CITY OF HOUSTON
2005 EMISSION REDUCTION PLAN REVIEW AND UPDATE

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TABLE OF CONTENTS

APPENDIX A - ESTIMATION OF AIR EMISSIONS FROM MOBILE SOURCES VEHICLES AND EQUIPMENT OWNED BY THE CITY OF HOUSTON

Executive Summary

Introduction

This document is a review of the city of Houston's (City) progress on the 2000 *Emissions Reduction Plan* (2000 ERP) that was developed as a framework for reducing the City's emissions impact on the Houston-Galveston-Brazoria air quality non-attainment region.[1] The 2000 ERP identified an emissions inventory of 1,586 tons per year (tpy) of NOx generated based on the City's 1999 vehicle and equipment database, capital improvement projects, and contractor emissions. Of the 1,586 tpy, 719 tpy* was attributable to city activities, exclusive of contractor emissions. It also identified a program of measures each department could implement to reduce the City's contribution to emissions of oxides of nitrogen (NOx). The pollutant NOx was targeted for reduction because of area-wide NOx reduction requirements in the State Implementation Plan (SIP). This plan was developed by the state of Texas to comply with the U.S. Environmental Protection Agency (EPA) ozone ambient air quality standards, of which NOx is an ozone precursor. This document reviews the 719 tpy of NOx emissions generated directly by City activities.

> ** Note: Due to changes in the standard emission estimating models for mobile sources between the two study years and independent assessments of stationary source emissions conducted by the Department of Aviation, and the Department of Public Works and Engineering, for purposes of this update, 1999 emissions were re-estimated (adjusted) using current models and data in order to provide comparative results for the two years. This resulted in an adjustment of NOx emissions from 657 tpy to 719 tpy as the 1999 baseline level. More information on adjustments to the 2000 ERP data can be found in Appendix A.*

Comparison of Emissions

The assessment determined that NOx emissions from City activities were reduced by 16% from 1999 to 2004. Currently, the majority of City NOx emissions (72%), directly produced by City operations, are from mobile sources such as motor vehicles and off-road equipment, with the remainder produced from stationary sources. Comparisons between the 1999 and 2004 inventory estimates indicate a decrease of 117 tons per year (tpy) (23%) in NOx emissions from mobile sources. Much of the mobile source emissions reduction can be attributed to an 11% reduction in the vehicle fleet, a reduction in vehicle miles traveled (VMT) of 22%, and the replacement of older vehicles with newer, lower emission vehicles.

The City also operates stationary sources such as boilers and heaters in buildings, and sludge dryers in wastewater treatment plants. Overall, only minor changes were made to stationary sources between 1999 and year-end 2004, resulting in a minor increase of 2-tpy due to the addition of new facilities. However, new replacement boilers installed by the Departments of Aviation, and Convention and Entertainment after the 2005 Plan Review cut-off date, are equipped with low-NOx burners that will reduce these stationary source emissions. New low NOx burners are also being installed at Public Works facilities during the current fiscal year.

[1] City of Houston, "*Emissions Reduction Plan*," July 2000;http://www.houstontx.gov/environment/reports/cleanair.pdf]

Emission Reduction Measures

A range of emission reduction measures to be implemented by City departments was identified in the 2000 ERP. In addition to those emissions reduction measures associated with the mobile sources noted above, some measures were directed to reduce employee emissions such as by allowing compressed work weeks, telecommuting and providing bus passes. Many of these measures have been implemented to varying degrees.

Additionally, measures such as retrofitting vehicles and equipment with emission control devices, which were a key component for providing substantial emissions reductions in the 2000 ERP, and installing low NOx burners in heaters and boilers located in City facilities, were also identified as potential emissions reducing measures. These measures have had limited success due to costs and the availability of technology.

The 2000 ERP set a goal to reduce NOx emissions by 75% from department operations, or 539 tpy. As of the close of 2004, the City achieved an overall reduction of 115 tpy or 21% of its goal. Much of the NOx reduction shortfall is directly attributable to the lack of diesel engine retrofit technologies, which was a key emissions reduction measure in the 2000 ERP.

Independent of the 2000 ERP, the Department of Aviation undertook additional initiatives to reduce air emissions from mobile sources primarily operated by airport tenants and not under the control of the department or the City. The department implemented a NOx emissions reduction plan to achieve a total NOx reduction of 1.809 tons per day. The plan was reviewed and approved by the Texas Commission on Environmental Quality (TCEQ) and is now part of the State Implementation Plan for reducing ozone formation in the Houston-Galveston area. A mix of strategies was used to achieve the targeted emissions reduction.

Notation of Actions Taken Since the 2005 ERP Review Cut-off Date

The data used in this 2005 ERP Plan Review is current as of December 31, 2004. This section is to acknowledge steps taken since that time to reduce emissions from mobile sources, the predominant source of NOx emissions from department operations, as well as measures taken to reduce stationary source emissions. These measures are noted as follows:

- **Installation of low NOx burners in wastewater treatment facilities and facility boilers and heaters.**
  Status: Public Works and Engineering will begin construction to replace the sludge dryers with lower emitting rotary drum dryers at the Almeda Sims facility in the third quarter of 2006, with completion projected in the fourth quarter of 2008. The expected result of this project is to decrease NOx emissions by 10 tpy.

  The 69th Street facility will have one of its sludge dryers converted to a low NOx burner in the third quarter of 2006, which will then be tested to determine the actual reductions achieved before making a determination to replace the remaining dryers.

However, if the retrofit reduces the emissions as anticipated, retrofitting all of the dryers at this facility should result in a 9.6 tpy NOx reduction.

In April 2006, Convention and Entertainment replaced three boilers at the George Brown Convention Center with low-NOx boilers and in the fall of 2005 the department of Aviation shutdown three of its older boilers, replacing them with two low-NOx boilers. These projects are anticipated to reduce NOx emissions from these sources by approximately 40%.

- **Expand the use of Texas Low Emission Diesel (TxLED) Ultra-low Sulfur Diesel (ULSD) fuel into all City departments' vehicle fleets.**
  Status: The City began using the fuel in May 2004, two years ahead of State and Federal requirements. It used 3.3 million gallons prior to regulatory requirements taking effect in February 2006. This fuel reduces NOx emissions from diesel engines by an average of 5.7%. The widespread availability of this fuel will also enable manufacturers to provide lower emission diesel technology beginning in model year 2007.

- **Explore additional ways to reduce overall fleet size and miles driven.**
  Status: The City is investigating technologies that will enable it to replace older vehicles and reduce VMT such as the use of motor pools and vehicle locating and tracking technologies.

- **Expand the vanpool/bus pass programs and develop telecommuting policies to enhance participation rates.**
  Status: The Mayor's Office has hired a full-time staff member charged with working with City departments and the private sector to increase the participation levels of these programs.

- **Develop a system of reporting and tracking activities related to emission reductions, and estimate the reductions on a periodic basis.**
  Status: The Mayor's Office of Environmental Policy has developed an "Air Quality Program Operating Plan" which it will use to incorporate tracking and measuring criteria for air emissions.

- **Develop a program to accelerate the acquisition of hybrid gasoline or diesel vehicles and other types of lower emission vehicles, to replace existing vehicles, especially those using older diesel engines.**
  Status: The City has a program in place to purchase the cleanest, most economically and operationally feasible technology on market. Part of the program calls for the City to convert 50% of its non-specialty, civilian duty fleet to hybrid technology by 2010. As of March 2006, the City owned 261 hybrid sedans and SUV's, which is 55% of the 474 planned vehicle purchases to-date; a shortfall resulting from Toyota's suspension of vehicles sales to fleets in 2006 due to high demand.

- **Enact an incentive program for contractors to utilize lower emission equipment on City projects.**
  Status: The City initiated an incentive program in October 2005 that provides a financial incentive to contractors to encourage the use of lower emission construction equipment on City projects.

- **Adopt standards that require higher efficiency standards and environmentally friendly building design for City owned facilities.**
  Status: In June 2004, the City adopted by resolution, the Leadership in Energy and Environmental Design (LEED) standard for all new City buildings over 10,000 square feet. There are currently 5 new structures planned that will seek the LEED's certification with an additional 5 structures that will be renovated to meet the standard.

1 Introduction

The City of Houston prepared an Emissions Reduction Plan in 2000 (2000 ERP) to provide a framework for reducing the City's emissions impact on the Houston-Galveston area.[2] This plan consisted of an emissions inventory based on the City's 1999 vehicles and equipment database and a program of measures each City department could implement to achieve an overall goal of a 75% reduction in emissions of oxides of nitrogen (NO**x**).

This report looks at the progress the City has made in implementing the emission reduction measures spelled out in the 2000 ERP and in meeting the 75% NO**x** reduction goal regarding its own activities. It compares 1999 and 2004 emissions from several source categories; mobile sources, which include on-road and off-road vehicles; and stationary sources that consist of boilers and heaters, emergency generators and sludge dryers. Additional emissions, such as particulate matter (PM) and carbon dioxide (CO_2), are included in parts of this review to broaden the potential for their use in future emissions reductions efforts, however a comprehensive assessment of these pollutants was not within the scope of this plan. As a result, data regarding 2004 emissions from contractors and other sources not directly controlled by the City are not included in this report.

City departments were polled to find out what 2000 ERP measures had actually been implemented, and to what extent. To evaluate the change in City emissions since the 2000 ERP's release, emissions have been estimated using the City's database on vehicles and equipment, current to the end of 2004. Some departments however, such as the Department of Aviation and the Department of Public Works and Engineering, conducted more detailed emissions calculations and/or actual exhaust stack testing to determine emissions from selected sources.

Due to improved computer emissions modeling capabilities, the 1999 on-road vehicle data used in developing the 2000 ERP has been reprocessed using updated computer modeling software. The Environmental Protection Agency's (EPA's) MOBILE5 model, which was originally used to generate the 1999 vehicle emissions data, has been upgraded to MOBILE6.2. This report assesses vehicle emissions for both the 1999 and 2004 data using MOBILE6.2 in order to produce comparative results. Examples of the impact on the overall City emissions from these computer model changes are shown in Appendix A.

Similarly, off-road emissions have been reassessed using the EPA's latest model for this class of vehicles, NONROAD2004.

Information on the models used in generating the emissions data and how they compare can be found on the EPA's internet website at http://www.epa.gov/otaq/mobile.htm.

[2] IBID

2 City of Houston Emissions, 1999 and 2004

Most of the City's emission sources (72%) fall into the mobile source category, which consists of vehicles and equipment designed to be self-powered and to be used in various locations. This group includes on-road vehicles (trucks, passenger cars, etc.) and off-road equipment (graders, mowers, tractors, etc.). Emission estimates for these two groups have been prepared, and are reported, separately because different computer models are used to estimate emissions from each source type. In addition to mobile sources, the City operates a number of stationary sources such as boilers, generators, and sludge dryers.

On-road and off-road emissions were calculated using the latest EPA emission estimating models, described in Appendix A. As discussed in the Introduction, emissions for the baseline year of 1999 as well as the 2004 emissions were estimated using the same models to rule out model differences as a cause of any perceived increase or decrease in emissions.

Overall, the City's NOx emissions have declined by 16% in the period from 1999 to 2004. As discussed above, stationary source emissions have not changed to a great degree, and the overall emissions decrease is attributable to changes in the mobile sources. For example, as noted in Table 1 below, overall emissions (mobile and stationary sources) of NO**x** have decreased from an estimated 719 tpy in 1999 to 604 tpy in 2004 with the reductions attributable to mobile sources.

Table 1 - Summary of City NOx Emissions
(tons per year)

Emissions Source Type		1999	2004	Reduction (tpy)	% change	75% Goal (tpy)	Change as % of Goal
Mobile	On-Road	322	254	-68	-21%	242	-28%
	Off-Road	193	144	-49	-25%	145	-34%
	Subtotal	**515**	**398**	**-117**	**-23%**	**386**	**-30%**
Stationary							
	Boilers/Heaters	54	56	2	4%	41	5%
	Generators	34	34	0	0%	26	0%
	Sludge Dryers	115	115	0	0%	86	0%
	Subtotal	**204**	**206**	**2**	**1%**	**153**	**1%**
	Total	**719**	**604**	**-115**	**-16%**	**539**	**-21%**

2.1 Mobile Equipment Fleet Overview

The City's fleet (on-road and off-road) consisted of 11,285 units at the end of 2004 compared with 12,674 units in 1999, an overall decrease of 11%. Of these, approximately 10,300 vehicles have some type of emission-producing engine necessary to operate the unit as opposed to non-powered vehicles such as trailers. Table 2 summarizes the fleet by department.

Table 2 - Total Equipment Fleet (On-Road and Off-Road)

Department	1999	2004	Unit Change	% change
Aviation	744	721	-23	-3%
Fire	984	943	-41	-4%
Parks	1,312	1,050	-262	-20%
Police	4,030	3,522	-508	-13%
Public Works	4,225	3,828	-397	-9%
Solid Waste	543	565	22	4%
Other	836	656	-180	-22%
TOTAL	**12,674**	**11,285**	**-1,389**	**-11%**

The category of "Other" departments in the table above (and in following tables) includes the following departments that operate less than 200 vehicles each:

Affirmative Action
Building Services
City Controller's Office
Conventions & Entertainment
Finance & Administration
Health & Human Services
Housing
Human Resources
Information Technology
Legal
Libraries
Mayor's Office
Municipal Courts
Planning & Development

Table 3 provides a comparison of overall emissions reductions from mobile sources for the two sample years, 1999 and 2004.

Table 3 –Comparison of Mobile Source Emissions, 1999 and 2004

Pollutant	Tons per year		%
	1999	2004	Change
VOC	97	62	-36%
NOx	515	398	-23%
CO	1,644	869	-47%
CO_2	91,344	80,118	-12%
PM_{10}	27	20	-25%

An interesting observation regarding the emission reductions between 1999 and 2004 is that the percentage reductions of pollutants other than CO_2 are greater than the reduction of CO_2 by a factor of at least 2. The significance of this is that CO_2 emissions are related almost entirely to the amount of fuel used, whereas the other pollutants are related to engine design and operating conditions and are subject to reduction by emission control technology advances. The CO_2 reduction indicates that there was a reduction in the overall amount of fuel used in the respective years. The fact that the other pollutants were reduced to greater percentages shows that the reductions were due to more than just reduced fuel consumption or lower activity levels – i.e., there has been a real effect of implementing emission control measures such as the replacement of older vehicles with lower-emission vehicles.

2.1.1 On-Road Vehicles

As mentioned in the Introduction, the 2000 ERP emission estimates were developed using emission factors from the MOBILE5 model; the emission estimates presented below are based on the MOBILE6.2 version. Because of the enhancements made to the newer model, the same inputs produce different results between the two versions of the model. This is a normal occurrence in the practice of estimating mobile source emissions.

As Tables 4 and 5 show, since 1999, the City has reduced its fleet size by 11% and its vehicle miles traveled (VMT) by an estimated 22%. Examples of methods implemented to reduce VMT include the Department of Solid Waste use of waste transfer stations to consolidate refuse truck loads prior to shipment to landfills, the use of Blackberry® technology by Code Enforcement staff to eliminate commute miles to offices to pick-up and submit daily reports, the centralization of various department operations into the downtown district, and the curtailment in vehicle home storage privileges.

Table 4 - On-Road Fleet – Number of Vehicles

Department	1999	2004	Unit Change	% Change
Aviation[1]	472	489	17	4%
Fire	822	784	(38)	-5%
Parks	652	516	(136)	-21%
Police	3,965	3,462	(503)	-13%
Public Works	3,291	2,963	(328)	-10%
Solid Waste	464	489	25	5%
Other	793	595	(198)	-25%
TOTAL	**10,459**	**9,298**	**(1,161)**	**-11%**

Table 5 - On-Road Fleet – Vehicle Miles Traveled (000's)

Department	1999	2004	VMT Change	% Change
Aviation[1]	2,819	3,929	1,110	39%
Fire	11,263	8,624	(2,639)	-23%
Parks	3,994	2,717	(1,277)	-32%
Police	60,120	45,759	(14,361)	-24%
Public Works	26,409	22,467	(3,942)	-15%
Solid Waste	5,654	4,372	(1,282)	-23%
Other	7,168	4,092	(3,076)	-43%
TOTAL	**117,427**	**91,960**	**(25,467)**	**-22%**

[1] In connection with independent NOx reduction initiatives, the Department of Aviation constructed a Consolidated Rental Car Facility (CRCF) at George Bush Intercontinental Airport. The use of the CRCF has resulted in the elimination of 96 shuttle buses owned and operated by the rental car agencies, which were replaced with 26 low-emission diesel buses owned by the department. The net result is a significant reduction in total area VMT (-5,500,000) and vehicle count (-70). The apparent increases reflected in the tables above in Department of Aviation vehicles and VMT are attributable to the addition of the 26 low-emission buses to the department's fleet that resulted from consolidating the privately operated rental car passenger shuttle services into the department's operations. The end result is a significant net decrease in area VMT and NOx emissions from shuttle bus operations at the main airport, equating to almost a full ton-per-day of NOx emissions. Excluding the addition of these buses to the department's fleet would result in a 3% reduction in VMT.

To translate the above vehicle and VMT reductions into emissions reductions, Table 6 provides a summary of on-road emissions and the percent change between 1999 and 2004.

Table 6 – Comparison of On-Road Emissions by Study Year Using Mobile6.2

Pollutant	Tons per year		
	2000 ERP	2005 Review	% Change
VOC	45	28	-38%
NOx	322	254	-21%
CO	835	391	-53%
CO_2	75,200	65,923	-12%
PM_{10}	7.6	6.3	-17%

2.1.2 Off-Road Equipment

The City's off-road fleet consisted of 1,987 pieces of equipment in 2004 as compared to 2,215 in 1999. In 2004, approximately 1,800 of these units had some type of engine used in the vehicle or unit's operation. Table 7 shows the equipment by department for each year-end.

Table 7 - Off-Road Equipment Fleet

Department	Number of Pieces		% Change
	1999	2004	
Aviation	272	232	-15%
Fire	162	159	-2%
Parks	660	534	-19%
Police	65	60	-8%
Public Works	934	865	-7%
Solid Waste	79	76	-4%
Other	43	61	42%
TOTAL	**2,215**	**1,987**	**-10%**

Total off-road emissions are listed for the two project years in Table 8, below. As with on-road sources, there has been an overall reduction in emissions. These were

due to a reduction in the number of pieces of equipment and by emission reduction measures that have been taken, such as replacement of older vehicles with newer, lower emission vehicles, and installation of emission controls discussed in Section 3.

Table 8 – Off-Road Emissions Summary

Pollutant	Tons per year		
	2000 ERP	2005 Review	% Change
VOC	52	34	-35%
NOx	193	144	-25%
CO	809	478	-41%
CO_2	16,144	14,195	-12%
PM10	19	14	-28%

2.2 Stationary Sources

Stationary sources for City operations are primarily limited to boilers, water heaters, emergency generators, plus a group of sludge dryers operated by the Department of Public Works at its wastewater treatment facilities. The number and operating characteristics of the City's stationary sources did not change substantially between 1999 and 2004. The Fire Department, however, has removed a boiler from service and the Departments of Aviation and Convention and Entertainment are scheduled to replace several large boilers. Additionally, the Department of Public Works is scheduled to replace the sludge dryers at the Almeda Sims facility with a more efficient rotary drum technology, and to install low NOx burners in the 69th Street facility.

Table 9 presents the estimated stationary source emissions by department for 2004. The changes in emissions shown in the table are the result of the removal of a boiler by the Fire Department and the addition of two new facilities, Terminal E and the Federal Inspection Facility, at the Department of Aviation. At the end of 2004, the Department of Aviation was also in process of installing and testing two new low-NOx boilers at Bush Intercontinental Airport (IAH) with plans to remove the old boilers in 2006.

Table 9
Stationary Source Emissions (tpy)

Buildings & Generators	**Boilers/heaters**			**Generators**		
Departments with facilities only	NOx	VOC's	PM10	NOx	VOC's	PM10
Aviation	24.30	0.90	1.20	7.40	0.20	0.10
Building Svcs.	9.58	0.53	0.73	1.23	0.10	0.09
Convention & Entertainment	1.67	0.09	0.13	3.20	0.26	0.23
Fire	2.86	0.16	0.21	0.64	0.05	0.03
Health & Human Services	0.66	0.04	0.05	0.00	0.00	0.00
Library	0.76	0.04	0.06	0.00	0.00	0.00
Municipal Courts	0.08	0.00	0.01	0.00	0.00	0.00
Parks & Recreation	1.44	0.08	0.11	0.04	0.00	0.00
Planning & Development	0.07	0.00	0.01	0.27	0.02	0.02
Police	5.50	0.30	0.43	5.85	0.48	0.41
Public Works & Engineering	9.71	0.53	0.74	15.41	1.24	1.07
Solid Waste Management	0.18	0.01	0.01	0.13	0.01	0.01
2004 Estimated Totals	**56.8**	**2.7**	**3.7**	**34.2**	**2.4**	**2.0**

2.3 Other Initiatives

The Department of Aviation completed independent NOx reduction measures involving non-city owned emissions sources. While these initiatives fall outside of the focus of this report, the benefit is not insignificant. These additional NOx emission reduction efforts are a result of a 2000 Memorandum of Agreement between the City of Houston and the TCEQ. The final NOx Emissions Reduction Plan included a mix of strategies to achieve the emissions reduction target of 1.809 tons per day. The strategies primarily involved mobile sources owned, operated, or under the control of the airport tenants, as opposed to the Department of Aviation or the City. The plan was reviewed and approved by the TCEQ and is now part of the State Implementation Plan for reducing ozone formation in the Houston-Galveston area.

One of the most significant components of the emissions reduction plan was the Consolidated Rental Car Facility (CRCF), which was discussed previously in Section 2.1.1. Other strategies included the electrification of the airport gates (reducing the use of small on-board turbines used by aircraft and gate-side diesel generators), the construction of the new North Runway at IAH (reducing aircraft congestion and taxiing time), the installation of an automated people mover at IAH, and improved staging of limousines at IAH.

The Department of Public Works completed an assessment of emissions at its' wastewater treatment facilities as discussed in Appendix A, page A-12, and is planning to replace the dryers at the Almeda Sims facility with a more efficient rotary drum drying system that is expected to decrease NOx emissions by 10 tpy. Additionally, it is also planning the retrofit of the 69th Street facility's burners with new, low NOx burners that, should a trial installation prove successful, will result in an additional 9.6 tpy reduction, if all of the dryers are retrofit. These projects are planned to begin in the third quarter of 2006.

3 City Department Emission Reduction Plans

For the 2000 ERP, each department drew up an emission reduction plan consisting of measures to be implemented to achieve the NO**x** reduction goal. These plans have been implemented to varying degrees by the respective departments. This section reviews the plans from the 2000 ERP, summarizes the actions taken to-date by the departments, and discusses additional steps for further emissions reductions.

3.1 2000 Plan

The 2000 ERP was anticipated to produce reductions of NO**x** emissions totaling approximately 539 tpy, primarily from mobile sources. Table 1 indicates that mobile source NO**x** emissions decreased from 515 tpy in 1999 to 398 tpy in 2004, a decrease of 117 tpy, or 23% of the NO**x** emission reduction goal.

During the development of the 2000 ERP, various diesel emissions control technologies were identified as potentially suitable for retrofit onto the vehicle exhaust system, or added to the fuel, which would provide substantial reduction in NOx emissions. The City pursued these technologies by initiating the *Diesel Demonstration Project* [3], which served to acquire and test technologies that showed promise in providing significant reductions of NOx in older diesel vehicles. In field trials, various technologies appeared capable of providing these reductions; however costs and operational issues prevented these technologies from reaching their anticipated potential. With the lack of proven, cost effective technologies, the retrofit program was precluded from expanding to the level originally intended, resulting in a significant shortfall in the emissions reductions anticipated in the 2000 ERP.

City departments were surveyed as to which proposed and/or additional measures have been accomplished. A summary of the most common emission reduction measures and their extent of implementation are presented in Table 10.

[3] http://www.houstontx.gov/environment/reports.html

Table 10

Summary of Most Commonly Implemented Measures

Department	Flex Schedule/ Telecommunting Personnel	Bus Pass Use	Alt. Fuel vehicles (Hybrid/CNG)	Low Emission Vehicles (LEV's excl. Alt. fuel)	Fleet Size Change	Equipment Retrofits
Affirmative Action	5	12	2		1	
Aviation	259	14	4	126	-23	
Building Services		30		11	75	
City Controller		18			-2	
Convention & Entertainment		11			13	
Finance & Administration		93	1		-38	
Fire		13			-41	
Health & Human Services			44	63	-47	
Housing					-16	
Houston Emergency Center *					3	
Human Resources		27	1	1	2	
Information Technology *		40			15	
Legal	79	28	2		0	
Library		100	1		6	
Mayor's Office **					11	
Municipal Courts		88			-3	
Parks & Recreation		6			-262	
Planning & Development		28	1		-199	
Police		210	4	1,660	-508	
Public Works & Engineering	495	219	34		-397	84
Solid Waste		6	1		22	20
Total All Departments	838	943	95	1,861	-1,388	104

* Departments that were not in existence for the 2000 ERP

** Many of Mayor's Office staff are accounted for in other department's personnel.

3.2 Discussion

The responses from City departments for this review indicate that most have made progress toward the goals established by the 2000 ERP. A more detailed and on-going program of tracking and reporting activities related to emission reductions would be a benefit to enhance the reporting (and recognition) of emissions reduction activities and encourage more participation by the departments.

4 Recommendations

As a result of this 2005 Plan Review, the following recommendations are provided to further the City of Houston's efforts to reduce its contribution to regional emissions. While this review focuses primarily on emissions from City sources, recommendations consistent with those identified in the 2000 ERP that address employee and contractor generated emissions are also provided.

Overall recommendations include:

- Enact written policies for the installation of low NOx natural gas-fired burners for the sludge dryers in wastewater treatment plants and in boiler and heater additions, replacements and upgrades.

- Enact written policies regarding standby generator testing, vehicle idling, clean vehicle, alternative fuel or lower emission vehicle acquisitions.

- Consider the use of vehicle locator technology to further reduce VMT and expand the use of technologies where appropriate to minimize commute travel to office locations.

- Improve data accuracy of the fleet management system for better reporting of fleet activities and emissions.

- Develop a system of reporting and tracking activities related to emission reductions (such as those listed in Table 10), and estimate the reductions on a regular basis.

- Improve the system of recordkeeping for mobile source equipment, including mileage (for on-road vehicles), hours of operation (for off-road equipment), and fuel usage (for all equipment).

- Continue the vehicle procurement policy to purchase the lowest emission vehicles available that are economically justifiable.

- Explore additional ways to reduce overall fleet size (e.g. downtown motor pool) and eliminate the oldest, highest emitting vehicles.

- Expand the vanpool/bus pass programs and develop telecommuting policies to enhance participation rates.

Appendix A

ESTIMATION OF AIR EMISSIONS FROM VEHICLES AND EQUIPMENT OWNED BY THE CITY OF HOUSTON

Introduction and Overview

This appendix presents a description of methods used to estimate the emissions presented in the preceding report. Due to changes in the standard emission estimating models, the 1999 data used in the City's 2000 Emissions Reduction Plan (ERP) was used to re-estimate 1999 emissions for a more appropriate comparison with the estimates of 2004 emissions.

The most recent version of models released by the U.S. Environmental Protection Agency (EPA) was employed - a major reason for re-computing 1999 emissions. The two models are:

- MOBILE6.2 – used for estimating emissions from on-road highway vehicles
- NONROAD2004 – used for non-highway, off-road equipment

These models, along with instructions and documentation, are available from the EPA's Internet website, at the address:

http://www.epa.gov/otaq/mobile.htm

From these two models, emissions have been estimated in terms of tons per year of:

- Hydrocarbons (HC, as converted to VOC),
- Carbon monoxide (CO)
- Carbon dioxide (CO_2), a greenhouse gas
- Oxides of nitrogen (NOx)
- Particulate matter (PM, as converted to PM_{10})

Data Preparation

Data was obtained in two batches. The first was prepared for the second half of 1999 (because the City's database did not include reliable information on activity in the first half of the year), meaning that vehicle activities were doubled to reflect annual emissions. The second was a more recent fleet update from the City reflecting 2004 vehicle and equipment activities. In general, the 2004 data was more robust than the earlier batch, as the computer data improved over time. However, there were some limitations, which required action before processing in an emissions model:

- Non-road equipment did not have any hourly usage rates, as only vehicle miles of travel and fuel consumption were supplied.

- Many data fields were blank, contained negative numbers, or had zero fuel and zero mileage – which is understandable because some equipment was trailers or was refueled by maintainer truck or portable container.

The data was processed to make it suitable for use as model input by deleting the entries that appeared to be unused vehicles and equipment and by filling blank data fields. In the case

where certain data was missing, an average for the vehicle/engine description was provided. This averaging was not done on the department level because it was determined that using several hundred vehicle/engine descriptions to create averages for approximately 10,000 units was adequate. The 1999 data contained many vehicle entries with negative mileage or unreasonably high mileage for six months: the solution was to replace these data with averages if they were below 100 miles or over 30,000 miles.

In addition, the vehicles and engines had to be assigned EPA categories for the purposes of modeling. In some cases the non-road assignments were rather subjective, such as assigning an "Aerator Core" to the "other commercial equipment" category. Four separate files were then developed and closely examined:

- 1999 non-road file
- 1999 on-road file
- 2004 non-road file
- 2004 on-road file

Approximately 800 lines of SAS™ programming code were written to process the data into formats suitable for MOBILE and NONROAD modeling. In addition to formatting and Q/A functions, SAS was used to:

- Assign EPA source categories
- Compute emissions from MOBILE emission factors (g/mile)
- Aggregate non-road population data for NONROAD processing

Emission Estimation Methodology - MOBILE

As opposed to estimating emissions directly as is done with the NONROAD model, MOBILE only estimates emission factors in terms of grams per mile. This allows emissions to be computed for every row of data with far greater ease. A sample MOBILE6.2 input file for Harris County was obtained from Eastern Research Group, which reflected the following parameters:

- Vehicle inspections (I/M programs) for all gasoline cars and trucks below 10,000 gross vehicle weight rating (GVWR)

- Use of reformulated gasoline

Simplifying assumptions were made because the MOBILE model has been developed to reflect a complex variety of speeds, highway types, and other factors. The model is designed for large regions with built-in assumptions for the number of vehicle miles of travel (VMT) as well as the mileage of highways, arterials, collectors, and local roadways, and an average assumed speed for each (by hour for each hour of the modeled day). Lacking this kind of data for the activity patterns of City vehicles, some of these default assumptions were overridden. For example, the model was set up to assume one speed (35 mph) using the arterial cycle (arterials are an intermediate road type in between highways and locals). This

assumed weighted average speed is intended to reasonably reflect much of the driving cycle of a fleet of urban city-owned vehicles, and is consistent between the 1999 and 2004 modeling. Note that if more information can be developed about the actual speeds and roads used by City vehicles, these estimates can be improved in future efforts.

Temperatures are also an issue (as with NONROAD) because gasoline engine emissions are sensitive to ambient temperatures. EPA guidance suggests modeling four seasons with known minimum, maximum, and ambient temperatures to fully account for diurnal, hot-soak, resting loss, and other evaporative emissions. As a simplification, temperatures were modeled as being 60-92 degrees F.

Light-duty trucks and heavy-duty vehicles are distinguished by the gross vehicle weight rating (GVWR). There are several light truck categories up to 8,500 GVWR, and eight heavy-duty vehicle categories between 8,500 and over 60,000 GVWR. More technical data can be found in the Highway Performance Monitoring System and table 1.2.3 of the MOBILE6 modeling guidance.

The output from MOBILE6.2 was then processed; the DATABASE command allows for emission factors to be output on a by-model year basis for the 28 vehicle types shown in Table A-1. These data were then imported back into SAS™ and emissions were computed by multiplying the vehicle miles of travel (VMT) for each row of data times the applicable emission factor.

Table A-1: MOBILE6 Vehicle Categories

Category	Description	GVWR range (lbs)
LDGV	Light-duty gasoline vehicles (cars)	All
LDGT1	Light-duty gasoline trucks	0-3,750
LDGT2	Light-duty gasoline trucks	3,751-5,750
LDGT3	Light-duty gasoline trucks	5,750 - 8,500
LDGT4	Light-duty gasoline trucks	5,750 - 8,500
HDGV2B	Heavy-duty gasoline vehicles	8,501-10,000
HDGV3	Heavy-duty gasoline vehicles	10,001-14,000
HDGV4	Heavy-duty gasoline vehicles	14,001-16,000
HDGV5	Heavy-duty gasoline vehicles	16,001-19,500
HDGV6	Heavy-duty gasoline vehicles	19,501-26,000
HDGV7	Heavy-duty gasoline vehicles	26,001-33,000
HDGV8A	Heavy-duty gasoline vehicles	33,001-60,000
HDGV8B	Heavy-duty gasoline vehicles	>60,000
LDDV	Light-duty diesel vehicles	All
LDDT12	Light-duty diesel trucks	0-6,000
HDDV2B	Heavy-duty diesel vehicles	8,501-10,000
HDDV3	Heavy-duty diesel vehicles	10,001-14,000
HDDV4	Heavy-duty diesel vehicles	14,001-16,000
HDDV5	Heavy-duty diesel vehicles	16,001-19,500
HDDV6	Heavy-duty diesel vehicles	19,501-26,000
HDDV7	Heavy-duty diesel vehicles	26,001-33,000
HDDV8A	Heavy-duty diesel vehicles	33,001-60,000
HDDV8B	Heavy-duty diesel vehicles	>60,000
MC	Motorcyles	All
HDGB	Heavy-duty gasoline bus	All
HDDBT	Heavyduty diesel transit bus	All
HHDBS	Heavy-duty diesel school bus	All
LDDT34	Light-duty diesel trucks	6,001-8,000

For information purposes, the following compares NOx emissions as originally estimated in 2000 and as calculated using MOBILE6.2 using the same data as used in 2000. However, the assessment of actual emission reductions needs to be made on the basis of the comparison of both years' emission estimates as calculated using the same model version. For purposes of this update, the information provided below compares on-road vehicle emissions as calculated using the MOBILE6.2 model.

Adjustment of MOBILE Model Results for NOx

Calculation Period	Model Version	NOx Estimate tpy
2000 ERP	MOBILE5	382
Adjusted 2000 ERP *	MOBILE6.2	322
	% Change	-16%

* This tpy estimate becomes the adjusted baseline for the 1999 data.

Emission Estimation Methodology - NONROAD

As with the on-road mobile source emissions, the conversion from an older emissions model to the newer model resulted in a significant change in the original 2000 ERP emissions estimates. In the case of off-road vehicles, however, the re-modeled emissions for 1999 increased from the original estimate, as illustrated below. To assess the change in emissions, a comparison must be made of each year's emissions as estimated using the same model. For purposes of this update, the data in the following discussion compares off-road equipment emissions as calculated using the latest EPA emissions computer model, NONROAD2004 for both the 1999 and 2004 data.

Adjustment of NONROAD Model Results for NOx

Calculation Period	Model Version	NOx Estimate tpy
2000 ERP	NONROAD2000	150
Adjusted 2000 ERP *	NONROAD2004	193
	% Change	29%

* This tpy estimate becomes the adjusted baseline for the 1999 data.

The NONROAD model computes emissions as a function of engine population and engine hours; all the emission factors and other procedures are self-contained and invisible to the user. A relatively good estimate of the equipment population was available, but as noted above the average hours per equipment types were not apparent and could not be estimated from fuel consumption. Attempts to back-calculate hours of use from mileage and fuel consumption were not successful, as there was significant variability in the data, as shown in the example in Table A-2.

Table A-2: Example of Mileage/Fuel Data - John Deere 40 HP Agricultural Tractor

Equip. Type	Distance Traveled (miles)	Fuel Used (gals)	Fuel Consumption (miles/gal)
Tractor	260	134	1.9
Tractor	784	710	1.1
Tractor	92	400	0.2
Tractor	385	365	1.1
Tractor	1,397	371	3.8
Tractor	6	484	0.01

Table A-2 shows that the mileage and fuel use figures do not correlate well; good correlation would be indicated by more consistent estimates of fuel consumption (miles divided by gallons). The solution was to use the default hour-per-year activity estimates contained in the NONROAD model, which in this case are 475 hours per year, which is equivalent to slightly over one gallon per hour – not an unreasonable amount. One limitation of NONROAD is that the model only allows one activity number for each source type, without any variation. As mentioned in the concluding sections, in the future it would be helpful to provide annual usage rates (hours per year) for different kinds of equipment, especially since in many cases maintenance such as oil changes are performed by number of hours, especially for the larger diesel equipment over 40 HP.

As part of general QA/QC, vehicle and equipment totals were examined so that they matched the equipment counts developed during data preparation. The NONROAD model does allow for a by-model year output function but as explained in the discussion section of this report, this did not appear appropriate when default hours of operation were modeled.

Findings – On-Road

On-road sources are reported first, in two different ways. First, emissions are reported by MOBILE6 vehicle category. Then emissions are reported for six departments and an "other" category so as to clarify the major contributors.

Table A-3: On-Road 1999 Activity and Emissions by Vehicle Type, Tons per Year

Type	VMT (thousands)	VOC	NOx	CO	CO_2	PM_{10}
HDDBT	16	0.02	0.4	0.2	45	0.04
HDDV2B	441	0.11	1.8	0.4	390	0.09
HDDV3	437	0.14	2.1	0.4	430	0.09
HDDV4	70	0.02	0.4	0.1	78	0.01
HDDV5	124	0.06	0.9	0.2	144	0.03
HDDV6	2,086	1.1	19	3.7	2,722	0.91
HDDV7	2,094	1.5	24	5.3	3,134	1.1
HDDV8A	6,661	4.0	130	20	11,578	3.3
HDDV8B	1,196	0.7	27	3.7	2,171	0.5
HDGV2B	3,422	1.4	17	18	3,347	0.2
HDGV3	5,540	2.3	28	31	5,845	0.4
HDGV4	207	0.10	1.1	1.2	220	0.01
HDGV5	318	0.29	2.0	4.5	396	0.03
HDGV6	151	0.39	1.5	5.5	205	0.03
HDGV8A	4.1	0.003	0.0	0.04	6.0	0.0002
LDDT12	56	0.01	0.0	0.01	4.5	0.004
LDDV	10	0.004	0.0	0.01	4.2	0.001
LDGT2	10,310	4.1	9.1	93	5,317	0.1
LDGT34	18,879	8.8	20	200	12,649	0.2
LDGV	65,405	19.4	38	446	26,515	0.5
Totals	**117,427**	**44.5**	**322**	**835**	**75,200**	**7.6**

Table A-4: On-Road 1999 Activity and Emission by Major Department

Department	VMT (thousands)	VOC	NOx	CO	CO_2	PM_{10}
Aviation	2,819	1.7	7.0	29	1,962	0.2
Fire	11,263	4.2	38	71	8,747	1.1
Parks & Rec.	3,994	2.5	20	35	3,641	0.9
Police	60,120	18	39	407	25,930	0.5
Public Works	26,409	13	129	209	23,264	3.3
Solid Waste	5,654	2.8	80	25	7,873	1.5
Other	7,168	2.7	8.9	58	3,783	0.2
Totals	**117,427**	**44.5**	**322**	**835**	**75,200**	**7.6**

Table A-5: On-Road 2004 Activity and Emissions by Vehicle Category, tpy

Type	VMT (thousands)	VOC	NOx	CO	CO_2	PM_{10}
HDDBT	1,284	0.3	17	3.4	3,305	0.2
HDDV2B	1,014	0.2	3.5	0.8	878	0.1
HDDV3	746	0.1	2.5	0.7	718	0.1
HDDV4	469	0.1	2.2	0.5	515	0.1
HDDV5	86	0.0	0.5	0.1	98	0.01
HDDV6	928	0.4	7.2	1.3	1,199	0.2
HDDV7	1,685	0.9	16	2.6	2,512	0.4
HDDV8A	4,326	2.2	57	11	7,424	1.4
HDDV8B	2,338	1.2	31	5.5	4,168	0.6
HDGV2B	10,613	4.5	50	55	10,311	0.7
HDGV3	4,839	1.7	22	25	5,060	0.3
HDGV4	194	0.1	1.0	1.3	205	0.01
HDGV5	270	0.1	1.5	1.8	331	0.02
HDGV6	7	0.03	0.1	0.4	10	0.001
HDGV7	18	0.01	0.1	0.1	24	0.001
HDGV8A	2	0.002	0.02	0.02	2.6	0.0001
LDDT34	13,801	6.1	16	8.3	9,107	1.8
LDGT34	204	0.1	0.3	2.5	138	0.002
LDGV	49,128	9.3	26	271	19,917	0.3
MC	10	0.02	0.01	0.1	2.0	0.0002
Totals	**91,960**	**27.7**	**253.9**	**391**	**65,923**	**6.3**

Table A-6: On-Road 2004 Activity and Emissions by Major Department, tpy

Department	VMT (thousands)	VOC	NOx	CO	CO_2	PM_{10}
Aviation	3,929	1.2	23	14	5,234	0.5
Fire	8,624	3.3	40	46	7,987	0.9
Parks & Rec.	2,717	1.1	12	7	2,581	0.4
Police	45,759	8.9	30	218	20,216	0.8
Public Works	22,467	10	94	73	20,803	2.7
Solid Waste	4,372	2.0	45	12	6,436	0.9
Other	4,092	1.5	9	22	2,666	0.2
Totals	**91,960**	**28**	**254**	**391**	**65,923**	**6.3**

The highest emissions levels were seen in police cars and public works trucks due to their large percentage of the overall vehicle population. Compared with diesel fueled vehicles, gasoline fueled vehicles emit relatively more VOCs and CO, while diesel fueled vehicles emit relatively more NOx and PM_{10}. The Police Department's emissions reflect their predominantly gasoline-fueled police cars, while departments such as Public Works and Solid Waste show a more diesel-oriented mix, with higher NOx than CO emissions.

Findings – Non-Road

Off-road estimates were aggregated by NONROAD model classification, such as agricultural, commercial, and construction equipment types. The emission estimates were developed separately for diesel and gasoline equipment; only one propane forklift was found so it was included as a gasoline-powered forklift. The relative percentages of diesel and gasoline equipment in the 1999 and 2004 off-road fleets are summarized in Table A-7.

Table A-7: Diesel and Gasoline Breakdown of Off-Road Equipment

	1999		2004	
Classification	**Diesel**	**Gasoline**	**Diesel**	**Gasoline**
Agricultural	98%	2%	98%	2%
Commercial	79%	21%	71%	29%
Construction	89%	11%	91%	9%
Industrial	47%	53%	45%	55%
Lawn & Garden	80%	20%	80%	20%
Motorboat	0%	100%	0%	100%
Utility Carts*	3%	98%	10%	90%

*These are classified as "Recreational Equipment" by the NONROAD model but are working utility carts similar in design to golf carts.

The relative percentages of diesel and gasoline equipment did not change significantly between the two years. The agricultural classification was mainly used for large mowers having the farm tractor design, and is almost exclusively diesel powered. Smaller mowers were categorized as being "commercial lawn & garden equipment;" they are also primarily diesel powered, although one in five is gasoline powered. Construction equipment included the Gradall wheeled excavators and like the large mowers is primarily diesel powered. Commercial equipment included welders, pumps, and air compressors, about 70% diesel powered in 2004, a decrease from 1999. The industrial classification included forklifts and was a "catch-all" for any equipment that did not easily fit into another sector. This classification is roughly half and half diesel and gasoline. Emissions for 1999 and 2004 are shown below.

Table A-8: 1999 Off-Road Emissions by Source Category, Tons per Year

Classification	VOC	NOx	CO	CO_2	PM_{10}
Agricultural	4.4	19	19	1,592	3.2
Commercial	2.9	18	39	1,300	1.4
Construction	17	96	215	7,824	9.5
Industrial	21	40	462	3,842	3.0
Lawn & Garden	5.4	19	61	1,552	2.3
Motorboat	0.8	0.01	1.4	9.0	0.1
Utility Carts	0.5	0.1	11	24	0.0
Totals	**52**	**193**	**809**	**16,144**	**19**

Table A-9: 2004 Off-Road Emissions by Source Category, Tons per Year

Classification	VOC	NOx	CO	CO_2	PM_{10}
Agricultural	4.2	26	23	2,451	3.7
Commercial	1.7	17	11	1,714	1.2
Construction	12	70	112	6,772	7.0
Industrial	13	22	284	2,428	1.3
Lawn & Garden	2.7	8.3	36	768	0.8
Motorboat	0.4	0.0	0.7	4.3	0.02
Utility Carts	0.6	0.6	11	58	0.03
Totals	**34**	**144**	**478**	**14,195**	**14**

Discussion and Conclusion

The emission estimates presented in this report show a significant decline in emissions from 1999 to 2004. However, the emissions should be considered as estimates and not as "hard" numbers due to:

- Uncertainty about the 1999 base year. (Estimates were based on data collected during the second half of the year and extrapolated to the entire year.)

- Difficulty in estimating the effect of low emission vehicles (LEVs). (The MOBILE models are designed with built-in default assumptions for the introduction of LEVs into a fleet; the models are not designed for the user to specify the number or percentage of LEVs.)

- Lack of data on non-road equipment annual hours of use. (The NONROAD model contains defaults but can accommodate actual hours per equipment type to produce a more accurate estimate.)

It should be noted that the number of vehicles and pieces of equipment has declined over the five-year period, which contributed to emission reductions. In addition, fleet turnover (defined as purchase of new engines and scrappage of old engines) has been robust. Replacement of an older vehicle or piece of equipment with a cleaner-emitting engine may reduce emissions more than 30% for key pollutants such as VOC and NOx.

Emissions Adjustment for Stationary Sources

Since there has been no change in the model used for stationary sources, these emissions were not recalculated. However, actual measurements conducted by the Department of Public Works and Engineering of wastewater treatment sludge dryers, and a review of emissions calculations conducted by the Department of Aviation did identify the need to adjust the emissions estimates for the 1999 data used in the 2000 ERP.

The Department of Public Works and Engineering

The difference between the two emissions inventories of the estimated emissions of NO**x**, VOCs and PM_{10} from the sludge dryers is shown below. The significant change from the 2000 ERP estimate is due to voluntary exhaust stack tests conducted by the department beginning in February 2003, using test protocols developed with, and approved by, staff at the TCEQ's Region 12 office. Burner tests confirmed that the burners are performing in accordance with the original estimates. As a result of the tests, the emissions increases have been attributed to the use of standard emission factors for natural gas fired, steam-generating burners, which were the state of knowledge when the plant was placed into service 20 years ago. What the standard emission factors apparently did not take into account are the emissions that appear to originate from the sludge itself as it dries. Even today, there is limited information on dryer emissions in the wastewater industry.

The emissions shown represent the normal operations of the nine sludge dryers installed at two-wastewater treatment plants.

Public Works and Engineering

	Sludge Dryers		
	NOx	**VOC's**	**PM_{10}**
2000 ERP	51.0	2.8	3.9
Adjusted 2000 ERP	115.2	66.0	20.8

The Department of Aviation

A review of the data by the Department of Aviation revealed the need to adjust its 2000 ERP data as well. This review resulted in the changes noted below.

Department of Aviation

	Boilers/Heaters			Generators		
	NOx	**VOC's**	**PM_{10}**	**NOx**	**VOC's**	**PM_{10}**
2000 ERP	16.90	1.06	1.48	0.00	0.00	0.00
Adjusted 2000 ERP	24.30	0.90	1.20	7.40	0.20	0.10