Air Quality Reference Guide for the Houston-Galveston-Brazoria Area

2010

Houston-Galveston Area Council

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Preface

The purpose of air quality regulation, enforcement, and research is the protection of public health and the environment. Comprehensive, accurate, and accessible data and information is essential to determine whether or not air quality is affecting public health and the environment. The Regional Air Quality Planning Committee (RAQPC) prepared this second edition of the *Air Quality Reference Guide for the Houston-Galveston-Brazoria (HGB) Area* (Guide) to provide accurate and up-to-date information about air quality in HGB to interested citizens and organizations. RAQPC members brought differing perspectives - industry, public health, government, citizens and the environmental community - to the Guide, and its contents represent a consensus of the group members. The RAQPC hopes that you will utilize this guide as a resource tool. To provide comments for improving the next edition, please go to http://www.h-gac.com/taq/airquality/raqpc/default.aspx.

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Dedication

It is with great honor and appreciation that RAQPC dedicates this Air Quality Reference Guide to Jacqueline Lentz in recognition of her efforts and achievements in improving air quality in the Houston-Galveston-Brazoria area.

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What is an Air Pollutant?

An air pollutant is any substance in the air that can potentially cause harm to humans or the environment. Air pollutants may take the form of solid particles, liquid droplets, or gases. Air pollution is the presence of a harmful amount of air pollutants. Air pollutants come from many different sources:

1) Large stationary sources including refineries, power plants, smelters, and boilers; and smaller sources such as dry cleaners and degreasing operations
2) Mobile sources including cars, construction equipment, buses, planes, trucks, marine vessels and trains
3) Naturally occurring sources such as wildfires, windblown dust, some tree species, and volcanic eruptions

The Clean Air Act (CAA) provides the principal framework for national, state, and local efforts to protect air quality. Congress enacted the CAA in 1970, amended the act in 1990, and periodically reviews the act.

Generally, the EPA classifies air pollutants into three categories: criteria pollutants, air toxics, and greenhouse gases.

Criteria Pollutants

Criteria pollutants are common air pollutants that are found worldwide at varying levels. These pollutants can harm human health and the environment and cause property damage. Criteria air pollutants include particulate matter, ground level ozone[1], carbon monoxide, sulfur oxides, nitrogen oxides, and lead.

The CAA requires that the EPA set National Ambient Air Quality Standards (NAAQS) for criteria pollutants by evaluating the effects of air pollution on human health and the environment. The NAAQS are established to protect public health and welfare by setting appropriate ambient (outdoor) air quality standards. The standards are based on the latest scientific knowledge with an ample margin of safety. The EPA reviews the NAAQS on a periodic basis to integrate the latest scientific understanding of the health effects of each criteria

[1] “Ground level ozone” is considered to be an air pollutant; ozone is also naturally present in the Earth’s upper atmosphere and filters the ultraviolet rays of the sun.

air pollutant and revises the NAAQS if deemed necessary. The CAA establishes two types of national ambient air quality standards for the criteria pollutants.

- Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly.
- Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

An area that fails to meet the NAAQS for a pollutant is said to be in *nonattainment* for that pollutant. Figure 1 lists the primary and secondary NAAQS for each criteria pollutant as of July, 2010.

Air Toxics/Hazardous Air Pollutants (HAPs)

The Clean Air Act Amendments of 1990 (CAAA) created a list of 187 chemicals called Hazardous Air Pollutants (HAPs) that are known or suspected to cause cancer or other serious health effects or adverse environmental and ecological effects. HAPs are also commonly referred to as toxic air pollutants or air toxics. Sources of HAPs include industrial processes, motor vehicle operation, combustion, pesticide use, dry cleaning, and building materials. People exposed to toxic air pollutants at sufficient concentrations and durations may have an increased chance of getting cancer or experiencing other serious health effects. These health effects can include damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory, and other health problems. In addition to exposure from breathing air toxics, some toxic air pollutants, such as mercury, can deposit onto soils or surface waters, where they are taken up by plants and ingested by animals and eventually are carried up the food chain.

Commonly known examples of HAPs include, but are not limited to, benzene, toluene, vinyl chloride, perchloroethylene, asbestos, arsenic, mercury, chlordane, chromium, 1,3-butadiene, formaldehyde, and xylene.

Most air toxics originate from human-made sources including industrial processes, mobile sources, combustion, pesticide use, dry cleaning, and building materials. The CAAA directs the EPA to establish standards for HAPs. Rather than set individual ambient air quality standards for each HAP, the EPA has established emission controls for the most significant “source categories” of HAP emissions.

Greenhouse Gases (GHGs*)*

Gases that trap heat in the atmosphere are often called greenhouse gases. Some greenhouse gases, such as carbon dioxide, occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted into the atmosphere solely through human activities. GHGs include:

- Carbon dioxide (CO_2) enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement). Carbon dioxide is also removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

- Methane (CH_4) is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

- Nitrous oxide (N_2O) is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

- Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases (High GWP gases).

GHGs are compared to each other on a CO_2-equivalant basis (CO_2e) based on their individual greenhouse gas warming potential.

The EPA's GHG mandatory reporting rule went into effect in 2010 for reporting in 2011. Congress is currently considering how best to regulate GHGs. The EPA found that the current and projected concentrations of six GHGs in the atmosphere have an effect on the planet and threaten the public health and welfare of current and future generations. This finding may be the basis for additional regulation.

Fig. 1: National Ambient Air Quality Standards[2]

	Primary Standards		Secondary Standards	
Pollutant	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9,000 ppb (10 mg/m^3)	8-hour (1)	None	
	35,000 ppb (40 mg/m^3)	1-hour (1)		
Lead	0.15 $\mu g/m^3$ (2)	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	53 ppb (3)	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour (4)	None	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour (5)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (6) (Arithmetic Average)	Same as Primary	
	35 $\mu g/m^3$	24-hour (7)	Same as Primary	
Ozone	75 ppb (12) (2008 std)	8-hour (8)	Same as Primary	
	84 ppb (12) (1997 std)	8-hour (9)	Same as Primary	
	124 ppb	1-hour (10)	Same as Primary	
Sulfur Dioxide	30 ppb	Annual (Arithmetic Average)	500 ppb	3-hour (1)
	140 ppb	24-hour (1)		
	75 ppb (11)	1-hour	None	

(1) Not to be exceeded more than once per year
(2) Final rule signed October 15, 2008
(3) The official level of the annual NO2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the one-hour standard.
(4) To attain this standard, the three-year average of the 98th percentile of the daily maximum one-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
(5) Not to be exceeded more than once per year on average over three years
(6) To attain this standard, the three-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m3.

[2] From http://www.epa.gov/air/criteria.html

(7) To attain this standard, the three-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m3 (effective December 17, 2006).

(8) To attain this standard, the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).

(9) (a) To attain this standard, the three-year average of the fourth-highest daily maximum eight-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 84 ppb.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as the EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(c) The EPA is in the process of reconsidering these standards (set in March 2008).

(10) (a) The EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard (anti-backsliding).
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 120 ppb is $\leq$ 1.

(11) (a) The final rule was published June 22, 2010 in the Federal Register. To attain this standard, the three-year average of the 99th percentile of the daily maximum one-hour average at each monitor within an area must not exceed 75 ppb.

(12) Many standards listed in this document have been converted from parts per million (ppm) to parts per billion (ppb) for document consistency.

What are the Criteria Pollutants?

Ozone (O_3)

Ozone is a reactive form of oxygen that is composed of three oxygen atoms (O_3), in contrast to the more common form of oxygen that has two oxygen atoms (O_2). It occurs in two areas of the earth's atmosphere – the stratosphere and the troposphere. Naturally occurring ozone is found in the stratosphere, 6 to 30 miles above the earth's surface, where it plays a positive role in absorbing ultraviolet rays emitted by the sun. Ozone is also found in the troposphere from ground level up to six miles above the earth's surface. Exposure to this ground level ozone in higher concentrations can result in adverse effects to humans, plants, and animals. Harmful levels of ozone, when they occur, usually are measured in urban areas because ground level ozone is largely formed from emissions created by human activities.

Photochemical smog, frequently referred to as "ozone" or "ground level ozone," is not emitted directly into the air, but occurs when nitrogen oxides (NO_x) and volatile organic compounds (VOCs) react in the presence of heat and sunlight.

NO_x is produced almost entirely as a byproduct of high temperature combustion. Common sources of NO_x include automobiles, trucks, construction equipment, marine vessels, incineration, power generation, industrial processes, forest fires, natural gas furnaces, and stoves and fireplaces. The primary noncombustion source of NO_x is the breakdown of nitrogen in the soil by soil microbes.

VOCs include many chemicals that vaporize easily, such as those found in gasoline and solvents. VOCs are emitted from:

- industrial sources, such as petroleum storage tanks, oil refineries, and petrochemical manufacturing plants;
- on-road mobile sources, such as automobiles, trucks, and motorcycles;
- off-road sources, such as airplanes, trains, boats, and construction equipment;
- area sources, such as gasoline stations, paint, gasoline powered lawn mowers, and printing operations; and
- biogenic sources from various trees and plants.

Not all VOCs, however, have equal potential to make ozone. VOCs that are more reactive, such as ethylene and propylene, contribute more readily to ozone formation than do less reactive VOCs, such as propane and ethane.

Ground level ozone in irritating or harmful concentrations is typically formed during periods of high solar radiation (i.e., no cloud cover), low wind speeds, elevated temperatures, and moderate-to-high concentrations of NO_x and VOCs. Varying wind patterns and the time required for ozone to form can result in exceedances of the ozone standard that occur at locations distant from the sources that emitted NO_x and VOCs.

Existing Ozone Standards

The existing primary standard for ozone is 75 ppb based on an eight-hour average of monitored values. In 2008 the EPA strengthened the eight-hour ozone standard from the 84 ppb value set in 1997 to the current 75 ppb value.

Attainment of this primary eight-hour ozone standard is based on a "design value" for a given area. To determine an area's design value, the annual average of all the fourth highest daily eight-hour readings for each monitor in the area is calculated over a consecutive three-year period. The monitor with the highest average after this process provides the design value for the area. This process statistically eliminates unusually high ozone readings so that a more representative design value can be developed for the area.

Originally in 1979, the EPA established a primary ozone standard of 125 ppb based on a one-hour average of monitored values. In June 2005, the EPA established a secondary ozone standard to provide increased protection against ozone-related adverse impacts on vegetation and forested ecosystems. The secondary standard is identical to the 2008 eight-hour primary standard of 75 ppb.

Figure 2, Daily Exceedances from 2006 to 2010, displays the number of days the Houston-Galveston-Brazoria Area (HGB), an eight county region consisting of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties, exceeded the eight-hour ozone standard of 75 ppb. HGB experienced a reduction in exceedance days of approximately 48% from year 2006 (64 total days) to 2009 (31 total days). Although data for the year 2010 is incomplete at this time, the trend indicates a reduction in the number of ozone exceedance days for each year. Figure 3 shows the historic eight-hour ozone design values from 1999 to 2009. The figure shows steady improvement in the ozone design value over the 10-year period with 2009 values below the 1997 standard.

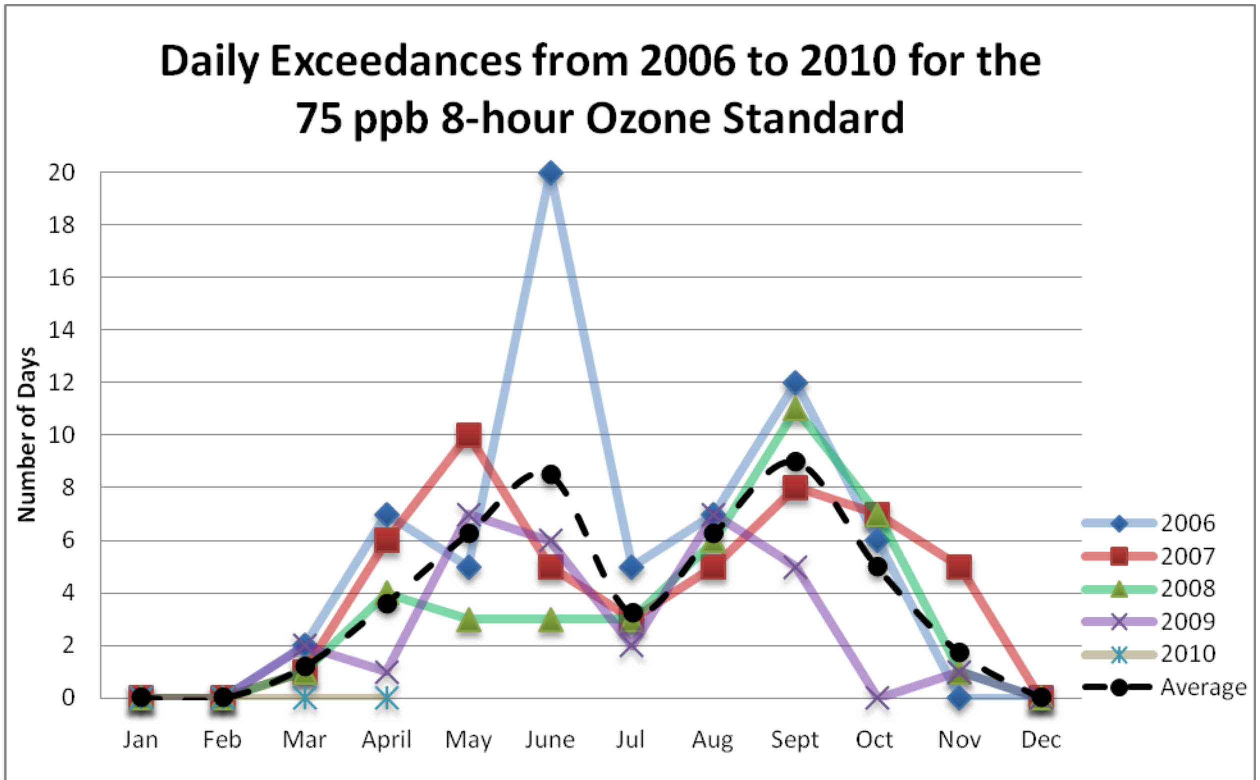

Figure 2: Daily Exceedances from 2006 to 2010 for the 75 ppb 8-hour Ozone Standard[3]

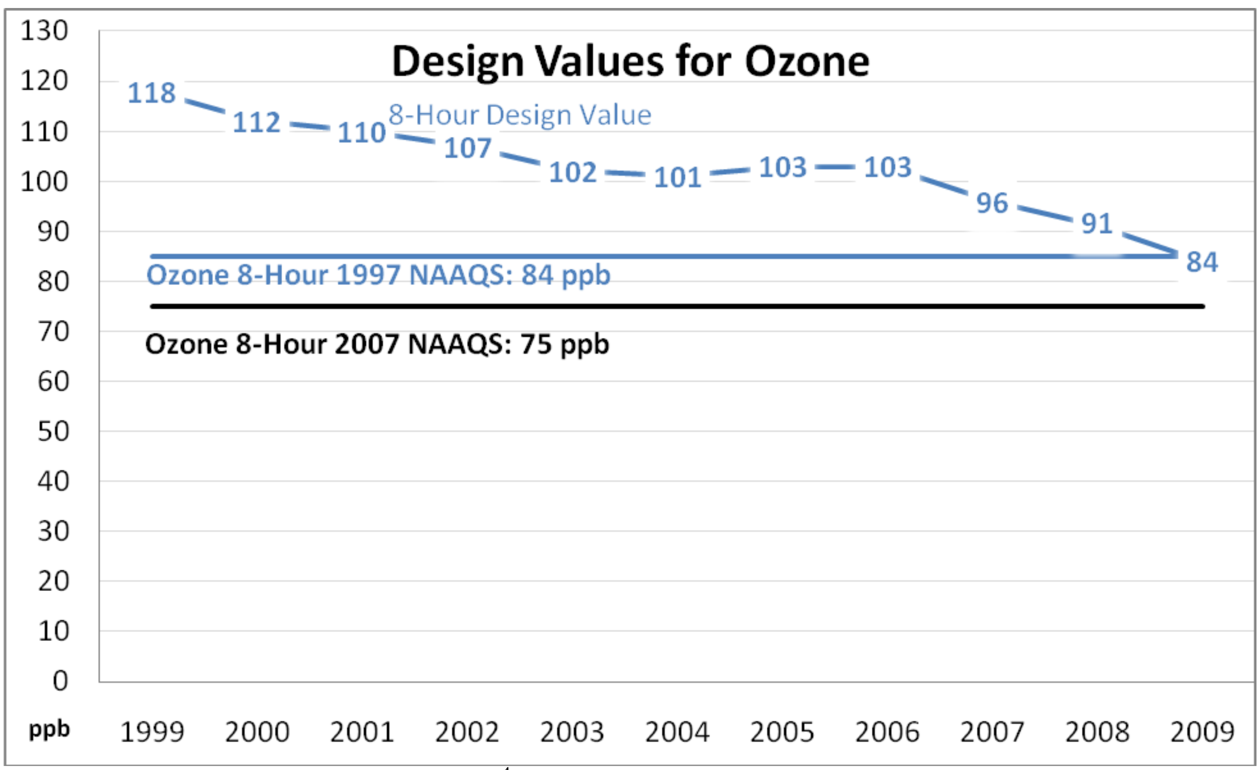

Figure 3: Design Value for Ozone for HGB[4]

[3] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

[4] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

Proposed Ozone Standard

In September of 2009, the EPA proposed strengthening the primary eight-hour ozone standard from 75 ppb to within the range of 60 to 70 ppb. If the lower standard is promulgated, many more areas of Texas and the U.S. may be designated as nonattainment for the new standard. Because each urban area has different geographical and meteorological conditions, as well as different emissions sources, different strategies to reduce pollutant levels must be considered for each area. The EPA also has proposed that the secondary ozone standard should be a cumulative, seasonal standard with the maximum index value within the range of 7,000 to 15,000 ppb.

Please visit http://www.epa.gov/air/ozonepollution/history.html for further information concerning the history of ozone standards.

Particulate Matter (PM)

Particulate matter is defined as small particles that are suspended in the air. These particles include inorganic salts, acids, metals, water, organic compounds, and soot. Particulate matter has historically been defined by the EPA based on its diameter or size. PM_{10} or "coarse" particulate matter is a particle smaller than 10 microns in diameter, and $PM_{2.5}$ or "fine" particulate is a particle that is less than 2.5 microns in diameter. A micron is approximately equal to 1/100th of the width of a human hair. PM_{10} and $PM_{2.5}$ particles come from:

- combustion, including gasoline and diesel-fueled cars and trucks, power generation, industrial processes, cigarette smoke, volcanoes, and forest fires;
- surface dust;
- abrasion of tires;
- chemical reactions in the atmosphere;
- soil disturbance from such sources as construction and agriculture;
- production or degradation of metals, such as chromium and platinum; and
- various naturally occurring sources, such as pollen, animal dander, and insect fecal matter.

Particulate Matter Standards

In 1987, the EPA established a primary standard for PM_{10} that is 10 microns (µg) or smaller in diameter based on a 24-hour average. In July 1997, the EPA strengthened the PM standard to include $PM_{2.5}$ based on an annual and 24-hour averaging period. Secondary standards were set identical to the primary standards. The new $PM_{2.5}$ standards set in 1997 require that

1. the annual mean concentration, averaged over three years, not exceed 15 µg/m^3; and
2. the 98th percentile of the 24-hour average concentrations, averaged over three years, not exceed 35 µg/m^3.

Also in January 2006, the EPA revised the 24-hour PM_{10} standard by establishing a new indicator for coarse particles (particles between 2.5 and 10µg). The EPA established the new $PM_{10-2.5}$ standard at a level of 70 µg/m^3 and revised the 24-hour PM_{10} standard to 150 µg/m^3.

$PM_{2.5}$ particles consist mainly of resuspended dust from high-density traffic on paved roads and PM generated by industrial sources and construction sources. Any ambient mix of $PM_{10-2.5}$ that is primarily rural windblown dust or PM generated by agricultural and mining sources is not included.

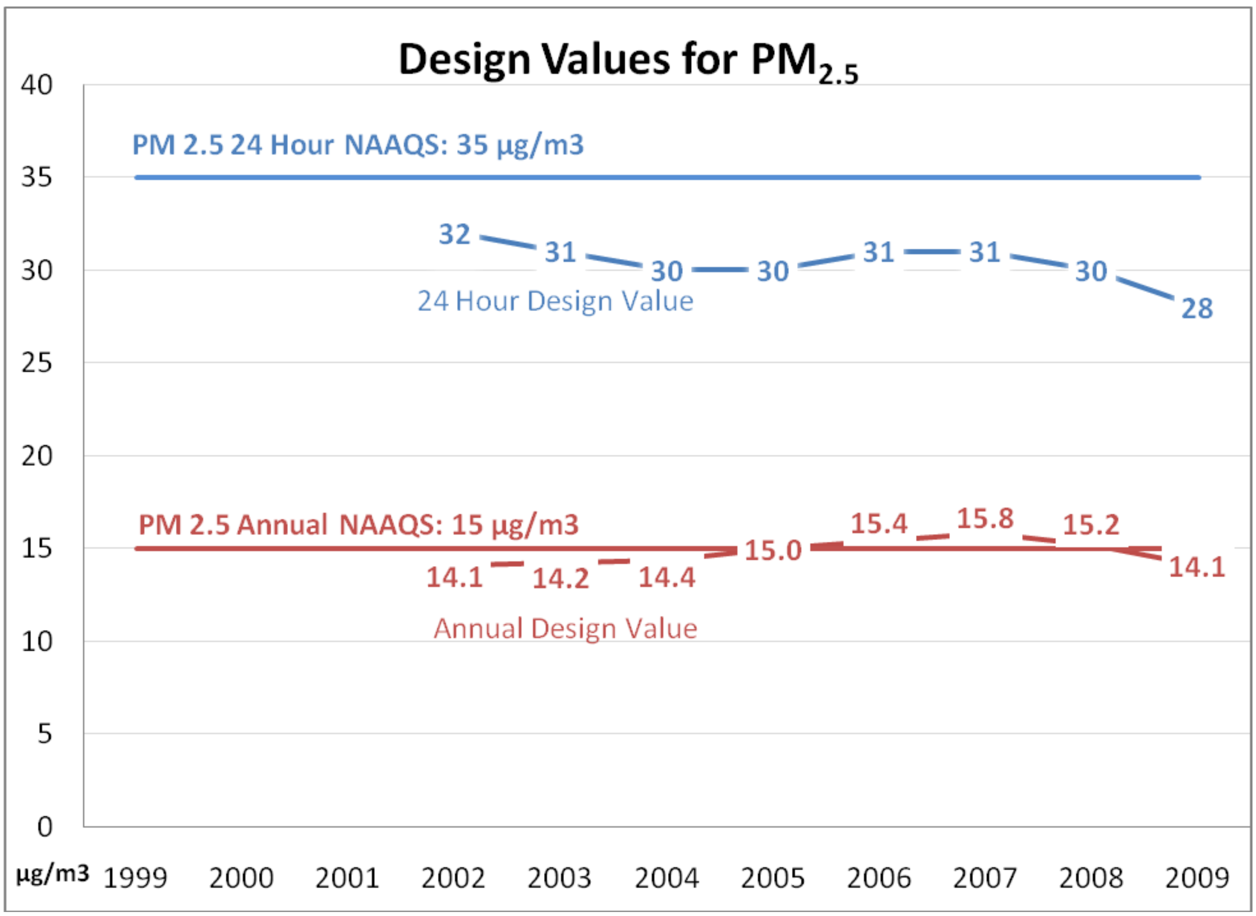

Figure 4: Design Values for $PM_{2.5}$ for HGB[5]

[5] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

Figure 4 indicates that HGB is in attainment for $PM_{2.5}$ after a slight rise in 2006 through 2008. The reduction of $PM_{2.5}$ was the result of reduction projects that targeted known $PM_{2.5}$ contributors.

Currently, the EPA is studying the benefits of strengthening the $PM_{2.5}$ standard to an undetermined but lower level.

Please visit http://www.epa.gov/air/particlepollution/history.html for further information concerning past PM_{10} and $PM_{2.5}$ standards.

Carbon Monoxide (CO)

Carbon monoxide (CO), a colorless, odorless gas, is emitted during the combustion of gasoline, wood, natural gas, and other fuels. Emissions of CO increase significantly from improperly tuned engines. The NAAQS for CO is 35,000 ppb averaged over one hour and 9,000 ppb averaged over eight hours (Figure 1).

Figure 5 shows the design values for CO. Although there has been an increase in both the one-hour and eight-hour average levels in recent years, HGB is still in attainment for CO.

Please visit http://www.epa.gov/air/emissions/co.htm for further information concerning CO standards.

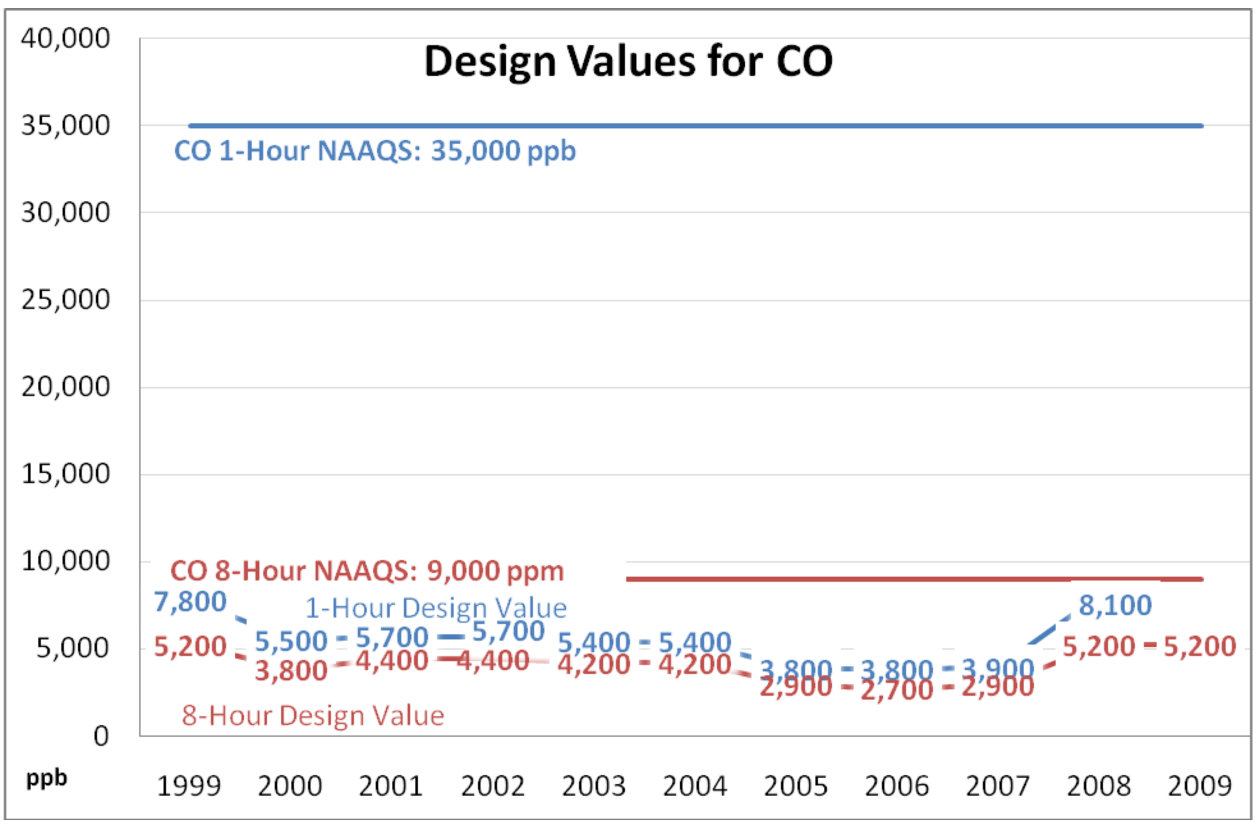

Figure 5: Design Values for CO for HGB[6]

[6] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

Sulfur Dioxide (SO_2)

Sulfur dioxide (SO_2) is a colorless, odorless gas at low concentrations, but has a pungent odor at higher concentrations. In Texas, SO_2 is emitted primarily by stationary sources including power plants that burn sulfur-containing coal, petroleum refineries, and sulfuric acid plants. Mobile sources that are powered by diesel fuel also contribute to SO_2 emissions. SO_2 can harm vegetation, impair visibility by the formation of sulfates, and contribute to acid rain, in addition to its effects on health. The NAAQS for SO_2 are 140 ppb averaged over 24 hours and 30 ppb averaged over one year for public health, and 500 ppb averaged over three hours for public welfare (Figure 1).

As shown in Figure 6, there has been a decrease in the 24-hour, and the annual average levels of SO_2. HGB is in attainment for SO_2.

New Sulfur Dioxide Standards

On June 22, 2010, the EPA published in the Federal Register that a new 1-hour primary NAAQS for SO_2 had been established and that the current 24-hour and annual primary NAAQS for SO_2 were being revoked. The new one-hour standard for SO_2 is 75 ppb (Figure 1). HGB appears to be in attainment with these newly-revised standards.

Please visit http://www.epa.gov/air/sulfurdioxide/ for further information concerning past SO_2 standards.

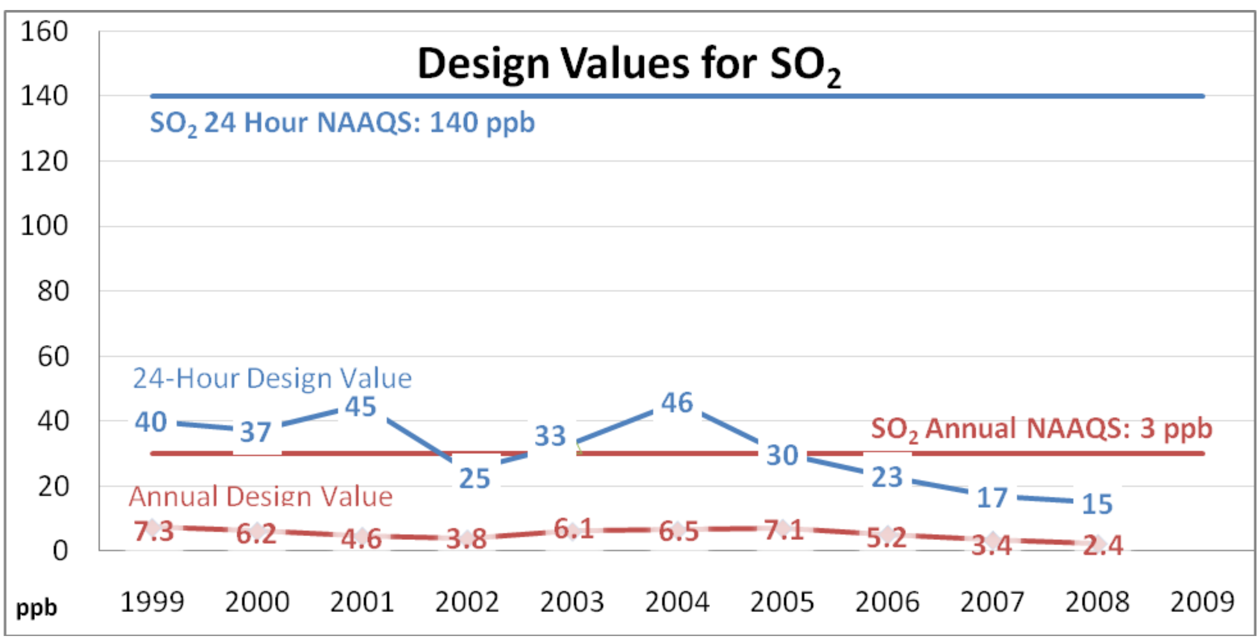

Figure 6: Design Values for SO_2 for HGB[7]

[7] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is a yellow-brown gas that is part of the family of pollutants referred to as NO_x. NO_x is formed almost entirely by high-temperature combustion, such as the burning of fuels in power generation plants, industrial boilers, cars, trucks, furnaces, and cooking stoves. In agricultural areas, the microbial breakdown of high-nitrogen fertilizers may also contribute to NO_x levels. The NAAQS for NO_2 is 53 ppb averaged over one year and 100 ppb averaged over a 1-hour interval (Figure 1).

As shown in Figure 7, there has been a decrease in the annual average level of NO_2. Although the HGB region is currently in attainment for NO_2, particular attention is paid to this pollutant because of its important role in the formation of ground level ozone.

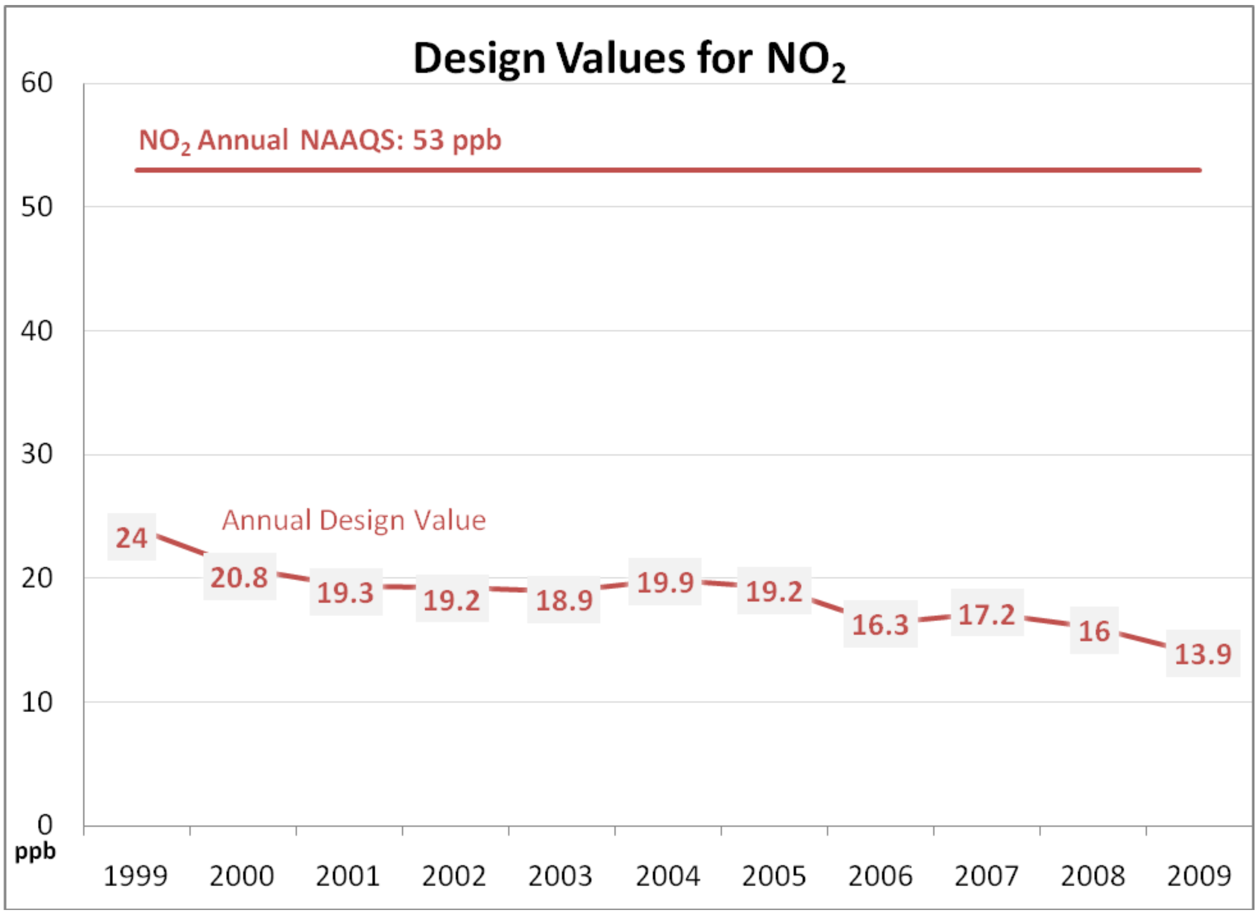

Figure 7: Design Values for NO_2 for HGB[8]

[8] Data for figure retrieved from http://www.epa.gov/ttn/airs/airsaqs/aqsweb/

Lead (pb)

Lead (Pb) is a toxic metal that was previously used as a gasoline additive and in most paints. In the United States, Pb has been phased out of gasoline, paint, and other consumer products because of its undesirable health effects. Pb is still emitted into the air by lead battery manufacturing plants, lead battery recovery plants, smelter operations, and the combustion of coal that contains lead. Levels of Pb in the air have decreased significantly. The NAAQS for Pb is 1.5 $\mu g/m^3$ averaged quarterly (Figure 1).

In 1997, TCEQ and the City of Houston phased out ambient monitoring in the eight-county area because all measurements of lead at the four monitoring sites in HGB were near or below the limit of detection (0.01 $\mu g/m^3$). HGB is in attainment for Pb.

What are the Health Effects of Air Pollution?

Each air pollutant has the potential to cause adverse health effects. These effects depend on the physical and biochemical nature of the pollutant, toxicity of the pollutant, pollutant level, mode and duration of exposure, and individual susceptibility. Higher pollutant levels and longer exposure times generally have greater effects. Lower pollutant levels and shorter exposures may cause adverse health effects to sensitive individuals or to persons with immune system or other dysfunctions that reduce their bodies' ability to detoxify pollutants. Exposure to multiple air pollutants generally, but not always, amplifies the effects of individual pollutants, and may cause effects different from exposure to the same pollutants individually. For more information please visit the TCEQ ESL website at: http://www.tceq.state.tx.us/implementation/tox/esl.

In Texas, the TCEQ has established Effects Screening Levels (ESLs) for many air toxics. ESLs are screening levels used in the air permitting process to evaluate predicted and potential impacts of exposure. ESLs are based on data concerning health effects, such as increased cancer risks, the potential for odors to be a nuisance[9], effects on vegetation, and corrosive effects. ESLs are typically between 1/100th and 1/1,000th of the occupational health standards for the same chemicals. Texas ESLs are not intended to serve as ambient air standards.

Criteria Pollutants

Ozone

Exposure to elevated levels of ozone can cause or aggravate various respiratory symptoms. These symptoms include decreased lung capacity, exacerbation of asthma, inflammation of lung tissue, and the secretion of mucus in the respiratory passages. These changes can lead to difficulty in breathing, and have been associated with increased hospital admissions and emergency room visits during and directly following days of high ozone levels. Exposure to ozone can also impair the body's immune system defenses, making people more susceptible to respiratory infections resulting in colds, bronchitis, and pneumonia. Individuals with asthma or chronic obstructive pulmonary disease (COPD) are especially at risk. Regular or prolonged exposure to ozone may lead to scarring and premature aging of the respiratory system.

The American Lung Association has a collection of recent ozone studies that identify high ozone levels as a contributor to increased asthma, cardiac arrhythmia, and airway

[9] No person shall discharge from any source whatsoever one or more air contaminants or combinations thereof, in such concentration and of such duration as are or may tend to be injurious to or to adversely affect human health or welfare, animal life, vegetation, or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property. http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/101a.pdf

obstruction.[10] A study published in 2002 found that children who play active team sports in areas with high levels of ground level ozone are more likely to develop asthma.[11] Recent studies, conducted between 2003 and 2008, by investigators at the University of Texas Medical Branch (UTMB) in Galveston found that healthy, adult lifeguards experienced increased airway obstruction as ozone levels increased throughout the day, even when ozone levels remained far below national standards.[12] Epidemiological studies also suggest that ozone may exacerbate cardiac arrhythmia, and have found a small, but statistically significant, increase in mortality associated with increased ozone levels[13]. Further summary of studies may be found in Appendix E. Ozone has not been shown to be carcinogenic.

Particulate Matter

Epidemiological studies have linked increased levels of PM_{10} to various health effects. These include an increase in respiratory-related hospital admissions and emergency room visits, asthma, acute respiratory symptoms (i.e., severe chest pain, gasping and aggravated coughing), chronic bronchitis, decreased lung function (which can be experienced as shortness of breath), and work and school absences. Several studies have also linked increased particulate levels to higher death rates from respiratory and cardiovascular diseases. Those most at risk include the elderly, children, asthmatics, and adults with pre-existing heart or lung disease.

These effects are observed at particulate levels considerably below the current NAAQS for PM_{10} and are now known to be largely caused by the $PM_{2.5}$. For example, the EPA published the *Integrated Science Assessment for Particulate Matter* in 2009. This study concluded that long-term exposure to fine particles in the $PM_{2.5}$ range is associated with increased mortality of people with cardiovascular disease and lung cancer.[14] When drawn into the deepest part of the lungs, these particles tend to stay there, trapped in millions of tiny alveoli, where the impact on lung function is the greatest. Some particulate matter, especially that found in diesel exhaust, has been shown to be carcinogenic.

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[10] http://www.lungusa.org/about-us/publications/

[11] McConnell, Rob, Kiros Berhane, Frank Gilliland, Stephanie J. London, Talat Islam, W. James Gauderman, Edward Avol, Helene G. Margolis, John M. Peters. "Asthma in exercising children exposed to ozone: a cohort study." *The Lancet* 359.9304 (2002): 386-391.

[12] http://www.stateoftheair.org/2010/health-risks/health-risks-particle.html Thaller et al, 2008

[13] http://www.stateoftheair.org/2010/health-risks/health-risks-particle.html Tsai SS, Goggins WB, Chiu HF, Yang CY. Evidence for an Association Between Air Pollution and Daily Stroke Admissions in Kaohsiung, Taiwan. Stroke. 2003; 34: 2612-6.

[14] U.S. EPA. Integrated Science Assessment for Particulate Matter (Final Report). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-08/139F, 2009.

Carbon Monoxide

CO prevents hemoglobin from carrying oxygen from the lungs to the tissues of the body. Persons with cardiovascular or respiratory disease are particularly susceptible to CO because their bodies may be receiving only minimal oxygen ordinarily. Individuals exercising near traffic are also at risk because CO levels can be high in those areas. CO levels may also affect people traveling in heavy traffic or stopped at traffic lights where CO concentrations may be elevated.

Chronic exposure to low levels of CO may lead to changes in the heart and brain caused by oxygen deprivation. Increased ambient levels of CO have also been associated with increased hospital admissions for heart arrhythmia and cardiovascular disease. Moderate exposure to CO can cause dizziness, headache, and fatigue. At higher concentrations in enclosed spaces, CO can cause unconsciousness and death.

Sulfur Dioxide

The health effects of exposure to SO_2 include a decrease in lung function, irritation of the eyes, tearing, coughing, and chest tightness. Urban levels of SO_2 have been shown to exacerbate allergies and asthma and have been associated with increased cardiovascular mortality. Sulfur dioxide contributes to the creation of sulfate particles and sulfuric acid aerosols, both of which have harmful effects at higher concentrations. Exposure to very high levels of SO_2 can result in severe breathing disorders, including respiratory paralysis and pulmonary edema.

Nitrogen Dioxide

Exposure to NO_2 can cause lung irritation, a lowered resistance to respiratory infections, exacerbation of allergies, and has been associated with cardiac arrhythmia and vascular changes. Exposure to NO_2 at high levels can cause pulmonary edema and death. Increased ambient levels of NO_2 are associated with increased hospital admissions due to asthma, COPD, and heart disease as well as respiratory mortality. NO_2 contributes to the creation of nitric oxide, peroxyacetyl nitrate, nitrate particles, peroxynitrite radicals, and nitric acid aerosols in the atmosphere. These other forms of nitrogen may have harmful effects at higher concentrations and may be responsible for some of the health effects correlated with NO_2. Some forms of nitrogen are mutagenic, causing sudden changes in inheritable genetic material.

Lead

The adverse health effects of Pb impact virtually every organ system in the body. There is evidence that Pb damages the kidneys and the immune system. The nervous system, especially in children, is particularly sensitive to the effects of lead. Children exposed to Pb can have numerous neurological effects, including abnormal neural development, reduced behavioral and cognitive function, and decreased Intelligence Quotient (IQ). Pb has been shown to be carcinogenic in animals.

Air Toxics

Exposure to air toxics, such as benzene, dioxin, toluene, formaldehyde, 1,3-butadiene, and others in high concentrations can result in the rapid onset of sickness (e.g., nausea, headache, confusion, seizures, and severe difficulty in breathing), and death. The most common health effects associated with air toxics are cancer and various immunological, hormonal, neurological, reproductive, developmental, and respiratory effects, depending on the specific air toxic, its concentration, and exposure time. Many air toxics are neurotoxins and can cause genetic damage. Exposure to each air toxic or multiple air toxics have their own potential health effects. As noted on page 18, TCEQ has established Effects Screening Levels (ESLs). ESLs are screening levels used in the TCEQ's air permitting process. For more information regarding ESLs, please visit http://www.tceq.state.tx.us/implementation/tox/esl/ESLMain.html.

The EPA created the Endocrine Disrupters Screening and Testing Advisory Committee (EDSTAC) to study the disruption of endocrine functions caused by extremely low levels of some pesticides and chemicals. Many of the diseases caused by air toxics take years to develop; therefore, the health effects of air toxics are often not recognized by patients and physicians. For example, the latency period following exposure to benzene, known to cause leukemia and aplastic anemia, is 5 to 30 years.

The EPA's annual Toxic Release Inventory (TRI) contains information on over 600 chemical compounds from releases and waste management activities at a wide variety of sources in the U.S. Every July data is submitted by sources subject to the TRI reporting rule for the previous year's activities. The TRI can be used to help understand the types and levels of air toxics. In 2008, Harris County ranked fourteenth in all U.S. counties for toxic air emissions. For more information on the TRI, please visit http://www.epa.gov/tri/.

Greenhouse Gases

Global emissions of GHGs may influence weather patterns and disturb life-supporting ecosystems and processes. It is, however, difficult to predict how GHGs will affect the health of humans. The range of health effects may be diverse, often unpredictable in magnitude, and sometimes slow to emerge.

Data regarding the health effects of GHGs is currently inconclusive. However, potential health effects may result from an increase of exposure to ultraviolet radiation (UVR). Increased exposure to UVR, if sustained over several decades, may lead to increased rates of skin cancer in light-skinned populations (especially the nonmelanoma cancers) and an increased number of eye cataracts, as well as possibly the suppression of the body's immune system.[15]

For more information about how GHGs relate to climate change, please visit http://www.epa.gov/climatechange/index.html.

[15] McMichael, A.J., A. Haines, R. Slooff and S. Kovats, Climate Change and Human Health, US Climate Change Science Program / US Global Change Research Program, Suite 250, 1717 Pennsylvania Ave, NW, Washington, DC 20006. Tel: +1 202 223 6262. Fax: +1 202 223 3065.

How is Houston's Air Monitored and How is the Data Used?

Because the HGB area currently fails to meet the 8-hr ozone NAAQS, most of HGB's air quality monitoring and analysis efforts are focused on (1) obtaining better measurement and understanding of the area's ozone levels and its precursors, and (2) identifying and implementing effective ozone reduction control strategies.

Air Monitoring for Ozone

Since 1971, the monitoring system in the HGB region has been significantly expanded. The City of Houston, Harris County, University of Houston, TCEQ, and Houston Regional Monitoring Corporation (HRM) operate these monitors. Most of these monitoring stations also measure the concentrations of the other criteria pollutants in the air, as well as air temperature, wind velocity, and other meteorological parameters. Some of the monitoring stations also measure the levels of an additional set of selected chemicals, and some measure pollen and mold spores. Twenty-two ozone monitoring sites are recognized by EPA for determining attainment with the ozone NAAQS. Ozone data from other sites are used by TCEQ to help issue projections for high ozone alerts for specific areas.

The TCEQ recently developed new monitoring methods, Air-Monitoring Comparison Values (AMCV), which allow for more frequent and faster determinations of concentrations. Because the effects of the duration of exposure can be different, the TCEQ has developed AMCVs for short-term (acute) and long-term (chronic) exposures. Acute AMCVs are intended to be compared to hourly monitoring, while chronic AMCVs are intended to be compared to annual monitored results.

Although the HGB region has numerous monitors, there are some counties, such as Liberty and Waller, which do not currently have monitors. In 2001, ozone monitors detected levels over the one-hour standard in all monitored counties, except Galveston. Aircraft measurements made during the Texas 2000 Air Quality Study (TexAQS 2000) suggested that additional monitors in these areas would provide valuable information for ozone mapping and model verification.[16] Since then additional monitors have been added.

Monitors in the HGB region have previously recorded some of the highest ozone readings in the nation. In 2007, HGB was listed as the fifth highest in ozone formation behind four California cities: Los Angeles, Bakersfield, Visalia-Porterville, and Fresno-Madera, Ca.

[16] www.tceq.state.tx.us/cgi-bin/compliance/monops/site_info.pl.

However, ozone exceedance days in the HGB have been steadily decreasing as a result of more emission controls for industry, cleaner burning vehicles and cleaner fuels. An exceedance day for the entire HGB area occurs when any single monitor in the area shows a level above the NAAQS standard. In 2009, HGB ozone design value for all regulatory ozone monitors was below the eight-hour ozone standard for the first time since monitoring began. The HGB region has yet to monitor attainment for the one-hour ozone standard.

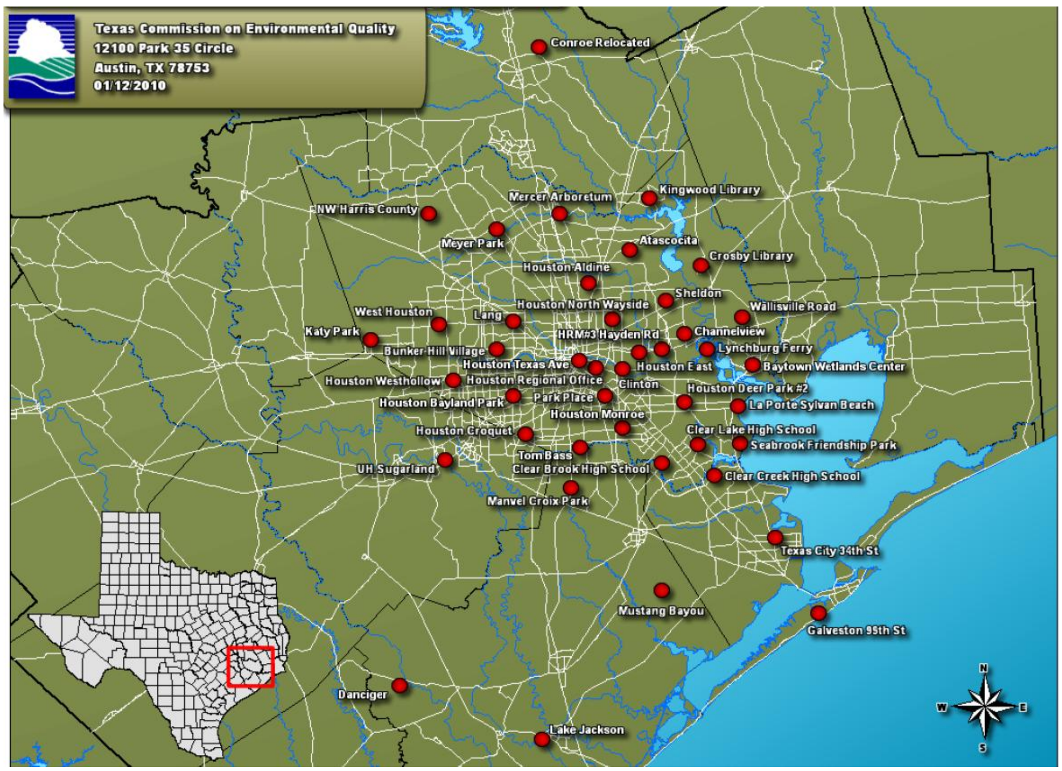

Figure 8: 2010 Ozone Monitoring Sites in the Houston-Galveston-Brazoria Region[17]

Our Ozone Nonattainment Status

The EPA defines ozone nonattainment based on the fourth highest monitored ozone levels each year at each monitor averaged over three consecutive years (i.e., 2006 - 2008 or 2007 - 2009). The highest monitor then determines the attainment status for the entire area. EPA categorizes ozone non-attainment areas into five classifications: Marginal, Moderate, Serious, Severe, and Extreme. Each classification has different pollution control requirements and different deadlines to attain the ozone standard. Areas with higher classifications are given more time to attain the standard, but must also implement more stringent pollution controls.

HGB is currently designated as Severe ozone nonattainment for the 1997 eight-hour ozone standard. Based solely on monitoring results, the area was originally classified as

[17] Map provided by TCEQ, 12100 Park, 35 Circle, Austin, Tx. 78753

Moderate and was given until 2009 to achieve attainment. However, in 2008, data indicated HGB would not attain the standard. In 2008, Governor Perry requested a two-level “bump up” to Severe. On January 16, 2009, EPA granted the reclassification of the HGB area to Severe and extended the date to comply with the 1997 8-hr ozone standard to 2019.

The downward trend in ozone levels has been generally considered to result from the efforts made to reduce emissions from various sources of VOCs and NO_x such as industry, cars, trucks, and small businesses. The business and industry sectors have reduced NOx emissions by an estimated 84 percent.

As previously discussed, the EPA is proposing to lower the 8-hr ozone standard even further. Once the ozone standard is revised, TCEQ will begin the process of reclassifying the HGB area and all other areas in Texas and initiating regulatory changes necessary to attain the new ozone standard.

Ozone Computer Modeling

The EPA requires states with ozone non-attainment areas (HGB for one) to develop forward-looking attainment demonstrations to show that the precursor controls being implemented will allow areas to attain the ozone NAAQS by the required attainment date. This is primarily done through the use of complex photochemical computer modeling. Some areas of the country, including HGB, use one of several EPA-approved computer models to analyze regional air pollution reductions. These photochemical models integrate complex equations based on atmospheric chemical reactions that form ozone. Models are used to predict ozone concentrations based on historical, actual, and projected future hourly emission rates from all sources of ozone precursors, and historical meteorological conditions. The process of projecting future ozone concentrations with computer models is inherently inaccurate due the challenge of accurately predicting future economic activity, transportation demand, weather patterns, and other needed data, as well as the challenge of accurately estimating emissions from all sources. The model results should be viewed as an educated guess, not as a precise prediction.

What Are Sources of VOCs and NO_x?

For air quality planning purposes emission sources of VOCs and NO_x are grouped into five categories. The total emissions of VOCs and NO_x from these categories are included in an overall emission inventory for the area.

Point Sources

Major point sources are defined, for emission inventory purposes, as industrial, commercial, or institutional plants/operations, which emit a minimum of 10 tons per year (tpy) of VOCs, 25 tpy $NO_{x,}$ or 100 tpy, or more of any other contaminant subject to NAAQS. Owners or operators of major stationary sources are required to report to the TCEQ the quantity of each pollutant emitted from each facility in an annual emission inventory. Refineries, chemical manufacturing facilities, power plants, breweries, and bakeries are included in this category.

Area Sources

Area sources emit less than major stationary sources. Area sources generally emit more VOCs than NO_x. The quantity and type of emissions from these sources are estimated using established emission factors and appropriate activity data from the area. For example, emissions from service stations can be estimated based on the number of such facilities in the area and knowledge of the amount of gasoline sold. Print shops, dry cleaners, restaurants, painting operations, degreasing and other solvent-using operations, small building heating, and outdoor burning are a few of the operations included in this category. While individual area source emissions are relatively small, collectively they make a significant contribution.

On-Road Mobile Sources

On-road mobile sources consist of automobiles, trucks, motorcycles, and other vehicles that travel on roadways in the HGB area. On-road mobile sources emit both VOCs and NO_x, although different vehicles emit different proportions. The Houston-Galveston Area Council (H-GAC) estimates the quantity and type of emissions from such sources using computer models approved by the EPA. These models estimate emissions from the engines and tailpipes of vehicles, as well as emissions caused by the evaporation of gasoline and other fluids.

Off-Road and Non-Road Mobile Sources

Off-road and non-road mobile sources include emissions from commercial and general aircraft operations, marine vessels, recreational boats, railroad locomotives, and a very broad subcategory of heavy duty equipment. This equipment includes construction equipment, lawn mowers, chain saws, and leaf blowers. Most engines in this category have few or no emission controls and are considered high emitters of VOCs and NO_x on a unit basis.

Biogenic Sources

Biogenic sources of emissions are from plant life in the area, including crops, trees, grass, and other vegetation. The TCEQ estimates the quantity and type of emissions from vegetation using such tools as satellite imaging and computer modeling. Since biogenic emissions are not manmade, it is not considered practical or desirable to reduce them. Biogenic sources emit VOCs that may contribute to ozone, but they also remove significant amounts of CO_2, SO_2, NO_2, O_3, and particles, and cool the air through shade and transpiration. This reduces VOC emissions from other sources. Scientists are still refining the techniques to estimate emissions from trees to ensure that the modeling is correct. Biogenic emissions of NO_x are generally low and are mostly associated with agriculture.

Use of Overall VOC and NO_x Emission Inventories

Figure 9 shows the relative contribution of sources (excluding biogenic) of VOCs and NO_x in the HGB area for the 2009 reporting year (based on the last validated Periodic Emission Inventory). Although the Periodic Emission Inventory is the most recent report of regional emissions of both VOCs and NO_x, emission inventories are regularly updated when new information becomes available.

Figure 10 is the projected 2018 Attainment Demonstration Budget for VOC and NOx emissions in HGB (included in the 2010 Attainment Demonstration submittal for the 1997 8-hr ozone NAAQS). This budget or inventory begins with the reported emissions inventory for the 2006 base year. Budgeted transportation projects and current emission reduction strategies are then used to project the estimated emissions inventory for the 2019 attainment deadline year. This projected data and its use in attainment demonstration modeling provides TCEQ with information to develop emission control programs by source type so attainment with the ozone NAAQS can be achieved.

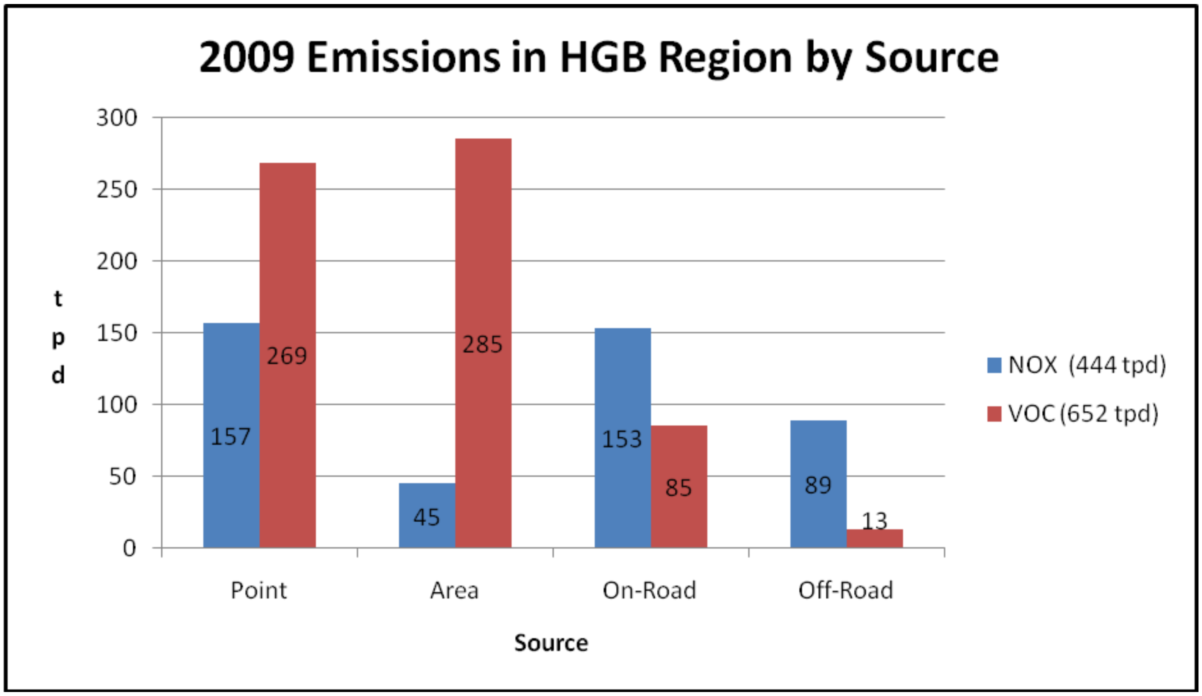

Figure 9: 2009 Validated HGB Emission Inventory for VOCs (State Implementation Plan)

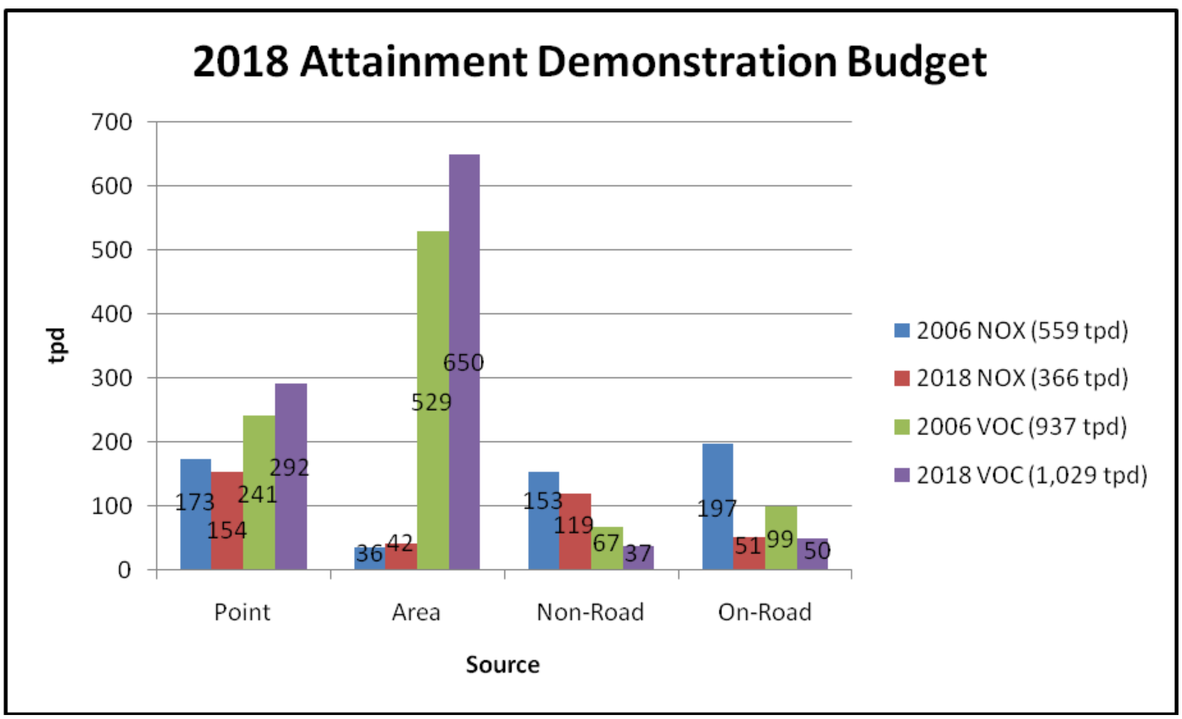

Figure 10: 2009 Validated HGB Emission Inventory for NO_x (State Implementation Plan)

What are We Doing to Clean Up the Air?

The State Implementation Plan for the Houston-Galveston-Brazoria Area

EPA regulations require states with areas failing to attain one or more of the NAAQS to prepare and execute a State Implementation Plan (SIP). This dynamic plan is a blueprint of how the state will achieve compliance with the NAAQS by the compliance date. The CAA requires the state to revise the SIP regularly to incorporate new information as it becomes available. The original ozone SIP for HGB was submitted in 1973 and has been revised many times. The Texas SIP documents are available at www.tceq.state.tx.us/implementation/air/sip/sipplans.html.

The last SIP update was approved by the EPA in April 2008. It used the information from the previous SIP updates and the data from the Texas 2000 Air Quality Study (TexAQS2000) model to focus control strategies on the appropriate sources (Appendix C). The TCEQ-chosen control strategies included an estimated 80 percent reduction in NO_x emissions from the industry sector. In early 2010 TCEQ submitted another ozone SIP package for the HGB area that projects attainment in 2019 with the 1997 8-hr ozone NAAQS.

Strategies to Help Achieve Compliance

Many other strategies are used to reduce emissions and improve our air quality. They are typically sponsored at one of three governmental levels: federal, state, and local, and are augmented by private efforts. The strategies are diverse in nature, from replacing or retrofitting older vehicles and equipment with cleaner vehicles and equipment to encouraging alternative commuting, and even education and advocacy. Some of the other strategies used for emission reductions include sponsorships on the federal, local, and state levels in the form of grants, loans, and various other projects. A more detailed description of these and other strategies are included in Appendix D.

Research Initiatives

Several research initiatives, reports, and programs are of particular interest to the study of air pollution and health in HGB area. A more detailed description of these and other strategies are included in Appendix E. They have been separated by the topics of: Improving Air Quality in the Houston-Galveston-Brazoria Region, Local Exposure and Health Effects Research and The Control of Air Toxics.

What Can I Do to Improve Air Quality?

Daily activities, such as driving, refueling, lawn mowing, painting, and the use of pesticides and high-nitrogen fertilizers, emit VOCs, NO_x and other pollutants. Frequently, the products we buy (carpeting, furniture, paints, etc.) and the services we use (dry cleaning, lawn care, etc.) also add contaminants to our air. With a population over four million in the region, the total of all the individual activities and products create a significant portion of our air pollution. Each of us can contribute to air quality improvement by making minor changes in our daily living patterns.

Change Driving Habits

We can change our driving habits and learn to limit activities that produce VOCs and NO_x whenever possible.

Drive for Better Fuel Economy and Fewer Emissions

Poor trip planning and bad driving habits can significantly increase vehicle emissions and personal exposure to VOCs and NO_x. Avoiding rush hour traffic can help eliminate stop-and-go traffic and reduce idling, both of which significantly increase vehicle emissions. Also, avoid situations that encourage idling, such as drive-throughs, whenever possible. Rapid acceleration, either from a stop or through a yellow light, should be avoided, as should tailgating, which increases levels of pollutants within the interior of your vehicle. Air conditioning in cars increases gasoline consumption (and resultant pollution) by approximately 15 percent and should be used only when necessary.

Reduce Unnecessary Trips

Combining trips and reducing miles driven will reduce the total emissions of air contaminants. Additionally, vehicles have higher emissions during the first few minutes of operation than they have once they are warmed up. By planning ahead, you may be able to combine trips and minimize your number of "cold starts," thus reducing the peak VOCs, NO_x and other pollutants from your car at start up.

Use Alternative Commuting Options

There are many different ways to commute that significantly reduce traffic congestion and your exposure to pollution. These options include carpooling, vanpooling, public transit, cycling, walking, teleworking, and compressed work schedules. Consider which choices are available to you.

Keep Vehicles in Good Repair

If you drive, make certain your vehicle pollutes as little as possible by keeping it in good repair. One fouled spark plug can result in 75 times the normal VOC emissions; a faulty oxygen sensor can increase VOC emissions by four times and CO emissions by 12 times. Driving a malfunctioning car, truck, or van can increase the levels of benzene and other pollutants inside the vehicle by as much as 30 times. Yearly tune-ups, routine oil changes, and optimum tire pressure not only reduce emissions of VOCs, $NO_{x,}$ and other pollutants, but increase fuel economy, protect your investment, and save money.

One good way to check if your vehicle is running properly is to have its emissions tested. The Inspection and Maintenance Program, called Air Check Texas, is more costly and may take more time, but is also more thorough.

<u>Become a Knowledgeable Consumer</u>

We can become knowledgeable consumers by making wiser purchases and managing products that pollute less. Such changes also reduce, sometimes substantially, our own exposure to these pollutants.

Reduce Use of Solvents

Oil-based paints, paint removers, caulk, cleaning solvents, and other materials that contain VOCs contribute relatively large quantities of VOCs to the air. Read product labels to know what you are buying and, whenever possible, request, purchase, and use water-based materials.

Reduce Use of Energy

Power generation to cool and light our homes is a large source of area NO_x emissions. Turn off lights not in use, use energy-efficient light bulbs and appliances, and as little air conditioning as is reasonable and comfortable. Weather strip, caulk, and insulate homes and businesses.

Upgrade Vehicles or Fleets

Upgrading your personal vehicle or company fleet to a model year with higher standards will help in emission reduction, and improve fuel mileage. This strategy has added benefits when vehicles are upgraded to alternative fuel vehicles or flex fuel vehicles.

The progression of different technologies has made purchasing a cleaner vehicle comparable to that of a traditional vehicle. Also, as regions across the nation promote cleaner air, the number of vehicle manufacturers producing "green" vehicles has rapidly increased. These factors present numerous opportunities to the public in terms of replacing vehicles for a cleaner form of transport that is still stylish, affordable, and available.

Select Low Emission Vehicles

Innovative changes have been made in the design and manufacture of cars and trucks to reduce emissions. Although diesel engines have been recommended for better fuel economy, they produce higher levels of harmful fine particle emissions.

To assist the consumer, the EPA has certified a number of vehicles as low emission vehicles. The EPA also has more stringent standards for ultra-low emission vehicles, super ultra-low emission vehicles, inherently low emission vehicles, and zero emission vehicles. When replacing currently owned vehicles, you can become informed about fuel efficiency and emissions of new vehicles by visiting the Green Car Guide on the EPA website www.epa.gov/greenvehicles.

Become a Well-Informed Citizen

We can become well-informed citizens by educating ourselves on environmental issues, attending public meetings, and joining organizations. As we learn and become active, we can help advance emission reduction programs and practices.

Become an Advocate

We can attend programs and meetings about improving air quality and ask questions or offer our ideas on the topics. We can pay attention to pending decisions by local, state, and national regulatory agencies concerning air quality, and write or call representatives with our evaluations of these issues. When each of us becomes involved in making environmental decisions and supporting programs that effectively reduce air pollution, we will make progress toward improving the air quality for all of us.

Reduce Emissions from Off-Road Sources

Gasoline engines on lawn mowers, leaf blowers, chain saws, boats, and other equipment have minimal emission controls and are significant polluters. An older gas-powered lawn mower operated for one hour emits the same amount of VOCs as a new car driven 340 miles; a chain saw operated two hours produces VOCs equivalent to driving 3,000 miles. Buy and use nonpolluting electric or manual equipment whenever possible to reduce VOCs and NO_x. Choose a landscaping service that uses newer or nonpolluting equipment, and, if they do not, encourage them to switch.

Postpone Polluting Activities on High Ozone Days

On days that are forecast to be high ozone days, postpone unnecessary trips, refueling vehicles, painting, spraying pesticides, and using gasoline-powered lawn mowers, leaf blowers, and other small gasoline engines. If you must perform these activities, try to do the activities when ozone production is less conducive (dawn, dusk, and at night). You may be able to add to this list and develop habits that will minimize your contribution to our air pollution and the illnesses caused by pollution.

What Happens if We Don't Improve Air Quality?

Ozone is and has historically been the most significant air quality issue for the HGB area. The consequences of failure to reach attainment with the ozone NAAQS by the designated attainment date, or failure to meet any other emission reduction milestones, are severe. Residents throughout HGB will continue to experience the adverse health effects of elevated ozone levels when they occur. Furthermore, the region may experience the loss of federal transportation funding, severe restrictions on growth of existing and new industry in the area, and the imposition of a Federal Implementation Plan (FIP) in lieu of state or local controls.

EPA actions are explicitly described in the CAA. Failure to meet any deadline starts a "sanctions clock" that gives the region 18 months to resolve the failure before the EPA must impose an "offset sanction." The offset sanction would increase the emissions offset ratio, which is required to obtain a permit for a new emissions source, from the current 1.3:1 to 2:1. After 24 months without resolution, the EPA is required to remove federal transportation funds from the affected region. Continued unresolved failures result in the development of an FIP for the region by the EPA.

Failure to demonstrate conformity of the long-range transportation plan with the SIP can lead to earlier impacts on the region than the SIP sanctions. Transportation projects will be halted if they are not part of a conforming long-range transportation plan. Unless projects are exempted from conformity (as are certain highway safety and transit projects), design and construction may not begin without a conformity finding. If the EPA notifies a region of failed conformity, new projects cannot be added to the plan or the TIP after 120 days. Currently, HGB is complying and meeting all designated dates for the pollutants for which the area is in nonattainment.

How Much Does Air Pollution Cost?

Air pollution is costly for our society. These costs include expenses for increased health care and property damage, as well as less tangible costs, such as decreased property values and diminished quality of life. Some of these costs are paid directly by individuals or businesses, and some are paid indirectly through insurance and decreased productivity.

Reduction of air pollution also costs our society. These costs include expenditures for installation, operation, maintenance, monitoring, and recordkeeping of emission control systems. Some of these expenditures are paid directly by individuals or businesses and some are paid indirectly through increased costs of consumer products and loss of business opportunities. Some of these expenditures may be offset by the recovery of wasted product or by the creation of business and job opportunities in the development and implementation of air pollution control systems.

The total costs incurred by society as a result of air pollution are very difficult to measure. Though some studies have attempted to quantify the health costs of air pollution in HGB, comprehensive studies of both the costs and benefits of regulations in this region have not yet been done. On a national level, attempts have been made to estimate the cost of specific new emission control regulations and the benefits those regulations will produce. Such estimates, if accurate, may help our society make balanced decisions in our future efforts to improve air quality.

Conclusion

HGB area businesses and individuals have made significant reductions in air emissions over the past quarter century and the area has seen reductions in ozone levels and other pollutants. Through that 25-year experience, much has been learned about air quality within HGB, but much still remains to be learned and achieved to meet this region's air quality goals. As we continue efforts to improve air quality, there will be a need to make difficult public policy decisions. We hope that this *Air Quality Reference Guide* will provide citizens with the background necessary to better understand the issues involved in such decision-making.

Appendix A: Resources and Information

In addition to the following list, RAQPC has organized a searchable database to help the region find appropriate organizations to give information on particular air quality issues. The database may be seen at www.HGB-AQ.com.

Air Alliance Houston	airalliancehouston.org 713-528-3779
AirNow (National Air Quality Information)	AIRNOW@epa.gov
American Chemical Council	www.americanchemistry.org
American Lung Association	www.lungusa.org 202-785-3355
American Lung Association of Texas Houston	www.texaslung.org 713-629-5864
American Petroleum Institute	www.api.org
Air & Waste Management Association, Gulf Coast Chapter	www.awma.org 412-232-3444
American Meteorological Society, Houston Chapter	www.amshouston.net 281-652-1000
Austin County County Judge Emergency Coordinator General Information	www.austincounty.com 979-865-5911 ext. 101 979-865-5911 ext. 148 979-830-0789
BikeHouston, Inc. (formerly Houston Area Bicyclist Alliance)	www.bikehouston.org 713-222-BIKE (2453)
Brazoria County County Judge Emergency Management Environmental Health	www.brazoria-county.com 979-864-1200 979-864-1201 979-864-1600
Business Coalition for Clean Air (BCCA)	713-844-3629
Chambers County County Judge Environmental Protection	www.co.chambers.tx.us 409-267-8295 409-267-8392
Citizens' Environmental Coalition	www.cechouston.org 713-524-4ECO (4232)
Citizens' Transportation Coalition	ctchouston.org 713-301-5716
Colorado County County Judge Health Department	www.co.colorado.tx.us/ips/cms 979-732-2604 979-732-2435 or 979-732-3662

East Harris County Manufactures'' Association	www.ehcma.org
Environmental Defense	www.edf.org/page.cfm?tagID=646
Texas	(512) 478-5161
Environmental Protection Agency	epa.gov
Region 6 Public Information Center	800-887-6063
Office of Air Quality Planning & Standards	epa.gov/oar/oaqps
	919-541-5616
Environmental Protection Agency – Region 6	epa.gov/region6/index.htm
Emergency Response Center	1-866-EPASPILL (372-7745)
South Central (Dallas)	214-665-6444
South Central (Houston)	281-983-2100
Fort Bend County	www.co.fort-bend.tx.us
County Judge	281-341-8608
Office of Emergency Management	281-342-6185
Environmental Health	281-342-7469
Health Department	281-342-7469
Health and Human Services	281-238-3233
Switchboard	281-342-3411
Vehicle Maintenance Department	281-341-4792
Fort Bend Family Health Center	713-342-1746
Galveston County	www.co.galveston.tx.us
County Judge	409-766-2244
Health Department (Switchboard)	409-938-7221
Pollution Control Department	409-938-2251
Recycling Department	409-766-2122
Office of Emergency Management	888-384-2000
Galveston-UTMB	www.utmb.edu
24/7 Access	409-772-2222
Operator	409-772-1011
Pediatric Specialty Clinic	409-747-9345
Greater Houston Partnership	www.houston.org
	713-844-3600
Gulf Coast Institute	www.livablehouston.org
	713-523-5757
Harris County	www.co.harris.tx.us
Switchboard	713-755-5000
County Judge	713-755-4000
Environmental Health	713-439-6270 or 713-439-6260
Health Services	713-439-6000
Office of Emergency Management	www.hcoem.org
	713-881-3100
Parks Planning Department	713-956-3024
Public Health and Environmental Services	713-920-2831
Harris County Hospital District	hchdonline.com
Ben Taub General Hospital	713-793-2000
LBJ General Hospital	713-500-0000
Medical Clinic	713-793-3145

Health Effects Notebok for Hazardous Air Pollutants	epa.gov/ttn/atw/hlthef/hapindex.html
Air RISK Hotline	919-541-0888
Houston Advanced Research Center (HARC)	www.harc.edu
	281-367-1348
Mitchell Center for Sustainable Development	281-363-7913
Houston Environmental Foresight	281-364-4008
Houston Bicycle Club, Inc.	www.houstonbicycleclub.org
	713-782-0885
Houston Chronicle	www.chron.com
	713-362-7171
Houston, City of	www.houstontx.gov
Mayor	mayor@cityofhouston.net
Bureau of Pollution Control and Prevention	http://www.houstontx.gov/health/Environmental/bpcp.html
Citizens' Assistance Office	832-393-0955
Department of Health and Human Services (Main)	832-393-4906
Department of Health and Human Services	832-393-5730 or call 311 to file a complaint
Parks & Recreation Department	832-395-7000
Public Works & Engineering Department	832-395-2511
Houston Bikeway Program	www.houstonbikeways.org
	832-395-2692
Houston-Galveston Area Council	www.h-gac.com
	713-627-3200
Clean Air Action Program	www.cleanairaction.org
	713-627-3200
Clean Cities/Clean Vehicles Program	www.houston-cleancities.org
	713-993-2488
Commute Solutions	www.commutesolutions.org
	713-627-3200
Area Emission Reduction Credit Organization (AERCO)	www.h-gac.com/taq/airquality/aerco/default.aspx
	713-993-4542
Regional Air Quality Planning Committee (RAQPC)	www.h-gac.com/agendas/raqpc/default.aspx
	713-993-4556
Regional Transportation Plan / Corridor Studies	www.h-gac.com/transportation
	713-993-4543
Houston Tomorrow	www.houstontomorrow.org
	713-523-5757
Houston TranStar	www.houstontranstar.org
	713-881-3000
Houston Regional Monitoring Corporation	www.houstonairquality.com
League of Women Voters of the Houston Area	www.lwvhouston.org
	713-784-2923
Liberty County	www.co.liberty.tx.us/
County Judge	936-336-4665
Matagorda County	www.co.matagorda.tx.us/
County Judge	979-244-7605
Environmental Health Department	979-244-2717
Metropolitan Transit Authority (METRO)	www.ridemetro.org

	713-635-4000 or 1-888-606-RIDE
Environmental Planning	713-635-4000
Mickey Leland Association	www.sph.uth.tmc.edu/mleland/ 713-500-3450
Montgomery County	www.co.montgomery.tx.us/
County Judge	936-539-7812
Environmental Health Services	936-539-7839
Montgomery County-UTMB	www.utmb.edu/mchd/index.htm 936-525-2800
Mothers for Clean Air	www.airalliancehouston.org 713-526-0110
National Petrochemical and Refiners Association	www.npra.org
Natural Resources Defense Council	www.nrdc.org 212-727-2700
Rice Design Alliance	ricedesignalliance.org 713-348-4876
Rice University	www.rice.edu 713-348-0000
Sierra Club Houston Regional Group	texas.sierraclub.org/houston
Air Quality Chair	713-664-5962
Sierra Club – Lone Star Chapter	lonestar.sierraclub.org/houston
Air Quality	512-477-1729
National Association of Clean Air Agencies (NACAA)	cleanairworld.org 202-624-7864
Texas A&M University	www.tamu.edu 979-845-3211
Texas Transportation Institute (TTI)	http://tti.tamu.edu/ 979-845-1713
Texas Association of Manufacturers	www.manufacturetexas.org
Texas Association of Business	www.txbiz.org
Texas Chemistry Council	www.txchemcouncil.org
Texas Oil & Gas Association	www.txoga.org
Texas, State of	www.texas.gov 800-843-5789
Governor's Office	governor.state.tx.us 512-463-2000
Lieutenant Governor	512-463-0001
Senate	senate.state.tx.us
Health & Human Services Committee	512-463-0360
House of Representatives	house.state.tx.us
Environmental Regulation	house.state.tx.us/committees/list81/260.htm 512-463-0770

Transportation	512-463-018
Texas Children's Asthma, Allergy Clinic	832-824-1319
Texas Department of Public Safety	www.txdps.state.tx.us/ 512-424-2000
Governor's Division of Emergency Management	www.txdps.state.tx.us/dem/ 512 424-2138
AirCheckTexas	www.airchecktexas.org
Vehicle Inspection & Maintenance (I/M) Program	512-424-2000
Texas Department of Health, Houston	www.hhs.state.tx.us/ 713-767-3000
Texas Department of Transportation, Houston	www.dot.state.tx.us 713-802-5000
Texas Commission on Environmental Quality (TCEQ)	tceq.state.tx.us/ 512-239-1000
TCEQ Air Quality Division	ac@tceq.state.tx.us 512-239-4900
Publications	512-239-0010
TCEQ Library	512- 239-0024
Environmental Law	512-239-0600
State Implementation Plans (SIP)	tceq.com/implementation/air/sip
Publications	tceq.com/comm_exec/forms_pubs/pubs/pd
Texas Emission Reduction Plan (TERP)	tceq.state.tx.us/implementation/air/terp 800-919-TERP (8377)
TCEQ Region 12 – Houston	713-767-3500 512-239-2545
Texas Vehicle Inspection and Maintenance (I/M) Program	tceq.state.tx.us/implementation/air/mobilesource/vim/overview.html
Smoking Vehicle Hotline	www.smokingvehicle.org 800-453-SMOG (7664)
Office of Compliance and Enforcement	
Monitoring Operations – Ozone Information	tceq.com/compliance/monitoring/air/monops
Small Business and Local Government Assistance	www.tceq.state.tx.us/assistance/sblga/sblga.html 800-447-2827
Pollution Prevention	p2plan.org/
Clean Texas Program	cleantexas.org
Texas Southern University	www.tsu.edu 713-313-7011
Center for Transportation Training and Research (CTTR)	713- 313-7924
University of Houston	www.uh.edu
Central Campus	713-743-2255
Clear Lake	www.cluh.edu 281-283-7600
Environmental Institute of Houston	www.eih.uh.edu 281-283-3950
University of Texas Pediatric Allergy Clinic	www.uthct.edu/patientcare/clinical/allergy/ 832-325-6516
Walker County	

County Judge	936-436-4910
Waller County	www.co.waller.tx.us/
County Judge	979-826-7700
Wharton County	www.co.wharton.tx.us/
County Judge	979-532-4612

Appendix B: Air Quality Abbreviations and Terms

μg	Microgram or 10^{-6} gram
AERCO	Area Emission Reduction Credit Organizations
AMCV	Air-Monitoring Comparison Values
AQI	Air Quality Index
ARRA	American Reinvestment and Recovery Act
BACT	Best Available Control Technology
BayTran	Bay Area Houston Transportation Partnership
BCCA	Business Coalition for Clean Air
BPA	Beaumont-Port Arthur
CAA	Clean Air Act of 1970
CAAA	Clean Air Act Amendments of 1990
CH_4	Methane
CMAQ	Congestion Mitigation/Air Quality funds under ISTEA, TEA21, and SAFETEA-LU
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2 e	CO_2 equivalent basis
CO_2	Carbon Dioxide
COPD	Chronic Obstructive Pulmonary Disease
DERA	Diesel Emissions Reduction Act
DERC	Discrete Emission Reduction Credit
DFW	Dallas-Fort Worth
EDSTAC	Endocrine Disrupters Screening and Testing Advisory Committee
EPA	Environmental Protection Agency
ERC	Emission Reduction Credit
ERP	Emissions Reductions Plan
ESL	Effects Screening Level
FIP	Federal Implementation Plan
GHG	Greenhouse Gas
HAP	Hazardous Air Pollutant
HCOEM	Harris County Office of Emergency Management
HEATS	Houston Exposure to Air Toxics
HFC	Hydrofluorocarbons
H-GAC	Houston-Galveston Area Council
HGB	Houston-Galveston-Brazoria
HONO	Formaldehyde and Nitrous acid
HOV	High-Occupancy Vehicle
HRM	Houston Regional Monitoring Corporation
HRVOC	Highly Reactive Volatile Organic Compound
I/M	Inspection/Maintenance program (for vehicle emission controls)
ILEV	Inherently Low Emission Vehicle
IQ	Intelligence Quotient
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
LEV	Low Emission Vehicle
LIP	Local Initiative Project
LIRAP	Low Income Repair and Assistance Program
LPG	Liquefied Propane Gas
MACT	Maximum achievable control technology
MDERC	Mobile Discrete Emission Reduction Credit
MERC	Mobile Emission Reduction Credit
METRO	Metropolitan Transit Authority of Harris County
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization

MTBE	Methyl Tertiary Butyl Ether
MTP	Metropolitan Transportation Plan
N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxide
NUATRC	National Urban Air Toxics Research Center
NWS	National Weather Service
O_2	Molecular Oxygen
O_3	Ozone
Pb	Lead
PFC	Perfluorocarbons
PM	Particle Matter
PM_{10}	Particulate Matter less than 10 microns in size
$PM_{2.5}$	Particulate Matter less than 2.5 microns in size
ppb	Parts per Billion
ppm	Parts per Million
RAQPC	Regional Air Quality Planning Committee
RCTSS	Regional Computerized Traffic Signal System
RFG	Reformulated Gasoline
RIOPA	Relationship of Indoor, Outdoor and Personal Air
RTP	Regional Transportation Plan
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act – A Legacy for Users
SF_6	Sulfur Hexafluoride
SIP	State Implementation Plan (plan detailing pollution controls for achieving attainment
SO_2	Sulfur Dioxide
SO_x	Sulfuric Oxide
SULEV	Super Ultra Low Emission Vehicle
TCAA	Texas Clean Air Act
TCEQ	Texas Commission on Environmental Quality
TCM	Transportation Control Measures
TEA21	Transportation Equity Act for the 21st Century (replaces ISTEA)
TERC	Texas Environmental Research Consortium
TERP	Texas Emissions Reduction Plan
TexAQS II	The Texas Air Quality Field Study II
TexAQS2000	Texas 2000 Air Quality Study
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMO	Transportation Management Organization
TPC	Transportation Policy Council
tpd	Tons per Day
tpy	Tons per Year
TRI	Toxic Release Inventory
TxDOT	Texas Department of Transportation
U.S.	United States
UEA	Urban Ecosystem Analysis
ULEV	Ultra Low Emission Vehicle
UTSPH	University of Texas School of Public Health
UVR	Ultraviolet Radiation
VMEP	Voluntary Mobile Emission reduction Program
VMT	Vehicle Miles traveled
VOC	Volatile Organic Compound
ZEV	Zero Emission Vehicle

Appendix C: Control Strategies

Documentation of control strategies where emission reduction can be calculated[18]

Control Strategy	Description	Emission Reduction Potential (tpd)	
		VOC	NOx
Bicycle and pedestrian action	Benefits from bicycle measures include new bicycle lanes as well as encouraging greater use of existing lanes instead of vehicle use. But it can be difficult to determine the benefits of such programs.	0.04	0.03
Encourage bicycle use by using ITS to increase safety in strategic bicycle/ automobile conflict areas	Duplicate or supplemental measure.		
Dedicated long route or subscription bus service	Long route or on demand personalized transit service similar to other commercial shuttle services but providing lower cost and less stressful methods of commuting or running errands in parts of town that are far from residences.	0.18	0.05
Accelerate rail expansion	Increase transit capacity. Rail evaluations would need to have specific proposals and market analyses.	Unknown	0.07
Compressed work week, telework, or other commuting alternatives	The benefits of this program could be included with a variety of commute reduction options. This represents one alternative of the reduced commuting options.	0.93	0.69
Internet ride matching services	Real-time ride matching offered via a website, by an employer, or by a third party (sponsored by city or transportation authority).	0.52	0.38
Purchase vans for vanpools	Commute reduction along with the opportunity to buy cleaner vans.	0.10	0.07
Local intersection signal improvements	Effectively increasing road capacity to reduced stop and go progression improving arterial speeds.	1.83	1.7
Traffic signal equipment or software updating	Effectively increasing road capacity to reduced stop and go progression improving arterial speeds.		
Emphasis on major route traffic signalization; through route traffic platooning	Effectively increasing road capacity to reduced stop and go progression improving arterial speeds.		
Real-time traffic flow management	Traffic signals that change timing/ cycles to accommodate real-time traffic conditions.		
Adaptive traffic signals and signal timing	Effectively increasing road capacity to reduced stop and go progression improving arterial speeds.		

[18] http://www.tceq.state.tx.us/assets/public/implementation/air/sip/hgb/hgb_sip_2009/Appendix_F.pdf
http://www.tceq.state.tx.us/implementation/air/sip/texas-sip/hgb/sip-hgb

Control Strategy	Description	Emission Reduction Potential (tpd)	
		VOC	NOx
Signal timing and coordination to promote traffic progression	Currently signal coordination tends to focus on reducing delay time for individual drivers; alter coordination to promote greatest movement for traffic as a whole.	1.83	1.7
Private sector clean fuel fleets	This measure is patterned after the H-GAC Clean Vehicles Program where clean engines (whether alternatively fueled or no) are purchased for fleets to reduce emissions.	N/A	1 – 2.5
Public agency clean fleet program	Commitment by public agencies to purchase cleanest practicable fleet vehicles could be an element in funding such as through the H-GAC Clean Vehicles Program or a voluntary commitment.	N/A	Depends on the program
Dedicated funding for school bus replacement	H-GAC Clean Cities/Clean Vehicle or state/federal funding sources. This program specifically targets school bus fleets that trend toward older models.	N/A	0.77
Increased use of hybrid buses	Hybrid or other lower emitting heavy-duty vehicles have been funded to date in current air quality programs.	N/A	0.23

Documentation of control strategies where emission reduction can not be calculated[19]

Control Strategy	Description
Continue passenger vehicle scrappage and buy-back program	Monetary compensation for old vehicle scrappage. Increase the range of vehicles and heavy-duty truck engines targeted for replacement credit or subsidy.
Pay-As-You-Drive Insurance (per-mile)	Insurance costs would be associated with mileage driving by a vehicle increasing the incremental cost per mile driven. The cost of insurance then becomes an incremental cost and could be combined with mileage based registration fees and fuel tax increases to add incentive to alternative transportation.
Limitations on idling of heavy-duty vehicles	Will require additional power sources for local major events. Large truck stops have constructed alternatives to idling partially funded by TERP.
Encourage/Mandate Livable Centers	Includes a host of ideas to reduce vehicle travel. Such ideas could be incorporated into ordinances promoting multi-use development.
Enhanced enforcement for smoking vehicles	Link to I/M test status: encourage local police to enforce existing smoking vehicle legislation-vehicle impounding for violators (like Dallas Emissions Enforcement Pilot Program)
Limitations on idling of heavy-duty construction equipment	Idle reduction either through the use of automatic shut-off devices or operator training.
Creation of regional government idling restriction MOU	Idling is usually a small portion of the emissions from vehicles.
Voluntary replacement / retrofit program: construction and other off-road	Cofunding measure for off-road engines and equipment–construction and others
Voluntary replacement / retrofit program: marine	Cofunding measure for off-road engines and equipment–marine
Voluntary replacement / retrofit program: locomotive	Cofunding measure for off-road engines and equipment–locomotive
Control Strategy	**Description**
Government construction incentives	This measure is considered to include money or tax relief to firms using clean equipment.
Promote use of cleaner lawn and garden equipment such as lower-emission four-stroke and electric-powered equipment	A retirement program, for old and malfunctioning lawn and garden equipment, and purchase of low emitting replacements.
Development of a Ports Clean Air Action Plan that seeks to minimize emissions port-related operations.	Clean Ports initiative including on-road and non-road source categories. (Vessel Speed Reduction (VSR), At Berth Control, Low Sulfur Fuel for Marine Vessel Main and auxiliary engines, Engine Improvements) Other off-road measures would follow measures #5b

[19] http://www.tceq.state.tx.us/assets/public/implementation/air/sip/hgb/hgb_sip_2009/Appendix_F.pdf
http://www.tceq.state.tx.us/implementation/air/sip/texas-sip/hgb/sip-hgb

Appendix D: Summary of Strategies

Federal Control Strategies

Vehicle Emission Standards

Some of the most significant pollution controls established through the Clean Air Act are motor vehicle emission standards. Beginning in the late 1960s, increasingly stringent vehicle emission standards have led to the widespread use of catalytic converters and fuel injection. In December 1999, the EPA announced an initiative to further reduce harmful air pollution from vehicles. The emissions standard, known as Tier 2, is 0.07 grams per mile for NO_x. Beginning in 2004, the Tier 2 standards also applies to sport utility vehicles and light duty trucks regardless of the fuel they are powered by. The standard reduced NO_x emitted from new cars by 77 percent, and NO_x emitted from sport utility vehicles and light duty trucks by a projected maximum of 95 percent.

In December 2000, the EPA finalized standards to significantly reduce emissions from heavy-duty diesel engines and vehicles through a phase-in approach. The proposed standard is projected to reduce NO_x from these vehicles by 95 percent and particulate matter by 90 percent.

Fleet Vehicle Requirements

The CAA requires that a steadily increasing percentage of fleet vehicles meet a set of stricter emission standards in severe ozone nonattainment areas, such as HGB. The Low Emission Vehicle standard for cars resulted in 70 percent less VOC emissions and 50 percent less NO_x emissions than conventional 1996 vehicles.

Cleaner Fuels - Gasoline

Reformulated gasoline (RFG), a conventional gasoline blended to burn cleaner and evaporate less, has been the only gasoline available for sale in the nonattainment area since 1995. One of the components of RFG is an oxygenate that helps the gas burn cleaner. RFG has resulted in significant reductions in VOCs and, to a lesser extent, NO_x in HGB.

RFG standards were implemented in 2000, and strengthened in the HGB nonattainment area. Phase II RFG removed an additional 41,000 tons of smog-forming pollutants in RFG areas, the equivalent of eliminating emissions from 16 million cars nationwide, from the air. Compared to conventional gasoline, Phase II RFG reduces emissions of VOCs by 27 percent and NO_x emissions by 7 percent.

To support the Tier 2 vehicle standards, the EPA adopted a rule in February 2000 to limit the sulfur content in gasoline. In 2004, refineries and importers were required to meet corporate average gasoline standards of 120,000-ppb sulfur, with a maximum of 300,000 ppb. In 2006, refiners began producing gasoline that averages no more than 30,000-ppb sulfur, with a maximum not to exceed 80,000 ppb in 2006.

Cleaner Fuels - Diesel Fuel

The EPA has regulated highway diesel fuel quality since 1993. Since 1994, federal law has allowed a maximum of 500,000-ppb sulfur diesel fuel for use in on-road vehicles. California diesel fuel allows the same 500,000 ppb, but requires low aromatics (10 percent aromatics maximum, compared to 25 percent to 35 percent aromatics in typical on-road diesel). In May 2000, EPA reduced the sulfur content that is required to allow pollution control technologies, particulate traps, and catalytic treatments to be effective in diesel vehicles. In 2006, the EPA adopted rules to establish and ultra low sulfur diesel of 15,000 ppb, and to amend the testing procedures that determine the ppb of sulfur in diesel. The rule ensured that fuel that is compliant with the 15,000 ppb sulfur requirement is not inappropriately deemed to be noncompliant simply because of the variability in testing.

While the federal low-sulfur diesel fuel has had only minimal impacts on NO_x reductions, it has resulted in larger reductions in sulfur and particulates. Reduced sulfur content has also been shown to extend engine life and reduce maintenance costs. Low-sulfur diesel is projected to reduce particulates by 10 percent to 20 percent, and NO_x by 7 percent to 10 percent.

Cleaner Fuels - Alternative Fuels

Alternative fuels are fuels that are not produced from a traditional petroleum base. The most commonly used alternative fuels in light-duty vehicles in this area are compressed natural gas, liquid propane, which are gaseous rather than liquid fuels, and electric power. The advantage of using alternative fuels is that they burn cleaner without the use of additives and produce virtually no particulates.

Although vehicles using these fuels make up a very small percentage of the total vehicle population, automakers are producing more vehicles that are equipped to run using these fuels. Currently, the majority of vehicles running on these fuels are in government fleets that are under a legislative mandate to run cleaner. However, there has been a significant increase in the purchase of alternative fuel personal vehicles beginning late in 2008. This increase is attributed to sharp increases in gasoline prices, an increase in technology performance, and providing financial incentives to purchase an alternative fuel vehicle.

Clean Cities/Clean Vehicles Program

The Clean Cities/Clean Vehicles Program is a locally based government/industry partnership to expand the use of cleaner fuels and vehicles. Clean Cities/Clean Vehicles provides assistance through the U.S. Department of Transportation's Congestion Mitigation/Air Quality (CMAQ) funds in addition to several other funding sources. Stakeholders include local businesses and federal, state, and local agencies that are committed to the use of cleaner engines and fuels. Funds are available to the state and local stakeholders that reside within the HGB nonattainment area. Funds may be used for the purchase and/or conversion of vehicles to operate on cleaner fuel and the purchase or upgrade of fueling infrastructure.

State Strategies

The TCEQ has adopted numerous VOC and NO_x controls designed to reduce emissions. These controls are expected to reduce ozone levels significantly in the HGB nonattainment area, as well as in other nonattainment areas and near-nonattainment areas across the state.

Emission Reductions by Grandfathered Facilities

The 1971 revision of the Texas Clean Air Act (TCAA) established air permit requirements for stationary sources. It is required to obtain an air permit from the TCEQ before a new facility is constructed. The new facility needs to display the "best available control technology" (BACT) to control air emissions in order to be approved for the permit. For facilities that were already in existence in 1971, air permits are not required until the facility is modified. A "modification" to an existing facility is a change to the facility that results in a significant increase in air emissions.

Under the TCAA, if an existing facility has never been modified, there is no requirement to obtain a permit and/or meet BACT. These unmodified existing facilities are referred to as grandfathered facilities. However, in 2001, the 77th Legislature passed House Bill 2912. This bill requires grandfathered facilities to obtain an air permit, applying a ten-year-old BACT. These requirements would not only reduce emissions in HGB, but emissions would decrease across Texas.

Texas Emission Reduction Program

The 77th Texas Legislature established the Texas Emission Reduction Plan (TERP) in 2001 through enactment of Senate Bill (SB) 5. The TERP includes a number of voluntary financial incentive programs, as well as other assistance programs, to help improve Texas air quality. The primary purpose of the TERP program is to reduce NO_x emissions through voluntary incentive programs, mainly from heavy duty on-road and non-road vehicles and equipment in ozone nonattainment areas. Any person or governmental entity that operates or plans to operate on-road heavy-duty vehicles, non-road equipment, or stationary engines primarily in one or more of the nonattainment areas in Texas is potentially eligible for a grant.

TERP continues to be a successful program in HGB. From 2001 to 2010, the TERP funded over 2,600 projects in HGB at an amount over $328,000,000. The NO_x reduction during this time is over 70,600 tons, at an overall cost per ton reduced ratio of $4,643 ($355 less than the program average). Due to the success of TERP, the TCEQ has allowed H-GAC to manage a Regional TERP. The Regional TERP is similar to the regular TERP except that applicants must be from HGB, and projects must spend the majority of time in HGB.

The TERP is funded through revenues deposited in the Emission Reduction Plan Fund, which consists of fees and surcharges established by the SB5. Since then, the guidelines of the TERP have been amended several times. For more information on the TERP program, availability of TERP funds, and TERP applications, please visit:

http://www.tceq.state.tx.us/implementation/air/terp/index.html

The TERP is also practiced at the local level. H-GAC has been successful in securing TERP funding to use specifically for local governments and drayage truck activities within our region. The H-GAC's Regional TERP program creates funding opportunities for local governments to reduce NO_x emissions of heavy duty diesel engines powering vehicles or equipment. The main differences between the state TERP and the Regional TERP is that applicants who receive Regional TERP funds must remain within the HGB Region.

The NO_x reduction from projects funded by the first year (2009) of the Regional TERP is approximately 101 tons per year. This equates to an approximate total reduction of 713 tons for the life of the projects.

Transportation Control Measures

The CAAA require regions in nonattainment areas to make enforceable commitments to implement, maintain, and monitor Transportation Control Measures (TCMs). H-GAC and the transportation project implementing agencies have committed to a number of TCMs for on-road mobile source emissions. These include High Occupancy Vehicle (HOV) lanes, arterial traffic flow improvements, park and ride lots, transit service improvements, bicycle facilities, area wide rideshare programs, computerized transportation management systems, and light rail.

Voluntary Mobile Emissions Reduction Program

The EPA adopted a policy in 1997 to allow credit in the SIP for voluntary mobile emission reduction programs (VMEP). The intent of the policy is to provide incentives for states, localities, and the public to voluntarily reduce air pollution in their communities. The EPA has made it easier for states to obtain SIP credits for VMEPs, and further encourages innovation and investment in effective programs and actions...

AirCheck Texas

The AirCheckTexas (Drive a Clean Machine Program) is designed to help vehicle owners comply with vehicle emissions standards. It targets the highest polluting vehicles by offering financial incentives to repair or remove them from the roadways, and allows citizens to contribute to the regional air quality solution.

Eligible residents receive vouchers for $3,000 toward the purchase of a newer qualifying car or truck, and $3,500 toward a qualifying hybrid vehicle from participating auto dealers. Alternatively, eligible residents may receive up to $600 for emissions repair assistance.

Recipients must meet income requirements and vehicles must meet certain conditions. For more information about the AirCheckTexas Drive a Clean Machine program, please visit http://www.h-gac.com/human-services/airchecktexas/default.aspx.

Scrappage

Associated with the Low Income Repair and Assistance Program (LIRAP), this program funds the removal of heavy emitting vehicles from HGB through destruction. The destruction is great enough to where the engine cannot be repaired. Typically, scrappage is the end result for the vehicle of equipment being replaced by state funds.

Smoking Vehicle Program

The Texas Smoking Vehicle Program is a citizen outreach strategy designed to encourage the proper maintenance and repair of cars, trucks, and buses with excessive emissions. This program promotes public awareness regarding the harmful emissions and air pollution caused by these vehicles. The program allows citizens to anonymously report motor vehicles that have been observed emitting exhaust smoke for more than 10 consecutive seconds. The owners of these smoking vehicles will be notified and encouraged to voluntarily repair their vehicles. Smoking vehicles can be reported by calling 1-800-453-SMOG, sending a fax to 512-239-2050, sending an e-mail to smog@tceq.state.tx.us, or by using the online reporting form at www.smokingvehicle.org.

Public/Private Fleet Emission Controls

Under these programs, emission reductions from vehicle fleets will be realized through clean vehicle purchases and retrofits of EPA-approved voluntary retrofit packages. These controls are mostly implemented in HGB through the Clean Vehicles/Clean Cities program.

Highway/Nonroad Demonstration Projects

Most demonstration projects in the HGB area apply diesel/water emulsion or catalyst after-treatment devices to highway diesel engines. These programs seek to expand current demonstration projects to other privately owned vehicle fleets or owner/operators of non-road equipment.

Memorandum of Understanding

A memorandum of understanding (MOU) is a statement that a business, industry, or local government will change its normal operating procedures in order to voluntarily implement new procedures that will help create emission reductions. For instance, an MOU was signed with Union Pacific, Burlington Northern, and Santa Fe Railroads to achieve emission reductions through improved efficiency, new engines, and other various controls. Additionally, an MOU was signed with Texas Waterway Operators and Texas Department of Transportation for emission reductions through retrofitting or replacing vessel engines, and other various controls. Both MOUs were entered into the SIP, and credit for emission reductions was claimed when possible.

Commute Solutions

Commute Solutions is a voluntary trip-reduction program that strives to reduce vehicle trips and/or vehicle miles traveled (VMT). It combines both current and future commute alternatives, such as regional mass transit, vanpooling, teleworking, and cash in lieu of paid parking.

Commute Solutions is also practiced at the local level. This program is designed to reduce traffic congestion, and improve mobility and air quality by promoting vanpooling, carpooling, transit, telecommuting, biking, walking, and other transportation-related options and services by providing incentives and services to commuters directly

Commute Solutions is a partnership to provide a one-stop approach and unified marketing theme for alternative commute programs in HGB for both commuters and businesses. Partners include H-GAC, the Metropolitan Transit Authority (METRO) and other transit agencies, the Texas Department of Transportation (TxDOT), and the region's Transportation Management Organizations (TMOs), including the Bay Area Houston Transportation Partnership (BayTran), Central Houston, North Houston Association, TREK, and other organizations. Please visit CommuteSolutionsHouston.org for more information.

Regional Computerized Traffic Signal System (RCTSS)

This measure is a compilation of individual initiatives to reduce vehicle congestion on surface streets through signal timing. Reduced idling and braking from mistimed lights will result in emission reductions.

Cool Cities

This strategy reduces ozone levels through code changes and increasing tree cover. Local governments would be responsible for administering this program either through direct funding or local regulations. The existing tree canopy coverage in our region will be used to calculate the economic and environmental benefits that trees provide in terms of pollution mitigation and cooling costs.

Smart Growth

This strategy reinvigorates the urban area by planning, developing, and redeveloping densely populated neighborhoods with ample multi-use opportunities such as retail, commercial, and other neighborhood services. This style of development promotes more alternative modes trips (walking, biking, mass transit) while discouraging personal vehicle trips.

Local Initiative Projects

A portion of LIRAP funding is applied toward air quality projects for counties of HGB that participate in the vehicle emissions inspection and maintenance programs. Eligible counties in HGB are Brazoria, Fort Bend, Galveston, Harris, and Montgomery. The Local Initiative Projects (LIP) funds are distributed according to the county's level of participation in these programs. LIP projects are required to create emission reductions by reducing congestion without adding capacity, or developing and implementing emission enforcement programs.

<u>Local Government Emission Reduction Programs</u>

Under this measure, cities, counties, and/or other public organizations will develop multi-component emission reduction strategies targeting on- and off-road mobile sources, as well as stationary sources.

Transportation Conformity

The regional transportation system, which includes freeways, surface roads, HOV lanes and buses, must contribute to improving air quality. It is the responsibility of H-GAC, serving as the area Metropolitan Planning Organization (MPO) for the region, acting through its Transportation Policy Council (TPC), and working with an interagency conformity consultation committee, to ensure that regional transportation does not increase regional NO_x and VOC emissions. Since the area is in nonattainment, the MPO must demonstrate that the Regional Transportation Plan (RTP), a 20-year long-range transportation plan, and the Transportation Improvement Program (TIP), a 4-year implementation plan, conform to the air pollution reduction goals laid out in the SIP.

To achieve transportation conformity, the HGB nonattainment area needs to demonstrate that the total on-road emissions inventory from 1990 has not increased due to changes in the transportation projects approved in the TIP. In other words, the area must not exceed the MVEB established in the SIP. The area must also show that transportation emissions continue to decline throughout the RTP timeframe, and that the HGB area is meeting the SIP commitments it has made.

Achieving transportation conformity is difficult when the projects in the plan increases the overall vehicle miles traveled. If transportation conformity is not achieved, the area is declared to have a “Conformity Lapse”, and some projects may not proceed. Transportation Control Measures (TCMs) aid in balancing the overall emission inventory. TCMs are projects or practices, much like many control strategies, that reduce emissions through reducing congestion. Some examples are HOV lanes, Park and Ride facilities, and traffic light synchronization projects.

Formations of Organizations and Committees

Several citizen driven organizations, and local government committees have been form to understand and advocate environmental issues. These organizations become useful educational tools the public may use. Several of the organizations and committees encourage public participation as well. The Regional Air Quality Planning Committee (RAQPC) is open to the public, and accepts public comments. Organizations such as Air Alliance Houston encourage you to get involve and become an advocate.

RAQPC has accumulated several regulating committees and advocacy organizations into a searchable internet database. The database may be searched by environmental issue, and by HGB area county. The database may be seen at www.HGB-AQ.com.

Public Transportation Systems

Many of the transit-oriented TCMs identified in the Clean Air Act are within METRO’s current and planned transit service and capital programs. METRO serves approximately 1,281 square miles (in Harris County, and small portions of Fort Bend and Waller counties) out of the 8,800 square miles in the HGB nonattainment area. METRO’s alternative transportation strategies include more than 1,400 buses, RideShare, park and ride lots, HOV lanes, and a carpool/vanpool program. METRO opened the Main Street light rail line in January 2004 to expand mobility options within the downtown Houston area. Five other light rail corridors are planned. The corridors will traverse the inner loop (IH 610) of the City of Houston to provide the most benefit to current and potential commuters and their destinations.

In addition to METRO, other transit systems operate within the region. Area transit systems include Island Transit serving the City of Galveston; Connect Transit serving Galveston and Brazoria counties; Colorado Valley Transit District serving Waller County; Brazos Transit District serving Montgomery and Liberty counties; Fort Bend County Public Transportation; and Harris County Transit Services serving East Harris County. Studies for additional transit corridors are being conducted.

Regional Bicycle and Pedestrian Program

The 1996 Bicycle and Pedestrian Plan ensures the continued, orderly development of a connective bicycle and pedestrian system in HGB. The plan is consistently evaluated to verify the comprehensive strategy for replacing enough vehicle trips during the next 25 years to make a significant impact on congestion, air pollution, and overall quality of life.

The current RTP identifies projects that will construct identifies a need for approximately 170 miles of bikeways. The estimated total cost for the projects is approximately $194,000,000. The majority of these facilities are planned within the city of Houston, although funds have also been authorized for Baytown, Texas City, and Tomball. There are over 375 miles of bicycle lanes and trails currently constructed in HGB.

Area Emission Reduction Credit Organization

The Area Emission Reduction Credit Organization (AERCO) promotes air quality and economic development through management of emission credits and allowances in HGB. AERCO assists in creating, documenting, and certifying emission reduction credits and allowances. AERCO is funded by donations and through Supplemental Environmental Projects development. AERCO buys credits and accepts donations equivalent to credits when employers implement clean air programs.

From April 17, 2007 to May 7, 2010, AERCO projects have reduced a projected total NOx amount of 7.41 tons/year. AERCO projects are used to help meet SIP requirements and for economic development purposes. All credits and allowances are certified through the TCEQ's Emissions Banking and Trading program.

Drayage Loan Program

The Drayage Loan Program is a revolving loan fund that assists drayage truck operators working at ports in HGB. The program leverages grants such as TERP and CMAQ funds by providing a "Bridge Loan" for the difference between the cost of the vehicle and the grant received. The anticipated result of the Drayage Loan Program is:

Emission	**Reduced (ton)**
NOx	1,638
PM	26.7
VOC	27.4
CO	239
CO2	3,636

Please visit www.h-gac.com/taq/airquality/drayageloans/default.aspx for more information.

Ozone Watches and Warnings

The ozone warning system issues notifications to the public based on measured levels of ozone in the atmosphere. Ozone watches are issued by the TCEQ and broadcast through the Ozone Alert system when weather conditions are predicted to be conducive to the formation of harmful levels of ozone.

The TCEQ receives data from the HRM and additional monitors in the HGB region and processes the data. If one monitor detects ozone above the NAAQS for ozone, the TCEQ issues an ozone warning to the Harris County Office of Emergency Management (HCOEM) server.

Ozone levels are measured at the regional network of approximately 30 ozone monitors that are connected to one central computer operated by the TCEQ in Austin. The number of monitors changes due to restructuring the monitoring system to create the most accurate readings possible.

Please visit the following website if interested in receiving ozone watches and warnings: www.tceq.state.tx.us/compliance/monitoring/air/monops/ozone_email.html.

Ozone Warning – Levels

Ozone warnings indicating the level of air pollution and recommended actions to take are a feature of the Ozone Alert system. The system uses the Air Quality Index (AQI), as displayed in Figure 11, established by the EPA in 1999. The AQI system can be used for any criteria pollutant.

OZONE LEVEL (PPB)	AIR QUALITY LEVEL	ALERT COLOR	
0 TO 50	GOOD		GREEN
51 TO 100	MODERATE		YELLOW
101 TO 150	UNHEALTHY FOR SENSITIVE GROUPS		ORANGE
151 TO 200	UNHEALTHY		RED
201 TO 300	VERY UNHEALTHY		PURPLE
301 TO 500	HAZARDOUS		MAROON

Figure 11: Air Quality Index Chart

The TCEQ receives data from the HRM and additional monitors in the HGB region and processes the data. If one monitor detects ozone above the NAAQS for ozone, the TCEQ issues an ozone warning via email to people who have opted to receive the warnings. Harris County Environmental Public Health Division monitors ozone levels daily and will issue a health advisory via local media (radio, TV, etc.) when real-time data indicates levels are nearing or exceeding the old 1-hour ozone standard.

The City of Houston has developed guidance for schools on recommended outdoor activities for the various ozone warning levels. The guidance may be viewed at www.cleanairaction.org.

Appendix E: Summary of Research Initiatives

Improving Air Quality in the Houston Region

The Texas Air Quality Field Study II (TexAQS II)

As a comprehensive research initiative, the TexAQS II program was initiated by the TCEQ to focus on photochemical and meteorological processes leading to formation and accumulation of ozone and particulate matter in east Texas. The study covered all of eastern Texas, including the Houston-Galveston-Brazoria and the Dallas-Fort Worth nonattainment areas. The TexAQS II study builds upon the success of the previous study, TexAQS 2000, to increase understanding of how air pollution is formed, how it travels throughout the region, and how successful various pollution control strategies may be in reaching federal standards. Various federal, state, and private-sector organizations were engaged in advanced air quality field measurement using platforms on aircraft and at ground-based sites and conducted modeling efforts to analyze the data collected. For general information on TexAQS II, please visit: http://www.tceq.state.tx.us/nav/eq/texaqsII.html. For specific findings, please see the Final Rapid Science Synthesis Report at: http://www.tceq.state.tx.us/assets/public/implementation/air/am/texaqs/rsst_final_report.pdf.

The Texas 2000 Air Quality Study (TexAQS 2000)

Researchers from government laboratories, universities, and industry completed data collection for a major field study of air quality in southeast Texas, with a focus on HGB. As part of the study, gas-phase and particle-phase pollutants were quantified, and meteorological measurements were collected from aircraft and at numerous ground locations.

The goal of the research was to provide a better understanding of the basic chemical, meteorological, and atmospheric transport processes that determine ozone and fine particle distributions, and develop new scientific understanding that will assist policy-makers in devising optimal ozone and PM management strategies. Initial results suggested that highly reactive VOCs act as a catalyst in the ozone formation process and, therefore, should be targeted in the TCEQ's emission reduction strategies.

For a copy of the original Texas 2000 Air Quality Study reports, please visit: http://www.utexas.edu/research/ceer/texaqsarchive/accelerated.htm.

Texas Environmental Research Consortium (TERC)

Since its inception in 2002, the TERC has sought to improve ozone science and air quality modeling capabilities within Texas. Since 2006, TERC has managed the New Technology Research and Development Program, which develops and verifies technologies used to reduce NO_x emissions from diesel engines. The TCEQ has legislative direction to continue to fund TERC as an external research program and has committed funding through 2013; however, this funding is not exclusively reserved for the TERC program.

Ongoing studies funded by TERC and other organizations continue to reveal new science and mitigation strategies that can contribute to improving air quality in the Houston region. The 2009 TERC Science Synthesis reports on the latest scientific findings, including:

- Atmospheric Chemistry – Reduction in radical precursors of ozone, like formaldehyde and nitrous acid (HONO), which are not currently included in air quality planning models or mitigation could contribute to improve ozone control.
- Meteorology – Improved understanding of vertical atmospheric mixing and of local wind patterns will contribute to more accurate air quality modeling.
- Emissions Inventories – Advanced measurements, from aircraft and remote sensing, find that mobile and industrial emissions are underestimated in emission inventories.
- EPA Ozone Standards – Instances of high background ozone in East Texas and the expectation of increasing VOC emissions will challenge the HGB region in attaining the EPA's increasingly stringent ozone standards.

The 2009 TERC Science Synthesis, which summarizes research findings, may be found at: http://files.harc.edu/Projects/AirQuality/Projects/H108/H108ScienceSynthesisReport.pdf. For more information about TERC, please visit www.tercairquality.org.

Houston Regional Monitoring

The Houston Regional Monitoring (HRM) Corporation is a privately sponsored ambient air monitoring network supported by 46 companies operating in the Houston-area. The monitoring network provides air quality readings for a 900 square-mile area, which includes the Houston Ship Channel. HRM member companies have accumulated ambient air measurements for all criteria pollutants and measurements of approximately 150 volatile organic compounds. HRM periodically publishes the "Houston Air Quality Trends Overview," which outlines trend levels for a number of pollutants measured in HGB. For more information on this publication, please visit http://hrm.radian.com/trends_info.htm.

Citygreen Urban Ecosystem Analysis

This study, with funding from the U.S. Department of Agriculture Forest Service and private funding from local sources, resulted in a model of urban tree canopy and a toolbox of recommendations for utilizing natural systems to address urban heat island effects. Using American Forests Citygreen® software, satellite images, low level digital imagery, and field plots, researchers established the economic impact of the area's urban forest on air pollution mitigation, storm water runoff, and energy conservation.

For more information on the Citygreen Urban Ecosystem Analysis (UEA), visit http://www.americanforests.org/downloads/rea/AF_Houston.pdf.

Local Exposure and Health Effects Research

Mayor's Task Force on the Health Effects of Air Pollution

The task force, composed of scientists, medical researchers, engineers, and public health experts, convened in 2006, to consider the significant health effects of criteria and hazardous air pollutant levels in Houston. The analysis identified 12 substances in Houston's air that are definite risks to human health. Despite scientific uncertainty due to incomplete or inadequate data, the report found that ambient air pollution is harmful to exposed populations. As a result of the task force, researchers and the University of Texas Institute for Health Policy published a report titled, "A Closer Look at Air Pollution in Houston: Indentifying Priority Health Risks." The report creates a ranking of risk for harmful pollutants. Decision makers can use the ranking when developing strategies for addressing air pollution in Houston. For a copy of the task force's report, please visit:
http://www.sph.uth.tmc.edu/uploadedFiles/Centers/IHP/UTReportrev.pdf.

Assessment of the Health Benefits of Improving Air Quality in Houston - Sonoma Technology, Inc.

The City of Houston commissioned researchers from Sonoma Technology, Inc., California State University, and the University of California, Irvine, to address the potential health and economic benefits of reducing area air pollution. Published in 1999, the overall purpose of the Sonoma Study is "to provide information that will assist decision-makers in setting priorities for emissions reductions based on the relative health benefits of different emission control strategies."

The authors noted that numbers used in the study are very conservative, and that a number of effects cannot be analyzed because of a lack of sufficient data and/or health studies meeting their inclusion criteria. The study was unable, for example, to evaluate mortality in children and adults less than 30 years old, the health costs of air pollution-induced cancer or the direct health effects of hazardous air pollutants. For a copy of the report prepared by Sonoma Technology, please visit http://www.greenhoustontx.gov/reports/improvingair.pdf.

The Relationship of Indoor, Outdoor and Personal Air (RIOPA)

Several projects and programs are of particular interest to the study of air pollution and health in HGB. The Mickey Leland National Urban Air Toxics Research Center (NUATRC), located in the Texas Medical Center, and the Health Effects Institute funded the Relationship of Indoor, Outdoor and Personal Air (RIOPA) study. This is a three-city study examining personal exposure to selected VOCs, fine airborne particles and other compounds. The 2001 study was funded to measure the impact of outdoor air sources on indoor air and personal exposure in at least 100 households per city in Houston; Elizabeth, N.J.; and Los Angeles.

The Houston component of this national study was conducted by researchers at the University of Texas School of Public Health (UTSPH). RIOPA provides the largest database available on residential indoor/outdoor concentrations and personal exposures to a broad range of air pollutants in Texas. It was the first study in the United States that monitored indoor, outdoor, and personal air concentrations of this broad range of air pollutants. The extensive database, created as a result of the RIOPA study, continues to be used for research and analysis. The Health Effects Institute published analyses of VOC and carbonyl exposure in 2005 and analyses of particulate matter exposure in 2007. For more information on RIOPA, please visit: http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5837/report/F.

Studies by Mickey Leland National Urban Air Toxics Research Center (NUATRC)

NUATRC also funded a study to investigate whether certain air toxics such as aldehydes and ketones play a role in the exacerbation of asthma in middle school children in the Aldine school district. Subjects wore personal air monitors 24 hours a day for 10 consecutive days to measure personal exposure to specific air toxics. These concentrations were compared to indoor, outdoor, and fixed ambient site monitors. This study was carried out by a team of researchers from the University of Texas School of Public Health, Texas Children's Hospital, and Baylor College of Medicine.

In addition, several health-based programs were conducted to better characterize and treat children with asthma, a significant health problem in urban areas. Baylor College of Medicine conducted a randomized clinical trial that targets Houston inner city children (5-14 years old), utilizing an educational multimedia interactive computer program to create customized asthma management plans. Baylor College of Medicine has also been designated one of 19 clinical research centers for asthma in the United States.

The Houston Independent School District participates in a school-based asthma intervention program, *Partners in School Asthma Management*, that is funded by the National Institutes of Health. The University of Texas Medical Branch in Galveston operates a home-based intervention program for children with asthma. The City of Houston Department of Health and Human Services, with funding from the Texas Department of Health, implemented an Asthma Surveillance Project in 2000. The project will educate students, school nurses, and others about effective interventions to reduce asthmatic symptoms in children, including taking appropriate action on days with poor air quality.

Notwithstanding the studies and programs described above, relatively few population-based studies have examined health effects in area residents in relation to air pollution. Much of the research described above found that there are significant gaps in our understanding of air toxics, especially on the local or regional level. Localized and site-specific epidemiological studies will be needed to collect extensive data on all pollutants, and carefully control confounders, such as weather, smoking, and socioeconomic status.

The Control of Air Toxics

The Control of Air Toxics: Toxicology Motivation and Houston

Published by Rice University, "The Control of Air Toxics: Toxicology Motivation and Houston," examined the effects of HAPs on the HGB region. The study focused on four HAPs: benzene, 1,3 butadiene, formaldehyde, and diesel particulate matter. While the ambient levels of HAPs in the Houston region has decreased over the past years, the study found that the concentrations found in Houston's air are still considerably higher than the levels found in other comparable cities. Based on their findings, the researchers for this study recommended immediate action to lower the ambient concentrations of the subject HAPs. Specifically, they recommended an interim goal of 1.4 ppb for benzene, 0.13 ppb for 1,3 butadiene, 0.29 $\mu g/m^3$ for diesel PM, and a 24-hour average of 10 ppb of formaldehyde. The study also recommended an annual standard of 0.14 ppb for benzene, 0.013 ppb for 1,3 butadiene, 0.03 $\mu g/m^3$ for diesel PM, and a 24-hour average of 10 ppb of formaldehyde.

For more information on this study, please visit http://hydrology.rice.edu/ceve/fraser/Executive%20Summary.pdf.

Preliminary epidemiologic investigation of the relationship between the presence of ambient hazardous air pollutants (HAPs) and cancer incidence in Harris County

The study, conducted by the University of Texas School of Public Health, investigated the link between exposure of HAPs and the incidence rates of cancer. Researchers conducted statistical analyses where HAP emission sources are located, such as the Houston Ship Channel, and examined the preliminary links between cancer incidences of the nearby population. Other analyses studied the relationship between cancer and the concentrations of benzene and 1,3 butadiene.

The epidemiologic investigation found that children living closer to the Ship Channel or living in regions with high 1,3 butadiene concentrations had a greater incidence of leukemia. However, the researchers found that it was more difficult to determine the relationship between HAPs exposure and cancer in adults. Results confirm the need for control of HAPs in ambient air. For more information, please visit: http://www.houstontx.gov/health/UT-executive.html.

Houston Exposure to Air Toxics (HEATS)

The Houston Exposure to Air Toxics Study (HEATS) examines if exposures to HAPs for adults in the Houston Ship Channel area are higher than those in other areas located in the county. VOCs were monitored for indoor, outdoor, and personal concentrations. Information on household and participant characteristics, indoor/outdoor time location budgets, and personal activities as well as air exchange rates was calculated. The study also measured the populations' perception of health symptom patterns and environmental risk.

The study concluded that exposures are similar and do not appear to reflect the differences in the type and density of point source emissions or the ambient concentrations as measured at fixed sites in the areas. The final HEATS report may be found at: http://www.sph.uth.tmc.edu/mleland/attachments/HEATS%20FINAL%20REPORT%20NARRATIVE%20103109.pdf