AIR QUALITY REFERENCE GUIDE

for the Houston-Galveston Area

September 2000

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The contents of this report reflect the views of the authors who are responsible for the opinions, findings and conclusions presented herein. The contents do not necessarily reflect the views or policies of the Federal Highway Administration, the Federal Transit Administration or the Texas Department of Transportation.

Regional Air Quality Planning Committee
of the Houston-Galveston Area Council
P.O. Box 22777
Houston, Texas 77227-2777
(713) 627-3200
http://www.hgac.cog.tx.us

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Preface

We have prepared the *Air Quality Reference Guide for the Houston-Galveston Area* to provide interested citizens and organizations with accurate and up-to-date information about air pollution in the greater Houston area. We intentionally brought differing perspectives–industry, public health, government, citizens, and the environmental community–to the preparation of this *Guide*, and its contents represent the consensus of the group. Consensus was not always easy, but the process gave each of us a more multifaceted appreciation of the complexity of the problems facing the Houston area. We hope that some of this sense of creating consensus out of differing points of view survives in this document, as consensus and working together are an integral part of the process if the area is going to reduce its levels of pollution significantly and within the time frame required. This document, however, is certainly not the final word on air pollution in the Houston area, and will be regularly revised as new information becomes available and as our understanding of the issues improves. We hope that you find the *Guide* to be useful, and we encourage you to offer suggestions how the *Guide* might be improved in the next revision.

The Reference Guide Consensus Group
Regional Air Quality Planning Committee
Houston-Galveston Area Council

Rob Barrett, Pollution Control Division, Harris County Public Health & Environmental Services Department

Anna Davis, Houston-Galveston Area Council

Winifred J. Hamilton, Ph.D., Galveston-Houston Association for Smog Prevention

Elizabeth Hendler, Greater Houston Partnership

Jacqueline M. Lentz, Bureau of Air Policy, Department of Health & Human Services, City of Houston

Frances V. Smith, M.P.H., Air Quality Committee, League of Women Voters of Houston

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David Crossley, Gulf Coast Institute
Tina Davies, Houston Advanced Research Council
Guy Donaldson, Environmental Protection Agency
Heather Evans, Texas Natural Resource Conservation Commission
Dick Flannery, Texas Natural Resource Conservation Commission
Matt Fraser, Rice University
Julie Gilbert, Metropolitan Transportation Authority
Bill Gill, Texas Natural Resource Conservation Commission
Dewayne Huckabay, City of Houston
Bill Jordan, Texas Natural Resource Conservation Commission
Bryan Lambeth, Texas Natural Resource Conservation Commission
Mike Magee, Texas Natural Resource Conservation Commission
Anne Mrok-Smith, Clean Air Action, Houston-Galveston Area Council
Robert Nolan, ExxonMobil
Karl Pepple, Houston-Galveston Area Council
Jim Smith, Texas Natural Resource Conservation Commission
Lily Wells, Houston-Galveston Area Council
G. Michael White, City of Baytown

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What Is Air Pollution?

The air we breathe consists largely of nitrogen and oxygen, with traces of other gases, such as carbon dioxide and tiny particles. Water vapor is also present in the air in varying amounts. Air pollution is the presence in the air of substances, both gases and particles, in amounts that are harmful to the health or comfort of humans or animals, or that cause damage to plants or materials. Although there are natural sources of air pollution, such as volcanic eruptions, forest fires and wind-blown dust, significant air pollution is usually the result of human activities (e.g. industrial processes and motor vehicle use).

At the start of the industrial revolution in the late 1800s, smoke from the burning of coal in homes and factories began to be recognized as an important source of air pollution in urban areas. In 1905, H. A. Des Voeux coined a new word, "smog," to describe the mixture of smoke, sulfur dioxide, and fog that hung over many industrial cities and which, during episodes of stagnant air, precipitated health crises that were linked to increased illness and premature death. Following the passage of clean air laws in several countries, which generally limited the burning of coal, this type of smog was generally reduced.

However, in some urban areas, despite these controls, the air quality did not improve. After many studies in Los Angeles, another type of air pollution, created from the combination of emitted nitrogen oxides and hydrocarbons in the presence of sunlight, was recognized and given the name "photochemical smog." One of photochemical smog's chief components is ozone. Other major components of photochemical smog include various hydrogen peroxides and organic nitrates. In addition, there are many minor reactive chemicals in photochemical smog. For practical purposes, however, photochemical smog is usually measured by the concentration of ozone in the air.

Some people use the terms smog and ozone interchangeably, perhaps because the measurement of ozone is often the principal guide to air quality in an area. The haze that limits visibility is largely created by the photochemical processes that make ozone, as well as by smoke and other small particles and water droplets.

Under the federal Clean Air Act (CAA) of 1970, which was significantly amended in 1990, the U. S. Environmental Protection Agency (EPA) is required to study the effects of air pollution on human health and the environment, and to establish appropriate ambient, or outdoor, air quality standards. These federal standards are known as the National Ambient Air Quality Standards (NAAQS) and are intended, based on the *latest scientific knowledge*, to protect public health and welfare.

Based on these health and welfare criteria, federal standards have been established for six ambient air pollutants: **ozone**, **carbon monoxide**, **sulfur dioxide**, **nitrogen dioxide**,

particulate matter, and **lead**. These six air pollutants have become known as the "criteria pollutants." Table 1 lists the primary standards, which are intended to protect public health, as well as the secondary standards, which are intended to protect public welfare (for example, by preventing plant, crop, and property damage), for each criteria pollutant. The CAA also addresses other pollutants, such as air toxics.

Ozone is the only criteria pollutant for which the eight-county Houston-Galveston area currently fails to meet the NAAQS. An area that fails to meet a NAAQS for a pollutant is said to be in "nonattainment" for that pollutant. The eight counties that make up the Houston-Galveston ozone nonattainment area for the one-hour standard are Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties (Figure 1). For this NAAQS, the area is the same as the Consolidated Metropolitan Statistical Area (CMSA) for the Houston region. In Texas, three other areas are also nonattainment areas. These are Beaumont-Port Arthur, Dallas-Fort Worth and El Paso areas. Some cities, as shown in Table 2, fail to meet more than one of the NAAQS. Because each urban area has different geographical and meteorological conditions, as well as different emissions sources, different strategies to reduce pollutant levels must be developed for each area.

FIGURE 1: The eight counties that comprise the Houston-Galveston nonattainment area for the one-hour federal ozone standard.

TABLE 1
National Ambient Air Quality Standards (NAAQS)
(Source: 40 CFR Part 50)

Pollutant	Primary Standard (Public Health)			Secondary Standard (Public Welfare)		
	Level	Averaging Time	Form	Level	Averaging Time	Form
Ozone	0.12 ppm	1-hour	More than 3 days over 3 years	Same as primary standard		
	0.08 ppm*	8-hour	3-year average of annual fourth highest daily maximum	Same as primary standard		
Particulate Matter 10 microns or smaller (PM_{10})	150 $\mu g/m^3$	24-hour	3-year average of annual 99 t percentiles	Same as primary standard		
	50 $\mu g/m^3$	Annual	Not to be exceeded			
Particulate Matter* 2.5 microns or smaller ($PM_{2.5}$)	65 $\mu g/m^3$*	24-hour	3-year average of annual averages	Same as primary standard		
	15 $\mu g/m^3$*	Annual	3-year average of 98t percentiles			
Carbon Monoxide	35 ppm	1-hour	More than once per year	No secondary standard		
	9 ppm	8-hour				
Sulfur Dioxide	0.14 ppm	24-hour	More than once per year	0.50 ppm	3-hour	More than once per year
	0.03 ppm	Annual	Not to be exceeded			
Nitrogen Dioxide	0.053 ppm	Annual	Not to be exceeded	Same as primary standard		
Lead	1.5 $\mu g/m^3$	Quarterly	Not to be exceeded	Same as primary standard		

ppm = parts per million ; $\mu g/m^3$ = micro-grams per cubic meter

* EPA established new ozone and particulate matter standards in July 1997. In May 1999, the U.S. Court of Appeals for the District of Columbia Circuit ruled that the EPA cannot enforce the new standards unless and until some constitutional issues are resolved. The EPA has appealed the decision. On January 28, 2000, the Department of Justice filed a petition seeking Supreme Court review of the decision.

TABLE 2
U.S. Cities with a Population Greater than 1 Million in Nonattainment for One or More Criteria Pollutants
(Source: USEPA, December 13,1999; www.epa.gov/airs/nonattn.html)

City	1-hr Ozone	Particulate Matter	Carbon Monoxide	Sulfur Dioxide	Nitrogen Dioxide	Lead	Total #
Atlanta	X						1
Baltimore	X						1
Chicago	X	X		X			3
Cincinnati	X						1
Cleveland		X		X			2
Dallas	X						1
Denver		X	X				2
El Paso	X	X	X				3
Houston	X						1
Los Angeles	X	X	X				3
Milwaukee	X						1
Minneapolis		X					1
New York	X	X	X				3
Philadelphia	X						1
Pittsburgh	X	X		X			3
Phoenix	X	X	X				3
Sacramento	X	~~X~~					2
St. Louis	X					X	2
San Diego	X						1
San Francisco	X						1
Seattle		X					1
Washington D.C.	X						1

X = Nonattainment

Criteria Pollutants

Ozone

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 which has two oxygen atoms (O_2). It occurs in two areas of the earth's atmosphere. Naturally occurring ozone is found in the stratosphere, that portion of the atmosphere 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, that portion of the atmosphere from the earth's surface 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. Because ground-level ozone is largely formed from emissions created by human activities, urban areas are where harmful levels of ozone usually occur.

Ground-level ozone is not emitted directly to the air but instead is formed by a series of complex atmospheric chemical reactions primarily involving nitrogen oxides (NO_x) and volatile organic compounds (VOCs), which are called "precursors," and sunlight.

NO_x is produced almost entirely as a by-product 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 break-down 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 many sources including (1) industrial sources such as petroleum storage tanks, oil refineries, and petrochemical manufacturing plants; (2) on-road mobile sources such as automobiles, trucks, and motorcycles; (3) off-road sources such as airplanes, trains, boats, and construction equipment; (4) area sources such as gasoline stations, paint, gasoline-powered lawn mowers, and printing operations; and (5) “biogenic” emissions from various trees and plants that naturally emit VOCs. Not all VOCs, however, are equal in their ozone-making potentials. VOCs that are more reactive, such as formaldehyde and isoprene, contribute more to ozone formation than do less reactive VOCs, such as acetone.

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. During unusual meteorological conditions, ozone may be transported down from the stratosphere. In addition, lightning can create ozone. In the Houston-Galveston area as in many other coastal communities, a “sea breeze-land breeze” effect is caused by temperature differences between the land and the Gulf of Mexico. This effect moves air from the land out over the Gulf during the night, and moves it back over the Houston area as temperatures rise the following day, enhancing the formation of ozone by recirculating polluted air.

Varying wind patterns and the time required for ozone to form can result in exceedances of the ozone standard at locations quite remote from the sources of NO_x and VOCs. For example, even though pollution sources are often concentrated along freeways and industrial corridors, high ozone levels occur throughout the eight-county nonattainment area, including in relatively rural areas.

Existing Ozone Standard

The current health and welfare NAAQS for ozone (O_3) is 0.12 parts per million (ppm) averaged over one hour. Because of mathematical rounding, an exceedance is considered to have occurred when O_3 levels equal or exceed 0.125 ppm, which equals 125 parts per billion (ppb). In 1999, there were 52 days when monitors in the area detected O_3 over the one-hour standard; the maximum O_3 concentration measured was 0.251 ppm. The Houston-Galveston area is not in attainment for O_3.

New Ozone Standard

In July 1997, EPA established a new ozone standard. The new standard states that the three-year average of the annual fourth-highest daily eight-hour average concentration, at the same monitor, shall be no greater than 0.08 ppm. EPA plans to designate areas that fail to attain the new eight-hour standard in the year 2000. States will then be required to submit an attainment plan for the eight-hour nonattainment areas by 2003. The attainment plan must be designed to attain the eight-hour standard by the year 2010. The existing one-hour standard will continue to apply to existing one-hour nonattainment areas until the one-hour standard is met. Because the Houston area must meet the one-hour ozone standard before the new eight-hour standard takes effect, the new standard will not affect the eight-county area for several years.

In May 1999, the U.S. Court of Appeals for the District of Columbia Circuit ruled that EPA's interpretation of its authority under the federal Clean Air Act to establish the new ozone standards was an unconstitutional delegation of legislative power from the Congress, and prohibited EPA from enforcing the new standards unless and until the constitutional issues are resolved; the EPA has appealed this decision. Although EPA plans to proceed with designating areas either attainment or nonattainment for the new ozone standards, the EPA cannot enforce the new standards unless this ruling is overturned or amended in a higher court. On January 28, 2000, the Department of Justice petitioned the U.S. Supreme Court to review the earlier decision.

In 1999, there were 62 days when monitors in the region detected ozone over the eight-hour standard; the maximum O_3 concentration measured over eight hours was 0.172 ppm. It is expected that the Houston-Galveston area will be designated nonattainment for the eight-hour ozone standard.

Carbon Monoxide

Carbon monoxide (CO), a colorless, odorless gas, is emitted during the combustion of gasoline, wood, natural gas, and other fuels. Emissions increase significantly from improperly tuned engines. In 1990, on-road mobile sources were responsible for approximately 59%, non-

road mobile sources for 32%, stationary point sources for 8%, and area sources for 1% of the CO emissions in the Houston-Galveston area. The NAAQS for carbon monoxide (CO) is 35 ppm averaged over one hour, and 9 ppm averaged over eight hours (Table 1). In 1999, the maximum CO concentration measured 6.3 ppm averaged over one hour and 4.1 ppm averaged over eight hours. The Houston-Galveston area is in attainment for CO.

Sulfur Dioxide

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 power plants that burn sulfur-containing coal, petroleum refineries, and sulfuric acid plants. Sulfur dioxide can harm vegetation, impair visibility by the formation of sulfates, and contribute to acid rain, in addition to its health effects. The NAAQS for SO_2 are 0.14 ppm averaged over 24 hours and 0.03 ppm averaged over one year for public health, and 0.50 ppm averaged over three hours for public welfare (Table 1). In 1999, the maximum SO_2 concentration measured was 0.048 ppm averaged over 24 hours, 0.0073 ppm as an annual average, and 0.158 averaged over three hours. The Houston-Galveston area is in attainment for SO_2.

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a yellow-brown gas. It is a component in the family of pollutants referred to as nitrogen oxides (NO_x), which are 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, microbial breakdown of high-nitrogen fertilizers may also contribute to the NO_x levels. The NAAQS for NO_2 is 0.053 ppm averaged over one year (Table 1). In 1999, the maximum annual NO_2 concentration measured 0.024 ppm. Although the Houston-Galveston region is currently in attainment for NO_2, particular attention is being paid to this pollutant because of its important role in the formation of ground-level ozone. Reducing NO_x emissions is an important part of the strategy to meet the ozone standard.

Particulate Matter

Particulate matter denotes small particles suspended in air. These particles are exceptionally diverse, and include inorganic salts, acids, metals, water, organic compounds, and soot-like material. In 1987, EPA established a standard for particulate matter 10 microns or smaller in diameter (PM_{10}). A micron is approximately equal to 1/100th the width of a human hair. PM_{10} particles come from (1) combustion, including gasoline- and diesel-fueled cars and trucks, power generation, industrial processes, cigarette smoke, volcanoes and forest fires; (2) road dust; (3) tire particles; (4) chemical reactions in the atmosphere; (5) soil disturbance, such as occurs in construction and agriculture; (6) production or degradation of metals such as

chromium and platinum; and (7) various naturally occurring sources such as pollen, animal dander and insect fecal matter.

Existing Particulate Matter Standards

The current NAAQS for PM_{10} are 150 micrograms per cubic meter of air ($\mu g/m^3$) averaged over 24 hours, and 50 $\mu g/m^3$ averaged over a year (Table 1). In 1999, the maximum concentrations of PM_{10} measured 204 $\mu g/m^3$ averaged over 24 hours, and 47.8 $\mu g/m^3$ as an annual average. The Houston-Galveston area is still legally in attainment for PM_{10} because attainment status is based on three years of data. However, special attention will need to be paid to PM_{10} to ensure that the Houston region remains in attainment for this pollutant.

New Particulate Matter Standards

In July 1997, EPA established new standards for particulate matter smaller than 2.5 microns in diameter ($PM_{2.5}$). The new standards state that: (1) the annual mean concentration, averaged over three years, shall not exceed 15.0 $\mu g/m^3$, and, (2) the 98^{th} percentile of the 24-hour average concentrations, averaged over three years, shall not exceed 65 $\mu g/m^3$. In the period 2002-2005 the EPA plans to designate areas that fail to attain the new $PM_{2.5}$ standards. Preliminary $PM_{2.5}$ monitoring conducted in 1997-98 suggests that the region will be in nonattainment of the new annual $PM_{2.5}$ NAAQS. Although no monitoring site exceeded the 24-hour average for $PM_{2.5}$, several sites exceeded the annual average. In 1997-98 the maximum 24-hour average was 38.3 $\mu g/m^3$ (at HRM site 3), and the maximum annual average was 16.3 $\mu g/m^3$ (at the Clinton site). TNRCC will be required to submit attainment plans between 2005 and 2008 for any $PM_{2.5}$ nonattainment areas in Texas. The plan must be designed to attain the $PM_{2.5}$ standards by the period from 2015 to 2018.

In May 1999, the U. S. Court of Appeals for the District of Columbia Circuit ruled that EPA's interpretation of its authority under the federal Clean Air Act to establish the new $PM_{2.5}$ standards was an unconstitutional delegation of legislative power from the Congress, and prohibited EPA from enforcing the new standards unless and until the constitutional issues are resolved. The EPA has appealed this decision and plans to proceed with setting up the monitoring network and designating areas either attainment or nonattainment for the new $PM_{2.5}$ standards. The U.S. Supreme Court is expected to review the earlier decision.

Lead

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

(Table 1). In 1997, because all measurements of lead at the four monitoring sites were near or below the limit of detection (0.01 $\mu g/m^3$), TNRCC and the City of Houston phased out ambient monitoring in the eight-county area. The Houston-Galveston area is in attainment for Pb.

Air Toxics

"Air toxics" are defined primarily by their effects. Exposure to air toxics increases a person's risk of developing cancer, immune and neurological damage, and reproductive and endocrine disorders, as well as the increase of the risk of birth defects in children. Although the term "air toxics" can be used to refer to any hazardous chemical or metal, in practice the term is usually reserved for the 189 chemicals and metals named in Title III of the 1990 Clean Air Act Amendments as "Hazardous Air Pollutants" (HAPs).

These chemicals and metals include benzene, toluene, vinyl chloride, perchloroethylene, asbestos, arsenic, mercury, chlordane, chromium, 1,3-butadiene, and formaldehyde. Sources of HAPs can include industrial processes, motor vehicles, combustion, pesticides, dry cleaners, and building materials. The EPA has not established ambient air standards for HAPs, but has established regulations to limit emissions of HAPs from specific major sources.

Emissions data supplied by industry for the Toxic Release Inventory (TRI) can be used to help understand the types and levels of air toxics in the area's air. Currently, 654 toxic chemicals and metals are required to be reported as part of the TRI. In 1998, Harris County ranked second in the U.S. for toxic air emissions (Table 3).

TABLE 3: 20 U. S. Counties with the Highest TRI Air Releases in 1998
(Source: USEPA; www.epa.gov/tri/tri98/index.htm)

Rank	County	Total TRI Air Releases (pounds/year)
1	Tooele, UT	57,697,790
2	Harris, TX	25,783,150
3	Jefferson, OH	23,811,556
4	Mobile, AL	21,212,173
5	Person, NC	20,156,374
6	Hamblen, TN	18,755,309
7	Marshall, WV	18,738,413
8	Ascension, LA	18,540,324
9	Bartow, GA	18,286,511
10	Adams, OH	17,270,474
11	Putnam, WV	16,836,530
12	Jefferson, TX	14,400,611
13	Hillsborough, FL	14,271,625
14	Washington, OH	13,927,844
15	Mason, WV	13,870,660
16	Monroe, MI	13,484,750
17	Escambia, FL	13,052,370
18	Anne Arundel, MD	11,914,425
19	Ottawa, MI	11,373,652
20	Jefferson, KY	11,332,029

For many years, TNRCC and HRM have been collecting 24-hour average air samples every six days to determine the concentrations of air toxics in the outdoor air. New monitoring methods are currently being developed to allow more frequent and faster determinations of concentrations. In Texas, the TNRCC has established Effects Screening Levels (ESLs) for many of the air toxics. The ESLs are typically between 1/100th and 1/1,000th of the occupational health standards for the same chemicals and are used by TNRCC staff, mostly during the permitting process for industrial facilities, to evaluate the potential impacts of these chemicals in the outdoor air. The Texas ESLs are not intended to reflect "safe" concentrations and are to be used only as guidelines. Concentrations of pollutants above their established ESLs trigger a more in-depth review by the TNRCC toxicology and risk assessment staff. Benzene is the only air toxic that is often found above its ESL in the Houston-Galveston air, though the area has had sporadic occurrences of other chemicals exceeding 24-hour ESLs, such as 1,3 butadiene in 1998, and carbon tetrachloride and isopentane in 1996. Elevated benzene levels are also found in some other cities.

What Are the Health Effects of Air Pollution?

Each air pollutant has potential for causing 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. Generally, higher pollutant levels and longer exposure times have greater effects. Sensitive individuals or persons with immune or other dysfunction that reduces their ability to detoxify or excrete pollutants, may experience adverse health effects at lower levels and following shorter exposures than the average person. 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.

Ozone

Exposure to ozone (O_3) can cause or aggravate various respiratory symptoms. These symptoms include decreased lung capacity, exacerbation of asthma, inflammation and swelling 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 or a few days after high ozone levels. Exposure to ozone can also impair the body's immune system defenses, making people more susceptible to respiratory infections, including 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. Exposure to ozone in conjunction with exposure to other air pollutants, allergens, and/or cigarette smoke may contribute to recently documented increases in the number of diagnosed cases of, and deaths from, asthma. These increases are most pronounced among children living in urban areas. Recent epidemiological studies have also suggested that ozone may exacerbate cardiac arrhythmia, and have found a small but statistically significant increase in mortality associated with increased ozone levels. Ozone has not been shown to be carcinogenic.

Carbon Monoxide

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 carbon monoxide because their bodies may be receiving only minimal oxygen ordinarily. Individuals exercising near traffic are also at risk as CO levels can be high near heavy traffic. CO levels inside cars in heavy traffic or at traffic lights may also be high. 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 cardio-vascular 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 sulfur dioxide (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 deleterious 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 nitrogen dioxide (NO_2) can cause lung irritation and a lowered resistance to respiratory infections and exacerbate allergies, and has been associated with cardiac arrhythmia and vascular changes. Increased ambient levels of NO_2 are associated with increased hospital admissions due to asthma, chronic obstructive pulmonary disease, heart disease, and with respiratory mortality. NO_2 contributes to the creation of nitric oxide, peroxyacetyl nitrate, nitrate particles, peroxynitrite radicals, and nitric acid aerosols in the atmosphere, all of which have deleterious effects at higher concentrations; some of the health effects correlated with NO_2 may actually be due to one of these other forms of nitrogen. At high levels, exposure to NO_2 can cause pulmonary edema and death. Some forms of nitrogen are mutagenic, that is they cause sudden changes in inheritable genetic matter.

Particulate Matter

Epidemiological studies have linked increased levels of particulate matter (PM_{10}) to various health effects. These include an increase in respiratory-related hospital admissions and emergency room visits; asthma; acute respiratory symptoms (including 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 thought to be largely caused by the "fine particulate" fraction ($PM_{2.5}$). Toxic chemicals and combustion products can also attach themselves to the particles. When drawn into the deepest part of the lungs, these particles tend to stay there, trapped in the 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.

Lead

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

Air Toxics

Exposure to air toxics, such as benzene, dioxin, toluene, chlordane, formaldehyde, 1,3-butadiene, and others, in high concentrations can result in rapid onset of sickness (e.g., nausea, headache, confusion, seizures, and severe difficulty in breathing), and death. Most people, however, are exposed to much lower levels of air toxics over an extended period. Many air toxics are neurological poisons and can cause genetic damage. The health effects most commonly associated with air toxics are cancer and various immunological, hormonal, neurological, reproductive, developmental, and respiratory effects. A growing concern that extremely low levels of some pesticides and chemicals may significantly disrupt endocrine function has led to the creation, by the EPA, of the Endocrine Disrupters Screening and Testing Advisory Committee (EDSTAC), which is studying this issue. The health effects of air toxics are often not recognized by patients and physicians because many of the diseases caused by air toxics take years to develop. For example, the latency period following exposure to benzene – known to cause leukemia and aplastic anemia – is 5 to 30 years.

What is the Quality of Houston's Air?

As noted earlier, ozone is the only criteria pollutant for which the eight-county Houston-Galveston area currently fails to meet the NAAQS. The majority of area air quality efforts are therefore focused on (1) better understanding and measurement of the area's ozone levels and its precursors, and (2) choosing and implementing effective ozone reduction control strategies.

Air Monitoring

Concentrations of ozone in outdoor air are measured at 25 air monitoring stations in the Houston-Galveston area (Figure 2), making this the most heavily monitored areas in the United States. The City of Houston, the Texas Natural Resource Conservation Commission (TNRCC), and Houston Regional Monitoring Corporation (HRM, an industry-funded monitoring network) operate these monitors. Most of these stations measure the concentrations of the 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 selected chemicals and some measure pollen and mold spores.

Ozone monitoring began in the Houston-Galveston area in 1971 by the City of Houston Bureau of Air Quality Control. The Texas Air Control Board, now replaced by TNRCC, began ozone monitoring in 1973. HRM began ozone monitoring in 1981. The ozone monitors operate continuously 24 hours a day, seven days a week, and are checked by technicians who perform equipment maintenance and conduct quality assurance checks.

Ozone monitors are currently sited in only five of the eight counties in the nonattainment area: Brazoria (one station), Chambers (two stations), Montgomery (one station), Galveston (three stations) and Harris (18 stations). All five counties with monitors experienced days on which monitors detected ozone over the one-hour ozone standard in 1999.

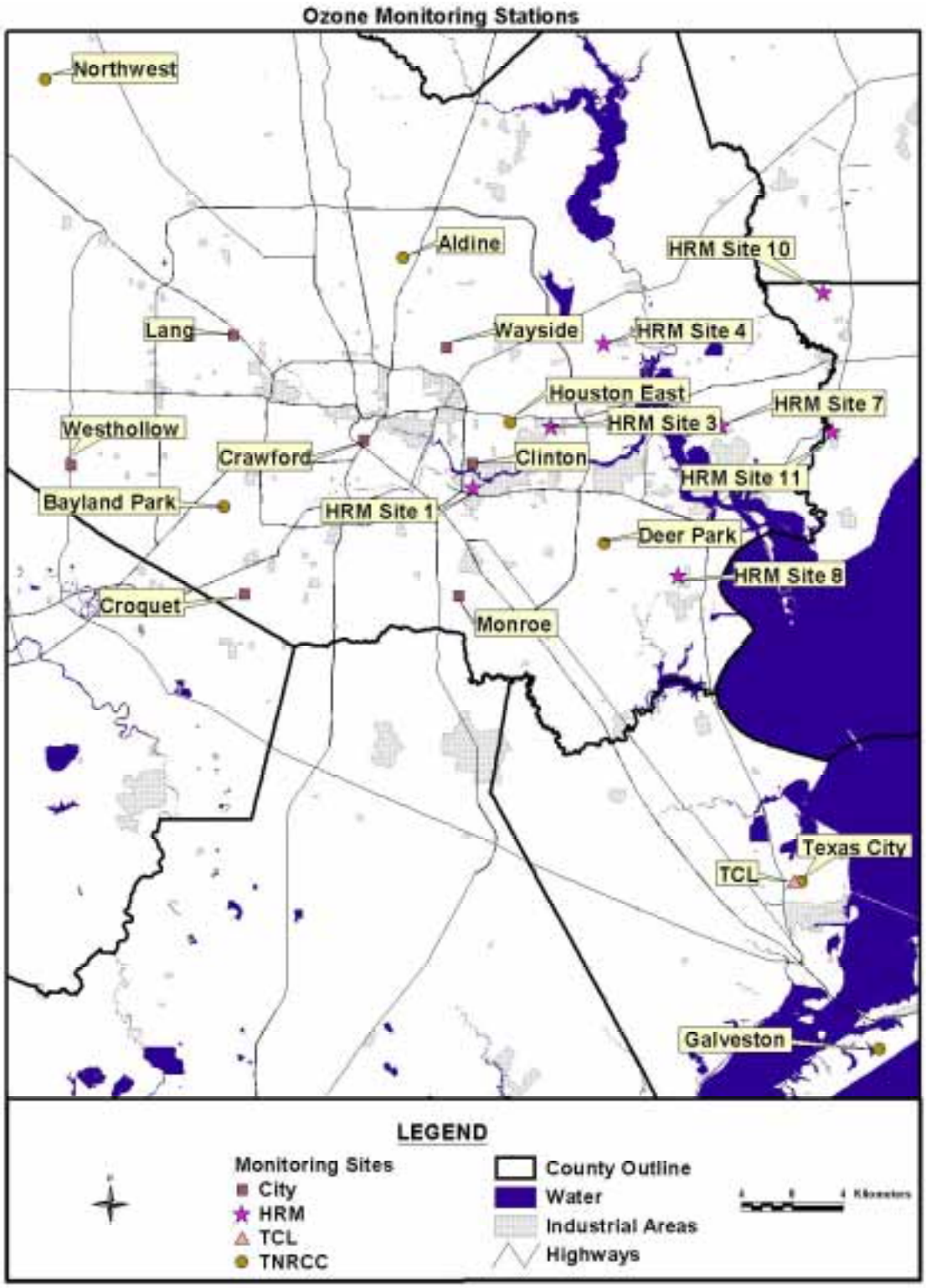


FIGURE 2: 1999 Ozone Monitoring Sites in the Houston-Galveston Area Excluding Clute and Montgomery Sites
(Source: URS Radian)

Introduction of $PM_{2.5}$ Monitors to Eight-County Area

With financial and technical assistance from EPA, TNRCC and the City of Houston have begun to deploy a new $PM_{2.5}$ monitoring network in the eight-county area. Sampling began in March 1999 in Houston. A total of four City of Houston monitors, six TNRCC monitors and two Galveston County monitors are listed in Table 4. Three years of validated monitoring data are required before EPA can determine the attainment status of an area. Because of early technical difficulties, three years of monitoring will be complete no sooner than March 2002. For a map of current operating monitor sites, please visit TNRCC's web site http://www.tnrcc.state.tx.us/air/monops/finepm/Hgb25.gif.

Samples collected by the new monitors will be analyzed to determine their composition (speciation), because composition of fine particles provides clues to the sources of emissions, and provides information about potential health effects. Monitors for PM_{10} continue to operate.

TABLE 4: $PM_{2.5}$ Monitor Locations and Active Dates

(Source: TNRCC, Houston, 6/99)

LOCATION	OPERATOR	ACTIVE START DATE
Deer Park	TNRCC	February 24, 1999
Channelview	TNRCC	March 9, 1999
Baytown	TNRCC	March 9, 1999
Houston Clinton	City of Houston	March 18, 1999
Houston Croquet	City of Houston	March 25, 1999
Houston Monroe	City of Houston	March 25, 1999
Houston Aldine	TNRCC	March 25, 1999
Clute	TNRCC	March 29, 1999
Texas City Nessler Pool	Galveston County	May 6, 1999
League City County Building	Galveston County	May 6, 1999
Houston Crawford	City of Houston	February 23, 2000
Conroe Airport	TNRCC	October 5, 1999

Our Ozone Nonattainment Status

The federal standard for ozone is a one-hour average concentration of 0.12 parts per million (ppm). To meet the standard, this one-hour average concentration cannot be exceeded at any one monitor in the area on more than three days over a three-year period. Another way to say this is: to meet the standard the fourth highest daily one-hour average ozone concentration measured at the worst monitor in the area over a three-year period cannot be more than 0.12 ppm. The Houston-Galveston area, along with 38 other areas in the United States, does not currently meet the one-hour ozone standard and therefore is "nonattainment" for the one-hour ozone standard.

Under the federal Clean Air Act Amendments (CAAA) of 1990, ozone nonattainment areas were classified according to each area's 1987-1989 or 1988-1990 "ozone design value" (Table 5). The ozone design value is the fourth highest daily one-hour average ozone concentration that was measured at the worst monitor in the area during the three-year period. The five classifications are "Marginal," "Moderate," "Serious," "Severe," and "Extreme." Each classification has different pollution control requirements and different deadlines to attain the ozone standard. Areas with higher ozone levels are given more time to attain the standard, but must also implement more pollution controls. The Houston-Galveston nonattainment area, which includes Harris County and the seven surrounding counties, is classified "Severe-17" nonattainment area, based on its 1987-89 ozone design value of 0.220 ppm, and was given 17 years to meet the one-hour ozone standard. Therefore the area's one-hour ozone attainment deadline is 2007. Several other nonattainment areas are also classified as "Severe," although the Houston-Galveston area has the highest ozone design value of the major metropolitan "Severe" areas. The Los Angeles nonattainment area is the only area classified as "Extreme," based on its 1987-89 ozone design value of 0.330 ppm.

Ozone Levels in the Houston-Galveston Area

One way to check a nonattainment area's progress toward attaining the ozone standard is to compare the ozone design value used to determine its original nonattainment classification with a more recent three-year period. An area will comply with the attainment of the one-hour ozone standard when its three-year ozone design value is reduced to 0.12 ppm. Of the 98 areas originally designated as nonattainment for the one-hour ozone standard based on their 1987-89 or 1988-90 design values, all but 39 were compliant in the three-year period 1997-1999. Even among the 39 areas that were not compliant, significant progress has been made in most areas (Table 5). For the period 1997 to 1999 0.203 ppm was the design value for the Houston-Galveston area and 0.211 ppm for the Los Angeles area.

TABLE 5: Ozone Nonattainment Areas for the One-Hour Standard, August 2000

(Sources: www.epa.gov/oar/oarpqs/greenbk/oytc.html; www.epa.gov/ttnotag1/areas/state/aq/aq99cnyy.htm)

Nonattainment Area (listed by Classification and Design Value)	State	Clean Air Act Classification	1987-89 or 1988-90 EPA Ozone Design Value (ppm)	1997-1999 EPA Ozone Design Value (ppm)
1. Los Angeles South Coast Basin	CA	Extreme	0.330	0.211
2. Southeast Desert Modified	CA	Severe-17	0.240	0.170
3. Houston-Galveston-Brazoria	TX	Severe-17	0.220	0.203
4. New York-New Jersey-Long Island	NY-NJ-CT	Severe-17	0.201	0.145
5. Chicago-Gary-Lake County	IL-IN	Severe-17	0.190	0.126
6. Milwaukee-Racine	WI	Severe-17	0.183	0.134
7. Baltimore	MD	Severe-15	0.194	0.152
8. Philadelphia-Wilmington-Trenton	PA-NJ-DE-MD	Severe-15	0.187	0.153
9. Sheboygan	WI	Severe-15	0.176	0.134
10. Ventura Co.	CA	Severe-15	0.170	0.134
11. Sacramento Metro	CA	Severe-15	0.160	0.148
12. San Diego	CA	Serious	0.185	0.135
13. Greater Connecticut	CT	Serious	0.172	0.147
14. San Joaquin Valley	CA	Serious	0.170	0.161
15. Springfield	MA	Serious	0.167	0.128
16. Washington	DC-MD-VA	Serious	0.165	0.132
17. Huntington-Ashland	WV	Serious	0.164	0.129
18. Baton Rouge	LA	Serious	0.164	0.126
19. Atlanta	GA	Serious	0.162	0.156
20. Charlotte-Gastonia	NC	Serious	0.158	0.132
21. Dallas-Fort Worth	TX	Serious	0.140	0.135
22. Manitowoc Co.	WI	Moderate	0.167	0.128
23. Beaumont-Port Arthur	TX	Moderate	0.158	0.130
24. St. Louis	MO-IL	Moderate	0.156	0.131
25. Portland	ME	Moderate	0.156	0.125
26. Louisville	KY-IN	Moderate	0.149	0.130
27. Pittsburgh-Beaver Valley	PA	Moderate	0.149	0.128
28. Richmond	VA	Moderate	0.142	0.134
29. Raleigh-Durham	NC	Moderate	0.141	0.127
30. San Francisco Bay Area	CA	Moderate	0.138	0.139
31. Nashville	TN	Moderate	0.138	0.127
32. Knoxville	TN	Marginal	0.135	0.138
33. Birmingham	AL	Marginal	0.133	0.128
34. Kent and Queen Anne Co.	MD	Marginal	0.131	0.130
35. Sussex Co.	DE	Marginal	0.130	0.125
36. Detroit-Ann Arbor	MI	Marginal	0.129	0.126
37. Jersey Co.	IL	Marginal	0.128	0.127
38. Memphis	TN	Marginal	0.128	0.126
39. Lancaster	PA	Marginal	0.125	0.128

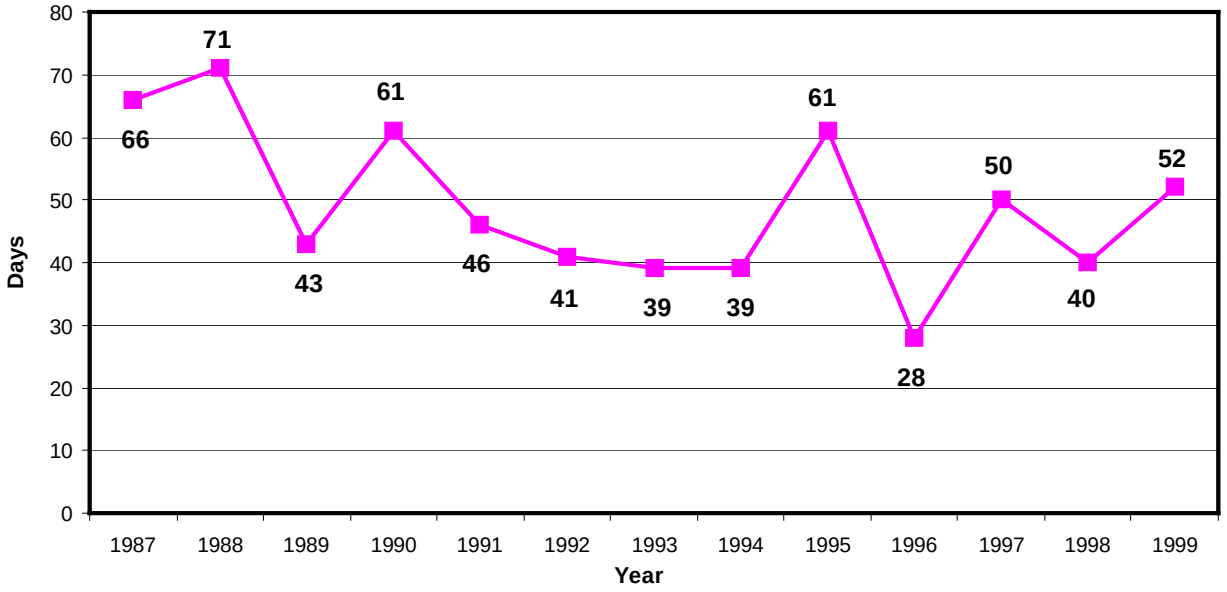


FIGURE 3: Number of Days When At Least One Monitor Exceeded the 1-Hour Ozone Standard

(Source: Houston Regional Monitoring, TNRCC, City of Houston, and USEPA, 2000)

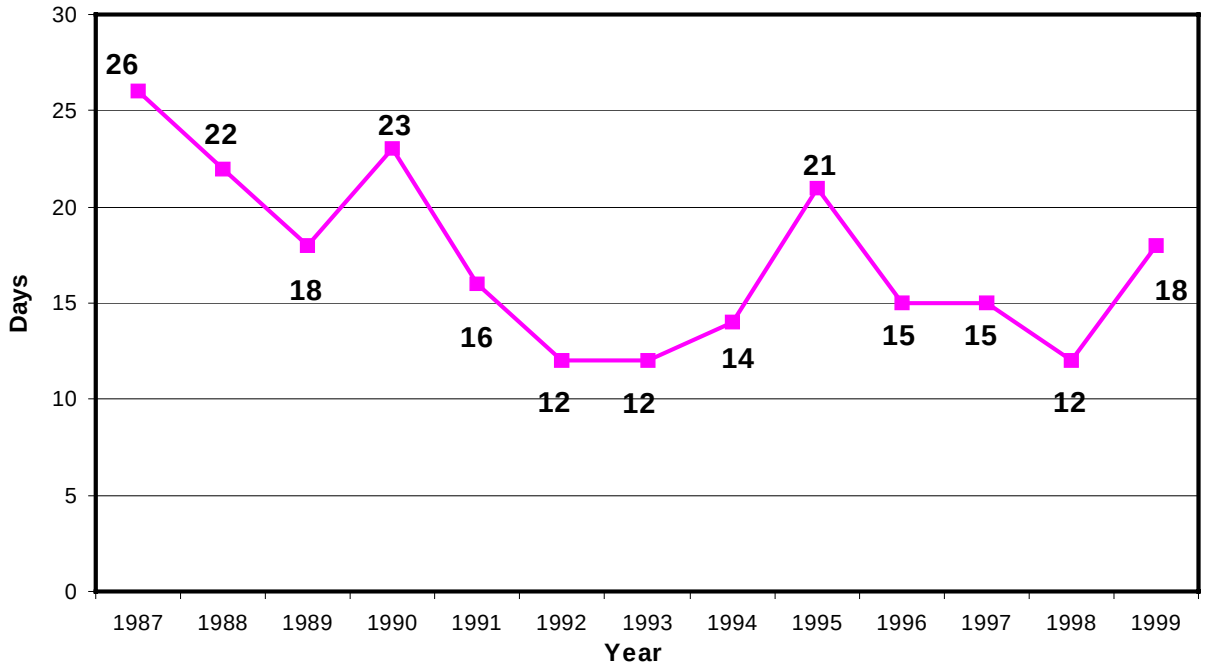


FIGURE 4: Number of Days When the Worst Monitor Exceeded the 1-Hour Ozone Standard

(Source: Houston Regional Monitoring, TNRCC, City of Houston, and USEPA, 2000)

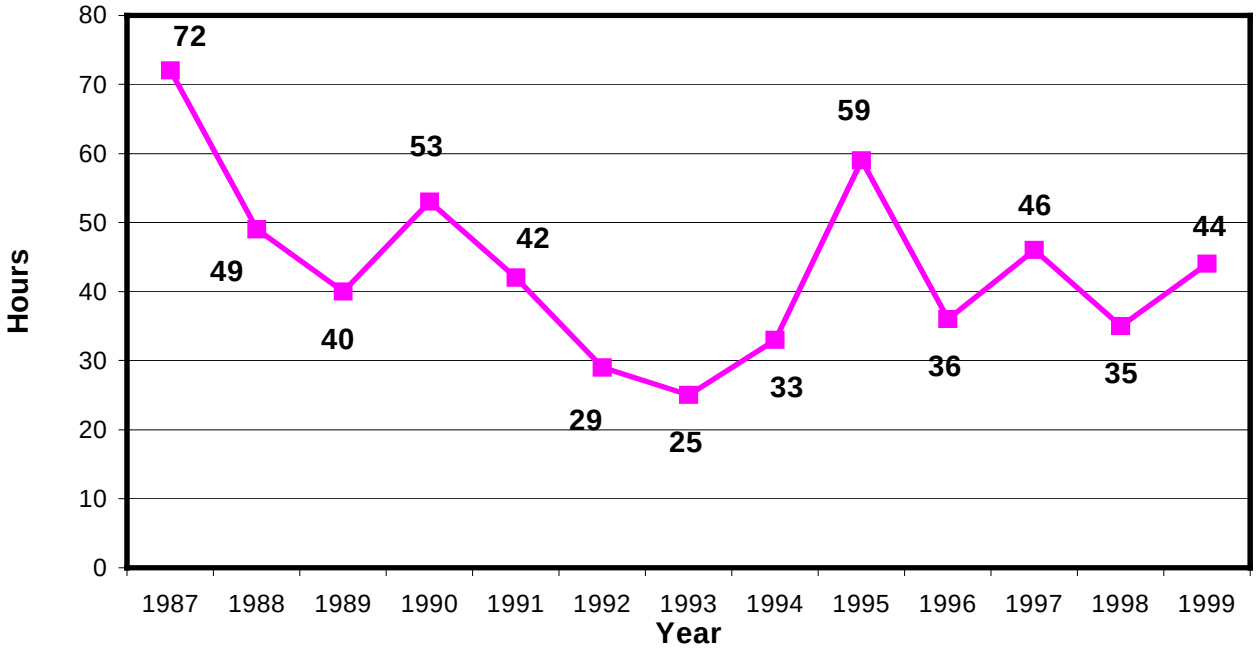


FIGURE 5: Number of Hours When the Worst Monitor Exceeded the 1-Hour Standard
(Source: Houston Regional Monitoring, TNRCC, City of Houston, and USEPA, 2000)

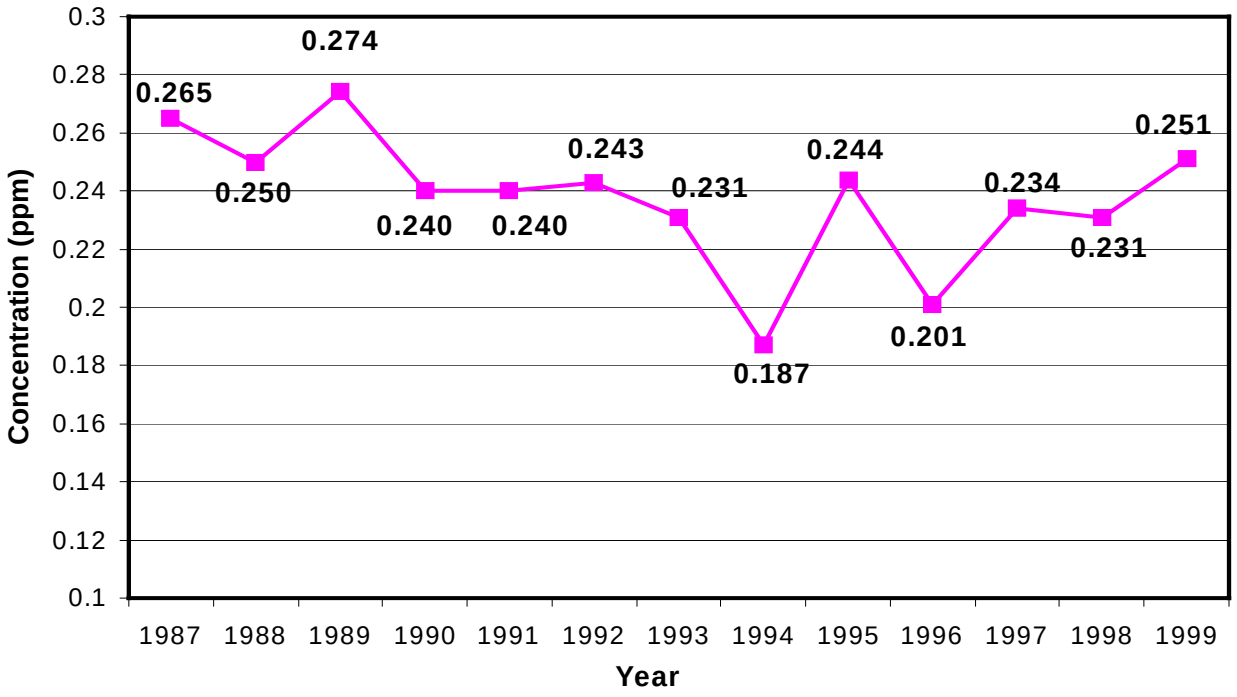


FIGURE 6: Maximum 1-Hour Ozone Concentration
(Source: Houston Regional Monitoring, TNRCC, City of Houston, and USEPA, 2000)

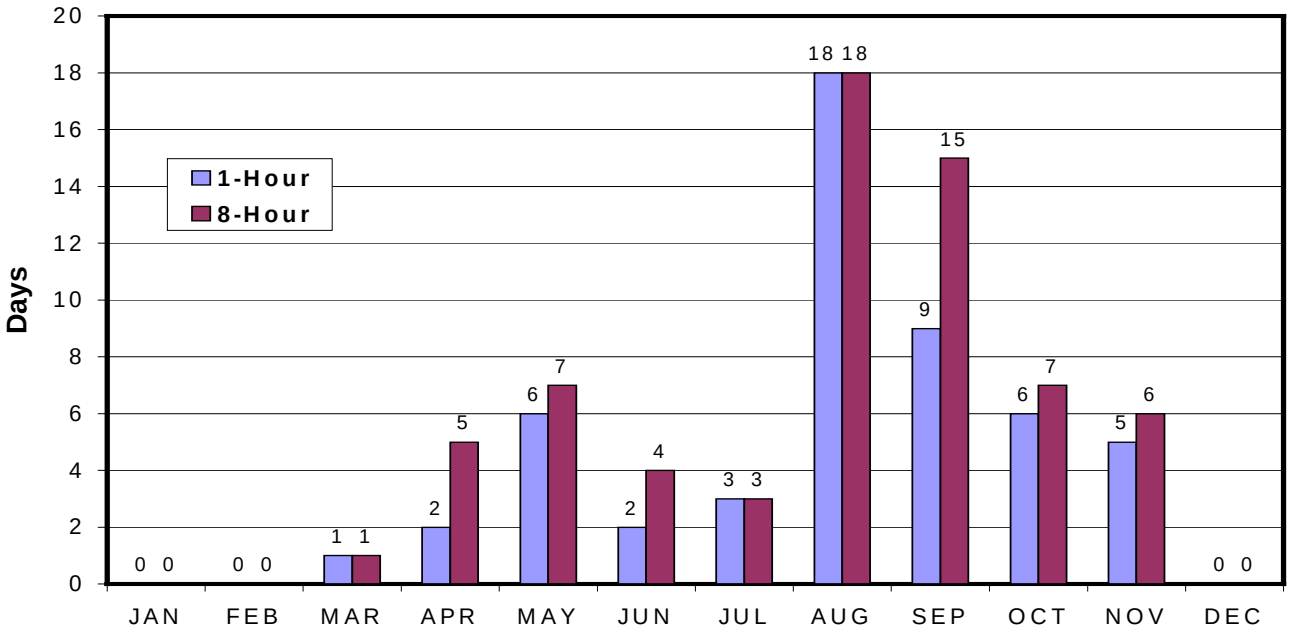


FIGURE 7: Number of Days in 1999 When At Least One Monitor Exceeded the 1-Hour or 8-Hour Ozone Standard (by Month)

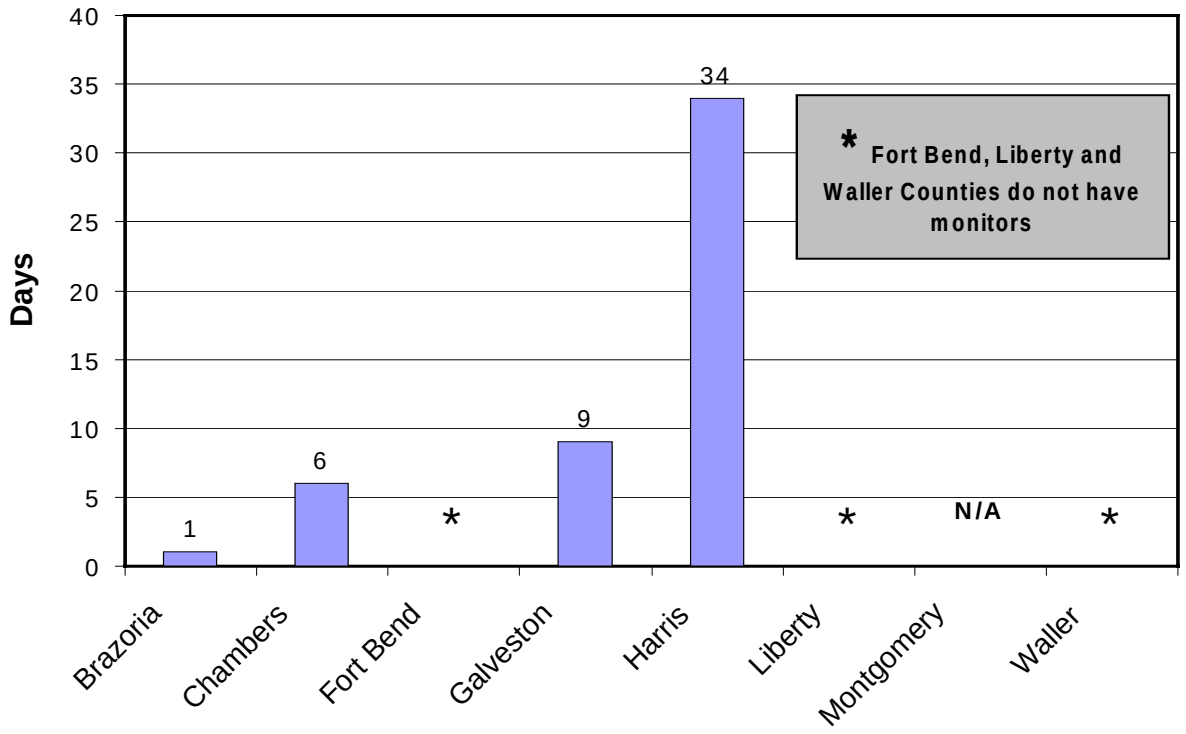


FIGURE 8: 1999 Ozone Exceedance Days by County

The long-term downward trend in ozone is generally considered to be the result of the efforts that have been made to reduce emissions from various sources of VOCs, such as industry, cars and trucks, and small businesses (Figure 11). The Houston-Galveston area has implemented many new controls on emissions since 1990, which have significantly reduced ambient levels of VOCs in the area. TNRCC issued a report in May 1997 in which they studied ambient monitoring data for VOCs and certain air toxics for the period 1987 to 1995. TNRCC concluded that there has been a reduction of greater than 50% in the average ambient VOC concentrations, and a reduction of 50% or more in the average ambient levels of benzene, toluene and xylene. However, as you can see in Figures 3 through 6, since 1990 there has been an apparent flattening of the progress toward the standard.

There is no general agreement on why monitored ozone levels have not continued the same progress, although there are several possible explanations. One possible explanation is that the ratio of VOCs to NO_x in the air may have been lowered to the point where additional reductions of VOCs do not have as much effect on reducing ozone formation as did the earlier reductions. A second possible explanation is that as ambient ozone levels get closer to the natural background concentration of ozone in the air, it becomes more difficult to reduce ozone. Another possibility is the estimates of emissions of VOCs and NO_x may be incorrect, and actual reductions in emissions may not be as great as estimated, or in some cases may have even increased. Finally, there is the possibility that weather conditions in recent years have been more favorable to ozone formation than before, which would partially offset the beneficial effects of the reductions in emissions of VOCs.

As you can also see from Figures 3 through 6, there can be a significant amount of year-to-year variability in ozone levels**.** In one year the ozone levels can be lower than the general trend but then will increase above the general trend the next year. This year-to-year variability is generally considered to be the result of the important role that weather conditions play in ozone formation. During years when there are a high number of sunny days combined with either stagnant wind conditions or winds that blow out into the Gulf of Mexico in the morning and then back onto the land in the afternoon, the eight-county area sees higher ozone levels and more exceedances of the one-hour standard. If the area is going to attain the federal ozone standard, a control plan must be developed that enables attainment during variable weather conditions.

Ozone Computer Modeling

The Clean Air Act (CAA) requires some areas of the country to use one of several EPA approved computer models to analyze to regional air pollution reductions. The TNRCC is currently using the comprehensive air quality model with extensions (CAMX) to model precursor pollutant emissions, air movement, chemical reactions, and resultant ozone concentrations. Data are fed into the model from hundreds of locations on a three-dimensional

grid system covering the region. Complex equations based on atmospheric chemical reactions are used to predict ozone concentrations in each grid for each hour, based on hourly emission rates and wind-flow patterns.

The model is run using conditions from some of the worst exceedance days in the past, and the results are compared to ozone levels actually measured at monitoring sites. If model results differ substantially from the monitored data, emissions and meteorological data are investigated, and if justified, modified to help provide better agreement between the predicted and actual ozone levels. Once satisfactory agreement between the predicted and actual ozone levels is achieved, meteorological parameters are kept constant and modeled emissions from sources are projected to the area's attainment deadline (2007). Then, the future emissions are adjusted to reflect potential control strategies. The photochemical grid modeling therefore attempts to predict what the ozone levels would be if various control strategies were implemented, and is helpful in determining the most useful strategies for achieving the federal ozone standard.

Emission Sources: Who Emits VOCs and NO_x?

"Emissions inventories" are detailed reports of where area emissions of VOCs and NO_x come from, identifying emissions by the types and locations of the sources. These sources of emissions are classified, for air quality planning purposes, into the following five "source categories."

Stationary point sources are defined for emission inventory purposes as industrial, commercial or institutional plants/operations which emit VOCs of 10 tons per year (TPY) or greater and/or NO_x or CO emissions of 25 TPY or greater. Owners or operators of such sources are required to annually report the quantity and type of emissions. Refineries, chemical manufacturing facilities, power plants, breweries, bakeries, and large building heating systems are included in this category. Point sources can emit both VOCs and NO_x, although different types emit different proportions.

Area sources are sources that emit less than the stationary point source definitions given above and are thus not practical to identify individually for emission inventory purposes. The quantity and type of emissions from these sources are estimated by 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. Area sources generally emit more VOCs than NO_x.

On-road mobile sources consist of automobiles, trucks, motorcycles, and other vehicles traveling on roadways in the eight-county nonattainment area. The Houston-Galveston Area Council (H-GAC) estimates the quantity and type of emissions from such sources using the latest computer models available from the EPA. These models estimate emissions from the engines and tailpipes of vehicles as well as emissions due to evaporation of gasoline and other fluids. On-road mobile sources emit both VOCs and NO_x, although different vehicles emit different proportions.

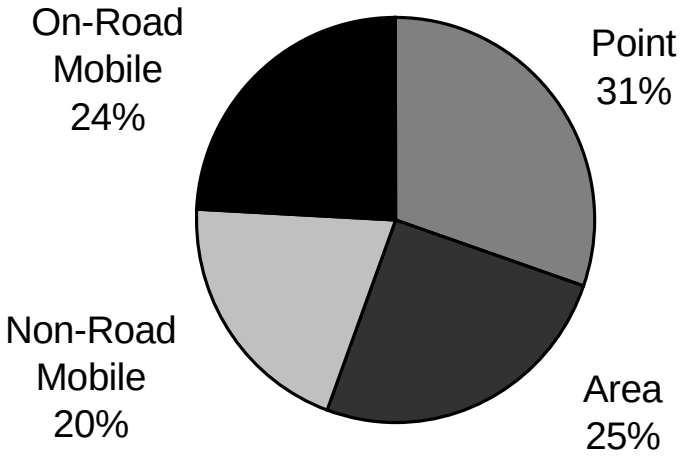
Off-road and non-road mobile sources include emissions from commercial and general aircraft operations, marine vessels, recreational boats, railroad locomotives, and a very broad subcategory that includes everything from engines on construction equipment to lawn mowers, chain saws, and leaf blowers. 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, although different types emit different proportions.

Biogenic sources include emissions from plant life in the area, including crops, trees, grass, and other vegetation. TNRCC estimates the quantity and type of emissions from vegetation using such tools as satellite imaging and computer modeling. While biogenic sources do emit VOCs into the atmosphere that may contribute to ozone formation, they also remove significant amounts of CO, SO_2, NO_x, O_3, and PM from the air, and cool the air through shade and transpiration, thus reducing VOC emissions from other sources. There is some debate about the relative reactivity of biogenic emissions, that is, their tendency to form ozone. Further investigation is needed to adequately understand their role. Although biogenic VOC emissions are important in the modeling of ozone formation, reduction of such emissions is not considered to be practical or desirable. Biogenic sources generally emit negligible amounts of NO_x.

Figure 9 shows man-made (excluding biogenic) emissions of VOCs and NO_x, with VOC and NO_x emissions allocated to source categories according to the 1996 Periodic Emission Inventory. Although the 1996 Periodic Emission Inventory is the most recent report of regional emissions of both VOCs and NO_x, emissions inventories are regularly updated as new information becomes available. The inventories used for the 2000 ozone modeling will be somewhat different than those show in Figure 9.

In 1996, all eight counties of the nonattainment area emitted VOCs and NO_x. While Harris County is the single largest source of emissions, per capita emissions are greater in most of the other counties (Figure 10).

a) Total 722 tons VOCs per Day



b) Total 1238 tons NO_x per Day

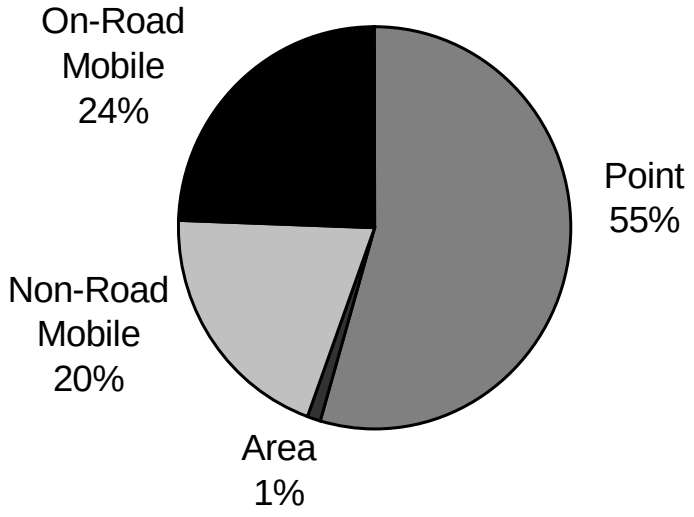


FIGURE 9: Man-made Emissions by Source Category in the Houston-Galveston Area for (a) VOCs and (b) NO_x

(Source: 1996 Periodic Emissions Inventory, TNRCC)

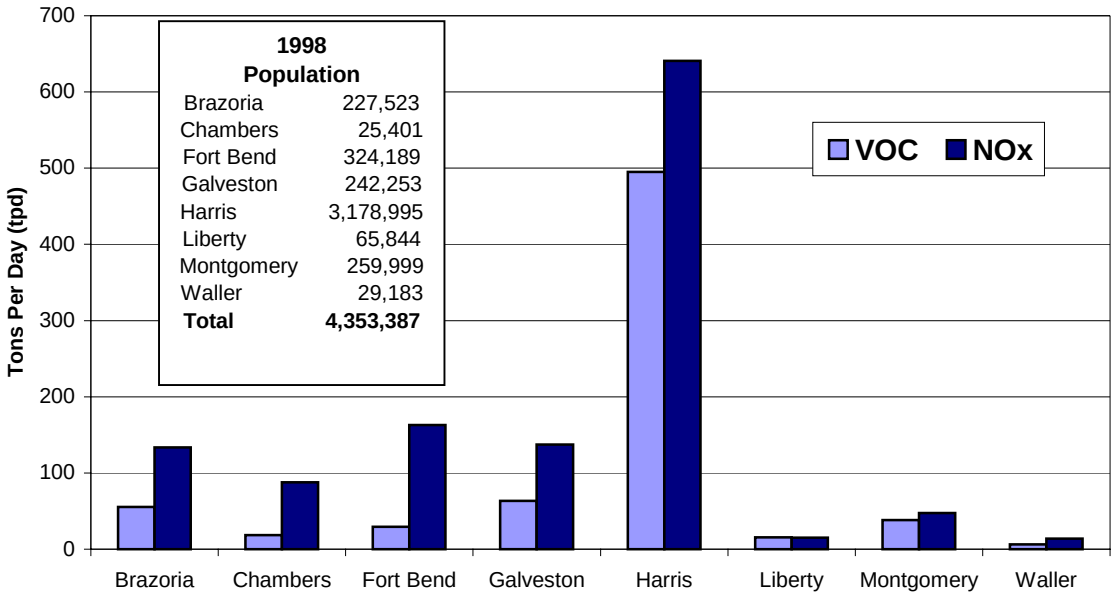


FIGURE 10: Man-made Emissions of VOCs and NO_x by County

(Source: 1996 Periodic Emissions Inventory, TNRCC, and the Texas State Data Center)

What Are We Doing to Clean Up the Air?

This section addresses what we are already doing to help clean the air and what we expect to do next.

The State Implementation Plan for the Houston-Galveston 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). A SIP is a blueprint describing how a nonattainment area will attain the standards. A SIP is a dynamic plan that is intended to be regularly revised as new information becomes available and as required by the Clean Air Act. Texas submitted its original ozone SIP for the Houston-Galveston area in 1973. The SIP has subsequently been revised many times. The Texas SIP documents are available on the TNRCC's Web site at www.tnrcc.state.tx.us/oprd/sips/cover.html.

Until recently, the primary strategy for reducing ozone concentrations in the Houston-Galveston area has been the reduction of VOC emissions. Based on emission inventories derived from numerous sources, emissions of man-made VOCs in the eight-county Houston-Galveston area have been reduced by approximately 50% between 1970 and 1990 (Figure 11).

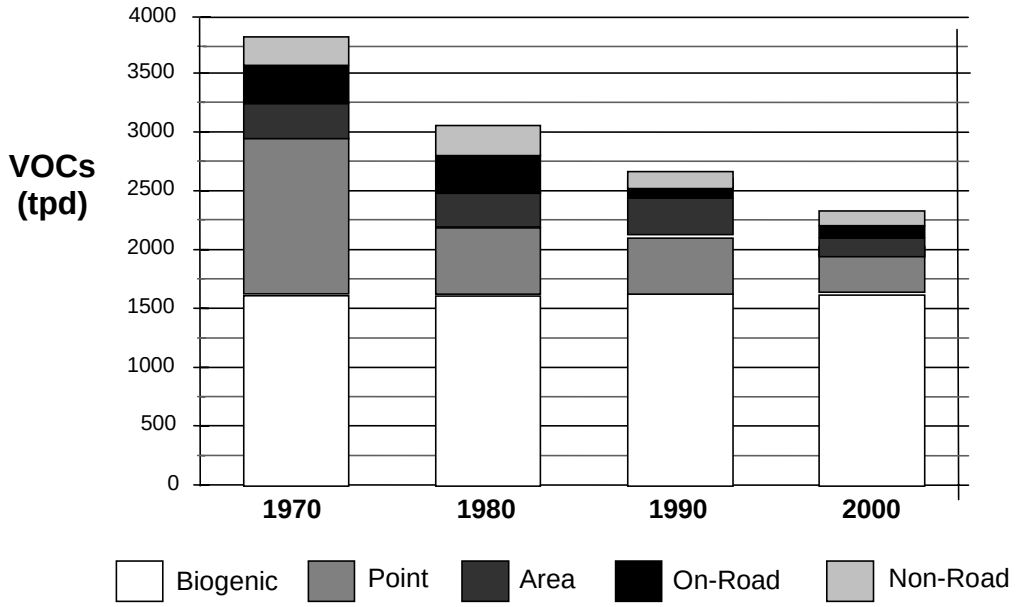


FIGURE 11: VOC Emissions in the Eight-County Area by Source Category

(source: HRM, TNRCC 1998)

Man-made emissions of VOCs are anticipated to be reduced by an additional 25% between 2000-2007. These more recent emission reductions result from new regulations affecting vehicle designs, gasoline composition, consumer products, vehicle inspection and maintenance, vehicle fueling, vessel loading, vessel cleaning, storage tanks, industrial process vents, industrial wastewater systems, industrial fugitive emissions, bakeries, printers, automobile refinishing, architectural painting, and small gasoline engines. Reductions are also expected from expansion or improvement of high occupancy vehicle lanes, traffic flow management, park-and-ride lots, public transportation, and rideshare programs.

In the SIP revision submitted to EPA in May 1998, TNRCC demonstrated, using a computer model, that although VOC reductions will reduce ozone, a reduction of 100% of the man-made VOCs would not be enough to bring the area into attainment. This is likely due to the influence of biogenic (natural) emissions within the area as well as to transported ozone and ozone precursors from outside the area. As illustrated in Figure 11, biogenic VOCs comprise a relatively large portion of total VOC emissions in the area.

The modeling also indicated that NO_x emissions from point, mobile (on-road, off-road, and non-road) and area sources would need to be reduced by 65-85% to attain the one-hour ozone standard. The modeling indicated that NO_x reductions from point sources alone would not be sufficient for attainment. Although NO_x reductions from mobile and area sources are more effective than reductions from point sources, they alone are also not sufficient for

attainment. NO_x reductions from all sources will be necessary. The modeling further indicated that an additional 15% reduction of VOC emissions will be necessary during the early stages of the NO_x reductions in order to offset what is referred to as the "NO_x disbenefit," a transitory increase in ozone levels that would occur if only NO_x emissions were initially reduced (see the Houston-Galveston SIP for a technical description of why this phenomenon would occur). The total reductions may need to be greater to offset growth in the regional population and economy.

The May 1998 SIP revision also lists various options for reducing NO_x and VOC emissions. However, in its evaluation of the May 1998 SIP revision for the Houston-Galveston area, the EPA determined that the SIP was incomplete in that it did not list sufficient specific control measures to bring the area into attainment of the one-hour ozone standard by 2007. The EPA requested that these control measures be submitted by November 1999. In early 1999, TNRCC conducted another round of modeling that included the control measures included in the May 1998 SIP revision as well as additional control measures.

The November 1999 SIP contains the following elements:

1. Photochemical modeling of potential specific control strategies for attainment of the 1-hour ozone standard in the Houston-Galveston area by attainment date of November 15, 2007.
2. An analysis of modeling scenarios reflecting various combinations of federal, state and local controls in the Houston-Galveston area.
3. Identification of the level of reductions of VOC and NOx needed to attain the one-hour ozone standard in the Houston-Galveston area by 2007.
4. 2007 mobile source emission budgets for transportation conformity.
5. Identification of specific source categories which, if controlled, could result in sufficient VOC or NOx reduction to attain the standard.
6. A schedule committing to submit by April 2000 an enforceable commitment to conduct a midcourse evaluation.
7. A schedule committing to submit modeling and adopted rules in support of the attainment demonstration by December 2000.

The emission control measures included in the November 1999 SIP include:

Stationary Sources:

- Fuel-gas treatment systems plus burner modifications for point sources in the eight-county area
- 50% NO_x reductions from all other electric utilities in eastern Texas
- 30% NO_x reductions from remaining grandfathered sources in eastern Texas

On-road Mobile Sources:

- Heavy-duty diesel vehicle standards

- National low emission vehicles (NLEV) standards
- Federal Motor Vehicle Control Program Tier 2 vehicle emission standards
- Phase II reformulated gasoline (RFG) in the Houston-Galveston eight-county area
- Federal Motor Vehicle Control Program Tier I
- Low sulfur gasoline (15 ppm)
- California diesel fuel standards
- Acceleration Simulation Mode (ASM) equivalent vehicle inspection and maintenance program in the eight-county area
- Accelerated replacement of older vehicles
- Yet-to-be defined transportation control measures

Non-road Mobile Sources:

- Heavy duty diesel vehicle standards
- Locomotive standards
- Compression ignition standards for vehicles and equipment
- Spark ignition standards for vehicles and equipment
- California recreational vehicle standards
- Commercial marine vessel standards
- Recreational marine standards
- California gasoline standards
- California diesel fuel standards
- Initiate a ban on use of specified construction equipment from 6 a.m. to noon

Area Sources

- Low NO_x standards for new water heaters and furnaces
- Stage I vapor recovery at service stations in other areas of eastern Texas
- Regional reductions from EPA mandates

The November 1999 SIP was developed by the TNRCC with significant input from the local community. The SIP included a list of measures that came close to demonstrating attainment. TNRCC's most stringent scenario resulted in a reduction of 645 tons per day of NO_x and 30 tons per day of VOC from the 2007 projection. A gap of 118 tons per day remains between the SIP and the target emissions level of 289 tons per day needed for attainment.

In late 1999, EPA engaged in settlement negotiations with the Environmental Defense and Natural Resources Defense Council regarding the requirements to demonstrate attainment, and led to a requirement imposed after the 1999 SIP submittal. TNRCC was therefore required to submit another SIP revision that addressed the gap in April 2000.

The April 2000 "Gap" SIP contains the following commitments by TNRCC:

1. To quantify the shortfall of NO_x reductions needed for attainment.
2. To list and quantify potential control measures to meet the shortfall of NO_x reductions needed for attainment.
3. To adopt the majority of the necessary rules for the Houston-Galveston area attainment demonstration by December 31,2000 and to adopt the rest of the shortfall rules as expeditiously as practical, but no later than July 31, 2001.
4. To submit a 1999 Rate-of-Progress (ROP) SIP by December 31, 2000.
5. To perform a mid-course review by May 1, 2004.
6. To perform modeling of mobile source emissions using MOBILE6, to revise the onroad mobile source emission budgets (MVEB) as needed and to submit the revised budgets within 24 months of the model's release. In addition, if a conformity analysis is to be performed between 12 and 24 months after the MOBILE6 release, TNRCC will revise the MVEB so that the conformity analysis and the SIP are calculated on the same basis.

EPA analyzed the November 1999 SIP and determined that there was a gap of 118 tons per day between the reductions in the plan and those needed for attainment. EPA required the immediate submittal of further control measures and commitments as the April 2000 SIP.

On August 9, 2000, the TNRCC Commission adopted a proposal of control measures (see Appendix G) to meet the commitments established in the "Gap" SIP. Figures 12 and 13 show the future emissions in 2007 with and without the regulations in the SIP. During September 2000, TNRCC will be soliciting comments from the public on the rules developed to implement the majority of the control measures from the November 1999 and April 2000 SIPs, and will submit the revised SIP to EPA by December 2000. TNRCC may also submit, by July 31, 2001, additional rules for the measures identified in the April 2000 SIP, if additional time is needed to complete the public input and evaluation process for a small number of new measures.

Dallas-Fort Worth was required to submit the rules for their SIP control measures before the Houston-Galveston area. Many of the rules adopted for Dallas are expected to be applied in the Houston-Galveston area as well.

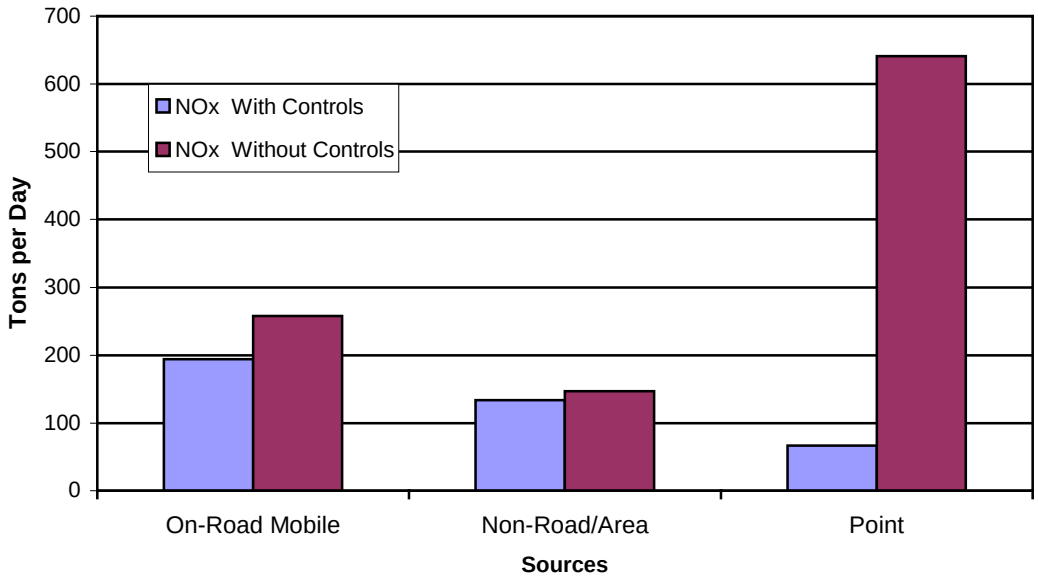


FIGURE 12: 2007 Total NO_x Tons per Day, With and Without Controls
(Source: TNRCC August 9, Proposed 2000 Attainment Demonstration SIP)

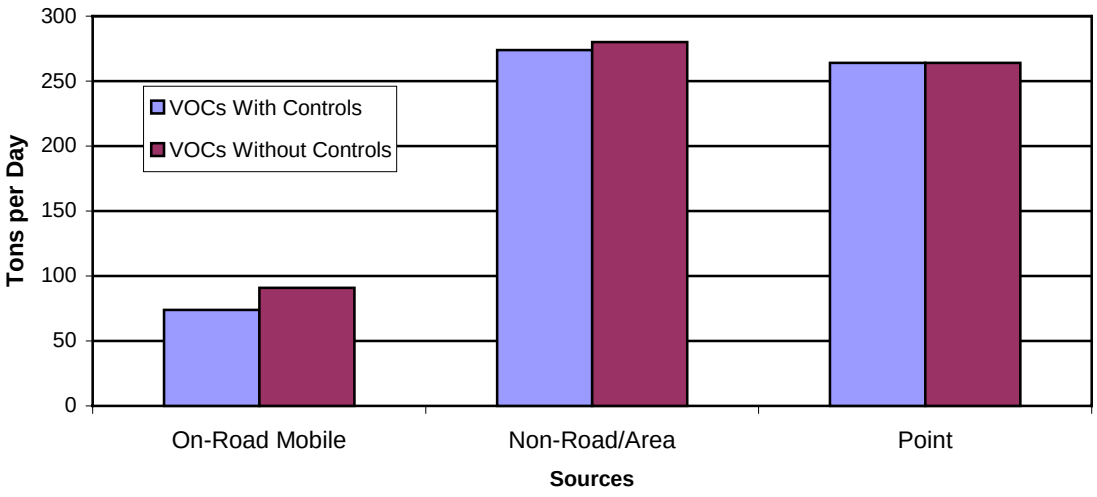


FIGURE 13: 2007 Total VOCs Tons per Day, With and Without Controls
(Source: TNRCC August 9, Proposed 2000 Attainment Demonstration SIP)

Voluntary Emission Reductions by Grandfathered Facilities

When the Texas Clean Air Act (TCAA) was revised in 1971, one of the revisions was the addition of a new air permit requirement for “facilities” that are stationary sources of air contaminants, such as furnaces and boilers, either by themselves or in a plant. Beginning in 1971, before a new facility can be constructed, an air permit must be obtained from the TNRCC and the new facility must use the "best available control technology" (BACT) to control air emissions. For facilities that were already in existence in 1971, which are called existing facilities, the TCAA did not require them to obtain an air permit until the facility was later 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 install BACT. These unmodified existing facilities are referred to as "grandfathered" facilities. The concept of grandfathering is not unique to Texas.

Although grandfathered facilities are not required to obtain an air permit and install BACT, they are subject to other state and federal requirements regarding air emissions. TNRCC currently has authority to require the installation of additional controls on grandfathered facilities, as well as permitted facilities, to control air pollution. For example, TNRCC has adopted extensive regulations for controlling VOCs at facilities such as petroleum refineries, chemical plants, and other industrial facilities. So far, TNRCC has adopted regulations for controlling NO_x that will result in a reduction of about 5% of total NO_x in the eight-county area. However, significant new NO_x control rules are anticipated in the next few years to implement the measures listed in the November 1999 and April 2000 SIPs. These new regulations will apply equally to grandfathered and permitted facilities.

To encourage grandfathered facilities to voluntarily reduce emissions and apply for a voluntary permit, in 1997 the Texas Legislature enacted House Bill 3019 that directed TNRCC to develop a voluntary emissions reduction plan for grandfathered facilities. To accomplish this, TNRCC appointed an eleven-member advisory panel, the Clean Air Responsibility Enterprise (CARE) Advisory Committee which provided its recommendations to TNRCC in December 1997. In 1999, the Texas Legislature enacted Senate Bill 766 that provides incentives to companies and additional authority for TNRCC to promote voluntary emission reductions through permits for grandfathered facilities. The Texas Legislature intends to review the progress on permitting grandfathered facilities during the 2001 Legislature. To date, approximately 22 companies in the eight-county area have submitted applications to permit their grandfathered facilities, and some have already obtained permits.

Inspection and Maintenance (I&M)

At present the TNRCC is considering a more stringent Inspection & Maintenance (I/M) program, including a new type of tailpipe emissions test. The Texas Motorist's Choice (TMC) vehicle emissions testing program is currently in place for cars registered in Harris County. TMC requires an annual inspection at certified vehicle emissions inspection stations. Though this two-speed idle program is relatively easy to run and inexpensive, it cannot measure NO_x emissions. The November 1999 SIP includes the adoption of the Acceleration Simulation Mode (ASM) and On-Board Diagnostic (OBD)-II system testing. These testing programs are more accurate than the TMC system. The ASM test measures emissions while a vehicle is on a treadmill that simulates driving conditions. The OBD-II, a new onboard computer system installed in all cars beginning in the mid-1990s, measures engine performance. Through a simple cable connection, a car technician can analyze a variety of data and, if necessary, adjust the system to minimize emissions. ASM tests are presently used in California, New York, New Jersey, and Georgia. If implemented in all eight counties, the ASM + OBD-II combined program could reduce NO_x emissions by 50 tons per day.

Remote sensor inspections to identify gross polluters in the commuter traffic from the counties surrounding Harris County is currently a part of the Department of Public Safety. Identification and repair of vehicles that are high emitters are extremely important in enabling the area to offset anticipated increases from a projected 2% annual increase in vehicle miles traveled.

Vehicle Emission Standards

One of the most significant pollution controls established through the CAA is 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 of 1999, the EPA announced its newest program to further reduce harmful air pollution from vehicles. Known as Tier 2, the new emissions standard is 0.07 grams per mile for nitrogen oxides and for the first time ever, subjects gasoline and diesel sport utility vehicles and light-duty trucks to the same emission standards as automobiles, starting with model year 2004 vehicles. The standard will reduce NO_x emitted from new cars by 77% and NO_x emitted from sport utility vehicles and light-duty trucks by up to 95%. Standards for vehicles under 6,000 pounds will be phased-in between 2004 and 2007, and for passenger vehicles weighing from 6,000 to 10,000 pounds will be phased in through 2009. The Tier 2 rule also requires a 90% reduction in the sulfur content of gasoline.

The California vehicle program is the only other alternative set of new emission standards allowed under federal law. The program requires the automobile industry to sell 10% of inventory in participating states as zero emission vehicles. California, New York,

Massachusetts, Maine, and Vermont have all adopted the California program.

In May 2000, the U.S. EPA proposed new standards to significantly reduce emissions from heavy-duty diesel engines and vehicles through a phase-in approach between 2007-2010. Corresponding low sulfur diesel fuel requirements would take effect in 2006. The proposed standards would reduce NO_x from these vehicles by 95% and particulate matter by 90%. The standards are expected to be finalized in December 2000.

Fleet Vehicle Requirements

The CAA requires that, in severe ozone nonattainment areas like the Houston-Galveston area, a steadily increasing percentage of fleet vehicles meet a set of stricter emission standards. These standards include the Low Emission Vehicle (LEV), Ultra Low Emission Vehicle (ULEV), Inherently Low Emission Vehicle (ILEV), and Zero Emission Vehicle (ZEV) standards. ZEV cars result in 100% less emissions from the vehicle than conventional cars, although there may be increased emissions from power generation sources for electric ZEVs. Although the only form of ZEV currently commercially available is electrically powered with a rechargeable battery, other power sources such as fuel cells are being developed. Some of these power sources, such as fuel cells, might eliminate power plant emissions in addition to operational emissions.

As an example of the effects of the standards, the LEV standard for cars results is 70% less VOC emissions and 50% less NO_x emissions than conventional 1996 vehicles (which themselves must meet standards that are less polluting than 1989 vehicle standards). In many instances, these stricter vehicle emission standards may encourage the use of alternative fuels such as natural gas or electricity. In the Texas Clean Fleet Program, the LEV emission standards are required for private fleets of more than 25 vehicles and local for government fleets of more than 15 vehicles in the Dallas-Fort. Worth, Houston-Galveston, and El Paso nonattainment areas. They are not required for vehicles purchased by the general public.

Cleaner Fuels - Gasoline

Since January 1, 1995, 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. The use of RFG has resulted in significant reductions in volatile organic compounds and, to a lesser extent, nitrogen oxides in this region. One of the components of RFG is an oxygenate which helps the gas to burn more cleanly. In the Houston area, methyl tertiary butyl ether (MTBE) has been the oxygenate of choice. However, growing concerns about the role of MTBE in water contamination has led to a recent decision by the EPA to phase out the use of MTBE in favor of other oxygenates, such as ethanol.

Beginning in January 2000, more stringent RFG standards (Phase II RFG) replaced

RFG in the Houston-Galveston nonattainment area. Phase II RFG will remove an additional 41,000 tons of smog-forming pollutants, an equivalent of 6 million cars nationwide, from the air. Compared to conventional gasoline, Phase II RFG will cut the release of VOCs by 27%, and NO_x emissions by 7%.

To support the new Tier 2 vehicle standards, the EPA also reduced the amount of sulfur in gasoline. By 2006, the sulfur allowed in gasoline will be 80 ppm sulfur; most refineries will be required to produce gasoline averaging no more than 30 ppm sulfur.

Cleaner Fuels - Diesel Fuel

Since October 1, 1994, federal law has allowed a maximum of 500 ppm sulfur diesel fuel for use in on-road vehicles). California diesel fuel allows the same 500 ppm but requires low aromatics (10% aromatics maximum compared to 25-35% aromatics in typical on-road diesel). While the federal low sulfur diesel fuel has had only minimal impacts on nitrogen oxide reductions, it has resulted in larger reductions in sulfur and particulates. The California diesel has been much more effective at reducing nitrogen oxide emissions than the federal low sulfur diesel.

In May 2000, the EPA proposed rules to limit sulfur in diesel fuel to a maximum of 15 ppm, effective in 2007. Reduced sulfur content is required to allow advanced pollution control technologies, particulate traps, and catalytic treatments to be effective in diesel vehicles. Reduced sulfur content has also shown to extend engine life and reduce maintenance costs. Low sulfur diesel is projected to reduce particulates by 10–20% and nitrogen oxides by 7–10%. In addition to sulfur reductions, the proposed rule also calls for a reduction in diesel exhaust particulates, from 0.10 to 0.01 grams per unit of engine energy, and a reduction in nitrogen oxide emissions from 0.25 to 0.20 grams per unit of engine energy. The final rules are expected to be adopted by December 2000.

Cleaner Fuels - Alternative Fuels

In addition to cleaner burning gasoline and diesel, alternative fuels are another category of cleaner fuels. These fuels 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 (CNG) and propane (LPG), which are gaseous rather than liquid fuels. These fuels require special hardware in order to be used with an internal combustion engine and must be kept at a constant high pressure, usually between 2,800 and 3,200 psi. CNG and LPG vehicles must also meet federal requirements for fuel tanks that are more stringent than those for conventional vehicles and fueling equipment is required to pressurize the fuel. Although these vehicles make up a very small percentage of the total vehicle population, automakers are producing more vehicles that are equipped to run on these fuels, and the fueling infrastructure is growing. Other alternative fuels include electricity (from batteries or fuel cells), ethanol, methanol, and

biodiesel. The advantage of using alternate fuels is that they burn cleaner without the use of additives, and produce virtually no particulates. Currently, the majority of vehicles running on these fuels are in government fleets that are under legislative mandate to run cleaner.

Transportation Conformity

As the area Metropolitan Planning Organization (MPO) for the region, the Houston-Galveston Area Council (H-GAC), acting through its Transportation Policy Council (TPC) and working in conjunction with the TNRCC, must ensure that the regional transportation system contributes to improving air quality. As a nonattainment area, the MPO must demonstrate that the Metropolitan Transportation Plan (MTP), a 20-year long-range transportation plan, and the Transportation Improvement Program (TIP), a three-year implementation plan, "conform" to the air pollution reduction goals laid out in the SIP. To conform, the eight-county nonattainment area cannot have an increase in on-road mobile source-generated VOC or NO_x emissions from those shown in the 1990 emissions inventory, even if the area experiences significant increases in vehicle miles traveled. The area must also show that transportation emissions continue to decline throughout the long-range transportation planning time, and that the area is meeting the SIP commitments it has made.

Emissions Budgets

SIPs must contain separate VOC and NO_x ceilings every third year (such as 1993, 1996 and 1999) the total emissions that cars, trucks and other vehicles operating in the area's transportation system may produce. These ceilings, known as "emissions budgets," are intended to apply discipline to local planning. To keep within emissions budgets, MPOs are expected to offset potential emission increases from new road construction with measures that are projected to reduce emissions, such as HOV lanes, grade separations, public transit projects, and carpooling incentives.

Transportation Conformity Lapse Situations

Whenever a change is made to a transportation plan in a nonattainment area, federal rules state that the revisions must adhere to the region's air quality plan. To receive federal approval, a new or revised transportation plan must show exactly how much pollution will be added to or subtracted from the region. Once these changes are modeled, the new SIP must be recertified by the EPA within an eighteen-month period, or conformity will lapse. A number of nonattainment areas throughout the country are currently in a conformity lapse. A conformity lapse allows only those transportation projects that are exempt from federal air quality conformity requirements (safety, maintenance, bicycle/ pedestrian projects), or be Transportation Control Measures (TCMs) that reduce emissions by improving traffic flow, reducing congestion or reducing vehicle use, to proceed. A lapsed area cannot increase roadway capacity until it demonstrates conformity. In November 1999, the Houston-Galveston

eight-county area found itself in a lapse. This lapse was resolved in May 2000. A further conformity demonstration must be completed by May 2001.

State Strategies

TNRCC has proposed an initiative to adopt some VOC and NO_x controls in most of eastern Texas**.** Portions of the plan, formerly known as the Texas Clean Air Strategy (TCAS), were adopted in the summer of 1999. The VOC and NO_x emission reductions from this program are expected to reduce ozone levels somewhat in the Houston-Galveston nonattainment area. The reductions are also expected to reduce ozone in other nonattainment areas and near-nonattainment areas.

Small Business Regulations

The TNRCC has adopted regulations and rules that affect area sources in the eight-county area. These regulations include not only emission limits, but also record-keeping, testing and deadline requirements. The following are examples of the regulations and rules affecting different types of small businesses.

Auto paint and body shops that exceed certain usage levels must install paint booths that have filters, utilize high transfer-efficiency spray guns, and utilize gun cleaners. There are also housekeeping and record-keeping requirements. Coatings and solvents used in paint and body shops must meet VOC emission limits.

Manufacturers of wood products (cabinets, furniture, etc.) have rules regulating their air emissions. As a result, businesses that exceed certain usage levels must utilize filtration equipment and exhaust systems for coatings, solvents, and stripping agents. There are also requirements for appropriate record keeping.

Foundries must meet certain requirements and be either exempted or have an air permit for their facility and processes. Foundries are also limited in the amount of visible emissions and sulfur dioxide coming from their facilities.

Automotive service shops that repair automobile engines, radiators, brakes, etc. must comply with regulations governing parts washers and other solvent applications. These regulations include limits on the amounts of solvents that can be used and the types of machines in which they can be used.

Metal finishers, specifically hard and decorative chromium platers and anodizers, have rules regulating their air emissions. The rules contain requirements for controls and record-keeping. Also included are testing and reporting deadlines.

Dry cleaners are affected by regulations that may require an air permit. The standards differ for a petroleum-based cleaning agent and a perchloroethylene-based cleaning agent.

Both cleaning agents have certain testing and record keeping requirements.

Gasoline-dispensing facilities that pump more than a certain amount of product each month are required to have vapor recovery devices on their storage tanks and on the delivery hoses through which gasoline is transferred into a vehicle. Record-keeping and pollution control devices are also required.

For more information, contact the TNRCC Small Business and Environmental Assistance Division at 713-767-3582, or the Small Business Assistance Program in Austin at 800-447-2827.

Consumer Products

Consumer and commercial products such as metal cleaning solvents, personal care products and household cleaning products contribute significantly to VOC emissions. Use of these products results in about six million tons of emissions each year. Recognizing these emissions, the TNRCC issued rules in 1994 to regulate emissions from 24 consumer product categories. The TNRCC rules were similar to rules in place in California. These rules were expected to reduce emissions from consumer products by 20%. As required by the 1990 Clean Air Act Amendments, the EPA issued rules in 1998 to regulate emissions from these same 24 categories. The EPA rules are quite similar to the Texas and California rules but apply nationwide.

Local Initiatives

In addition to controls considered for inclusion in the next SIP revision, the following efforts have been initiated at the local level.

Regional Air Quality Planning Committee

The Regional Air Quality Planning Committee (RAQPC) was created in 1991 to advise the H-GAC board of directors and Transportation Policy Council on issues relating to air quality. RAQPC is composed of 26 representatives of local government; environmental, public health and citizen groups; and business and industry from all eight counties of the nonattainment area. The committee conducts monthly meetings, which are open to the public.

Principles for Cleaner Air

In January 1999, the H-GAC Board of Directors, Harris County, the City of Houston, and area business and environmental leaders participated in a news conference to endorse nine principles that address regional air quality. The *Principles for Cleaner Air* (Appendix C) provide a framework for developing a regional consensus on air pollution reduction measures, and endorsement of the *Principles* represents a willingness of diverse interest groups to work together for cleaner air. To date over 70 area governments, agencies and organizations,

including environmental groups, technical and professional societies, civic organizations, chambers of commerce, and economic development groups, have endorsed the *Principles for Cleaner Air*, and it is hoped that additional endorsements will be added during the year. H-GAC has prepared a videotape and educational packet, available to any group or organization on request, which discusses the area's pollution problems and the *Principles*.

Houston Air eXcellence and Leadership (HAXL) Program

The City of Houston has been working on an alternative air quality strategy called the Houston Air eXcellence and Leadership (HAXL) Program. The HAXL differs from the approaches of the federal CAA in that it is (1) driven primarily by studies of local air pollution problems, (2) focuses on the health benefits to be obtained from air pollution controls, and (3) takes a more holistic approach, addressing not only ozone, but also particulates, air toxics and any other pollutants that studies indicate have a significant health effect on area residents, regardless of their attainment status. During 1999, HAXL obtained funding for a major economic study of the health benefits of reducing area pollution. The final results of this study, "Assessment of the Health Benefits of Improving Air Quality in Houston, TX" by Sonoma Technologies, Inc., were released in November 1999 (see Research Initiatives).

The Clean Air Action Program

The federally funded Clean Air Action Program is a public outreach program of the Houston-Galveston Area Council. Its goal is to assist the region in attaining compliance with federal air quality standards by reducing ground-level ozone pollution. It is designed to complement and support existing air quality and related transportation outreach efforts throughout the eight-county area. The program works with representatives from the U.S. EPA and TNRCC, local governments, business and industry, chambers of commerce, environmental and health organizations, transportation agencies, public interest groups, and schools.

The Clean Air Action program uses the "Principles for Cleaner Air," educates the public on the health hazards of exposures to high levels of ozone smog and encourages voluntary actions (Appendix C) to reduce vehicle emissions. Program elements include media and public service programs, public affairs programming, an ongoing public relations campaign, and participation in special events throughout the region. The largest incentive to encourage significant emission reductions has been the August "Clean Air Month" promotion during which all METRO bus fares have been subsidized by 50%. This September, Clean Air Action will also participate in "Commute Solutions Month," an annual regional campaign for commute alternatives jointly promoted in the Austin, San Antonio and Houston-Galveston areas.

Houston-Galveston-Brazoria Ozone Communication System

Ozone Watch/Warning – System

The new ozone watch/warning system for the Houston-Galveston-Brazoria ozone nonattainment area is a collaboration among public, private and not-for-profit groups to connect resources and utilize available technology to better inform the public on air quality status, especially ground-level ozone levels. The system is operated jointly by the TNRCC; City of Houston Department of Health and Human Services, Bureau of Air Quality Control (BAQC); Galveston County Health Department Pollution Control; Harris County Office of Emergency Management (OEM) and Health and Environmental Services Department; H-GAC's Clean Air Action Program; Houston Regional Monitoring Corporation (HRM); and the National Weather Service (NWS).

The ozone readings from which ozone watches and warnings will be generated come from the regional network of 23 outdoor ozone monitors which are connected to one central computer operated by the TNRCC in Austin. When any of these monitors detects ozone above the federal health standard for outdoor air, the TNRCC computer sends a notice to the Harris County Office of Emergency Management (OEM) server. The Harris County OEM server then sends emails and pager notifications to those who have signed up to be notified. Additional ozone warnings will be issued when additional monitors detect ozone over the federal health standard. No "all clear" will be issued after ozone levels drop. This is primarily because ozone typically dissipates after sunset. Real-time pictures of ozone conditions are available on the TNRCC web site.

As of June 2000 over 1000 entities, including schools, media, businesses, and private citizens have requested to be notified. Anyone who has access to email can request to be included at http://www.hcoem.org. The City of Houston Health Department, the Harris County Pollution Control and the H-GAC's Clean Air Action Program also issue fax broadcasts in parallel with the new email system.

Ozone Warning – Levels

Ozone Warnings indicating the level of air pollution and recommended actions to take are a new feature of the Ozone Warning system. The system now uses the Air Quality Index (AQI) established by the EPA in 1999. This system includes colors and ranks the quality of outdoor air. Although the AQI system can be used on any criteria pollution, in the Houston area the system is used almost exclusively for one-hour ozone levels.

Air Quality Index

Index Value	Descriptor	Color	1 Hr. Ozone ppb
0-50	Good	Green	---
51-100	Moderate	Yellow	---
101-150	Unhealthy for Sensitive Groups	Orange	125-164
151-200	Unhealthy	Red	165-204
201-300	Very Unhealthy	Purple	205-404
300-500	Hazardous	Maroon	405-604

When any of the monitors detects ozone in the "unhealthy" (level red) or "very unhealthy" (level purple) ranges, the TNRCC notifies the NWS which generates an ozone warning message for immediate broadcast. This is sent out to all media outlets. It is also available to all other users who have access to the NWS information and is posted on the NWS Web page. This warning will be re-issued if the Ozone Warning is upgraded from Level Red to Level Purple. When the initial NWS Ozone Warning (Level Red or Level Purple) is issued, it will be broadcast on the weather radio in both Galveston and Houston with a tone alert. If the Ozone Warning is upgraded from Level Red to Level Purple, a new message will be generated and will be broadcast on the weather radio with a tone alert. Text for the warnings was developed by a collaboration among implementers and stakeholders.

City of Houston Clean Air Initiatives

In addition to its support of the HAXL program, RAQPC, and the Principles for Cleaner Air, the City of Houston has recently initiated two programs, a list of recommendations for city actions (Appendix D) aimed at reducing particulates, and a list of recommendations for city actions (Appendix E) aimed at reducing emissions. The two plans are intended to demonstrate the commitment of the City's leadership to making real improvements in public health by enhancing the City's air quality through focusing on ozone and fine particulate reductions as well as a multipollutant approach, reducing the contributions of City operations to air pollution, pursuing local commitments to reduce emissions, and advocating for strong state and federal controls on vehicles, equipment and fuels.

In 1998 the City commissioned the "Sonoma Study" (see Research Initiatives) to look at the health effects caused by area pollution, and in early 1999 created a new bureau, the Bureau of Air Policy (BAP), within the City's Department of Health and Human Services. The BAP coordinates multiple internal and external stakeholder groups to develop a comprehensive, coherent and consistent approach to addressing air issues. The BAP will expand the City of Houston's focus on local public health issues relating to air quality and cleaning the air. The current City of Houston Bureau of Air Quality Control (BAQC) will continue to monitor the air, report on air quality, enforce permits, and inspect facilities for

compliance with air regulations.

In January 1999 the City of Houston signed an agreement with the EPA to participate in its Urban Heat Island Reduction Initiative (HIRI). This initiative will explore ways to lower the increased temperatures associated with the heat island effect (Appendix F), as well as the role that heat island reduction can play in reducing urban ozone concentrations. Under this Heat Island Reduction Initiative, the EPA and the City of Houston will work together for the next two years to develop a broad-scale program that:

- determines the effectiveness of heat island mitigation measures on the region's air quality problem,
- implements cost-effective heat island mitigation measures within a few years, and
- quantifies the projected ozone reductions so that they may potentially be included in the State Implementation Plan.

Business Coalition for Clean Air

The Business Coalition for Clean Air is a project of the Greater Houston Partnership. It endeavors to bring together business interests in the eight-county nonattainment area to explore effective, feasible strategies to reduce ozone levels. It is currently engaged in four primary projects: a technical feasibility study, to determine the technical feasibility of varying levels of industrial and other controls; an economic analysis which will estimate costs of new controls relative to costs in the area that could be incurred if ozone air quality is not improved; a comprehensive public information and education campaign that will reach both member companies' employees and the community as a whole; and advocacy work with local, state, and national elected officials.

Clean Air Partnership

Mayor Brown, Judge Eckels, and the Chairman of the BCCA have formed the Clean Air Partnership. The core group of local leaders, with representation for the environmental community, health profession, and civic organizations, will serve as a voice of unified leadership on clean air issues in the region. The group will also serve to coordinate and communicate various efforts underway by each Partner to optimize the effectiveness of these efforts.

Harris County Tax Abatement Initiative

In June of 1998, Harris County Commissioners Court modified their review criteria for considering tax abatements designed to encourage economic and job-market growth. The review was enhanced by requiring consideration of environmental and quality-of-life criteria, such as past environmental and safety performance records. There are four environmental elements of the tax abatement policy:

1. The environmental impact of the proposed project must be provided in the initial

general description of the project.

2. The guidelines specify that Commissioners Court has broad discretion to evaluate environmental performance of all facilities operated by the owner, as well as by the parent, subsidiary or every other member of a joint venture or partnership applying for the tax abatement.
3. The application must contain a history of environmental compliance for all facilities located in the State of Texas.
4. Any plant receiving a tax abatement that has a grandfathered facility on site must commit to submit a technically complete permit application to the TNRCC within three years of receiving the abatement.

Houston Environmental Foresight Program

Houston Environmental Foresight is a non-governmental, consensus-based program convened by the Houston Advanced Research Center (HARC) to develop recommendations that address high priority regional environmental issues, including air pollution. During Phase One (1994 to 1997), air pollution was identified as one of the highest priority issues facing the region. In Phase Two (1998 to 2000), a broad-based stakeholder working group was organized. The group includes business, industry, health, environmental, and government representatives, representatives of minority and affected groups, and university and industry experts. The working group (1) examined current efforts being made to address issues surrounding outdoor air pollution and indoor air contamination; (2) identified gaps and needs for further research and education; (3) explored interrelationships with health, population growth, transportation, and other environmental issues; (4) examined long-term as well as short-term strategies, including non-regulatory and voluntary measures, for reducing ozone, particulates, and air toxics; and (5) developed recommendations directed toward decision-makers and the public. These recommendations will be published in the summer of 2000. Foresight Phase Three will focus on outreach, education and special events designed to raise awareness about issues discussed in the recommendations. Foresight is supported by various foundations, public agencies and businesses.

Smart Growth / Sustainable Development

Because of the anticipated growth in the area, future clean air will depend heavily on the manner in which the area develops in coming years. Smart Growth initiatives around the country address long-term planning, coordination of planning among stakeholders, regional transportation, protection of greenspace, energy efficiency, pedestrian-oriented development, and other issues relating to long-term growth and quality of life. In the Houston region, the Gulf Coast Institute (GCI) and the City of Houston's Department of Planning and Development are particularly active in examining these issues. The GCI is a broad-based nonprofit organization that focuses on coordinating the efforts of various stakeholders, and disseminating

information on smart growth programs (www.livablehouston.org). In 1999, the GCI sponsored a conference called "Strategies for Smart Growth" for architects, planners, and developers, and was a co-sponsor of "Houston Cool and Green!," a two-day workshop that focused on the urban heat island effect (see Appendix F). GCI also issues a weekly electronic newsletter, *Gulf Coast Growth News*, and facilitates the Houston Gulf Coast Smart Growth Initiative, which meets monthly and has several task forces.

The concept of Sustainable Development complements that of Smart Growth, but tends to focus more on sustainable economic development initiatives, such as economic enterprise zones and more efficient processes that use less energy and create less pollution. A number of sustainability initiatives are currently active in the Houston area. The University of Health Science Center Sustainability Program, based on The Natural Step process, has led to millions of dollars of savings in electricity and water costs, improved indoor air quality, and long-term investment in sustainable practices including photovoltaics, campuswide composting, and education programs. A number of industries, including area refineries and Port of Houston Authority tenants, are participating in the TNRCC's Permanent Pollution Prevention Program (P4) which focuses on reducing energy consumption and "nonproduct" output (i.e., waste and pollution), while simultaneously increasing profits. In 1999, the Center for Global Studies (CGS) of the Houston Advanced Research Center, the Community Design Assistance Center, Inc., Courtney Harper Partners Architects, Flora Yun Yeh Landscape Architect and Texas A&M Engineering Extension Service, in collaboration with the City of Houston Planning and Development Department, published the *Houston Corridor Guide to Sustainable Development for Enhanced Enterprise Community Corridors in Houston, Texas.* Other recent sustainability publications produced by the CGS include *Sustainable Corporations: Reconciling Wealth Creation with Global Sustainability* (1999), and *Corporate Incentives and Environmental Decision Making: A Case Studies and Workshop Report* (September 1999). These documents are available online at www.harc.edu/cgs/publications.html. The CGS will also be hosting a workshop, "Corporate Decisions, Incentives and Tools: Making Sustainability Work in the 21st Century," on January 28-30, 2001, in The Woodlands.

Area Emission Reduction Credit Organization

Under the authority of the CAA, Area Emission Reduction Credit Organizations (AERCO) were created by the Texas legislature to encourage the improvement of air quality while helping to mitigate the adverse economic impacts of control strategies on nonattainment areas. AERCOs in nonattainment areas may buy and sell credits, which are tracked in tons per year of emissions reduced within a nonattainment area. Certified emission reduction credits are granted by the TNRCC to sources, typically industrial, when quantifiable reductions are made in excess of the allowable permitted emissions. All credits are certified with TNRCC's Emission Banking Program.

The CAA allows for industrial sources to purchase air emission credits in nonattainment areas when building a new or expanding an existing facility, if offset elsewhere in the nonattainment area. The CAA requires that the emission reductions offset the new emissions by a 1.3 to 1.0 ratio in severe nonattainment areas, such as the Houston-Galveston nonattainment area. The emission reductions may take place anywhere in the Houston-Galveston nonattainment area. Emission credits (in tons per year) may also be purchased by environmental, governmental or other entities or individuals for the purpose of removing the emissions from the market.

Transportation Programs

Transportation has a significant affect on air quality. As noted earlier, 24% of both VOCs and NO_x in the non-attainment area come from on-road mobile sources. Current programs focused on on-road emission reductions include METRO projects, Commute Solutions, the Regional Bicycle and Pedestrian Plan, Transportation Control Measures (TCMs), Transportation Conformity, Clean Fuels, and the Greater Houston Regional Clean Cities Program. Although few local programs currently address emissions from off-road mobile transportation sources, such as planes, trains, ships and construction equipment, these sources are significant contributors to area pollution and controls for these sources are included in the November 1999 and April 2000 SIPs.

Public Transportation Systems

Many of the transportation control measures identified in the Clean Air Act are transit-oriented and are within Metropolitan Transit Authority's (METRO) current and planned transit service and capital programs. METRO serves roughly 1,281 square miles (all in Harris County) out of the roughly 8,800 square miles in the eight-county nonattainment area. Services include 1,400 buses, along with several other alternative transportation strategies such as RideShare, Park & Ride lots, High Occupancy Vehicle (HOV) lanes, and a carpool/vanpool program. The total system ridership (including fixed route bus service; special bus services; HOV, carpool, and vanpool use; and non-METRO buses) for fiscal year 1999 was approximately 117.7 million boardings, up 5.5% from 1998. METRO is also investing in cleaner diesel technology, is retrofitting older buses with catalytic converters, and is experimenting with natural gas and electric buses to help reduce air pollution. METRO is also currently designing a light rail line down Houston's Main Street corridor to further expand mobility options within the area.

In addition to METRO, three other transit systems operate within the region. Island Transit serves the City of Galveston; Brazos Transit System serves Montgomery and Liberty counties with commuter buses and vanpools; and Connect Transportation provides an on-demand service for Brazoria County and the Texas City-LaMarque area of Galveston County.

Commute Solutions

A voluntary trip-reduction program, Commute Solutions (previously known as Regional Commute Alternative Program), is being implemented to reduce vehicle trips and/or vehicle miles traveled (VMT) throughout the eight-county Houston-Galveston Transportation Management Area (TMA). Commute Solutions is a partnership of H-GAC, METRO and the region's Transportation Management Organizations (TMOs), including The Bay Area Transportation Partnership, Downtown in Motion (Central Houston), North Houston Association, and TREK (Galleria area). The purpose of this partnership is to respond to commuters' need for a one-stop approach and unified marketing theme for alternative transportation programs in the Houston-Galveston region. Commute Solutions supports the promotion of vanpooling, carpooling, transit, telecommuting, and other transportation-related options and services. H-GAC, METRO and the TMOs will also be working together to reduce commuting trips by providing incentives and services to commuters directly. As part of the Commute Solutions initiative, these organizations will be reaching out to area employers to provide assistance and to encourage promotion of transportation alternatives to their employees. Their approach will focus on the needs of businesses such as improving employee recruitment and retention, reducing commute-related stress and increasing job satisfaction and morale.

With Commute Solutions, all trips, regardless of purpose, time of day, or maker, will count toward the area's overall trip-reduction goal. Trip reduction is an important part of the area's long-term approach to ozone attainment because eliminating vehicle trips and/or VMT reduces emissions of both VOCs and NO_x, unlike many transportation-related emission reduction measures which reduce one while increasing the other. Reducing VMT also reduces area CO, particulate, SO_2, and air toxic emissions, as well as the heat and noise associated with vehicle travel.

The Regional Bicycle and Pedestrian Plan

The Transportation Policy Council of H-GAC adopted the Regional Bicycle and Pedestrian Plan in April 1996 to ensure the continued, orderly development of bicycle and pedestrian facilities in the Houston-Galveston Transportation Management Area. Presently, there are approximately 160 miles of bicycle and pedestrian facilities, most of which are in 'master planned communities' in the unincorporated areas of the region. An additional 75 miles of construction will be completed by the end of this summer. The current long-range transportation plan calls for construction of 391 miles of on-and-off road facilities at a cost of approximately $86 million. The majority of these facilities are within the City of Houston, although Baytown, Texas City and Tomball have also received funds for bikeway projects. Once completed, over 500 miles of bicycle and pedestrian facilities (not including sidewalks) that will be interlinked in a comprehensive, cohesive network.

Transportation Control Measures (TCMs)

For the on-road mobile source category of emissions, H-GAC and the transportation project-implementing agencies have committed to a number of Transportation Control Measures (TCMs). These include high-occupancy vehicle lanes, arterial traffic flow improvements, park-and-ride lots, transit service improvements, bicycle facilities, area-wide rideshare programs, and computerized transportation management systems. Such measures are projected to contribute about 0.50 tons per day of VOC reductions in 1999

Greater Houston Regional Clean Cities Program

The Greater Houston Regional Clean Cities Program includes energy providers, fleet operators, government, and citizen organizations. The region was designated a "Clean City" in September 1997 by the U. S. Department of Energy. The Clean Cities coalition of stakeholders pledges to help clean the air and to encourage national energy security through the use of alternative fuel vehicles and development of alternative fuel infrastructure in the region.

Research Initiatives

Assessment of the Health Benefits of Improving Air Quality in Houston, Texas

The so-called "Sonoma Study," commissioned by the City of Houston, addressed the potential health and economic benefits of reducing area air pollution. Researchers from Sonoma Technology, Inc., California State University and the University of California, Irvine performed the study. The overall purpose of the study was "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." Major findings included the following.

- Total annual economic benefits associated with improved health if the area were in compliance with the one-hour ozone and PM2.5 NAAQS in 2007 would be $2.9 billion to $3.1 billion.
- The health benefits of lower exposure to fine particles outweighed the benefits of reduced ozone exposure significantly.

The authors noted that numbers used in the study were very conservative, and that a number of effects could not 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 under the age of 30 years old, the health costs of air pollution-induced cancer or infections addressed, or the direct health effects of hazardous air pollutants, CO, NOx and SO2.

The Texas $PM_{2.5}$ Sampling and Analysis Study

From March 11, 1997 to March 12, 1998, outdoor PM2.5 levels were monitored at nine outdoor sites in the Houston-Galveston area by a joint effort of the City of Houston, TNRCC, and HRM. Air was also monitored at one indoor site from September 13, 1997 to March 12, 1998. Key findings of the study included:

- On regularly scheduled days (every six days), only one site (Clinton) exceeded the proposed annual NAAQS for PM2.5 of 15 μg/m3; on forecast days (days conducive to air pollution) 8 of the 9 monitors were above the annual NAAQS.
- Total carbon and sulfate were the largest contributors to PM2.5 mass in Texas, accounting for about 27% each.

Attainment status for the proposed PM2.5 standard will be based on data from the PM2.5 monitoring stations currently being installed areawide. Preliminary data appear similar to those collected during the 1997-98 study and indicate that the area will be in nonattainment for the PM2.5 NAAQS for PM2.5.

Local Medical Research

A number of studies have been done in the Houston area that have examined, for example, ozone and lung capacity; ozone and visits to Texas Children's Hospital, and allergen levels and asthma. A 1998 study looked at cancer mortality in Texas by census tract, and a 1988 study looked at air pollution and lung cancer mortality in Harris County. Other studies by area investigators have looked at occupational exposure to HAPs; others have developed experimental models to examine the effect of different air pollutants, such as particles or HAPS, on DNA or lung cells; and still others are working to establish mathematical models to accurately assess exposure.

Currently several projects and programs are of particular interest to the study of air pollution and health in the Houston-Galveston area. The Mickey Leland National Urban Air Toxics Research Center, which is housed in the University of Texas School of Public Health (UTSPH) at the Texas Medical Center, is funding a study examining personal indoor and outdoor exposure to various VOCs; the Houston component of this national study is being conducted by researchers at the UTSPH. A separate study is similarly examining personal exposure to $PM_{2.5}$.

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

Independent School District participates in a school-based asthma intervention program, funded by the National Institutes of Health, titled *Partners in School Asthma Management*; and the University of Texas Medical Branch in Galveston operates a home-based intervention program for children with asthma. Last, 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. This school-based project focuses on incorporating a baseline survey on breathing problems into the kindergarten enrollment process at 10-12 area schools to allow the creation of a central database to study the prevalence in Houston of children with breathing problems. The project will also work on educating students, school nurses and others on 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 the area residents in relation to air pollution. The estimates used in the Sonoma Study were based on studies done in other urban areas, and one of the recommendations of that study was that epidemiological studies need to be done in the area, noting the need to collect extensive data on all pollutants and to carefully control for confounders such as weather, smoking, and socioeconomic status.

The Texas 2000 Air Quality Study (TexAQS 2000)

Researchers from government laboratories, universities and industry have begun a major field study of air quality in southeast Texas, with a focus on the Houston-Galveston area. Data collection is expected to be completed by September 2000. The study will collect detailed ozone, chemical, aerosol and meteorological measurements from aircraft and at numerous ground locations. The goal of the study is to provide better understanding of the basic chemical, meteorological, and atmospheric transport processes that determine ozone and fine particle distributions, and to develop new scientific understanding that will assist policy-makers in devising optimal ozone and PM management strategies. For more information, visit www.utexas.edu/research/ceer/texaqs.

Houston PM SuperSite (Gulf Coast Aerosol Research and Characterization) Program

The U.S. EPA has awarded $3.65 million to a consortium of universities, led by The University of Texas as Austin, to study PM in the Houston region. The 16-month study will begin data collection in August 2000, and is being closely coordinated with the TexAQS 2000 (see above). The program is part of the EPA's Particulate Matter SuperSite Program, the goal of which is to collect air quality data in five distinct geographic areas of the United States to improve understanding of the sources and fates of fine particulate matter and the impact of particles on human health. In the Houston area, air samples will be obtained at three core sites and 20 peripheral sites. Parameters to be studied include the chemical make-up of PM, its

sources and formation, variations by time of day and season, how it is transported, and how it affects lung tissue. For more information, visit www.utexas.edu/research/ceer/texaqs/supersite.

CITYgreen Regional Ecosystem Analysis

This study, funded by the U.S. Department of Agriculture Forest Service and private donations, is expected to be completed by the end of summer 2000. Using CITYgreen software, digital maps and field studies, investigators led by a team from American Forests will establish the economic impact of area trees on air pollution, storm water runoff, and energy use. For more information or to review analyses of other urban areas, visit www.americanforests.org/garden/trees_cities_sprawl/urban_analysis/rea_subhome.html.

What Are Other Areas Doing?

California

California leads the nation in implementing measures to improve air quality. The state of California has established its own air quality standards, which are more stringent than the NAAQS, for five of the six ambient air pollutants. The standard for lead is the same as the NAAQS.

California has controls on most sources of air pollution in the state including transportation, industry and small businesses and real estate development. The state also regulates lawn mowers, outboard motors, outdoors lighter fluid, and many other sources.

In addition, California is a leader in reducing vehicle emissions with standards more stringent than current federal standards. The state has implemented parking-and-transportation infrastructure controls, alternative commuting programs, and a strong inspection-and-maintenance program that includes all light duty vehicles.

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, contribute VOCs, NO_x and other pollutants to the air we breathe. 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 of over 4 million in the region, these individual activities and products together create a significant portion of our air pollution. This offers an opportunity for each of us to contribute

to air quality improvement by making minor changes in our daily living patterns.

We can change our driving habits and learn to limit activities that produce VOCs and NO_x whenever possible. We can become knowledgeable consumers, purchasing and following directions carefully when using products that can pollute the air. Such changes also reduce, sometimes substantially, our own exposure to these pollutants. We can also become well-informed citizens. We can pay attention to programs, news items, and meetings about improving air quality, and offer our ideas on the topics. Everyone has the right to know the facts about pollution, and governmental agencies welcome participation by the general public. When each of us becomes involved in environmental decisions and supports programs that effectively reduce air pollution, we will make genuine progress towards improving the air quality for all of us.

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. Turn off lights not in use, use energy-efficient light bulbs and appliances, and use as little air conditioning as is reasonable and comfortable. Weather strip, caulk and insulate homes and businesses. Power generation to cool and light our homes is a large source of area NO_x emissions. The use of air conditioning in cars increases gasoline consumption (and resultant pollution) by approximately 15%.

Reduce Unnecessary Trips. Even the newer vehicles of today 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 your car emits into the air at start up.

Use Alternative Commuting Options. Carpooling, vanpooling, public transit, cycling, walking, telecommuting, and compressed work schedules are all alternative commuting options that significantly reduces the number of cars and trucks on the road and the congestion on our streets and highways, thereby reducing vehicle-emitted pollution and subsequent ozone levels. Most of these options also reduce your exposure to pollution. Consider which choices are available to you.

Avoid Quick Starts, Stop-and-Go Traffic, and Idling. 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. In addition, avoid situations that encourage idling, such as drive-throughs and long queues, 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.

Use Vapor-Recovery Systems when Refueling. All except small-volume service stations in the area have now installed vapor recovery systems to capture gasoline vapors that are released during refueling. Some systems are obvious to the motorist because of the "bellows" on the nozzle; other systems are vacuum-assisted and are less obvious. Use of either system reduces the escape of ozone precursors and toxic gasoline fumes into the air significantly (90% or more), as well as reducing your own exposure. Never "top" your tank, as this increases emissions considerably

Keep Vehicles in Good Repair. Did you know that one fouled spark plug can result in 75 times the normal VOC emissions? Or that a faulty oxygen sensor can increase VOC emissions by 4 times and CO emissions by 12 times? And that 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. If you drive, make certain your vehicle pollutes as little as possible by keeping it in good repair. 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 you money. One good way to check if your vehicle is running properly is to have its emissions tested.

Reduce Emissions from Off-Road Sources. Gasoline engines on lawn mowers, leaf blowers, chain saws, boats, and other equipment have, as a group, minimal emission controls and are therefore significant polluters. An older gas-powered lawn mower operated for one hour emits the same amount of VOCs as does a new car driven 340 miles; a chain saw operated two hours produces VOCs equivalent to driving 3,000 miles. Whenever possible, buy and use nonpolluting electric or manual equipment to reduce VOCs and NO_x. If you use a landscaping service, ask if it uses newer or nonpolluting equipment and encourage them to switch if not.

Postpone Polluting Activities on High Ozone Days. On days that are forecast to be high ozone days, postpone unnecessary trips, vehicle refueling, painting, pesticide spraying, and use of gasoline-powered lawn mowers and leaf blowers, and other small gasoline engines. With a little thought, 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?

The consequences of failure to reach attainment by 2007 or failure to meet any other emission reduction milestones are severe. Firstly, Residents and businesses in the eight-county area will continue to experience the adverse health effects of ozone. Furthermore, the region

may experience the loss of federal transportation funding, severe restrictions on growth of existing and new industry in the area, and imposition of a Federal Implementation Plan (FIP) in lieu of state or local controls.

EPA actions are explicitly described in the CAAA. Failure to meet any deadline starts a "sanctions clock" that gives the region 18 months to resolve the failure before 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 2.0:1. After 24 months without resolution, EPA is required to remove federal transportation funds from the affected region. Continued unresolved failures result in a Federal Implementation Plan being developed for the region by 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 EPA notifies a region of failed conformity, new projects cannot be added to the plan or TIP after 120 days.

How Much Does Air Pollution Cost?

Air pollution costs 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 such things as insurance and decreased productivity.

Reduction of air pollution also costs our society. These costs include expenditures for installation, operation, maintenance, monitoring, and record-keeping 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 our society as a result of air pollution are very difficult to measure. Though the recent study done by Sonoma Technologies Inc. attempted to quantify the health costs of air pollution in the Houston-Galveston area (see Research Initiatives), comprehensive studies summing both the costs and benefits of regulations in this region have

not yet been done. On a national level, attempts have been made in recent years 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

Houston-Galveston area businesses and individuals have made significant reductions in air emissions over the past quarter century and the area has seen long-term reductions in ozone levels and other pollutants. Through that 25-year experience, much has been learned about air quality within the Houston-Galveston area but much still remains to be learned. As we continue efforts to improve air quality, there will sometimes 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.

Appendices

Appendix A: Resources & Information

American Lung Association	www.lungusa.org 1-800-lung-usa (586-4872)
American Lung Association of Texas Houston and Southeast Region	713-629-1600
Air & Waste Management Association, Gulf Coast Chapter	www.awma.org 713-260-0441
American Meteorological Society, Houston Chapter	281-337-5074 www.ametsoc.org/AMS
Austin County *Health Department*	409-865-5911 ext. 145
Brazoria County *Health Department*	281-756-1484
Chambers County *Environmental Health Department*	409-267-8392
Citizens' Environmental Coalition	713-524-4232 www.cechouston.org issues@cechouston.org
Colorado County *Health Department*	409-732-3662
Fort Bend County *County Judge* *Health Department* *Vehicle Maintenance Department*	 281-341-8608 281-342-7469 281-341-4792
Galveston County *Environmental Health Department* *Health Department (Switchboard)* *Pollution Control Department*	 409-938-2411 409-938-7221 409-938-2251
Galveston-Houston Association for Smog Prevention	713-528-3779 www.neosoft.com/~ghasp/ ghasp@neosoft.com
Greater Houston Partnership *Business Coalition for Clean Air (BCCA)*	www.houston.org 713-844-3629
Gulf Coast Institute	www.livablehouston.org www.gulfcoastideas.org 713-523-5757 crossley@gulfcoastideas.org
Harris County	www.co.harris.tx.us

County Judge	713-755-4000
Office of Emergency Management	www.hcoem.org
Public Health and Environmental Services	713-439-6000
Pollution Control	713-920-2831
	rob_barrett@co.harris.tx.us
Houston Advanced Research Center (HARC)	281-367-1348
Center for Global Studies	www.harc.edu/cgs/index.html
	cgs@harc.edu
Houston Area Bicycle Alliance	713-729-9333
	www.bikehouston.org
	haba@bikehouston.org
Houston Chronicle	713-220-2000 4AIR
	www.chron.com
Houston, City of	www.ci.houston.tx.us/
Mayor	mayor@ci.houston.tx.us
Bureau of Air Quality Control	713-640-4200
Citizens' Assistance Office	713-247-1888
Department of Health and Human Services	713-794-9320
Houston Environmental Foresight	www.harc.edu/cgs
	281-364-4008
Houston-Galveston Area Council	713-627-3200
	www.hgac.cog.tx.us
Area Emission Reduction Credit Organization	lwells@hgac.cog.tx.us
	www.hgac.cog.tx.us/intro/introaerco.html
Clean Air Action Program/Clean Air Coalition	713-993-2488
	www.cleanairaction.org
Clean Cities/Alternative Fuels Program	www.houston-cleancities.org
Regional Air Quality Planning Committee	lwells@hgac.cog.tx.us
Houston Regional Monitoring Corporation	www.hrm.radian.com/
	(713) 914-6612
League of Women Voters of Houston	713-784-2923
	www.neosoft.com/lwv
	lwv@neosoft.com
Liberty County	
Health Department	281-592-6714
Matagorda County	
Environmental Department	409-244-2717
Metropolitan Transit Authority (METRO)	713-635-4000
	www.ridemetro.org
Montgomery County	
Environmental Health Department	409-539-7839

Mothers for Clean Air	713-526-0110 mfca@socrates.hern.org
Natural Resources Defense Council	www.nrdc.org
Regional Commute Alternatives Program	1-888-606-RIDE
Commute Solutions	www.commutesolutions.org
Sierra Club, Houston Regional Group	713-895-9309 www.sierra.bayou.org
STAPPA & ALAPCO	202-624-7864
(State and Territorial Air Pollution Program Administrators & Association of Local Air Pollution Control Officials)	www.4cleanair.org
Texas, State of	512-463-2000, 1-800-843-5789
Governor's Office	www.governor.state.tx.us
Lieutenant Governor	1-800-441-0373
Senate	www.senate.state.tx.us
House of Representatives	www.house.state.tx.us
Texas Department of Public Safety	512-424-2000 www.txdps.state.tx.us
High Emitter Identification Program	jimmy.guckian@txdps.state.tx.us
Vehicle Inspection & Maintenance (I/M) Program	
DPS Regional Office, Houston	713-957-6120
DPS Regional Office, N. Houston-Rosslyn	281-272-1150
Texas Department of Health, Houston	713-767-3000 www.tdh.state.tx.us
Texas Department of Transportation, Houston	713-802-5000, 1-800558-99368 www.dot.state.tx.us
Texas Natural Resource Conservation Commission, Austin	512-239-1000 www.tnrcc.state.tx.us
Agency Communications	ac@tnrcc.state.tx.us
TNRCC Library	512-239-0020
Office of Air Quality	air@tnrcc.state.tx.us
Air Quality Planning & Assessment Division	aqp@tnrcc.state.tx.us
Smoking Vehicle Hotline	1-800-453-SMOG (7664)
Office of Compliance & Enforcement	oce@tnrcc.state.tx.us
Monitoring Operations - Ozone Information	monops@tnrcc.state.tx.us
Small Business and Environmental Assistance	oppr@tnrcc.state.tx.us
Pollution Prevention & Conservation	ppc@tnrcc.state.tx.us
Clean Texas 2000 Program	cleantx@tnrcc.state.tx.us
P4, P2, SAV programs	www.tnrcc.state.tx.us/exec/sbea/p2tech.html
Texas Natural Resource Conservation Commission, Houston	713-767-3500
U. S. Environmental Protection Agency	www.epa.gov/
Public Information Center	1-800-887-6063
Office of Air Quality Planning & Standards	919-541-5616

	www.epa.gov/oar/oaqps/ www.epa.gov/airnow
Air RISC Hotline	919-541-0888
U. S. Environmental Protection Agency, Region 6-Dallas	214-665-6444 donaldson.guy@epa.gov
U.S. Environmental Protection Agency, Houston	281-983-2100
Walker County *Health Department(University of Texas Medical Branch)*	409-295-7474
Waller County *Health Department*	409-826-7670
Wharton County *Health Department*	409-543-7414

SUBJECT MATTER

Air Chemistry

EPA Office of Air & Radiation: www.epa.gov/oar/
Airsite(U. North Carolina and U. Leeds,UK): http://airsite.unc.edu/

Air Quality

EPA Office of Air Quality Planning and Standards: www.epa.gov/oar/oaqps/, www.epa.gov/airnow
EPA Office of Air & Radiation: www.epa.gov/oar/
TNRCC Office of Air Quality: www.tnrcc.state.tx.us
H-GAC Air Quality Section: www.hgac.cog.tx.us/air/index.html
The California Air Resources Board: www.arb.ca.gov/
OTAG: http://capita.wustl.edu/OTAG/

Air Toxics

EPA Office of Air Quality Planning and Standards: www.epa.gov/oar/oaqps/
Environmental Defense Fund: www.scorecard.org

Alternative Fuels/Vehicles

Houston Clean Cities: www.houston-cleancities.org/
Rocky Mountain Institute: www.rmi.org
HyperCar Inc.: www.hypercar.com
TNRCC Texas Clean Fleets Program: www.tnrcc.state.tx.us/air/ms/tcfprgm.htm.
CALSTART: www.calstart.com
Electric Vehicle Association of Greater Washington, DC: www.evadc.org
Fuel Cells 2000: www.fuelcells.org
DOE Alternative Fuels Data Center: www.afdc.nrel.gov/

Community Information Sources

The Clean Air Coalition: www.cleanairaction.org
Citizen's Environmental Coalition: www.cechouston.org
Environmental Defense Fund: www.edf.org
Galveston-Houston Association for Smog Prevention: www.neosoft.com/~ghasp/
Gulf Coast Institute: www.livablehouston.org
The Houston Dept. of Health & Human Services: www.ci.houston.tx.us/departme/health/

Natural Resources Defense Council: www.nrdc.org
State and Territorial Air Pollution Program Administrators (STAPPA) & Association of Local Air Pollution Control Officials (ALAPCO): www.4cleanair.org/

Current Monitoring Data

TNRCC, Office of Monitoring
EPA

Emissions Inventory

EPA Office of Air Quality Planning and Standards: /www.epa.gov/oar/oaqps/
TNRCC Office of Air Quality: www.tnrcc.state.tx.us/air/aqp/eidata.shtml

Environmental Law/ The Clean Air Act

EPA Office of Air Quality Planning and Standards: www.epa.gov/oar/oaqps/

Health Effects of Pollution

EPA Office of Air Quality Planning and Standards: www.epa.gov/oar/oaqps/

Heat Island Effects

Lawerence Berkeley National Lab Heat Island Group: eetd.lbl.gov/HeatIsland/
American Forests: www.americanforests.org
U.S. National Assessment: Potential for Climate Variability & Change: www.nacc.usgcrp.gov/

International Agencies

The United Nations (Development Programme): www.undp.org/indexalt.html
The World Health Organization (Guidelines for Air Quality): www.who.org/peh/air/airindex.htm

Metropolitan Planning/Transportation

H-GAC Transportation Planning: www.hgac.cog.tx.us/intro/introtrans.html

Pollution Prevention

EPA Pollution Prevention Clearinghouse: www.epa.gov/opptintr/library/libppic.htm
EPA Enviro-sense: http://es.epa.gov/
TNRCC Pollution Prevention and Recycling: www.tnrcc.state.tx.us/exec/sbea/p2tech.html

Public Transit

American Public Transit Association: www.apta.com/sites/transus/transus.htm
Federal Railroad Administration: www.fra.dot/o/hsgt/

Urban Sprawl

HARC Center for Global Studies, Sustainable Development projects: www

Appendix B: Air Quality Abbreviations and Terms

AERCO	Area Emission Reduction Credit Organizations
BACT	Best Available Control Technology
BART	Best Available Retrofit Technology
BCCA	Business Coalition for Clean Air
CAA	Clean Air Act of 1970
CAAA	Clean Air Act Amendments of 1990
CARE	Clean Air Responsibility Enterprise
CMAQ	Congestion Mitigation Air Quality funds under ISTEA and TEA21
CMSA	Consolidated Metropolitan Statistical Area *(the Houston-Galveston-Brazoria CMSA consists of the Houston PMSA [Chambers, Fort Bend, Harris, Liberty, Montgomery and Waller Counties], the Galveston-Texas City PMSA [Galveston County], and the Brazoria PMSA [Brazoria County])*
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COAST	Coastal Oxidant Assessment for Southeast Texas
COG	Council of Governments
COPD	Chronic Obstructive Pulmonary Disease
EPA	Environmental Protection Agency
ESL	Effects Screening Level
ETR	Employer Trip Reduction
FCFF	Federal Clean Fuel Fleet
FTA	Federal Transit Administration (*formerly UMTA – Urban Mass Transit Administration)*
GHP	Greater Houston Partnership
GHRCP	Greater Houston Regional Clean Cities Program
GIS	Geographic Information Systems
HAP	Hazardous Air Pollutant
HAXL	Houston Air eXcellence and Leadership Program
HC	Hydrocarbons
H-GAC	Houston-Galveston Area Council
HRM	Houston Regional Monitoring Corporation
I/M	Inspection/Maintenance program *(for vehicle emission controls)*
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
LEV	Low Emission Vehicle
LNG	Liquefied Natural Gas
MACT	Maximum Achievable Control Technology
METRO	Metropolitan Transit Authority of Harris County
MPO	Metropolitan Planning Organization
µg	Microgram or 10^{-6} gram
NAAQS	National Ambient Air Quality Standards
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NLEV	National Low Emission Vehicle
NO_x	Nitrogen Oxides
O_2	Molecular Oxygen
O_3	Ozone

OTAG	Ozone Transport Assessment Group
$PM_{2.5}$	Particulate Matter less than 2.5 microns in size
PM_{10}	Particulate Matter less than 10 microns in size
PMSA	Primary Metropolitan Statistical Area
PMT	Personal Miles Traveled
PPM	Parts Per Million
RACT	Reasonably Available Control Technology
RAQPC	Regional Air Quality Planning Committee
RCAP	Regional Commute Alternatives Program
RFG	Reformulated Gasoline
SIP	State Implementation Plan *(plan detailing pollution controls for achieving attainment status required of TNRCC by the USEPA through the CAA of 1970 and 1977)*
SO_2	Sulfur Dioxide
SOCMI	Synthetic Organic Chemical Manufacturing Industry
SOV	Single Occupant Vehicle
SUV	Sport Utility Vehicle
TAFF	Texas Alternative Fuel Fleet Program
TCAA	Texas Clean Air Act
TCMs	Transportation Control Measures
TCP	Transportation Control Plan (*as envisioned by EPA to reduce mobile source emissions enough to meet the NAAQS)*
TDM	Transportation Demand Management
TEA21	Transportation Equity Act for the 21st Century *(replaces ISTEA)*
TIP	Transportation Improvement Program
TMA	Transportation Management Area
TMO	Transportation Management Organization
TNRCC	Texas Natural Resource Conservation Commission *(replaced the Texas Air Control Board and the Texas Water Commission)*
TPC	Transportation Policy Council
TPD	Tons per Day
TPY	Tons per Year
TxDOT	Texas Department of Transportation *(formerly known as the Texas Highway Department)*
ULEV	Ultra Low Emission Vehicle
USDOT	United States Department of Transportation
VOC	Volatile Organic Compound
ZEV	Zero Emission Vehicle

Appendix C: The *Principles for Cleaner Air*

The following principles should guide the creation of a strategy enabling the region to reach attainment of the ozone standard. A collaborative process involving the various stakeholders in the region should be utilized to forge air quality solutions from this point forward.

- Contributions to ozone non-attainment come from every segment of the region. Consequently, every person, government entity and all businesses of the region, including mobile sources, off road construction equipment, permitted or grandfathered point sources, should do their part to reduce nitrogen oxides (NO_x) and volatile organic compound (VOC) emissions.
- Control strategies should be implemented as expeditiously as practicable to realize health benefits and prevent imposition of sanctions upon the region.
- The ozone standard should be attained at the lowest economic and social costs considering effects on lifestyle to the citizens of the region.
- Local flexibility should be preserved to the greatest extent possible.
- Some emission control strategies are best implemented at the national level, such as those on automobiles and consumer goods, and, hence, should be accelerated if they contribute to attainment at lower costs and less adverse impacts than other controls.
- Control strategy options considered should include all technically feasible ones prioritized by their relative benefit to cost characteristics.
- Economic incentives should be explored as part of the area's attainment approach.
- All reasonable efforts should be made to avoid State Implementation Plan (SIP) disapproval by EPA. If ozone attainment cannot be reached by reducing ozone precursors to the maximum technically feasible and cost-efficient extent, other options to obtain SIP approval will be explored.
- Encourage TNRCC to undertake a comprehensive air quality research strategy to provide additional scientific information necessary for design of ozone control programs that can be reasonably expected to reduce ozone formation and public exposure to ozone.

The public health of area residents, the vibrancy of the region's economy, and continued transportation improvements are only assured if a sound, acceptable ozone compliance plan is developed and implemented.

Appendix D: The City of Houston Mayor's Short Term Fine Particulate List of Recommendations for City Actions

Mayor's Short Term Fine Particulate Work Group List of Recommendations For City Actions

1. Require on road diesel in lieu of off road diesel in City contracts.
2. Conduct Selective Catalytic Reduction diesel catalyst demonstrations..
3. Conduct other diesel catalyst demonstrations.
4. Conduct diesel fuel (including water emulsion) demonstrations.
5. Include opacity check in truck safety inspection program.
6. Establish clean-burning vehicle and equipment preference (including fine particulates).
7. Enhance traffic signalization program to reduce fine particulates.
8. Increase enforcement of materials transport controls (open truck bed covers).
9. Require construction dust control & construction unpaved staging/transition controls.
10. Develop and implement airport ground service equipment reduction options (including fine particulates reductions).
11. Initiate taxi incentives/controls/opacity tests to encourage low particulate emitting vehicles.
12. Assess air quality impacts (fine particulates) of speed hump devices.
13. Assess air quality impacts (fine particulates) of fireworks shows.
14. Support Texas 2000 Air Quality Study.
15. Enhance clean air public education and information (including fine particulates)*.

* Indicates Work Group recommendation for all participating organizations and groups.

Appendix E: City of Houston Emissions Reductions Plan

City of Houston Emission Reduction Plan

Executive Order 1-45 led to the creation of the Mayor's Clean Air Team. The team consisted of Air Quality Liaisons from each city department as well as other department and private sector stakeholders. The team collectively used an 8-step process, which resulted in the creation of the City of Houston's Emissions Reduction Plan and subsequent supporting guidelines.

1. Identify sources and quantify amounts of emissions.
2. Define the emissions reductions target goal.
3. Document and quantify previous emissions reductions.
4. Identify citywide emissions reductions controls and establish timelines for their implementation
5. Identify needed department emissions reductions controls and establish a timeline for implementation.
6. Adopt citywide and departmental emissions reductions controls sufficient to meet the target goal.
7. Implement the adopted emissions controls.
8. Monitor the actual emissions reductions versus the estimated emissions reductions and make adjustments to ensure achievement of the target goal.

In order to achieve optimal success and reach the target of 75% NO_x emission reductions, a set of eight citywide (seven operational and one construction) and five departmental controls were designed and evaluated.

Cost/benefit analyses of the respective controls were completed and the controls were then ranked in order from most cost effective to least cost effective. Based on this ranking, it was required to use all eight citywide controls and three of the five departmental controls to reach the target.

The plan consists primarily of the following controls:

1. Continue existing policy of requiring new purchases of clean vehicles and equipment
2. Purchase very low sulfur gasoline and diesel fuel starting in Fiscal Year 2002
3. Conduct field demonstrations of diesel catalysts in Fiscal Year 2001 and retrofit the city's diesel fleet with the successful catalysts, starting in Fiscal Year 2002
4. Retrofit the city's stationary emission sources (i.e. boilers, generators) starting in Fiscal Year 2002
5. Expand Employee Commute Options (bus passes and van/car pools) citywide starting in Fiscal Year 2002
6. Require city contractors to meet the same emissions reduction requirements as city operations with the major costs starting in Fiscal year 2003.

At the heart of the plans' controls is the Diesel Field Demonstration Project. The city was awarded grants in the amount of $671,057.00 in April 2000 for this project. It is important to note that if the field demonstration does not validate a retrofit emission control system capable of achieving 75% NO_x reductions, the entire city plan will need to be reassessed and revised. The project will consist of field demonstrations using diesel catalysts on various vehicles and equipment from the summer of 2000 through the spring of 2001. The successful outcome of these demonstrations will allow the city to retrofit that part of its 2700 item inventory of on-road and off-road diesel equipment for which new clean replacements are not purchased. The results of the project will also assist city contractors in meeting the city's contractual requirements for clean vehicles and equipment on all city contracts starting in July 2002.

Implementation Phases			
Phases	**Citywide Actions**	**Department Actions**	**Schedule (M/Y)**
Pre-Implementation			
	Plan Development		1/00-6/00
	Plan Adoption		07/00-08/00
Implementation			
One: Existing actions, field demonstrations and new clean vehicles & equipment	Control 1: Clean Vehicles & Equipment	Control 1: Reduce VMT and hours used	05/00-06/03
	Control 2: Restrict Idling	Control 2: Compressed Work Week	
	Conduct diesel field demonstrations	Control 3: Global Positioning System	
		Control 4 – Reduce fleet and equipment	
Two: Reformulated fuels and diesel retrofits; expand employee commute options	Control 3: Expand free bus passes		07/01-06/03
	Control 4: Use very low sulfur gas & diesel		
	Control 5: Install diesel retrofits		
	Control 6: Implement generator/boiler combustion controls		
	Control 7: Subsidize car/van pools		
Three: Expand contractor requirements	Control 8: Construction and O&M Contracts		07/02-06/03
Post Implementation	Monitor, Review, Assess		07/03-10/03

Appendix F: Urban Heat Island Effects

Meteorologists have known for almost fifty years that cities are 6 to 8 degrees hotter than the surrounding countryside. Figure G1 shows a sketch of this phenomenon, the "heat island effect," which results from the replacement of trees and vegetation with buildings, parking lots, and roadways as a result of urban growth. Trees block solar radiation and cool the surrounding area by evapotranspiration - using heat to evaporate water from leaves. When trees are cut and vegetation cleared for development, this effect is lost. When the sun beats down on buildings covered with dark non-reflective roofing materials, most of the heat goes inside and increases the demand for air conditioning. In addition, dark-colored pavement absorbs heat and releases it only slowly at night.

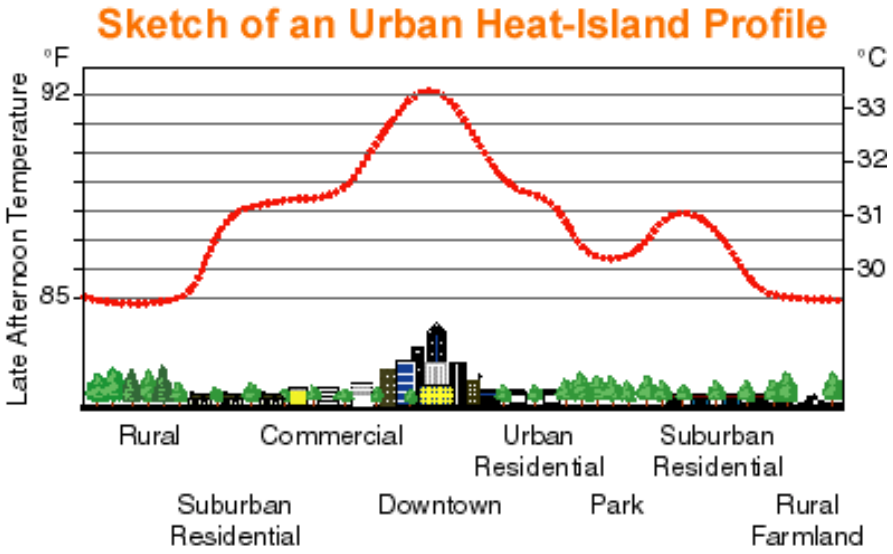


FIGURE G1: The Temperature Profile of an Urban Heat Island

(Source: http://eetd.lbl.gov/HeatIsland/)

Increased use of energy for air conditioning leads to higher NO_x emissions and results in a higher rate of ozone formation during the summer months. Heat can also be viewed as a type of pollution because it exacerbates health problems such as heat stress and asthma. In the hot summer months, hot air plumes can even increase the amount of precipitation that falls on the city and change local weather patterns.

Experience in Atlanta, Salt Lake City, Baton Rouge, and other urban areas suggests that a combination of three long-term mitigation measures can reduce urban heat island effects: (1) planting shade trees in strategic locations, (2) replacing dark roofs with reflective, lighter roofs or planting roof gardens, and (3) using lighter, more reflective surfaces for pavement. Strategic planting of trees not only cools the city, but can also decrease storm water runoff and erosion

and decrease urban noise. Replacing dark roofs with highly reflective roofs can keep buildings cooler and save money through reduced energy use. Increasing the albedo (reflectivity) of the surrounding area by installing reflective pavement adds to the overall decrease in ambient air temperature.

At the Lawrence Berkeley National Laboratory, recent simulations have shown that reducing summer temperature for the Los Angeles area by 6 degrees F. would result in an overall smog reduction of about 12%. In Los Angeles, for example, for every degree Fahrenheit the temperature rises above 70°F, the incidence of smog increases by 3%. EPA is working with state air quality offices to develop a method that could potentially allow states to include heat island reduction strategies into their air quality plans as a control measure for ozone reduction.

Because summertime temperatures in the Houston-Galveston area are so high naturally, area specific analysis must be performed to determine what the ozone benefits would be if the heat island effect was reduced.

Appendix G: Houston-Galveston Area's Attainment Demonstration Control Measures

Short Title	Rule Description	Area Affected
Emission Banking and Trading	• Creates overall NO_x emissions cap. • Implement emissions banking and trading program for flexibility in complying with the cap. • Modifies the existing banking and trading program statewide to make it compatible with the allowance cap program in the Houston area. • Includes mobile source trading.	• Houston-Galveston eight-county area. • Statewide for emissions banking and trading modifications.
HGA Post-1999 ROP/Attainment Demonstration SIP	Speed Limit Reduction • The speed limit on all roadways with a maximum speed limit above 55 mph. • Starts May 1, 2002.	• Houston-Galveston eight-county area.
HGA Post-1999 ROP/Attainment Demonstration SIP	Transportation Control Measures • SIP control strategy (no rules required) • Numerous projects have been identified by the Houston-Galveston Area Council for inclusion in the SIP, such as traffic signalization and bicycle/pedestrian projects.	• Houston-Galveston eight-county area.
Inspection and Maintenance	• Requires Acceleration Simulation Mode or equivalent testing as well as On-Board Diagnostics testing. • Begins May 1, 2002 for Harris County. • Begins May 1, 2003 for Brazoria, Fort Bend, Galveston and Montgomery Counties. • Begins May 1, 2004 for Chambers, Liberty and Waller Counties	• Houston-Galveston eight-county area.
Construction Equipment Operating Restriction	• Establishes a restriction on the use of heavy-duty diesel construction equipment from 6:00	• Houston-Galveston eight-county area.

	a.m.-noon starting April 2005. • Only applies during Daylight Savings Time each year (first weekend in April through the last weekend in October). • Exempts wet concrete operations and emergency operations. • Also provides an exemption from the rule if an alternative plan is submitted assuring equivalent emission reductions.	
Accelerated Purchase of Tier 2 / Tier 3 Diesel Equipment	• Requires the early retirement of older equipment and purchase of newer, clean, off-highway diesel equipment. • Phased-in implementation beginning in December 2004. • Also provides an exemption from the rule if an alternative plan is submitted assuring equivalent emission reductions.	• Houston-Galveston eight-county area.
Cleaner Diesel Fuel	• By May 1, 2002 the fuel will have improved aromatics and centane for all on-highway sales statewide and for all on and off-highway sales in East/Central Texas. • By May 1, 2004 sulfur will be reduced to 30 parts per million (ppm) in East/Central Texas for on- and off-road fuel. • By May 1, 2006 all on-highway fuel statewide will go to 15 ppm (equivalent to the proposed federal rule), and off-highway fuel will go to 15ppm in East/Central Texas.	• Statewide for on-highway fuel. • East/Central Texas for on and off-highway fuel.
Airport Ground Support Equipment	• Requires ground support equipment fleets to reduce emissions by 90% by 2005. • Phased-in implementation – 20%, 50% and 90% in 2003, 2004 and 2005, respectively. • Allows for the implementation of alternative emission reduction measures that produce equivalent NO_x reductions.	• Hobby, Bush Intercontinental and Ellington Airports.
Low Sulfur Gasoline	• Requires a low sulfur gasoline (15 ppm). • Enhances emissions performance of newer cars.	• East/Central Texas.

	• Begins May 1, 2004.	
California Spark-Ignition Engines	• Requires manufacturers to ensure that all affected large spark-ignition (LSI) engines are certified under California LSI standards. • Begins May 1, 2004. • Exempts agriculture and construction equipment less than 175 hp, recreational equipment, stationary engines, marine vessels, and equipment on tracks.	• Statewide.
Point Source NO_x Controls	• Requires a wide variety of minor and major stationary sources to meet new emission specifications and other requirements in order to reduce NO_x emissions. • Total NO_x reductions required from these sources is 90%. • Requires sources with a design capacity to emit 10 tons per year or greater emissions to participate in the Emissions Banking and Trading Program.	• Houston-Galveston eight-county area.
Residential and Commercial Air Conditioners	• Requires new units to reduce ozone by at least 70% and retain a minimum ozone reduction efficiency of 50% for 15 years. • Begins January 1, 2002.	• East/Central Texas.
Diesel Emulsion	• Requires retail on-highway diesel fuel sales for heavy-duty vehicles over 26,000 pounds to be diesel emulsion fuels. • Requires off-highway diesel equipment over 175 horsepower to use diesel emulsion fuels. • Begins May 1, 2004.	• Houston-Galveston eight-county area.
NO_x Reduction Systems	• Requires a reduction system for locally registered (Houston-Galveston eight-counties) on-highwaypre-1997 diesel trucks over 26,000 pounds by May 1, 2004. • Requires a reduction system for all off-highway diesel equipment over 175 horsepower by May 1, 2004. • Requires a reduction system for all locally registered on-	• Houston-Galveston eight-county area.

	highway heavy-duty pre-1997 gasoline powered trucks over 26,000 pounds by May 1, 2004.	
Vehicle Idling Restrictions	• Limits idling for all vehicles over 14,000 pounds to five consecutive minutes. • Begins April 1, 2001. • Only applies from April 1 through October 31 each year.	• Houston-Galveston eight-county area.
Lawn Service Equipment Operating Restrictions	• Restricts the use of small gasoline equipment between the hours of 6:00 a.m. – noon starting in 2005. • Only applies April 1- October 1 each year.	• Houston-Galveston eight-county area.

Bibliography

American Lung Association: *Air Pollution Primer*. American Lung Association.

California Environmental Protection Agency Air Resources Board: *The California State Implementation Plan for Ozone. Volume 1: Overview of the California Ozone SIP*. CEPAARB, November 15, 1994.

Channing L. Bete Co.: *Needed: Clean Air*. Channing L. Bete Co., 16162D-8-91.

City of Houston, Houston Air eXcellence and Leadership (HAXL) Program, October 1998.

Foresight Science Panel, "Houston Environment 1995," ed. John Wilson, Sabrina Strawn, and David Hitchcock, Houston Advanced Research Center, 1996.

Houston Environmental Foresight Committee, "Seeking Environmental Foresight," Houston Advanced Research Center, January 1996.

Houston-Galveston Area Council Transportation Policy Council: *Vision 2020 Metropolitan Transportation Plan*. H-GAC, October 1997.

Houston Regional Monitoring Corporation: *Exposure to Ozone in Houston Area Continues to Declin*e. HRM Corp, 1995.

National Research Council: *Rethinking the Ozone Problem in Urban and Regional Air Pollution*. National Academy Press, 1991.

Texas Natural Resource Conservation Commission: *Air Monitoring Report.* TNRCC, 1991, AS-19.

Texas Natural Resource Conservation Commission: *Air Quality in Texas*. TNRCC, 1992, No. 4010.

Texas Natural Resource Conservation Commission: *Community Air Toxics Monitoring Program Report.* TNRCC, October 1992-September 1993, AS-27.

Texas Natural Resource Conservation Commission: *Ozone Is It Good? Is it Bad?* TNRCC, GI-65.

Texas Natural Resource Conservation Commission: *1993 Periodic Emission Inventory*, TNRCC, July 1995

Texas Natural Resource Conservation Commission: *Revisions to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution: Fix-ups to the 15% Rate of Progress SIP for Dallas/Fort Worth, El Paso, Beaumont/Port Arthur and Houston/Galveston Ozone Nonattainment Areas and Post-1996 Rate-of-Progress SIP for Beaumont/Port Arthur and Houston/Galveston Ozone Nonattainment Areas and Summary of the Revised 1990 Base Year Ozone Nonattainment Area State Implementation Plan Emission Inventory for All Texas Nonattainment Areas*. TNRCC, July 24, 1996.

Texas Natural Resource Conservation Commission: *Community Air Toxics Monitoring Report January-December 1995*. TNRCC, AS-111. February 1997.

Texas Natural Resource Conservation Commission: *Decrease in Ambient Air Concentrations of Benzene, Toluene and Total Xylenes in Southeast Texas*. TNRCC, AS-134. May 1997.

Texas Natural Resource Conservation Commission: *Revisions to the State Implementation Plan (SIP) for the Control of Ozone Air Pollution., Attainment Demonstration for Houston-Galveston Ozone Nonattainment Area*, TNRCC, May 6, 1998.

Texas Natural Resource Conservation Commission: *Smarter Air Monitoring for Texas*. TNRCC, GI-112.

Tropp, Dr. Richard, Mr. Steven D. Kohl, Dr. Judith Chow, and Dr. Clifton A. Frazier, *Final Report for the Texas PM2.5 Sampling and Analysis Study*, Desert Research Institute, Document No. 6570-685-7770.F, December 15, 1998.

United States Environmental Protection Agency: *The Plain English Guide to the Clean Air Act*. USEPA, EPA 400-K-93-001.

United States Environmental Protection Agency: *What You Can Do to Reduce Air Pollution*. USEPA, EPA 450-K-92-002.

United States Environmental Protection Agency Office of Air Quality Planning and Standards: *Review of National Ambient Air Quality Standards for Ozone: Assessment of Scientific and Technical Information (External Review Draft)*. USEPA OAQPS, February 1995.

United States Environmental Protection Agency: *Air Quality Trends, 1996*. January 1998.

Clean Air Action Program
A Program of the
Houston-Galveston Area Council
P.O. Box 22777
Houston, Texas 77227-2777
Phone: 713.993.2488
Fax: 713.993.4508
www.cleanairaction.org

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