearly state that the vehicle emission factors are based on national data. (p.7 ¶6)

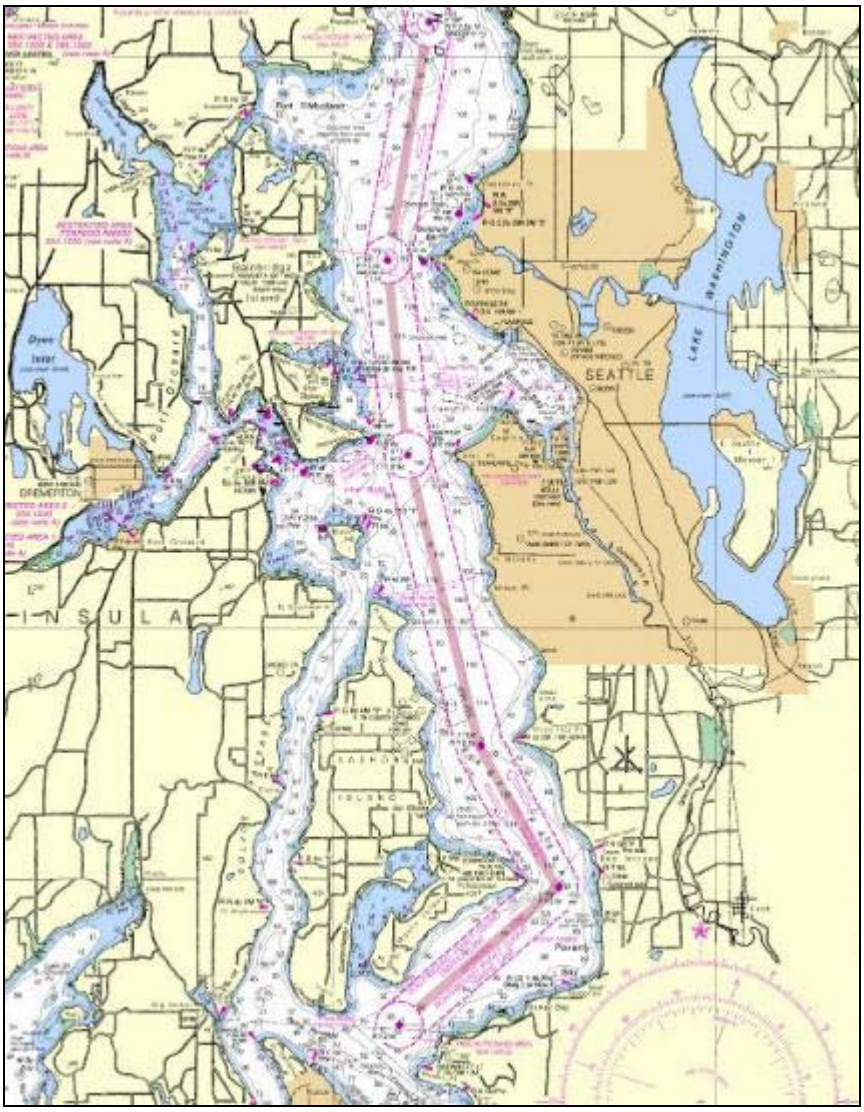
Text to this effect has been added.

While the factors used in the 2005 Inventory are justified and should be used as supplied, the uncertainty in the results due to choices in the method of calculation of emission factors should be noted. (p.8 ¶1)

Text to this effect has been added.

Because the west boundaries of Seattle and King County are coincident and the distances transited outside Seattle but within King County by any vessel arriving at the Port of Seattle from the Pacific Ocean are small compared to the distance inside Seattle, it may be more accurate to use the value of 98,562.5 tons CO_2e from Table 3-42 rather than the total of 61,369.5 tons CO_2e from Table 3-58. (p.8 ¶2)

The totals in **05-151** Table 3-42 include all ocean-going vessel (OGV) transit through King County, regardless of destination. King County extends considerably southward of the City of Seattle, and hence the substantial ship traffic headed toward the Port of Tacoma, not occurring within the Seattle city limits, will be captured by this figure. Furthermore, the southbound shipping lane lies to the west of the nominal midline of Puget Sound (see figure below), outside the traditional definition of Seattle's western city limit (see discussion, inventory p. 10). Hence, the value from Table 3-42 includes a substantive contribution from OGV emissions occurring outside the city limits. No change.



Nautical map showing south- and northbound shipping lanes in Puget Sound. Source: NOAA.

[T]he 2005 Inventory uses emissions estimates for rail activity specific to the Port of Seattle rather than values that might better represent general Seattle activity. The only major rail facility in King County outside Seattle is the Auburn yard, which is primarily used for storage and minor sorting and thus will be only a minor emissions source. Emissions from the mainline traffic north and south of Seattle or east to Stampede Pass will be small by comparison to the Seattle activity. A more careful estimate would yield a different figure but 90% of the estimated King County emissions from Table 6.11 would be 71,310 tons CO_2, compared to the 40,327 tons CO_2e used in the 2005 Inventory. (p.8 ¶3)

Rail emissions have been recalculated as recommended.

The estimated emissions for King County International Airport (KCIA) report only the emissions from landing and takeoff (LTO) aircraft activities based on 2003 data from the Puget Sound Clean Air Agency. Since the 2005 Inventory was prepared the Agency has calculated 2005 data. The emissions from operations of ground equipment do not appear to have been captured by other transportation calculations. . . . The LTO

emissions computed for 2005 by the Puget Sound Clean Air Agency are 115,600 $MgCO_2e$ (9% greater than 2003) and the emissions from ground equipment operations are 13,100 $MgCO_2e$. (p.8 ¶5)

KCIA emissions have been recalculated as recommended.

Commercial oil and small equipment fuel consumption is apportioned to Seattle based on a ratio of employees in Seattle and Washington state for 2004. This is a reasonable approach given the magnitude of the values. However, this same ratio is used to estimate 1990 usage. An economic census (U.S. Census Bureau) is available for 1992 and would have provided employee data that would give a closer estimate for 1990. (p.9 ¶4)

U.S. Census Bureau economic census data do not provide sufficient geographic resolution to estimate the ratio of Seattle to Washington employees. The 2004 ratios in the inventory were calculated from Washington State ES-202 data, not from U.S. Census Bureau data. Equivalent state data for 1990 to that used for the 2004 ratio are not available. No change.

Industrial process emissions estimates include two cement manufacturers and one steel plant. No estimate was made for 1990 for the one steel plant. It would be reasonable to scale the 2005 emissions to 1990 using the ratio of total product from the emitting process. (p.9 ¶5)

1990 steel plant emissions have been recalculated as recommended.

A second local steel plant using the same technology was not included in the inventory. (p.9 ¶5)

Emissions attributable to the Jorgensen Forge steel plant have been added to the inventory.

The estimates for fluorinated hydrocarbons are scaled from the national estimates. The national estimates and the Seattle computations do not include the chlorofluorocarbons as they are not a listed compound for the Kyoto inventories, since their continued use was to be phased out anyway under a separate international treaty. However the amounts expected to have been released in 1990 are substantial. Leaving out any mention of them or their estimated 1990 global warming potential (GWP) leaves the impression that the effort to eliminate ozone depleting substances has been a step back with respect to global warming. (p.9 ¶6)

We agree regarding the misleading impression, but the practice is consistent with IPCC accounting practices. The city can avoid the impression by excluding HFCs and PFCs from GHG emissions targets and monitoring, if it wishes. No change.

The inventory of landfills does not include the actively emitting landfills at Montlake and West Seattle and only a portion of the South Park landfill. (p.9 ¶7)

2005 emissions from the Montlake landfill were estimated by the University of Washington; the estimate has been added to the 2005 geographic inventory (in 1990 the Montlake landfill was flared and hence is assumed to produce zero emissions). The emissions estimates for the South Park landfill have been increased to reflect the entire

landfill. Emissions estimates for the West Seattle landfill have been added to the inventory.

More important is determining if the solid waste landfills and the West Point treatment plant values should be used without any adjustment as a Scope 1 emission. For example, the West Point treatment plant serves an area significantly beyond the geographic boundaries of the 2005 Geographic Inventory, to the north and northeast of the city. Alternatively, it does not serve the entire city in the southeast. A portion of southeaest Seattle is served by the Renton treatment plant. As will be discussed below and with respect to the 2005 Corporate Inventory, this is an example of imported and exported wastes that may more properly be handled directly, with adjustments for service areas, as a Scope 3 emission, in spite of the actual locations of the treatment plants. (p.10 ¶3)

Text in the Inventory clearly defines Scope 1 as constituting sources inside the Seattle City Limits, regardless of the nature of such sources. The reporting of the waste treatment plant emissions is consistent with the definition and Scope 1 values should not be changed.

In future inventories, The City of Seattle may add Optional Information describing imported and exported emissions related to wastewater.

The estimate provided for imported electricity use in Scope 2 appears to be reasonable for a geographic inventory. However the source note for this category should report that zero emissions for 2005 was achieved in part by crediting sales of surplus Stateline wind power at a rate of 0.6 $MgCO_2$/MWhr (net of "green tags" sold) but that no credits were taken for sales of surplus hydropower. (p.10 ¶4)

The offsets are discussed at length in the Corporate Inventory Optional Information, Section *Electric Utility Exports and Offsets*, and a cross-reference to this section has been added to the geographic inventory source note.

Scope 3 is intended to report indirect emissions that are the result of activities treated in Scope 1 and Scope 2. The inclusion of travel away from the geographic entity is controversial. The national inventories do not include international travel or shipping while in international waters, in part because of sovereignty issues associated with international negotiations. Extrapolating this to the city level, travel and freight outside the city would be excluded. (p.10 ¶5)

Sea-Tac Airport emissions reported in Scope 3 of the geographic inventory are estimated *only* for the portion of flight activity induced by Seattle residents. Since Scope 1 and 2 of the geographic inventory treat the activities of the residents of Seattle, included their air travel in Scope 3 is reasonable. No change.

[S]*urface travel by city residents outside the city boundaries is not estimated. For businesses, commuter travel by employees is one of the first Scope 3 calculations that is recommended. Values to support a calculation of local commuter trips from Seattle to surrounding areas are likely to be available from the Puget Sound Regional Council, although it may be difficult to separate these from inbound commuting. (It could be argued that inbound commuting is due to the commercial activities inside the city boundaries and should also be counted.) It is recommended that resident commuting be included in Scope 3 if the calculations can be done with reasonable effort.* (p.10 ¶5)

We agree, but there is no viable method for estimating surface travel by city residents outside the city limits. This limitation and possible, future solutions were discussed in an October 20, 2006 memo delivered with the draft inventory.

While the magnitude of the air travel values makes it is useful to have them reported in the inventory it is not clear that it should be reported as a Scope 3 item if commuter and other travel is not reported in Scope 3. In this case, without reporting other travel, it may be more appropriate to have them reported as Optional Information. (p.11 ¶2)

Citizen air travel has been moved to Optional Information.

Also not reported in Scope 3 are the emissions from the city's solid waste transportation and disposal outside the geographic boundaries, which is included in the 2005 Corporate Inventory. Clearly the removal of waste from the city to outlying landfills is a necessary part of urban life in a fully built-up city. (p.11 ¶3)

Emissions due to MSW collection and hauling, as well as the methane commitment at the destination landfill, have been added to Scope 3. Carbon sequestration at the landfill, as well as emissions reductions associated with recycling, have been added to Optional Information.

Also among the other Scope 3 emissions that are not reported are the losses to the natural gas pipeline system that brings the natural gas from the well-head to individual Seattle buildings. Various national estimates of loss range from 1.9% to 4.1% by volume. (p.11 ¶4)

The City of Seattle has chosen to exclude this Scope 3 item from the inventory due to the high degree of uncertainty regarding its value. No change.

The Optional Information section of the 2005 Geographic Inventory does report two calculations that provide interesting additional information about greenhouse gas emissions. The first provides a hypothetical estimate of emissions in 1990 from a cement plant that began operations in Seattle in 1992. This is consistent with a requirement for baseline adjustment for companies that dispose of factories or sectors of their company between the baseline year and the current year. This avoids the appearance of reductions in emissions when it is only a change in business structure that has caused the reduction. Symmetry requires that acquisitions be treated similarly. However in this case the start up of a new company with the geographic limits is more like the natural growth of a prosperous company than a merger or an acquisition of a on-going firm. Natural growth is not accounted for in a baseline adjustment. While it is useful to offer the information, it would be advisable to not include it in the summary table where most people will focus on the very bottom line and to provide more information on its appropriateness in a geographic inventory. At a minimum the grand total should be removed and the table presented as the 2005 Corporate Inventory is presented. (p.11 ¶5)

The grand total line has been removed.

We do not have enough information at this time to determine if the closure of the prior [cement] *plant resulted in increased activity at the other cement manufacturing facility during the years before operation resumed at this site, which would imply the counterfactual presented may represent double counting.* (p.12 ¶1)

It does appear from historical production records that production at the second cement plant decreased slightly in response to introduction of the new plant. The baseline correction has been reduced slightly to reflect this.

The 2005 Inventory should be more explicit regarding the high degree of uncertainty in [sequestration by the urban forest]. (p.12 ¶2)

The source note has been expanded to reflect this.

The text accompanying [Table 18] *does not make sufficiently clear that this value is for new carbon sequestered each year and not total stock in the urban forest*. (p.12 ¶2)

The title of the table has been edited for clarity.

City Light has published the incremental and total avoided demand associated with its past energy efficiency programs for its entire service territory from the early 1970's to the present. It would be reasonable to report an adjusted value both as a 1990 base value and the increment between 1990 and 2005. (p.12 ¶4)

Energy conservation accomplishments are now described in an Optional Information subsection of the Geographic Inventory.

City Light did not require all the power that it was able to generate from its owned resources or that it had contracted to acquire from other sources. These power sales exceeded the amount of power purchases. However this does not reduce the greenhouse gas responsibility that it acquired along with the purchased power. The "clean" power that it sold will be counted by the purchasers as free of greenhouse gas emissions unless City Light had a contractual arrangement to retain a "green tag" credit from the power sales (n.b., no evidence is presented of such arrangements). Spreadsheet 05-013 reports that City Light did sell "green tag" credits for 36,200 MWhr of the power generated from the Stateline wind farm but retained credits for 315,869 MWhr. Thus in Scope 2 it would be correct to reduce the 335,000 $MgCO_2e$ from Contracts and Treaties by 57,000 $MgCO_2e$ in Net Market Purchases. This is currently reported, in slightly different form, under Optional Information in the 2005 Corporate Inventory. (p.14 ¶1)

[Agreed that the reporting of (net) offsets needs to be clarified, especially in the corresponding Optional Information subsection of the Corporate Inventory. But we need to do this together with Corinne Grande. See also the rest of the auditor's comments on this topic in paragraphs 1-3 of p.16 of the audit.]

The emissions from natural gas heating of City-owned buildings required the development of data from several departments and Puget Sound Energy accounts. This was a substantial effort but it is not presented in as complete a manner as is recommended by the protocols. Because the buildings included in the inventory are not always named on the supporting spreadsheets and a list of the City-owned buildings that are excluded is not provided it is not easy to verify that all buildings that are heated by natural gas have been included. Among the potentially missing City-owned buildings are the Woodland Park Zoo, the Rainier Beach Pool, several community centers, the Animal Shelter, the Pacific Place Garage, the Museum of History and Industry, the North Precinct of the Seattle Police Department, CAMP, SPARC, the Central Area Senior Center and the Greenwood Senior Center. Some of these may have been excluded because they are not owned by the City, another party holds a capital lease or because

they are entirely electrically heated, as is the Seattle Municipal Tower. Leased space, such as the Wallingford Branch of the Library, is properly excluded because of the equity share basis of reporting but a listing of such facilities would also be useful to assure that all necessary facilities have been captured. . . . This section merits a thorough review. (p.14 ¶2)

The City of Seattle is focusing resources on improving the geographic inventory rather than the corporate inventory; hence this comment will be considered in future corporate inventories but no change has been made to the current corporate inventory.

The reported building natural gas emissions from 1990 are actually emissions for 2000, which were originally used for 1990 values in the absence of 1990 data. The 2000 data do include an upstream natural gas loss factor. Looking at the individual department totals reveals several anomalies: Parks and Recreation at 1,556,000 therms in 2000 and 2,780 in 2005; Public Utilities at 415,000 therms in 2000 and 93,354 in 2005. In part, this may be due to departments moving into the Municipal Tower between these dates but an examination and explanation of the changes would increase the relevance to the reader. (p.14 ¶3)

The City of Seattle is focusing resources on improving the geographic inventory rather than the corporate inventory; hence this comment will be considered in future corporate inventories but no change has been made to the current corporate inventory.

The employee commuting emissions were computed for 7,350 City employees at eight generalized sites. The City reports having 10,013 employees overall, but it is not clear if this includes 1,040 temporary employees in the Parks and Recreation Department (DPR). An example of the difference is DPR, which reports 798 full-time and 126 part-time employees while the commuting emissions detail spreadsheet lists 185 employees. (p.15 ¶3)

The City of Seattle is focusing resources on improving the geographic inventory rather than the corporate inventory; hence this comment will be considered in future corporate inventories but no change has been made to the current corporate inventory.

It would be helpful if the inventory clearly stated that [upstream emissions from concrete and asphalt purchased by the City] *must be an understatement of the total construction related emissions.* (p.15 ¶4)

A note to this effect has been added to the “Concrete and Asphalt” subsection of the Corporate Inventory, Scope 3.

A section on electric utility exports provides a calculation of the greenhouse gas emissions associated with electric power that was sold by City Light and exported to other customers. The sentence beginning “It may be appropriate . . .” should be deleted and replaced with an explanatory sentence at the end of the paragraph along the following line: “Under the emissions accounting procedure used in this inventory the embedded greenhouse gases exported remain the responsibility of Seattle City Light. Under other, commonly used, accounting procedures they could be passed along to the ultimate users and subtracted from the overall City totals. They are reported here for information purposes only.” (p.16 ¶1)

[part of offsets rewrite]

The discussion in Optional Information reports a lower value of Stateline offsets that can be applied against City Light responsibility than described in the comments on Scope 2 because it discounts the Stateline project by useable load to avoid double counting against the exported emissions credit, described in the previous paragraph. (p.16 ¶2)

[part of offsets rewrite]

The discussion in Optional Information goes on to describe "over 600,000 $MgCO_2e$ of transferable emissions reductions" owned by Seattle City Light, which it is using in part to offset its 2005 emissions. Claiming such credits requires substantially more documentation if it is to be included in the 2005 Corporate Inventory. The use of offsets is highly controversial and the quality of offsets is the subject of much discussion. Because some of the credits City Light has obtained were through the Climate Trust, which are generally of high quality, it is important to for this information to be laid out to ally such concerns. (p.16 ¶3)

[part of offsets rewrite]

There appears to be a typographical error in the item on Forest Sequestration. The material from "Industrial Baseline Adjustment ..." to the end of the associated source notes appears to be unrelated to this item and present as a simple error. (p.16 ¶4)

This has been repaired.