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Via Email LCastanuela@tceq.state.tx.us
Via Hand Delivery
And Via First Class Mail

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Texas Commission on Environmental Quality (TCEQ)
MC-105
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Re: Renewal of Flexible Permit No. 2167 Houston Refining, LP
Comments and Second Request for Contested Case Hearing

The City of Houston requests a contested case hearing on the application and flexible permit of Houston Refining, LP, which is located within the City of Houston's corporate limits. The permit in question has not been reviewed with public participation in eight years. Since then, the refinery's enforcement history and relevant scientific developments mandate that the ostensibly "incremental change"—18th in a series of such "changes"—be evaluated fully and thoroughly in a process where the City of Houston may present evidence and be heard. The questions on which the City seeks to present evidence are set out in detail below, but they all concern the following issue, which is of great concern to the health and well-being of the citizens of Houston:

> **Given that benzene is a known Class A human carcinogen, and that this refinery emits more benzene into the air than any refinery in the *nation*, would a full evidentiary hearing concerning benzene's harmful effects on Houstonians, the assumptions that underlie the permit application, and the compliance history of this plant support issuing the permit—or would these facts instead, support further restrictions on permitted emissions of benzene in any permit to be issued to Houston Refining to protect the public health?**

The City of Houston has grave concerns about the City's air quality. Over the last several years, it has enacted local ordinances to curb smoking, and to address other issues affecting air quality, as well as aggressively enforcing these requirements, but the existence and regulation of benzene emissions in the City continues to present a serious public health hazard to Houston's citizens.

To grant the 18th in a series of permit changes, without an evidentiary hearing at which the public can be heard, is not in the public interest—particularly when the City has requested, and is entitled to obtain, a contested case hearing.

The Legislature has directed that the TCEQ give "maximum consideration to a local government's recommendations" when it acts upon a permit. Tex. Health & Safety Code §382.112. In this instance, the City recommends a full, contested case hearing. The City is prepared to gather and present evidence, at its own expense, even though it should be Houston Refining's obligation to justify renewal of its permit, to ensure that the TCEQ has a full and adequate record upon which to decide the issues raised by the permit. An opportunity for the citizens most affected by the plant to be heard, and to present and cross-examine witnesses, is *essential* to address the serious public health concerns raised by the permit. Both the industry and the TCEQ have responded to Houston's requests for assistance by urging the City to engage in the TCEQ's permitting process, where the emissions of concern are authorized or denied. We therefore urge TCEQ to refer this matter for a contested case hearing in the public interest to address the unique and significant adverse public health impacts presented by the permit renewal, all of which deserve the highest level of scrutiny and public participation.

Among the many issues on which a contested case hearing should be granted are these:

- This permit represents TCEQ's largest authorization of benzene air emissions in Harris County, and most likely the largest authorization of benzene air emissions in the state. In light of the significant contribution of Houston Refining to the City, Harris County and the State of Texas's overall benzene emissions, is an approval of a requested permit renewal, after a long series of permit changes that have incrementally altered the permit, without public review, sufficient to protect the public health?

- This permit has not undergone a review with public participation in eight years[1], during which time a great deal of information about the refinery's adverse impact has become known. What would a fully transparent, public contested hearing demonstrate about the toxic consequences of the refinery's benzene emissions and the refinery's incremental impact on the region's overall emissions of benzene and other toxic emissions?

- This refinery is in a TCEQ-designated Air Pollution Watch List area, which means the permit is subject to the highest level of scrutiny prior to authorization. Is approving the 18th incremental permit change for this facility, without a contested case hearing, consistent with the high scrutiny required as a result of this designation?

- This refinery emits more benzene into the air than any other refinery in the nation.[2] Are these emissions safe for public health, and how is that safety to be demonstrated in light of the absence of the adoption of a benzene ambient air standard?

[1] This flexible permit was issued in February, 1999. Since that time, Houston Refining has applied for and received approval of alterations to the permit on 17 occasions. Only one of those applications, dated October 18, 2000, was subject to public comment.
[2] TRI On-site and Off-site Reported Disposed of or Otherwise Released (in pounds) for facilities in Petroleum (324) BENZENE U.S. 2006; www.epa.gov/triexplorer

- This refinery's rate of benzene air emissions per barrel of refined product is 50% higher than the average of all Texas refineries, and the average of Texas refineries is 100% higher than the national average.[3] Given that Houston Refining's feedstocks and processes yield much greater emissions per barrel refined than other refineries, should its permit be further restricted to redress and remedy the facility's adverse effects on public health?

These factors distinguish this application from the hundreds that TCEQ processes each year. If there ever was a benzene permit that qualified for a contested case hearing in the public interest, this would be it. The following information is submitted for consideration by the TCEQ to support the request for contested case hearing, and to stand as the City of Houston's comments on the application. The comments detail disputed issues of fact that are material and relevant to the decision on the permit application.

COMMENTS

A. Houston Refining's benzene air emissions pose an unreasonable health risk to Houstonians.

Benzene causes cancer in humans. The toxicology of benzene and its adverse impact on the human body is well documented in the scientific literature. The main health concerns associated with benzene exposure are the result of bone marrow toxicity leading to myelodysplastic disease and various leukemias including AML (Lou Gehrig's disease). Benzene exposure is also associated with chromosomal damage. An excellent summary of the literature on this subject can be found in a report prepared by scientists at several Texas universities entitled *The Control of Air Toxics: Toxicology Motivation and Houston Implications* at 20-34 (2006), which is available at http://www.greenhoustontx.gov/reports/controlofairtoxics.pdf .

1. The concentrations of benzene in Houston neighborhoods downwind of Houston Refining are too high.

The TCEQ's ambient air monitoring network includes three sites within the City of Houston downwind of Houston Refining that record the concentration of benzene in neighborhoods every hour of every day of the year. These monitors are located at a high school (Cesar Chavez 1.5 miles from the facility), a City park (Milby Park 0.5 miles from the facility), and in a neighborhood (Clinton Drive 1.4 miles from the facility). The ambient concentrations of benzene at these sites exceeded the EPA's one in a million cancer risk threshold virtually 100% of the time during 2007. These concentrations also exceeded the TCEQ's effects screening level (ESL) which is set at ten in a million excess cancer risk, 34%, 23% and 37% of the time, respectively, during 2007. (Attachment A).

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[3] Energy Information Administration (EIA), Form EIA-820, "Annual Refinery Report." Table 3: Capacity of Operable Petroleum Refineries by State as of January 1, 2007; and Environmental Protection Agency (EPA), Toxics Release Inventory (TRI), TRI-Explorer NAICS 324 Benzene 2006.

TCEQ recognized the benzene problem in the area of the refinery and added the area to the Air Pollution Watch List in 2000. When TCEQ investigated this area in late 2007, its mobile monitoring equipment reported concentrations downwind of Houston Refining as high as 12 ppbV (over 8 times the TCEQ's screening level), which was attributed by TCEQ to multiple points within the Houston Refining refinery.[4]

The benzene concentrations detected by these monitors are too high and pose an unreasonable risk of cancer to Houstonians. A carcinogenic health risk concentration level in ambient air is an air concentration level of a particular carcinogen that is associated with a specified risk of contracting cancer. The concentration associated with a cancer risk is dependent upon the toxicity of the chemical. A more toxic chemical has a lower concentration associated with the same level of risk as a less toxic chemical. The EPA publishes the toxicity of chemicals in its Integrated Risk Information System (IRIS) after extensively reviewing all of the available evidence. In the analysis of data regarding the potential human carcinogenicity of chemical agents, the EPA uses the approach described in its Guidelines for Carcinogen Risk Assessment (51 FR 33992-34003, Sept. 24, 1986). The toxicity of the chemical is published along with an indication of the degree of certainty associated with the carcinogenic evidence. Benzene is classified as a Class A human carcinogen, which is the highest level of certainty that EPA assigns to toxics.

IRIS posts the toxicity of benzene as a range rather than as a single value to account for variability. IRIS also contains the concentrations associated with the population risk levels specified in the Clean Air Act: one in 1,000,000 excess cancer cases; one in 100,000; and one in 10,000. Because of the range of toxicity associated with benzene, there are two numbers for each specified population risk range: a high end and a low end.

The EPA Office of Air Quality Planning & Standards (OAQPS) publishes only one toxicity value instead of the range of values listed in EPA's IRIS. The value that EPA OAQPS recommends is the most protective end of the toxicity range within the IRIS values. Roy L. Smith, Ph.D., of the EPA Office of Air Quality Planning & Standards (OAQPS) explains that these values are used in screening risk assessments and since "some reasonable number of false positives are (sic) acceptable but false negatives are not acceptable, we used the conservative end of the range."[5]

Texas does not have a benzene ambient air standard by which to measure adverse impact on public health. TCEQ has established regulatory guidelines by setting "effects screening levels" (ESLs) for air toxics including benzene. ESLs are used to evaluate the *potential* for effects to occur as a result of exposure to concentrations of constituents in the air. According to the TCEQ, if ambient levels of constituents in air exceed the screening levels, it does not necessarily indicate a problem but rather triggers a review in more depth. (See *What are Effects Screening Levels* at http://www.tceq.state.tx.us/implementation/tox/esl/ESLMain.html.)

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[4] Interoffice Memorandum from Valerie Meyers, Ph.D., Toxicology Section, Chief Engineer's Office, Texas Commission on Environmental Quality, dated July 31, 2008.
[5] E-mail to Loren Raun from smith.roy@epa.gov Tuesday, May 27, 2008, 6:54 a.m.

The table below lists the carcinogenic risk-based concentrations for the range of risk levels and toxicity. The concentrations are provided in two sets of units: ppb and $\mu g/m^3$.

EPA Clean Air Act Risk Range Based on Number of People Protected			Benzene concentration (ppb) at the **most protective** end of toxicity range		Benzene concentration (ppb) at the **least protective** end of toxicity range	
			$\mu g/m^3$	ppb	$\mu g/m^3$	Ppb
Protects the fewest number of people	1 excess cancer case per 10,000 people	$1x10^{-4}$	13.0	4.0	45.0	14.0
Midpoint	1 excess cancer case per 100,000 people	$1x10^{-5}$	1.3*	0.4*	4.5**	1.4**
Protects the greatest number of people	1 excess cancer case per 1,000,000 people	$1x10^{-6}$	0.13	0.04	0.45	0.14

*Concentration developed using EPA OAQPS recommended toxicity
** TCEQ's ESL

The ultimate question raised by this application for renewal of a permit for the largest benzene air emitting refinery in the country is whether the impact of the proposed emissions adversely affects public health. The ESL does not answer this question, and there is no ambient standard in Texas to provide guidance. The ESL as a regulatory guideline is not designed to address the cumulative public health impact of the facility's benzene emissions combined with other emissions from the same facility or the facility's additive impact when combined with other toxic emissions in Houston. The parties to the contested case hearing—Houston Refining and the City of Houston—should present evidence concerning the health effects of the proposed emissions, including the studies by EPA and other regulatory bodies, including the TCEQ. This process will enable the fact finder to determine whether the excess cancer risk posed by this facility's toxic emissions poses an unreasonable risk to public health. A contested case hearing permitting the presentation of evidence regarding the public health impacts raised by this application will provide a vehicle to carry out the legislature's directive that, "[t]he commission shall give maximum consideration to a local government's recommendations."[6]

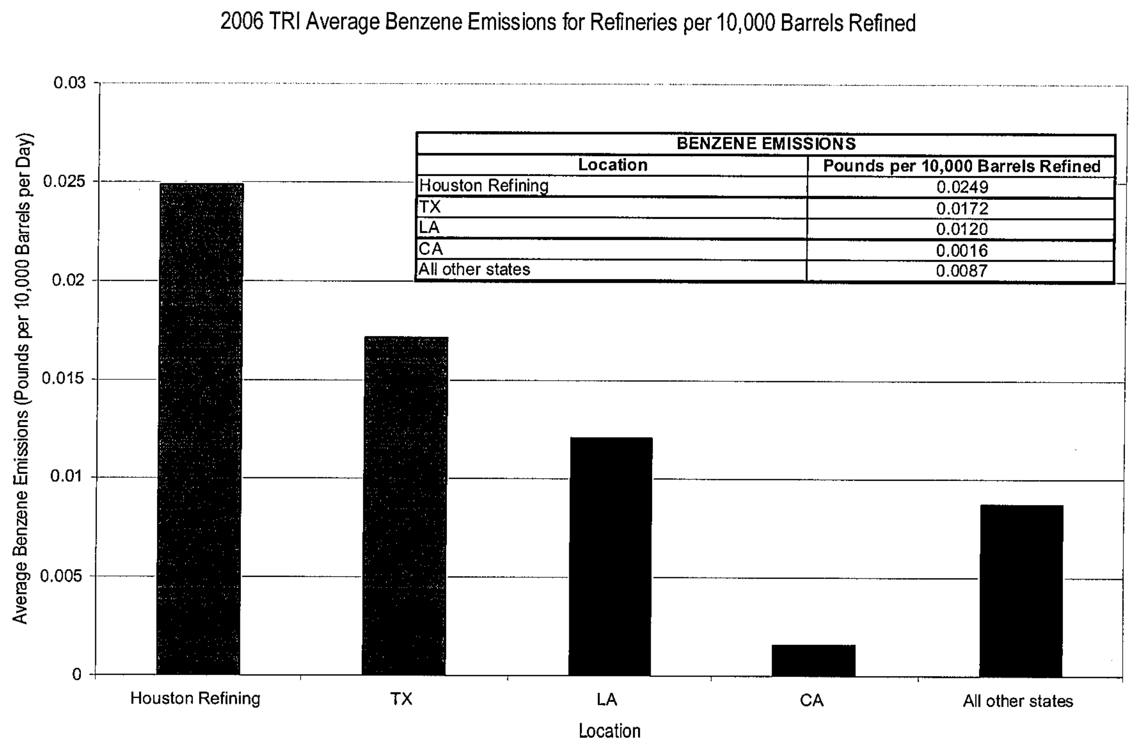
2. Houston Refining is a substantial source of benzene air emissions in Houston.

Houston Refining's own data, as reported to the EPA, shows that it emits more benzene into the air than any refinery in the country, and it has held this ignominious position for the last three years for which data is available. According to data reported by Houston Refining to the US Energy Information Administration, its daily production capacity is 270,000, which makes it the

[6] Tex. Health & Safety Code § 382.112.

15th largest refinery in the US, and approximately half the size of the largest refineries, all of which emit less benzene.

In addition to its ranking as the largest emitter by volume, Houston Refining's rate of benzene emissions is substantially higher than other refineries in Texas and elsewhere. A refinery's rate of benzene emissions is calculated by dividing its volume of benzene emissions by its volume of production. This enables a comparison of emissions across refineries without regard to the size of the refinery. The chart below shows the benzene emission rate for Houston Refining as compared to the emission rates of all refineries in Texas, Louisiana, California, and other states.



BENZENE EMISSIONS	
Location	Pounds per 10,000 Barrels Refined
Houston Refining	0.0249
TX	0.0172
LA	0.0120
CA	0.0016
All other states	0.0087

The analyses above are based on self-reported benzene air emissions of the refineries. If the actual emissions are higher than the self-reported emissions, the above analyses likely understate the impact of Houston Refining on the public. There is a large body of credible evidence that indicates that these emissions are understated because of erroneous emission factors and the exclusion of emissions from certain sources and events. A detailed description of the data quality errors that cause underreporting of refinery emissions was presented by the City of Houston in a Request for Correction to the EPA in July, 2008. The Request for Correction can be accessed at http://www.greenhoustontx.gov/reports/epaletter20080709.pdf and is incorporated herein by reference and is not reproduced to conserve paper. As the Request for Correction details, refinery emissions are likely underestimated by several orders of magnitude. One of the reasons the EPA and others have concluded that refinery emissions are underestimated is that actual, direct observation with technologies such as DIAL (which the TCEQ has employed at another refinery) show significant emissions beyond those reported. On information and belief, Houston Refining has employed this technology and has in its possession more reliable and accurate data on its emissions than what has been reported to the EPA and TCEQ. TCEQ should use this data to conduct a full evaluation of the entire refinery site and its proposed permit.

3. **The benzene emissions from Houston Refining contribute significantly to the elevated benzene levels in Houston neighborhoods.**

A significant portion of the benzene detected by the monitors located in Houston neighborhoods is attributable to Houston Refining. Attachment A contains an analysis of the impact of wind direction upwind and downwind of Houston Refining on ambient benzene concentrations in the Houston neighborhoods near the facility. The analysis shows that when the wind blows from the refinery toward the monitors, benzene concentrations are significantly higher at the monitors than when the wind is not blowing from the direction of the refinery. The most striking difference between upwind and downwind concentrations occurs at the Milby monitor. When the monitor is downwind of the facility , the concentration exceeds the one in 100,000 cancer risk limit 75% of the time, compared with only 25% of the time when the monitor is upwind of the facility. The TCEQ's toxicology report of July 31, 2008 also attributes high levels of benzene in Galena Park to Houston Refining based on wind direction analysis.

4. **The cumulative risk imposed on the public by Houston Refining is severe and must be accounted for in the permitting process.**

Houston Refining's benzene emissions should be considered in light of other toxic emissions from the same facility, benzene and other toxic emissions in Harris County (including the substantial emissions from other facilities owned and operated by LyondellBasell, Houston Refining's owner) and the cumulative impact of this facility's benzene emissions when added to other toxic emissions in Houston.

Benzene concentrations in the City of Houston and in other areas impacted by Houston Refining show few statistically significant reductions over time, according to a comprehensive analysis of seven statistics over five, seven, and ten year periods, regarding benzene concentrations at monitors in the Houston area. The analysis can be accessed at http://www.greenhoustontx.gov/reports/benzeneandbutadiene.pdf and is appended at Attachment B. The analysis shows that there are very few statistically significant downward trends in benzene concentrations, particularly over the last five years. In fact, of the 70 statistics examined for the past five years, significant improvements were detected for only 19 statistics. A relative ranking of benzene contamination based on 2007 data over 12 benzene monitors (based on seven statistics per monitor) ranks the monitors that are within the City of Houston as the third, fifth, and seventh most contaminated sites. It is against this backdrop that TCEQ must evaluate Houston Refining's application.

a. Emissions from maintenance, start up and shut down (MSS)

Houston Refining has a separate application in process regarding its MSS emissions. The emissions from six sources of MSS activities are reported to be 12.1 tons of benzene per year. There are many questions relating to the MSS permit application and whether it is sufficient to warrant issuance. As the TCEQ considers the current application, these additional emissions by the same facility should be taken into account as TCEQ evaluates the application before it. The cumulative impact of the MSS emissions is significant and increases the health risk to the exposed population.

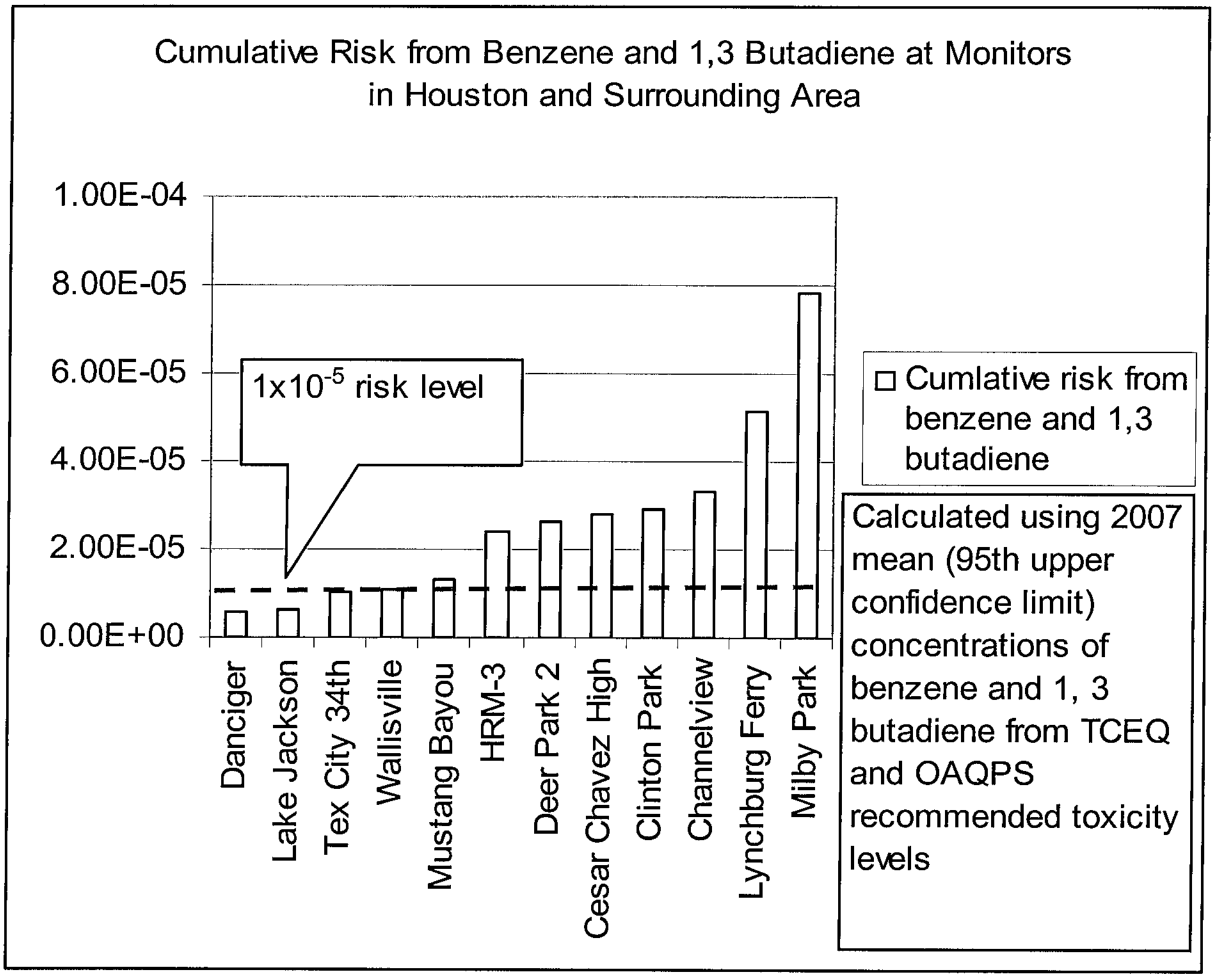
b. Emissions from other LyondellBasell operated facilities

In addition to Houston Refining, LyondellBasell operates three other facilities within Harris County, all of which are significant benzene emitters. These facilities are Equistar Chemical (Channelview), Equistar Chemical (La Porte), and Lyondell Chemical (Channelview). Together, the four Lyondell facilities emitted 117.3 tons of benzene in 2006, approximately 33% of all the benzene air emissions by refineries and chemical companies in Harris County.

c. Cumulative impact of other toxic emissions

Benzene is not the only carcinogen to which Houstonians are exposed. In some of the neighborhoods impacted by Houston Refining's benzene emissions, the residents are also subjected to high concentrations of as many as 7 pollutants that scientists have identified as definite health risks to Houstonians.[7] Regulation of a single pollutant without consideration of exposure from others is ineffective in protecting human health. When the risk from two air toxic emissions of concern in Houston are combined (benzene and 1,3 butadiene), the cumulative risk exceeds the one in 100,000 risk level for all but two monitors in the region, as depicted in the chart below.

[7] Institute for Health Policy, *A Closer Look at Air Pollution in Houston: Identifying Priority Health Risks* (2006) available at http://www.greenhoustontx.gov/reports/UTreport.pdf



The concentration of 1,3 butadiene and benzene in the vicinity of the Houston Refining and Milby Park monitor yield an average cumulative risk of approximately eight in 100,000. This is eight times higher than the TCEQ's ESL risk threshold, and only takes into account two pollutants. The TCEQ must consider the true impact on public health of the Houston Refining permit in light of the real risk to citizens from other sources, to which Houston Refining is additive.

B. Houston Refining has a poor record of compliance with its existing permit

Pursuant to 382.055(d), Tex. Health & Safety Code, the Commission is required to review the facility's compliance history and the "condition and effectiveness of the existing emission control equipment practices." In addition, TCEQ rules require that Houston Refining provide information in its renewal application demonstrating that "the facility is being operated in accordance with all requirements and conditions of the existing permit, including representations in the application for permit to construct and subsequent amendments. 30 Tex. Admin. Code § 116.311(a)(2). An examination of Houston Refining's history of operating under its current permit demonstrates that its practices are not sufficient to support a renewal of its application without significant changes.

Three governmental agencies receive complaints about and are empowered to take enforcement action against Houston Refining: TCEQ, City of Houston's Bureau of Air Quality Control (BAQC), and Harris County's Public Health and Environmental Services (PHES). In the past three years, TCEQ, BAQC, and PHES have received 15 complaints from citizens reporting from locations near Houston Refining. The complaints included concerns about odors (benzene and other chemical odors) and visible emissions. The three agencies issued a total of 30 Notices of Violation between 2002 and 2008. A total of 30 Notices of Enforcement were also issued. TCEQ has entered into 16 Agreed Orders regarding this facility since 2002, and has five Agreed Orders still pending. Houston Refining has paid a total of $876,631 in penalties since 2002. These penalties represent only a fraction of the amounts that could have been levied against Houston Refining. It is apparent that Houston Refining considers these fines and penalties as a cost of doing business rather than as a deterrent to violating environmental laws. Attachment C details the full complaints and enforcement history.

C. The application contains numerous errors and omissions that require TCEQ's rejection.

1. The benzene reductions claimed in the permit are not supported by actions that will result in reductions.

The benzene emissions reduction included in the application are generally not supported by changes in operations, additional environmental controls or monitoring data to show that past emissions were over reported. To the contrary, most of these reductions appear to be based on revised calculations for which there is no supporting information. Specifically, the steps taken in reduction of benzene emissions include the following unsubstantiated changes: (1) adjusting the benzene emission factors for heater and boiler emissions; (2) implementing more stringent 28 MID monitoring for components that were previously subject only to 28 VHP; (3) removing shutdown and demolished sources from the permit; (4) improving fittings for numerous external floating roof storage tanks; and (5) removing " insignificant emissions" from the permit. While taking credit for some of these actions may be allowed, additional information must be included in the application to justify Houston Refining's claims.

2. The application does not propose verification via direct observation or monitoring of benzene emissions, rendering the permit virtually unenforceable.

The emissions projections made by Houston Refining in the permit must be verifiable, or the permit may not protect the public health. The permit does not propose any form of monitoring of actual emissions, nor does it contemplate fence line monitoring. The TCEQ should require a valid verification program before it authorizes emissions.

a. Direct observation

A number of studies over the past several years have used advanced technologies to document the actual emissions of petroleum refineries. These studies indicate that refinery emissions that are calculated by using traditional emission factor methodologies, including the exclusion of certain equipment from the calculations, result in a drastic undercounting of VOC emissions, including benzene. The EPA acknowledged this problem in two reports issued in 2006 and 2007.[8] TCEQ recognized the value of these new technologies in determining actual emissions when it deployed this direct observation technology at the BP refinery in Galveston County in 2007. On information and belief, this same technology—DIAL—has been deployed at Houston Refining. Because TCEQ is aware of the discrepancies between calculated emissions and actual, observed emissions, and because there may be direct observation data available to the applicant, the Agency can and should carefully and critically examine the applicant's claims regarding its benzene emissions.

b. Fence line monitoring

The City of Houston's concern with Houston Refining's emissions begins at the fence line. OSHA and others regulate the health of those on premises. Fence line monitoring is an effective mechanism for identifying emissions that come from a facility with many point sources, especially in areas such as the Houston Ship Channel where there are multiple facilities and point sources in close proximity. An example of the benefits of fence line monitoring in terms of emission verification can be found in the case of Texas Petrochemicals, a chemical company located within the City of Houston. This facility had a high level of 1,3 butadiene emissions and both the City and the TCEQ commenced enforcement actions against the company. The resolution of both matters included the installation of fence line monitoring by the company on the upwind and downwind sides of the facility and an enforceable commitment that by a specified date, the downwind fence line monitor would achieve a health-protective ambient air level. The TCEQ should require similar monitoring and ambient air level commitments before issuing the requested permit to Houston Refining.

3. Neither the applicant nor the TCEQ has conducted dispersion modeling to support application.

TCEQ staff rely on air dispersion modeling to set permit terms. The Commission is authorized by the Act to impose additional requirements at renewal to "avoid a condition of air pollution or to ensure compliance with an otherwise applicable federal or state air quality control requirements." Tex. Health and Safety Code § 382.055(e). How can the Commission make this determination if the application does not include modeling and the modeling has not been performed for the entire site.

4. The application does not account for the presence of a school within 3000 feet.

Tex. Health & Safety Code § 382.052 requires agency consideration of health impacts to those attending the school facilities. The application states that there are no schools within 3000 feet of

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[8] Office of Inspector Gen., U.S. Envtl.Prot.Agency, EPA Can Improve Emissions Factors Development and Management (No. 2006-P-00017) (Mar. 22, 2006) and Memorandum from Brenda Shine, U.S. Envtl.Prot. Agency, on Potential Low Bias of Reported VOC Emissions from the Petroleum Refining industry to EPA docket No. EPA-HQ-OAR-2003-0146 (July 27, 2007). See also Refinery Demonstration of Optical Technologies for Measurement of Fugitive Emissions and Leak Detection ,available at http://www.greenhoustontx.gov/reports/20080709a.pdf; A Review of Experiences Using DIAL Technology to Quantify Atmospheric Emissions at Petroleum Refineries, available at http://www.greenhoustontx.gov/reports/20080709c.pdf; and Fugitive VOC-Emissions Measured at Oil Refineries, available at http://www.greenhoustontx.gov/reports/20080709d.pdf.

the facility, yet Richey Elementary School is within this area. Rucker Elementary School is 3010 feet from the refinery, Neither TCEQ nor Houston Refining has conducted the research necessary to enable TCEQ to make a determination regarding the health impact of the facility on the students.

5. **There are significant errors and omissions in the application regarding emissions from heaters and boilers, flares, delayed coker units, storage tanks, cooling towers, wastewater system, fugitives, and fluidized catalytic cracking unit.**

The application fails to include the level of information and underlying data sufficient to justify the projected emissions. Throughout the application, Houston Refining makes reference to "tests" without explaining what kinds of tests, when they were conducted or what the results were. In some instances, the application is explicit about the use of direct measurements, but only when such measurements support a claimed reduction; the application is less forthcoming in other circumstances. Relying upon "actual test data," or "testing of the fuel gas and selected heater exhausts," or "testing of the FCCU Wet Gas Scrubber Stack," or "emissions test data," or "the best currently available data without more explanation is insufficient. Considering that Houston Refining asks that this permit support its operations for the next ten years, and a thorough review with public participation before then is unlikely, the TCEQ should require that the application be complete, understandable, and supported by verifiable facts.

a. Heaters and boilers

The application does not accurately account for emissions from heaters and boilers due to the use of refinery fuel gas. Although heaters and boilers will be allowed to use refinery fuel gas as well as natural gas according to the application, the emission calculations are based on the exclusive use of natural gas. There are 70 of these sources at the refinery, and using the wrong emissions factor results in a very significant under calculation of potential benzene and other emissions, possibly by as much as 2860%. Houston Refining should provide statistically significant data regarding the benzene content in their refinery fuel gas over time and recalculate its benzene emissions.

b. Flares

Although there are 7 flares at the refinery, and flares are known sources of benzene and other emissions (and reported as such by Houston Refining to the TCEQ and EPA), the proposed permit does not include any benzene emissions from flares. If these emissions have never been permitted, then they constitute new sources and must be permitted via an amendment and not a renewal. See Tex. Health & Safety Code § 382.056(g). See also, Tex. Water Code § 7.149 (Criminal Offenses and Penalties – False Statements).

In addition to the omitted benzene emissions, Houston Refining reported in 2006 that more than 100 tons per year of volatile organic compounds were emitted from the refinery's flares. In the application, Houston Refining states "The flares meet TCEQ BACT guidelines..." Routine flaring should not be considered BACT because the efficiency of flares, assumed by TCEQ guidance to be 98% or better, is most likely lower than 98%, especially during periods of high wind speeds and when excessive amounts of steam are added to the flare tip. Flare gas recovery and the use of high efficiency control devices should be considered BACT in lieu of flaring, since many other refineries have demonstrated the cost effectiveness and significant emissions reductions through their use. In addition to requiring flare gas minimization, flare tip steam rates should be specified relative to waste gas flow rates, during periods when waste gas flow rates exceed the amounts that flare gas recovery/minimization techniques can divert, process or control, and additional flare monitoring and recordkeeping should be required to demonstrate compliance.

c. Delayed coker units

The application represents that the delayed coker units will not emit benzene or any other VOC, and thus the application contains no emission calculations. However, benzene is known to be emitted from refinery delayed coker units. If these emissions have never been permitted, then they constitute new sources and must be permitted via an amendment and not a renewal. See Tex. Health & Safety Code § 382.056(g). See also, Tex. Water Code § 7.149 (Criminal Offenses and Penalties – False Statements).

d. Storage tanks

The calculations for storage tank emission rates are not supported because the vapor pressure data is not realistic and there are no benzene emissions associated with certain tanks in distillate, crude, gas oil, naphtha, wastewater/slop oil and gasoline service. The application does not include an explanation of the benzene speciation methodology, so it is impossible to understand how the benzene calculations were made and it is not possible to verify the benzene or other emissions data. For those tanks that are sources of benzene emissions, but have never been permitted, then they constitute new sources and must be permitted via an amendment and not a renewal. See Tex. Health & Safety Code § 382.056(g). See also, Tex. Water Code § 7.149 (Criminal Offenses and Penalties – False Statements). Additionally, the contents of 46 storage tanks are vaguely described as "chemicals" in the application. It is impossible to make a determination as to the possibility of benzene emissions from a storage tank when the contents are described merely as "chemicals".

e. Cooling towers

Cooling tower emission estimates do not follow the TCEQ guidance because the emission calculations were based on an emissions factor for "controlled" cooling tower emissions. There should be cooling tower monitoring records if in fact the cooling towers are controlled, and Houston Refining should use that monitoring data to quantify cooling tower emissions representations. Without monitoring data to demonstrate that the cooling towers are controlled, TCEQ guidance requires the use of "uncontrolled" emission factors. Although the application states there is such a cooling tower monitoring system, it is not described nor is any supporting data provided in the application. In addition, the application uses a very low benzene to VOC ratio for all of its cooling towers, when in fact the ratio would vary from cooling tower to cooling tower. Individual testing and calculations should be required.

f. Wastewater system

The calculation of these emissions also appears to be low and unsubstantiated. For example, based on the data in the application, 16.4 tons per year of benzene is contained in the refinery wastewater. The benzene emissions from the wastewater system, however, are calculated to be 2.8 tons per year, indicating that 13.6 tons of benzene are consumed by the wastewater processes. Houston Refining should be required to demonstrate through microbiological testing that their wastewater system microbes can in fact degrade the benzene in the wastewater, or the represented benzene wastewater emissions should be increased by 13.6 tons per year.

g. Fugitives/equipment leaks

These calculations are not explained in the application. For example, the basis for the benzene percentage in various streams is not explained. Therefore, it is not possible to evaluate the data for the benzene emissions included in the permit application. Moreover, many of the benzene concentrations used by the applicant are unrealistically low which would result in an underestimation of potential benzene emissions. Fugitive benzene emissions from a refinery generally reflect, and refinery fugitive benzene emissions estimates should be based upon, the benzene content of the incoming crude oil that a refinery processes. Therefore, Houston Refining should be required to represent, and applicable fugitive benzene emissions limits should be based upon, the actual benzene content of the crude oil Houston Refining intends to process.

h. Fluidized catalytic cracking unit

Like flares and coker units, these units are known to emit benzene and other VOCs and Houston Refining has failed to include such emissions in its application. If these emissions have never been permitted, then they constitute new sources and must be permitted via an amendment and not a renewal. See Tex. Health & Safety Code § 382.056(g). See also, Tex. Water Code § 7.149 (Criminal Offenses and Penalties – False Statements).

6. This permit does not comply with the EPA requirements regarding benzene emissions.

Emissions from Houston Refining are permitted through a "flexible permit." Flexible permits are not approved by the Texas State Implementation Plan for permitting of major sources, like Houston Refining. The permit terms violate federal law and are not federally enforceable. Houston Refining could have sought other, SIP-approved permitting. Deficiencies in the flexible permit rules and the Houston Refining flexible permit application include the following:

• *Failure to assure compliance with Major NSR, including:* the application fails to assure compliance with terms and conditions of existing major NSR permit terms, fails to include adequate procedures for assuring NSR compliance for major modifications, and improperly uses permits by rule to authorize facility changes that may cause an exceedence of a flexible permit cap or that modify conditions of existing NSR permits.

• *Lack of Practical Enforceability and Failure to Protect NAAQS, including:* the application fails to require adequate emission limits (annual limits should be based on a 12-month rolling average and short term limits should be required); allows too many dissimilar units to be covered by a single cap; does not clearly subject maintenance, startup, and shutdown emissions to caps; does not include an adequate, replicable standard for monitoring, reporting, recording and testing; fails to require identification of the types of modifications authorized pursuant to the permit, and fails to require an air quality analysis for the existing and any future amendments that increase emission limits.

• *Inadequate Public Participation:* the public participation requirements for flexible permits do not meet the requirements of 40 CFR Part 51. Notice of the draft permit (including the state's preliminary determination) should be given for Houston Refining's current application which includes an amendment to the existing permit through the "rolling in" of the MSS permit by rule.

7. **The City of Houston proposed a benzene reduction strategy to Houston Refining in early 2007 that should be considered by TCEQ in connection with this permit application.**

In February, 2007, the City of Houston published a voluntary benzene reduction plan for major sources. For the seven facilities that posed the greatest risk to public health on account of the volume of their benzene emissions and proximity to affected populations, the City produced facility-specific data showing the impact of each facility on populations, and also developed an individualized benzene reduction plan for each of those facilities. Houston Refining was one of those facilities, and the analysis and recommendations made for this facility are appended as Attachment D.[9] The recommendations, which were to be implemented over five years, included equipment installation and practice/process improvements affecting heaters and furnaces, tanks, fugitives, emissions and monitoring. All of the recommendations were financially and technologically feasible and would have resulted in a significant reduction of benzene from the refinery. The City met with Houston Refining officials regarding the plan on two occasions. Houston Refining did not agree to the City's proposal nor did it offer one of its own.

REQUEST FOR CONTESTED CASE HEARING

The City of Houston requests a contested case hearing on the application and flexible permit of Houston Refining, LP, which is located within the City of Houston's corporate limits. The City of Houston may be contacted though Mayor Bill White's Office, Attention: Elena M. Marks, 901 Bagby, 3rd Floor, Houston, Texas 77002 or by e-mail to Elena.marks@cityofhouston.net.

As required by TCEQ rules, the City of Houston qualifies as an "affected person" with a justiciable interest who may seek a contested case hearing. 30 TEX. ADMIN. CODE § 55.203(a). The relevant sections of TCEQ's rules on affected party status at 30 TEX. ADMIN. CODE § 55.203 state:

[9] The full plan is accessible at http://www.greenhoustontx.gov/reports/benzenereductionplan.pdf

> (a) For any application, an affected person is one who has a personal justiciable interest related to a legal right, duty, privilege, power, or economic interest affected by the application. An interest common to members of the general public does not qualify as a personal justiciable interest.
> (b) Governmental entities, including local governments and public agencies, with authority under state law over issues raised by the application may be considered affected persons.
>
> (c) In determining whether a person is an affected person, all factors shall be considered, including, but not limited to, the following:
>
>> (6) for governmental entities, their statutory authority over or interest in the issues relevant to the application.

The City has statutory authority over or interest in issues relevant to the application as well as justiciable interests related to legal rights, duties, privileges, powers or economic interests affected by the application. See, respectively, 30 TEX. ADMIN. CODE §§ 55.203(c)(6) and (b).[10]

The City of Houston has a significant interest in ensuring that any permit renewal, amendment or alteration issued for Houston Refining complies with all applicable statutory and regulatory requirements to ensure protection of public health. The pollutants that would be authorized by the proposed permitting actions degrade the air quality for the residents of the City of Houston. The City seeks to ensure protection of public health, environment and the property of its citizen through participation in a contested case hearing.

Moreover, the City has its own interests in this permitting activity, which are distinct from those of the public at large. For example, the City has a distinct economic interest in the reduction and accurate measurement of benzene emissions from the application. Benzene is a volatile organic compound (VOC) that may impact the achievement of ozone standards. The City has a clear economic interested in achieving ozone standards. Lack of such achievement can have adverse economic impacts on the vitality of the City's economy.

The application of Houston Refining for renewal of flexible permit no. 2167 is deficient and cannot be granted in its current form. The City of Houston respectfully requests that this Commission refer all of the relevant and material disputed issue of fact, as laid out above, to the State Office of Administrative Hearings for a full evidentiary hearing in which the City of Houston and the Executive Director are parties.

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[10] See, for example, TEX. HEALTH & SAFETY CODE § 121.003 (stating that a municipality may enforce any laws reasonably necessary to protect public health), TEX. HEALTH & SAFETY CODE § 382.111 (setting out local government authority to inspect and enter property) and TEX. HEALTH & SAFETY CODE § 382.113 (setting out municipal powers and rights subject to the policy and purpose of the Texas Clean Air Act).

CONCLUSION

The City of Houston respectfully requests that the TCEQ refer this matter for a contested case hearing so that the City may present evidence on disputed issues critical to the public health of Houstonians raised by the renewal application including:

- The significant contribution of this permit – the largest authorization of benzene air emissions in Harris County – to the City, Harris County and the State of Texas' overall benzene emissions.

- The additive impact of permitted emissions to the region's overall toxic emissions.

- The serious public health consequences of the largest benzene emitting refinery in the nation and the appropriate measure of its public health impacts.

- The potential for reduction in this refinery's rate of benzene air emissions per barrel of refined product, which is currently 50% higher than the average of all Texas refineries.

- The errors and omissions in the permit application.

This refinery is in a TCEQ-designated Air Pollution Watch List area, and as such the permit application is subject to the highest level of scrutiny prior to authorization. Approval of the 18th incremental permit change for this facility should be subject to a contested case hearing so that the City's recommendations regarding the application are afforded "maximum deference".

Sincerely,

Bill White

Bill White
Mayor

cc: Mark Vickery, Executive Director, TCEQ
Buddy Garcia, Chairman, TCEQ
Larry Soward, Commissioner, TCEQ
Bryan Shaw, Commissioner, TCEQ

ATTACHMENT A

Statistical Analysis of Ambient Benzene Concentrations in the Vicinity of Houston Refining (formerly Lyondell):
Focus on Carcinogenic Human Health Risk

Statistical Analysis of Ambient Benzene Concentrations in the Vicinity of Houston Refining (formerly Lyondell): Focus on Carcinogenic Human Health Risk

Loren Raun, PhD
Mayor's Office of Environmental Programming
City of Houston

There are three automatic gas chromatograph ambient air monitors which collect hourly benzene data in the vicinity of the Houston Refining Facility (formerly Lyondell): Clinton Park, Cesar Chavez and Milby High School. The benzene data from these monitors were assessed in four key ways:

1. Overall ambient concentrations in 2007 were statistically assessed and compared with cancer risk limits to determine if the concentrations exceed the risk limits
2. Temporal trend of concentrations above the $1x10^{-5}$ risk level were assessed to determine if there is improvement in the percent of time the level is exceeded annually
3. Concentration profiles when these monitors are upwind and downwind of the facility were compared to determine if differences exist in the concentration profile before and after wind passes over the facility
4. Benzene concentration profile human health risks were added to human health risk from 1,3 butadiene to determine the magnitude of additive risk in the vicinity of the facility

The results of the analysis indicate that:

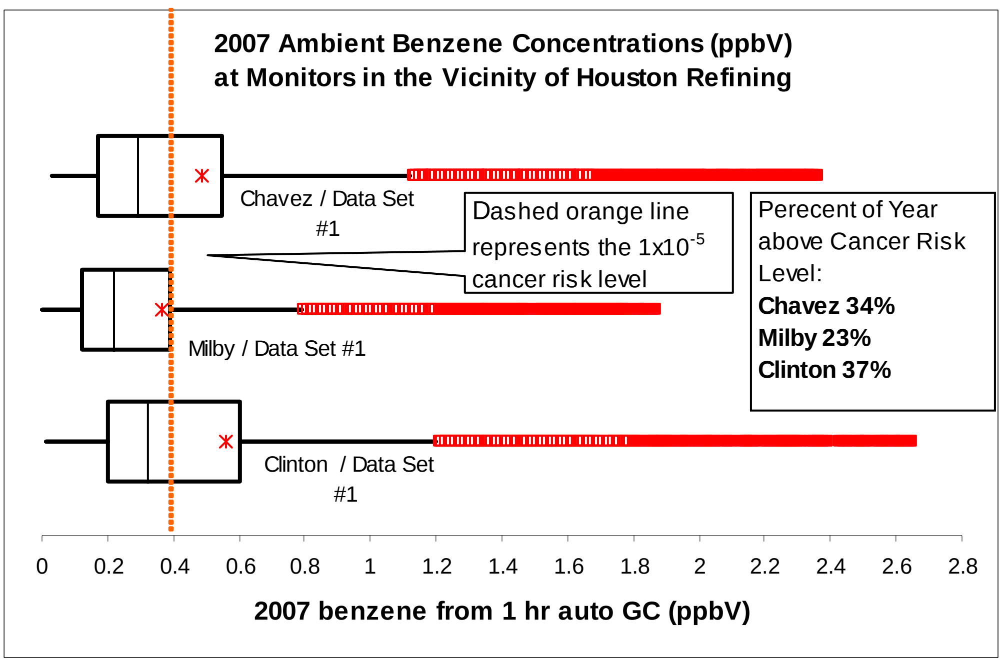
- Concentrations in the vicinity of these monitors continue to exceed the EPA $1x10^{-5}$ cancer risk level of 0.4 ppb benzene one fourth to one third of the year (http://www.greenhoustontx.gov/reports/benzenerisk.pdf).
- Overall annual average concentrations exceed the 1x10-5 cancer risk level in the vicinity of Clinton and Cesar Chavez.
- Concentrations have not shown statistically significant improvement in the past five years
- Concentrations downwind of the facility are statistically different from upwind concentrations
- The combined human health risk from benzene and 1,3 butadiene are the highest in the region at the facility vicinity monitor at Milby Park (approximately $8x10^{-5}$).

Details are provided below.

1. Overall ambient concentrations in 2007 as compared with risk limits

The 1-hr auto GC benzene concentrations from TCEQ monitors at Clinton, Milby and Cesar Chavez were statistically assessed and compared with the benzene cancer risk levels as defined by EPA OAQPS (http://www.greenhoustontx.gov/reports/benzenerisk.pdf). Annually, benzene concentrations at Clinton, Milby and Chavez exceed the risk level of $1x10^{-5}$ 37%, 22% and 34% of the time respectively. Average concentrations and the 95th upper confidence limit of the mean concentrations exceed the $1x10^{-5}$ risk level at Clinton and Chavez. The statistics are presented below in a table followed by side by side boxplots of the 2007 benzene concentration distributions.

2007 Benzene Statistics (ppbV)	Clinton	Milby	Chavez
number of hours measured	7546	7740	7860
% of time above $1x10^{-4}$	0.72	0.22	0.19
%of time above $1x10^{-5}$	37.33	22.61	34.21
%of time above $1x10^{-6}$	94.69	93.68	95.20
minimum	0.005	0	0.015
mean	0.54	0.35	0.46
median	0.31	0.2	0.28
95th upper confidence limit of the mean	0.56	0.36	0.48
t-statistic	1.645	1.645	1.645
standard deviation	1.16	0.55	0.65
maximum	66.93	21.03	17.44

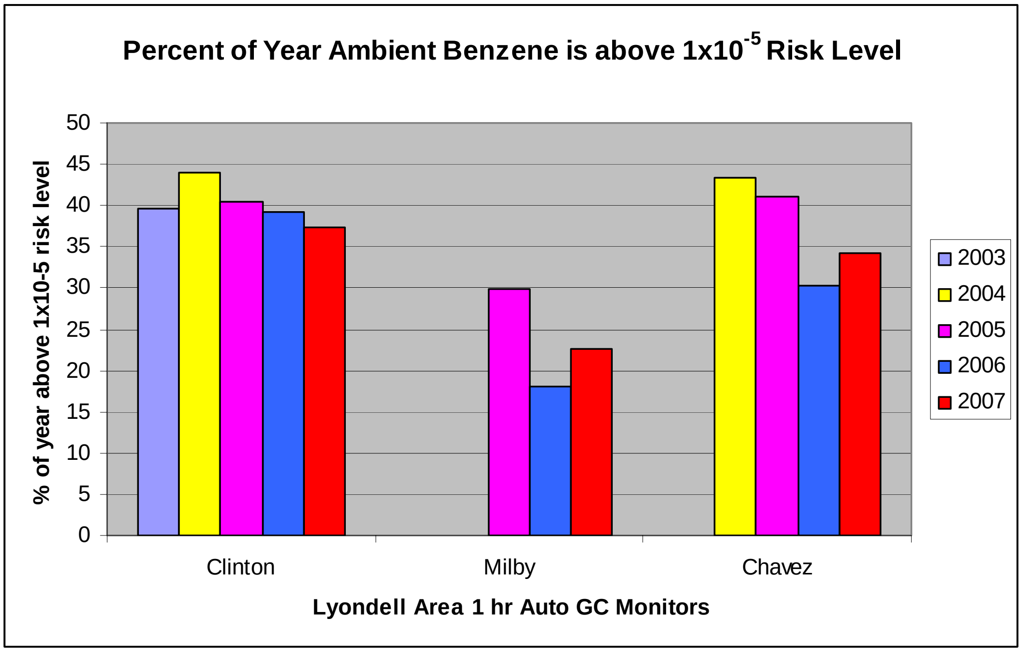


2. Temporal trend of concentrations above the $1x10^{-5}$ risk level were assessed to determine if there is improvement in the percent of time the level is exceeded annually

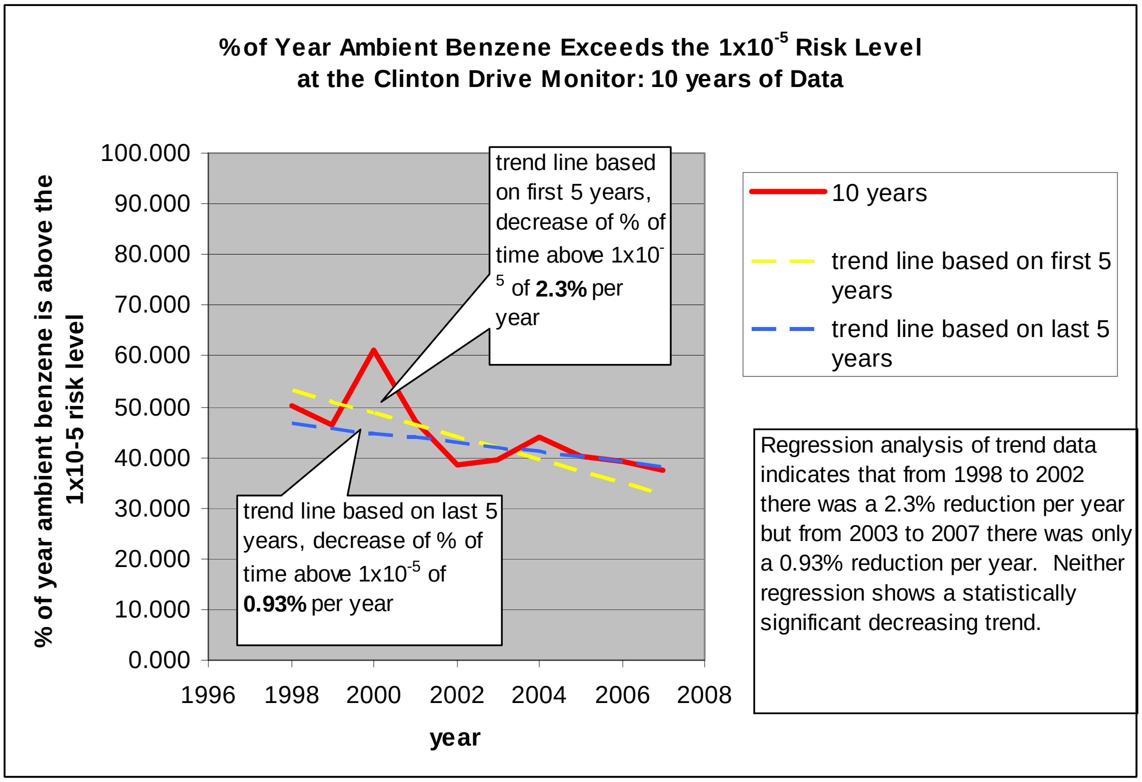
A more comprehensive trend analysis report on benzene and 1,3 butadiene in the Houston area is available at (http://www.greenhoustontx.gov/reports/benzeneandbutadiene.pdf). This trend analysis focuses on the percent of the year ambient benzene exceeds the 1x10-5 cancer risk level. Ten years of data are available at the Clinton monitor while three and four years are available at Milby and Chavez respectively. The bar graph below of the most recent five years indicates Clinton exceeds the level between 44% and 37% annually, Milby 22% to 29% annually and Chavez between 43% and 30% annually.

% of the Year Ambient Benzene Exceeds the $1x10^{-5}$ Risk Level of 0.4 ppb

Year	Clinton	Milby	Chavez
1998	50.29		
1999	46.51		
2000	61.08		
2001	47.03		
2002	38.58		
2003	39.6		
2004	44.05		43.44
2005	40.36	29.92	41.05
2006	39.29	18.13	30.34
2007	37.33	22.61	34.21



A more thorough look of the trend conducted on the ten years of data available at Clinton indicates a decreasing trend at a rate of 2.3% per year in the first five years (1998 to 2002) slowed by 60% to 0.93% in the most recent five years (2003-2007). Neither the first or second five year regressions have a statistically significant slope. The ten year overall regression does have a statistically significant slope (with an outlier in year 2000). These results indicate that decreases which occurred in the first half of the 10 years assessed have slowed in the second half and are not significant.



Regression diagnostics output:

Regression for Clinton last 5 years

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.597
R Square	0.357
Adjusted R Square	0.142
Standard Error	2.280
Observations	5.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.000	8.649	8.649	1.664	0.288
Residual	3.000	15.597	5.199		
Total	4.000	24.246			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	1904.776	1445.674	1.318	0.279	-2696.005	6505.557	-2696.005	6505.557
year	-0.930	0.721	-1.290	0.288	-3.225	1.365	-3.225	1.365

RESIDUAL OUTPUT

Observation	*Predicted Clinton*	*Residuals*	*Standard Residuals*
1.000	41.986	-2.386	-1.208
2.000	41.056	2.994	1.516
3.000	40.126	0.234	0.119
4.000	39.196	0.094	0.048
5.000	38.266	-0.936	-0.474

Regression for Clinton last 10 years
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.705
R Square	0.497
Adjusted R Square	0.434
Standard Error	5.458
Observations	10.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.000	235.375	235.375	7.900	0.023
Residual	8.000	238.361	29.795		
Total	9.000	473.736			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	3426.817	1203.423	2.848	0.022	651.718	6201.915	651.718	6201.915
Year	-1.689	0.601	-2.811	0.023	-3.075	-0.303	-3.075	-0.303

RESIDUAL OUTPUT

Observation	*Predicted Clinton*	*Residuals*	*Standard Residuals*
1.000	52.013	-1.723	-0.335
2.000	50.324	-3.814	-0.741
3.000	48.635	12.445	2.418
4.000	46.946	0.084	0.016
5.000	45.257	-6.677	-1.297
6.000	43.567	-3.967	-0.771
7.000	41.878	2.172	0.422
8.000	40.189	0.171	0.033
9.000	38.500	0.790	0.153
10.000	36.811	0.519	0.101

Regression for Clinton first 5 years
SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.444
R Square	0.197
Adjusted R Square	-0.070
Standard Error	8.433
Observations	5.000

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.000	52.441	52.441	0.737	0.454
Residual	3.000	213.351	71.117		
Total	4.000	265.792			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4628.698	5333.554	0.868	0.449	-12345.051	21602.447	-12345.051	21602.447
Year	-2.290	2.667	-0.859	0.454	-10.777	6.197	-10.777	6.197

RESIDUAL OUTPUT

Observation	*Predicted Clinton*	*Residuals*	*Standard Residuals*
1.000	53.278	-2.988	-0.409
2.000	50.988	-4.478	-0.613
3.000	48.698	12.382	1.695
4.000	46.408	0.622	0.085
5.000	44.118	-5.538	-0.758

3. Concentration profiles when these monitors are upwind and downwind of the facility were compared to determine if differences exist in the concentration profile before and after wind passes over the facility.

In order to ascertain what portion of the ambient concentrations may be attributable to the facility, the 2007 annual concentrations were broken down into wind profiles of upwind of the facility, downwind of the facility and crosswind of the facility. The facility is:

- Southeast of Clinton between 115 and 167 degrees
- East of Milby between 55 and 94 degrees
- Northeast of Cesar Chavez between 3 and 43 degrees

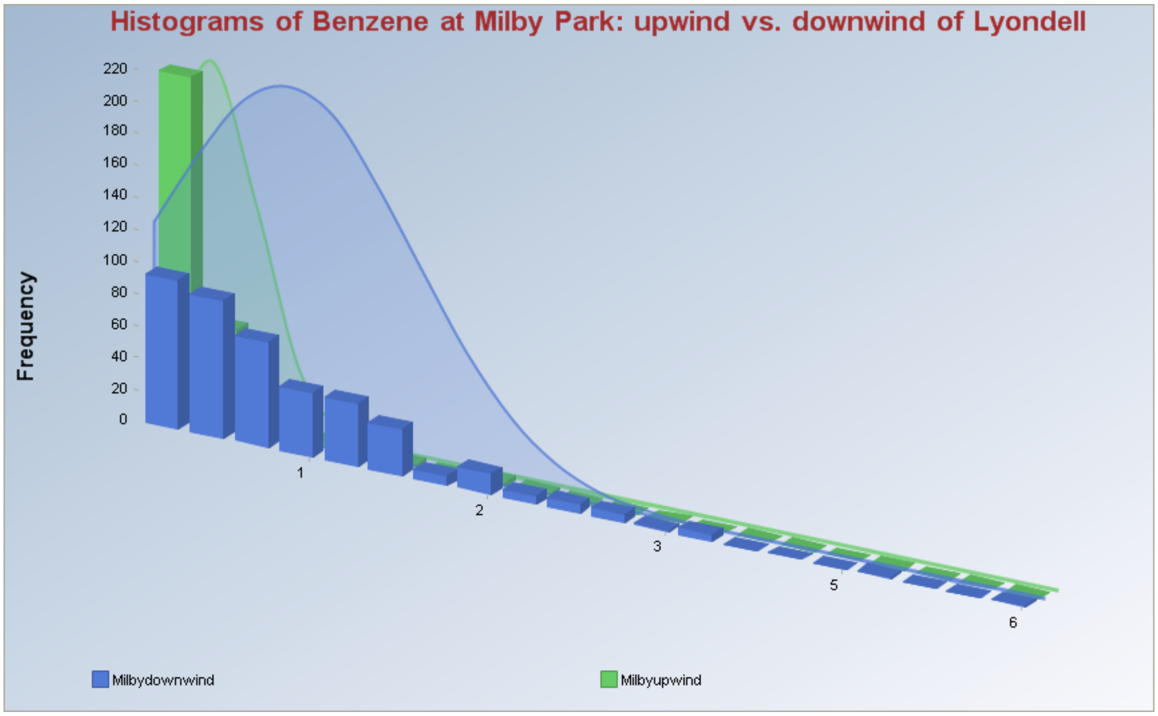
After the concentrations were divided in to upwind, downwind and crosswind bins by directions, the data sets were further refined. Concentrations associated with a standard deviation of wind direction greater than 30 degrees were eliminated, concentrations associated with a windspeed greater than 13 were eliminated and concentrations occurring during hours 10:00 am to 6:00 pm were eliminated.

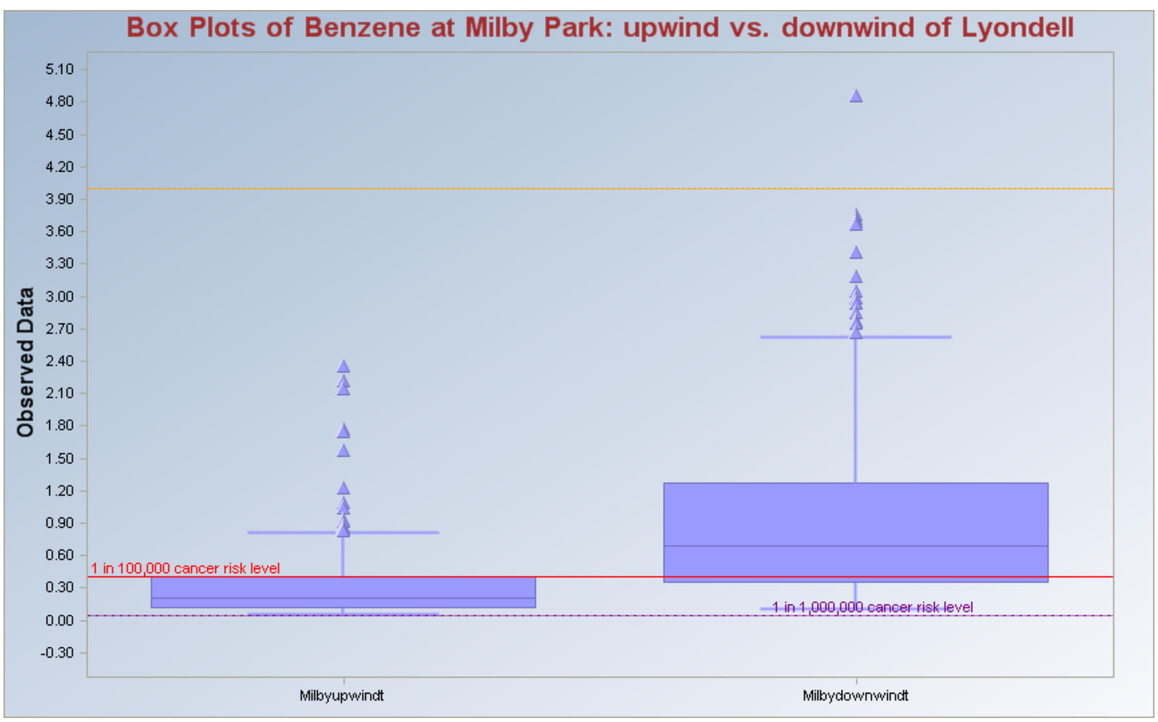
The most striking difference between upwind and downwind concentrations occurs at the Milby monitor. When the monitor is downwind of the facility , the concentration exceeds the $1x10^{-5}$ cancer risk limit 75% of the time, compared with exceeding the limit 25% of the time when the monitor is upwind of the facility

2007 Benzene Statistics (ppbV)	Milby Downwind of Houston Refining	Milby Upwind of Houston Refining
number of hours	395	308
% of time above $1x10^{-4}$	0.5	0.0
%of time above $1x10^{-5}$	70.4	24.7
%of time above $1x10^{-6}$	100.0	100.0
minimum	0.09	0.05
mean	0.92	0.31
median	0.69	0.21
95th upper confidence limit of the mean	0.99	0.34
t-statistic	1.649	1.650
standard deviation	0.79	0.32
maximum	5.78	2.36

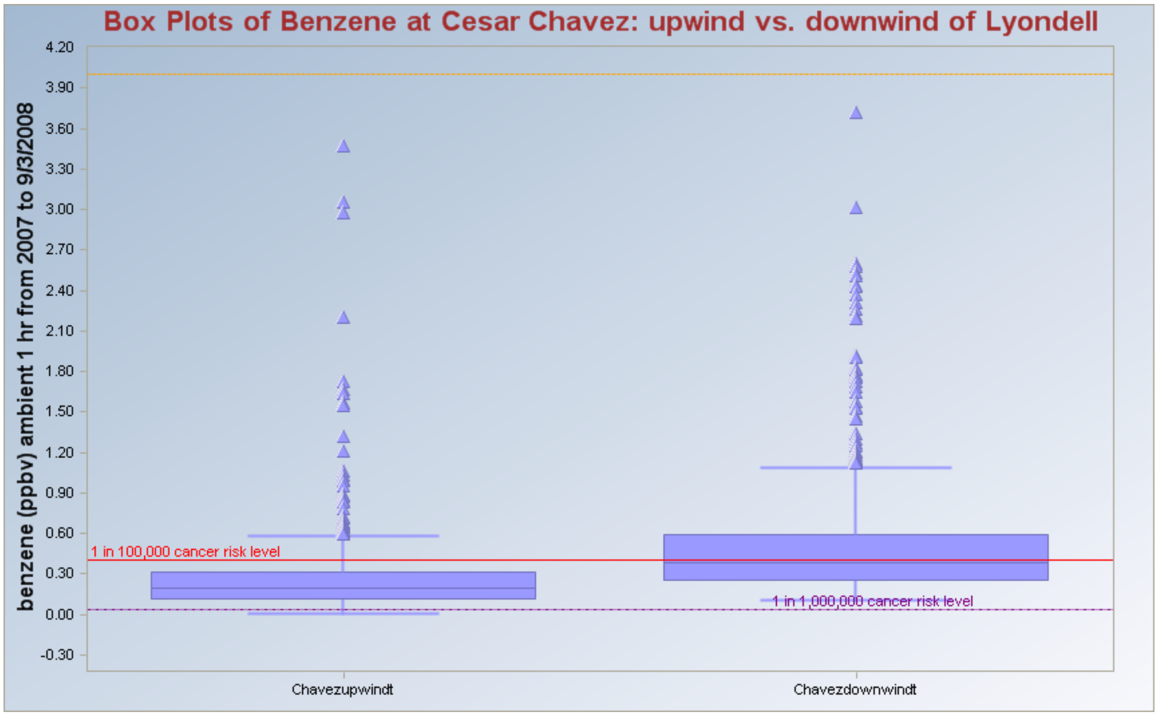
The concentration profiles at the Milby monitor upwind and downwind of the facility and at the Chavez monitor upwind and downwind of the facility are shown below in terms of side by side boxplots and side by side histograms. The Clinton monitor profiles were less interesting and not shown. The side by side graphs of upwind and downwind benzene concentrations indicate that concentrations are significantly lower when the monitors are upwind of the facility compared with downwind of the facility.

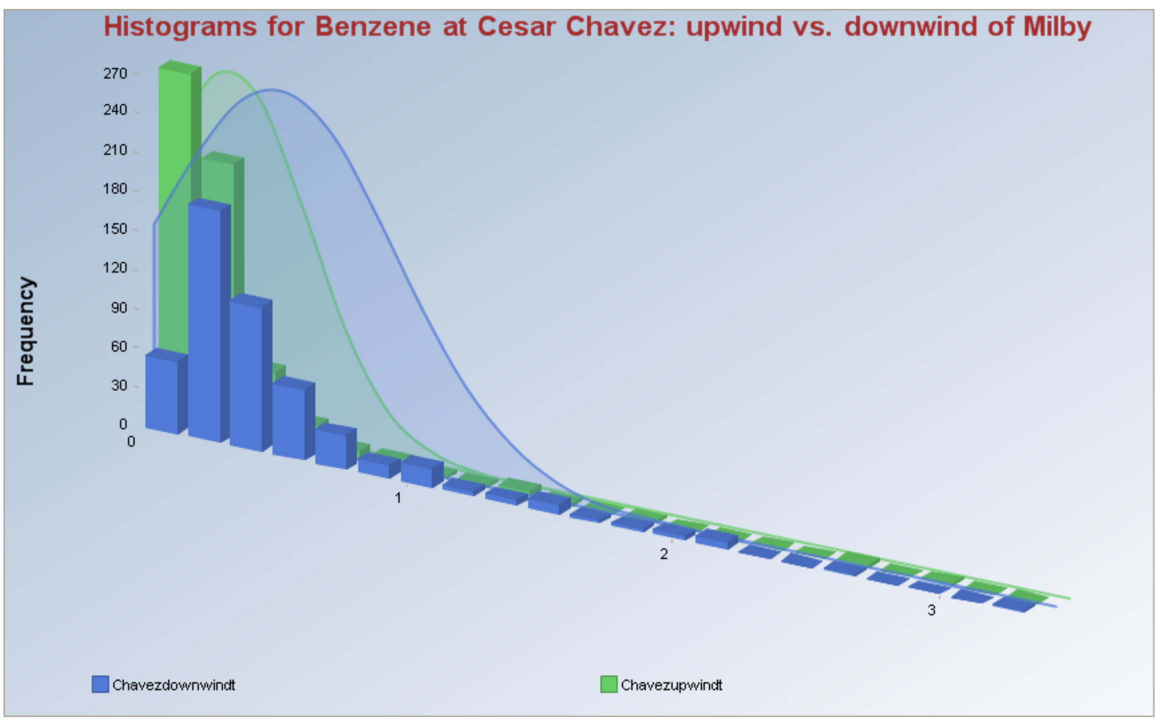
Milby: Side by Side Histograms and Boxplots Upwind and. Downwind of Facility





Chavez: Side by Side Histograms and Boxplots Upwind and. Downwind of Facility

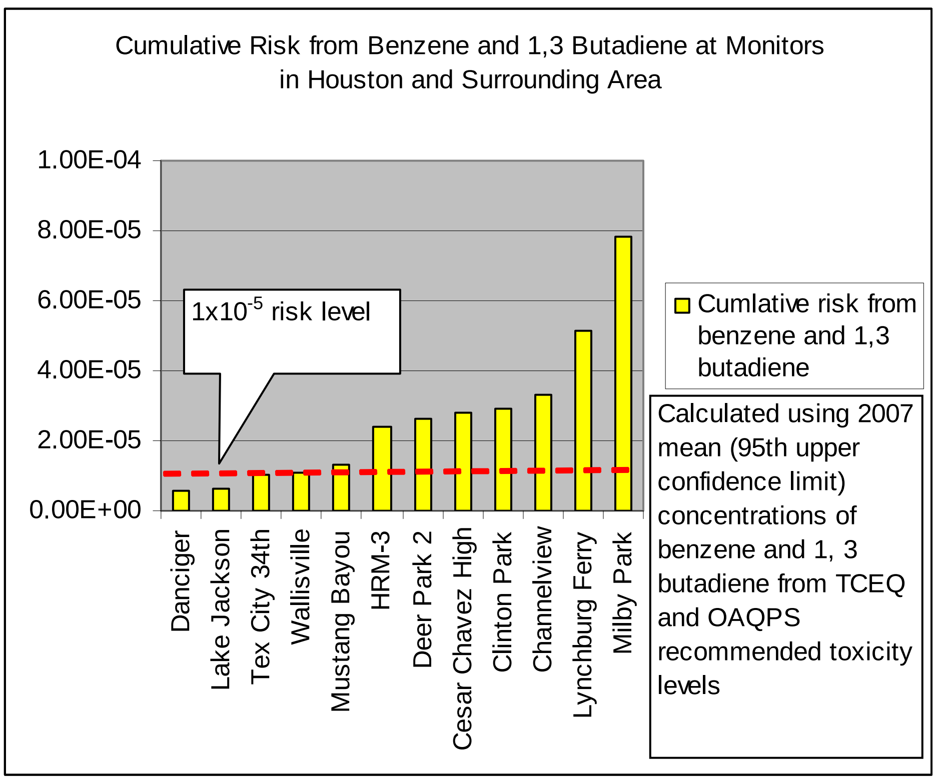




4. Benzene concentration profile human health risks were added to human health risk from 1,3 butadiene to determine the magnitude of additive risk in the vicinity of the facility

Citizens of the City of Houston and surrounding community are exposed to several criteria pollutants and air toxics simultaneously. Regulation of a single pollutant without consideration of exposure from others is ineffective in protecting human health. For example, when the risk from two main air toxics of concern in Houston are combined, the cumulative risk exceeds the 1×10^{-5} risk level for all but two locations. There are 7 pollutants posing a definite risk in Houston and the surrounding area as identified by experts on the Mayor's Task Force on the Health Effects of Air Pollution.[1] (Institute for Health Policy, 2006), therefore the risk will be even higher than those shown below. The concentration of 1,3 butadiene and benzene in the vicinity of the facility and Milby Park monitor yield an average (95th upper confidence limit of the mean) cumulative air risk of approximately 8×10^{-5}.

Figure 4. Cumulative risk for benzene and 1,3-butadiene at Houston area monitors



ATTACHMENT B

Statistical Assessment of
Benzene and 1,3-Butadiene
in Ambient Air in Houston Region

Statistical Assessment of Benzene and 1,3-Butadiene in Ambient Air in the Houston Region

Loren Raun, PhD
Mayor's Office of Environmental Programming
City of Houston
June 2008

Executive Summary

A statistical analysis of 5, 7, and 10 year trends of ambient levels of benzene and 1,3-butadiene 1 hour automatic gas chromatograph concentrations in the Houston region was conducted to determine whether annual levels were statistically decreasing. Trend tests were conducted on seven statistical measures of each air pollutant at 10 monitoring sites. For benzene, the analysis revealed that of the 70 statistics (7 measures for 10 monitors), only 27% (19 statistical measures) showed improvement in the past five years despite increased regulation and controls. Four of the 10 monitoring sites showed no improvement in any statistic for the 5, 7 or 10 year trends. For 1,3-butadiene, the analysis revealed worsening trends at two monitors and extremely high 2006 annual mean concentrations at a third monitor. Statistically significant decreasing trends were detected early on in the ten year period but absent in the most recent five years. These results indicate that regulation and controls which were initially effective in improving air quality have hit a plateau.

Introduction

Concentrations of air toxics in the Houston region have been a source of controversy for many years. The debate has covered topics such as whether the biggest source is industry or vehicles, and the authority the City has to regulate toxic air pollution that comes from outside the city limits. Both of these issues contribute to the complexity of the air toxic problem in Houston: multiple air toxics coming from multiple sources, many of which are located in close proximity to residential areas.

This report presents an objective analysis of the annual trends of two pollutants of concern in Houston known to pose a definite risk of developing cancer. The results provide a retrospective look at the efficacy of air toxic regulation and controls as well as a baseline for measuring future progress to cleaner air.

Summary of Analysis and Results

In order to answer the question, "Have benzene and 1,3-butadiene levels in the Houston area decreased over time?" a statistical analysis of available benzene and 1,3-butadiene data for the past 10 years was conducted. Data were analyzed using seven statistical measures to evaluate trends at ten monitoring sites. For those monitors having sufficient data for 10, 7, and 5 years, a trend analysis was conducted to determine if air quality was improving.

The reporting of statistical findings of improvement in Figure 1 is objective but lenient. A monitor was classified as improving if any one of the seven statistical measures showed improvement. Therefore, a monitor could have six statistical measures that show no improvement with one that shows improvement and the monitor would still receive an "improvement detected" rating.

Overall results for benzene indicate six of the ten monitors evaluated show an improving trend in benzene concentrations, while four do not. Closer examination of the data reveals that more decreasing trends are found in the 10 year analysis than in the seven or five year analyses. Of ten monitors evaluated from 2003-2007, only half show improvement or a decreasing trend in any of the seven measures. For this same period, seventy statistics (7 measures at 10 monitors) were evaluated, but only 19 show improvement – a 27% improvement rate. The improvement rate for the seven year trend is even lower with only 3 of 21 statistics showing improvement, a meager 14%.

An additional analysis was done to rank twelve monitoring sites from most to least contaminated by benzene for the most recent year, 2007. This most to least ranking, based on current conditions, is key to interpreting the impact of a decreasing trend or no decreasing trend. A "contamination rank" was calculated based on an average of the rankings of seven statistical measures for 2007. Each monitor was given a rank for each of the seven statistical measures. All seven ranks for each monitor were then averaged to produce a single average rank for each monitor, the "contamination rank." Monitors were ordered in a table showing most contaminated at the top to least contaminated at the bottom (Figure 2).

Figure 1. Annual Average Benzene Concentrations for 2007 and 5 Year Trends (2003-2007)

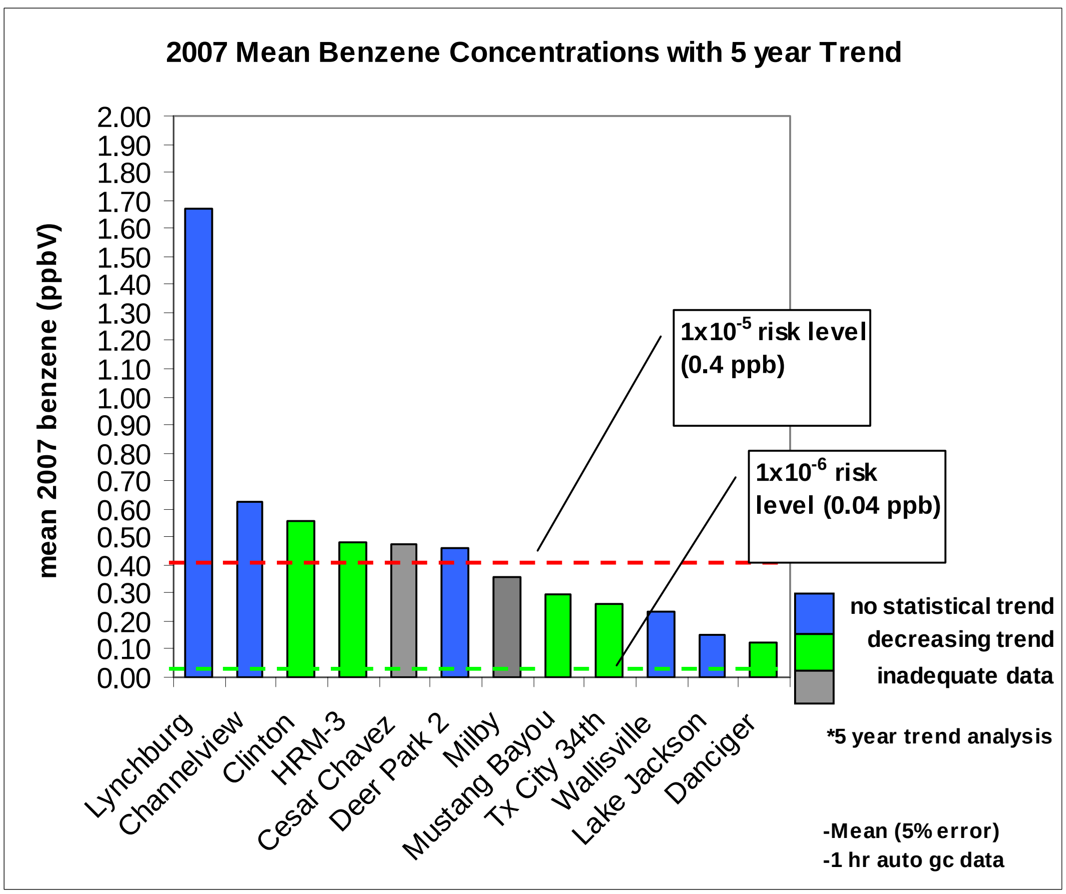


Figure 2. Ten, Seven and Five Year Trend Test Results for Benzene

Benzene — Trend Test Results Which Show Improvement

Order of Most Contaminated	2007 contamination rank	10 yr Trend	7 yr Trend	5 yr Trend	Improvement detected?
Lynchburg	10.71			0/7	no
Channelview	10.71		0/7	0/7	no
Clinton	9.57	5/7	1/7	2/7	yes
HRM-3	8.71			5/7	yes
Cesar Chavez	7.71				
Deer Park 2	7.43	4/7	2/7	0/7	yes
Milby	6.86				
Mustang Bayou	4.86			4/7	yes
Tx City 34th	4.14			6/7	yes
Wallisville	3.43			0/7	no
Lake Jackson	1.71			0/7	no
Danciger	1.29			2/7	yes

ordering based on average rank of 7 statistical indicators
trend summary is the number of trend statistics showing statistically significant improvement in trend of air quality out of 7 trend tests on different statistics (α=0.05)
= not enough data

The situation for 1,3-butadiene is somewhat more encouraging. Only one monitor did not show improvement in the trend analysis of the 1 hour automatic gas chromatograph data and measurements at that site are close to an acceptable risk level (Figure 3). However, there were worsening trends for two statistical measures each at the Deer Park 2 and Wallisville monitors.

Figure 3. 2007 Mean 1,3-Butadiene Concentrations with 5 year Trend

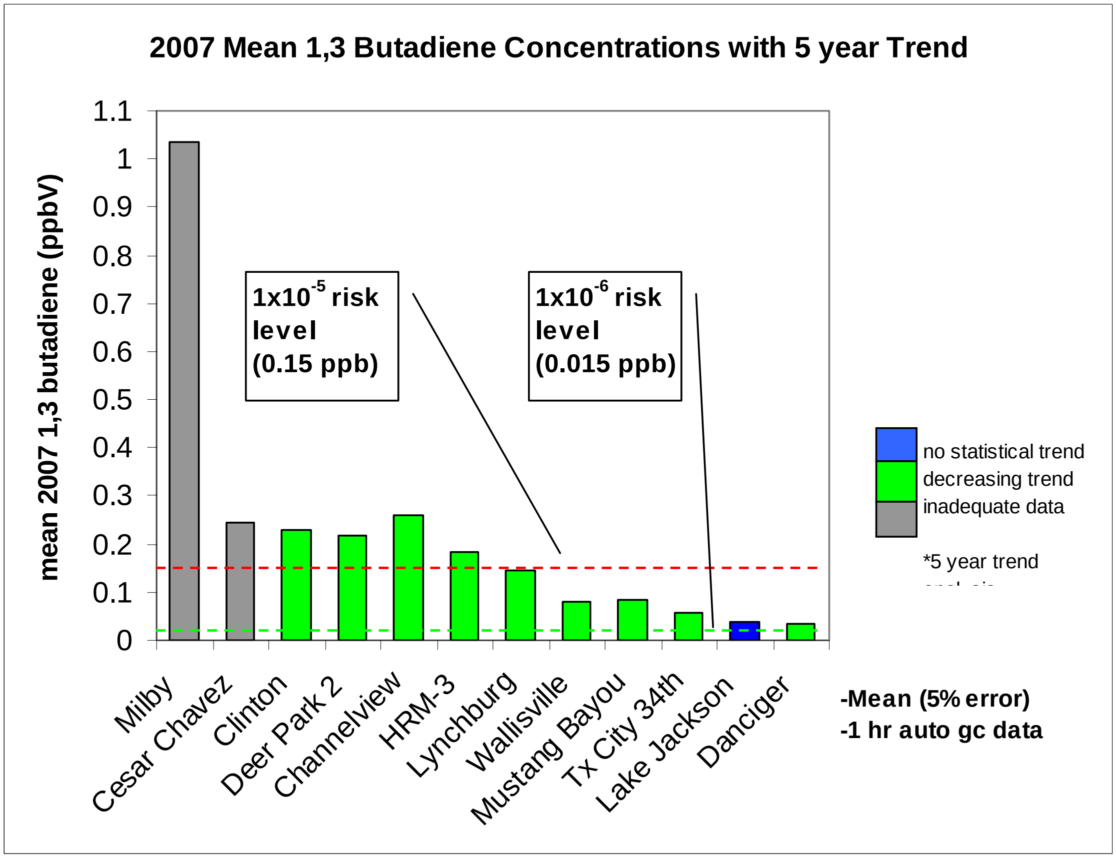


Figure 4. 1,3-Butadiene. Trend test results which show improvement

1,3-butadiene Trend Test Results Which Show Improvement

Order of Most Contaminated	2007 contamination rank	10 yr Trend	7 yr Trend	5 yr Trend	Improvement detected?
Milby	11.4				
Cesar Chavez	9.3				
Clinton	9.1	5/7	1/7	4/7	Yes
Deer Park 2	8.9	2/7	0/7	2/7	Yes
Channelview	8.4		3/7	2/7	Yes
HRM-3	7.7			5/7	Yes
Lynchberg	6.1			4/7	Yes
Wallisville	4.7			2/7	Yes
Mustang Bayou	4.4			2/7	Yes
Tx City 34th	3.6			1/7	Yes
Lake Jackson	1.6			0/7	No
Danciger	1.6			3/7	Yes

ordering based on average rank of 7 statistical indicators

trend summary is the number of trend statistics showing statistically significant improvement in trend of air quality out of 7 trend tests on different statistics (=0.05)

= not enough data

*Wallisville and Deer Park 2 have one 5 yr trend of worsening conditions

*Deer Park 2 has three 7 yr trends of worsening conditions

*Deer Park 2 has one 10 yr trend of worsening conditions

Extremely high annual mean concentrations of 1,3-butadiene are measured at Milby Park. The maximum concentration measured at Milby Park in 2006 was thirteen times greater than the previous maximum measured in the Houston region. One hour gas chromtograph data from Milby has only been available since 2005, so no trend analyses were conducted*. However, concentrations of 1,3-butadiene at Milby Park in the most recent three years consistently exceed the one in one-hundred thousand health risk level for all statistical measures, with only one exception. (*Note: Canister data for Milby Park dating back to 1999 shows improvement. However, this trend analysis focuses only on the 1 hour gas chromatograph data.)

The trend analyses and the statistical measures are discussed in detail below.

Benzene trend analysis

The following seven statistical measures were calculated for each of the years that data were available at each site and were used for the trend analysis: mean at 95th upper confidence limit (statistically assured average), maximum concentration, median concentration (midpoint), median of concentrations above the $1x10^{-5}$ limit health limit, percent of time above $1x10^{-4}$ health limit, percent of time above $1x10^{-5}$ health limit, and percent of time below $1x10^{-6}$ health limit.

A trend analysis using the Mann Kendall test was conducted on the statistical measures for the most recent 5, 7 and 10 years to determine increases and decreases in benzene concentrations over time. Decreasing trends are counted as improvements except for percent of time below $1x10^{-6}$ health limit, which is counted as an improvement if it has an increasing trend. The number of improvements is listed in the numerator of the fractions in Figure 2. If even one of the trends measured in the past 10 years showed a decrease, that monitor was considered as “improving.”

Evaluation of annual data for 2007 indicated that the Lynchburg Ferry and Channelview sites ranked as “most contaminated” for seven benzene measures, and the Lake Jackson and Danciger sites were least contaminated (Figure 2 and Appendix Figure P-1). Only two sites, Clinton and Deer Park 2, had sufficient annual data for a 10-year trend analysis. Both showed improvement in several of the seven measures in the 10 and 7-year trend analyses. Clinton showed improvement in the 5-year trend analysis, but the Deer Park 2 monitor showed no improvement.

Although an improvement in the ten year trend of benzene concentrations is seen at Clinton and Deer Park 2, improvement was detected at only half of the ten sites evaluated for the last 5 years. In addition to the Clinton site, HRM-3, Mustang Bayou, Texas City 34th St., and Danciger showed improvement. HRM-3 and Texas City 34th St. had the most improvement with 5 and 6 of 7 measures showing decreases, respectively. Mustang Bayou had improvement in 4 of 7 measures, and Clinton and Danciger in 2 of 7.

In addition to Deer Park 2, four other monitors showed no improvement in the past 5 years: Lynchburg Ferry, Channelview, Wallisville, and Lake Jackson. However, annual mean benzene concentrations at Wallisville and Lake Jackson have remained below $1x10^{-5}$ (ten in a million) risk level for the past 5 years (Appendix Figure A-1); therefore improvement in any of the seven measures would be unexpected. In contrast, although Deer Park and Clinton monitors show statistical improvement (Figure 2), annual mean benzene concentrations at these two monitors have remained above the $1x10^{-5}$ (10 in a million) risk level for the past ten years (Appendix Figure A-1).

Acceptable benzene risk levels at Lake Jackson and improving five-year trends at Mustang Bayou and Danciger are consistent with the values for the percent of the year below the $1x10^{-6}$ (one in a million) risk level (Appendix Figure H-1). In 2004, Lake Jackson experienced acceptable risk levels for 42% of the year and from 22% to 25% for years 2003, 2005, 2006 and 2007. In addition, Mustang Bayou and Danciger had acceptable levels of benzene for at least 10% of the last five years.

Lynchburg Ferry and Channelview sites ranked highest for annual benzene measures in 2007 and have shown no improvement in the past 5-7 years in any of the seven measures evaluated.[1] When comparing annual means (Appendix Figure A-1) and medians (Appendix Figure D-1) at all ten monitors for each of the years that data are available, the annual mean is higher in all cases than the median, indicating that values greater than the middle point are affecting the mean.

Maximum one-hour values are in the $1x10^{-4}$ (100 in a million) risk range for all but two years at two different sites (Appendix Figure B-1). At Lynchburg Ferry, maximum values each year have been greater than 400 ppbV/hour for the past five years. The acceptable $1x10^{-6}$ risk level is 0.04 ppbV.

By looking only at the data that exceed the $1x10^{-5}$ (10 in a million) risk level, one can see the severity to which the concentrations exceed the limit at Lynchburg Ferry. In 2003, 2005 and 2006 the median of those concentrations was three times the 10 in a million risk level (Appendix Figure E-1) and benzene concentrations exceeded the $1x10^{-4}$ (100 in a million) risk level for more than 10% of the year (Appendix Figure F-1). The $1x10^{-5}$ (10 in a million) risk level was exceeded for more than 50% of the year in 2003 and 2005 and more than 40% for 2004, 2006 and 2007 (Appendix Figure G-1).

In the past five years, the $1x10^{-5}$ (10 in a million) risk level was also exceeded for more than 50% of the year at HRM-3 and Channelview monitors in 2003 (Appendix Figure G-1).

1,3-Butadiene trend analysis

A similar analysis conducted for available data on 1,3-butadiene at the same ten monitors gave a more positive outlook than was seen for benzene. Only the Lake Jackson monitor did not show a decreasing trend for 1,3-butadiene over the past five years (Figure 3) whereas four monitors did not show a decreasing trend for benzene. In ranking the twelve sites for 2007, Milby ranked

[1] In 2001, the Channelview site had only a 21% frequency of detection.

highest for the seven 1,3-butadiene measures and Lake Jackson and Danciger were again the lowest (Figure 4 and Appendix Figure P-2).

Clinton and Deer Park 2 were the only two sites that had sufficient data for a 10-year trend analysis and both showed improvement in several of the seven measures in the 10, and 5-year trend analyses. The Deer Park 2 site showed no improvement in any of the seven measures in the 7-year trend analysis and the Clinton site showed improvement in only one measure. Three of seven measures showed improvement at the Channelview site in the 7-year trend analysis.[2]
In the five year trend analysis, all ten sites showed improvement for measures of 1,3-butadiene except Lake Jackson. As was the case with benzene, annual mean 1,3-butadiene concentrations at Lake Jackson have remained below $1x10^{-5}$ (ten in a million) risk level for the past five years and the seven statistical measures would not be expected to show much improvement. HRM-3 showed the most improvement with 5 of 7 measures. Clinton and Lynchburg Ferry had improvement in 4 of 7 measures, and Danciger in 3 of 7. Twenty-five of the seventy statistics evaluated for 1, 3-butadiene showed improvement in the past five years versus nineteen for the benzene statistics (Figure 4) Five years of data are not available for Milby Park or Cesar Chavez monitors, so they are not included in the trend analysis.

One major difference between the benzene and 1,3-butadiene trend analysis is the appearance of "worsening" trends for 1,3-butadiene. The Deer Park 2 monitor had worsening trends for percent of year below $1x10^{-6}$ for the 10, 7, and 5 year trend analyses, and also for percent of year above $1x10^{-5}$ for the 7 year trend (Appendix Figures H-2 and G-2). The Wallisville monitor had one worsening trend for the maximum statistic for the five year trend analyses. All of these worsening trends were caused by increases in statistical measures in 2006. No worsening trends were seen in the benzene analysis.

On a more positive note, one site had a risk level of less than one in a million ($1x10^{-6)}$ for one of the statistical measures. The annual median for Mustang Bayou was 0.01 ppbV for 2003 and 0 ppbV for 2006 (Appendix Figure D-2). The remaining three years, 2004, 2005 and 2007 had an annual median of 0.02 ppbV. The acceptable risk level for 1,3-butadiene is 0.015 ppbV.

Both the highest annual mean concentration of 1,3-butadiene (Appendix Figure A-2) and the greatest annual maximum concentration (1611.25 ppbV) were measured at the Milby Park monitor in 2006. This value is 13 times greater than the second highest maximum (121.87 ppbV), which was measured at Lynchburg Ferry in 2005 (Appendix Figure B-2).

Looking only at the highest concentrations measured at Milby Park, those that exceed the $1x10^{-5}$ (10 in a million) risk level, gives a better picture of the severity of 1,3-butadiene measures. In 2005 and 2007 the median of those concentrations was six times the 10 in a million risk level and four times in 2006 (Appendix Figure E-2). In 2005 and 2007, 1,3-butadiene concentrations exceeded the $1x10^{-5}$ (10 in a million) risk level for more than 50% of the year (Appendix Figure G-2) and for 49% of 2006. Milby Park exceeded the $1x10^{-4}$ (100 in a million) risk level for 22%, 13% and 19% of the year in 2005, 2006, and 2007 respectively (Appendix Figure F-2). The

[2] In 2001, the Channelview site had only a 21% frequency of detection.

Lynchburg Ferry and Deer Park monitors also exceeded 1x10^{-5} (10 in a million) risk level for more than 50% of the year for one of the past five years.

Figure 5. Map of Houston area monitors with automated gas chromatographs

Methods
This analysis is a statistical assessment of 10 years (1998-2007) of all of the available benzene one-hour automated gas chromatograph (autoGC) data in the Houston region. All concentrations are in parts per billion by volume (ppbV). Each year is evaluated in terms of 8 statistical measures for both benzene and 1,3-butadiene: mean at 95th upper confidence, arithmetic mean (Appendix Figure C-1 and C-2), maximum, median, median of concentrations above the 1x10^{-5} limit risk level, percent of time above 1x10^{-4} risk level, percent of time above 1x10^{-5} risk level, and percent of time below 1x10^{-6} risk level. A summary of the statistics generated for the 8 measures at twelve monitors, including sample distribution for benzene and 1,3-butadiene, is presented in Appendix Figure I-1 and I-2.

The percent of each year having missing data or non-detectable values was calculated to ensure that the years are representative. Data that were below the detection limit of the equipment and could not be measured were replaced with a value that is one-half the detection limit. This more accurate method is recommended by the EPA for handling data below the detection limit. (Appendix Figures Q-1 and Q-2, R-1 and R-2, S-1 and S-2).

All monitors had some years when frequency of detection was less than 80% except the Cesar Chavez and Milby Park monitors that were only analyzed for 2007. In 2003, all monitors except the Channelview monitor had less than 80% frequency of detection (Appendix Figures R-1 and R-2). In those years when frequency of detection was between 50% and 80%, data was interpreted cautiously. For the five year trend analysis, a lower frequency of detection would tend toward less improvement because higher concentrations would be less likely to be measured. The low frequency of detection in 2003 would have less of an effect on the ten year trend analysis.

The trend of each statistic was evaluated using the EPA recommended Mann Kendall test for trend at the 5% significance level, one sided. The Mann Kendall test is a widely accepted trend test especially suited for environmental data (Appendix Figure T-1 and T-2).

Only seven of the eight statistics evaluated at each site were used in the ranking and trend analysis; the arithmetic mean rank was not used because it duplicates the mean rank at 95% confidence. A trend test (Mann Kendall) was conducted for each of the seven statistics at monitors with adequate data (α=0.05). Trend test results calculated from the Mann Kendall test at 10, 7 and 5 years are presented in Appendix Figures J-1 and J-2, L-1 and L-2, and N-1 and N-2 respectively. Improvements in benzene measures for the same trend analyses are listed in Appendix Figures K-1 and K-2, M-1 and M-2, and O-1 and O-2.

The health levels are derived from the EPA Office of Air Quality Planning and Standards unit risk levels (http://cfpub.epa.gov/ncea/iris/index.cfm?fuseaction=iris.showSubstanceList. 5/30/2008). The $1x10^{-6}$ risk level for benzene is 0.04 ppbV and for 1,3-butadiene is 0.015 ppbV.

Figure 5 shows the sites with automated gas chromatographs. All of these sites are in the Houston region. Clinton, Milby and Cesar Chavez are in the city limits, HRM-3 is just outside of the city limits and Channelview, Deer Park 2, Wallisville, and Lynchburg are close to the Houston Ship Channel and within Harris County. Texas City, Mustang Bayou, Lake Jackson, and Danciger are located along the Gulf Coast but within the 8-county metropolitan statistical area and considered to be part of the Houston region. The data were obtained from the Texas Commission on Environmental Quality that maintains a network of monitors in the Houston region.

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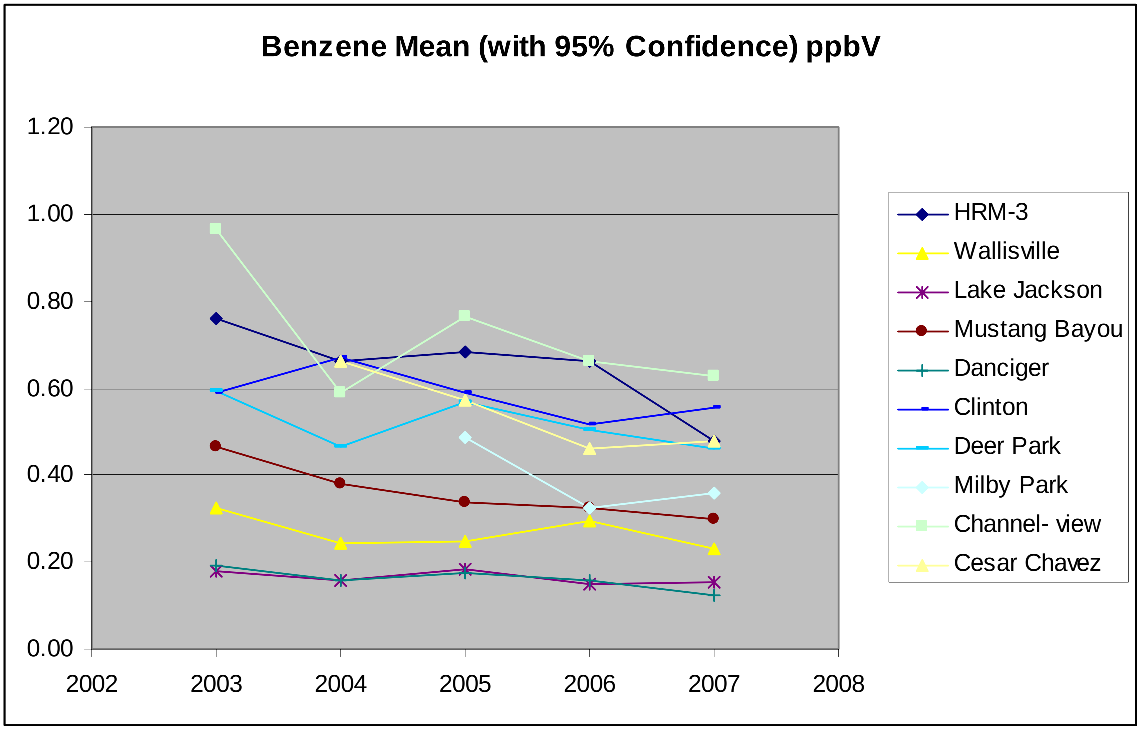
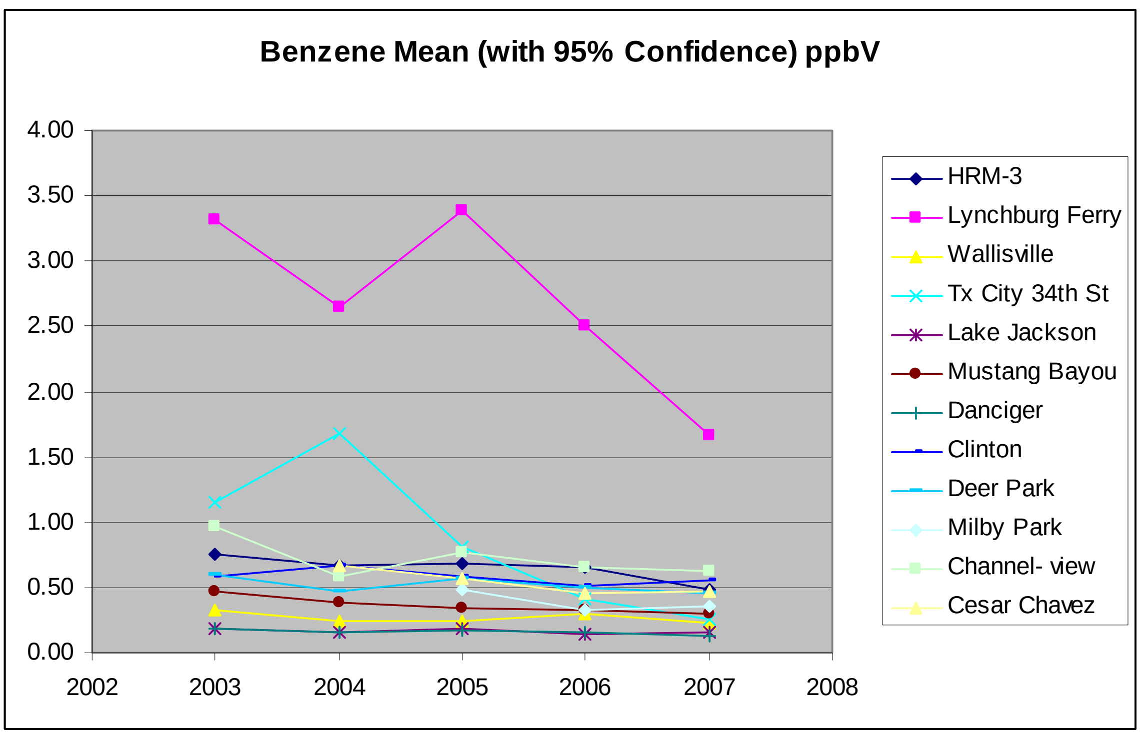
Figure A-3. Benzene and 1,3-Butadiene Combined Inhalation Risk

Figure A-1. Benzene mean with 95% confidence





Benzene Mean (with 95% Confidence) ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1.16		0.76	0.66	0.68	0.66	0.48
Lynchburg Ferry						3.32	2.65	3.39	2.51	1.67
Wallisville						0.33	0.24	0.25	0.29	0.23
Tx City 34th St						1.15	1.68	0.80	0.41	0.26
Lake Jackson						0.18	0.16	0.18	0.15	0.15
Mustang Bayou						0.47	0.38	0.34	0.32	0.30
Danciger						0.19	0.16	0.18	0.16	0.13
Clinton	0.72	0.75	0.82	0.68	0.58	0.59	0.67	0.59	0.52	0.56
Deer Park	0.66	0.78	0.47	0.55	0.64	0.60	0.46	0.57	0.50	0.46
Milby Park								0.49	0.33	0.36
Channel-view				0.91	0.68	0.97	0.59	0.76	0.66	0.63
Cesar Chavez							0.66	0.57	0.46	0.48

This statistic is the upper 95th confidence limit of the annual mean of the hourly automatic gas chromatograph data. Although the true mean cannot be known without analyzing all of the air, the probability that the true mean is higher than this number is held to 5%.

red	= $1x10^{-4}$ risk, 4.0 ppbV, or greater
orange	=$1x10^{-5}$ risk, 0.4 ppbV, or greater
yellow	=$1x10^{-6}$ risk, 0.04 ppbV, or greater
green	=less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure B-1. Benzene maximum

Benzene Maximum ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				13.64		25.37	31.74	153.96	296.58	44.12
Lynchburg Ferry						525.58	1551.92	770.78	418.98	912.74
Wallisville						9.28	7.39	7.22	8.88	10.67
Tx City 34th St						115.86	177.01	179.24	57.95	14.14
Lake Jackson						4.31	19.92	3.79	8.9	3.5
Mustang Bayou						10.15	13.51	8.19	15.52	13.83
Danciger						4.49	6.83	6.23	5.4	2.68
Clinton	113.68	77.59	52.19	43.53	23.82	27.52	73.54	26.09	8.52	66.93
Deer Park	32.56	27.03	13.37	25.68	15.63	17.03	16.2	23.6	20.85	41.8
Milby Park								25.59	21.1	21.03
Channel-view				44.31	17.75	70.95	23.84	133.48	26.57	25.68
Cesar Chavez							20.93	15	32.21	17.44

This statistic is the maximum concentration of the 1 hour annual data.

red = $1x10^{-4}$ risk, 4.0 ppbV, or greater

orange =$1x10^{-5}$ risk, 0.4 ppbV, or greater

yellow =$1x10^{-6}$ risk, 0.04 ppbV, or greater

green =less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure C-1. Benzene mean

Benzene Mean ppbV

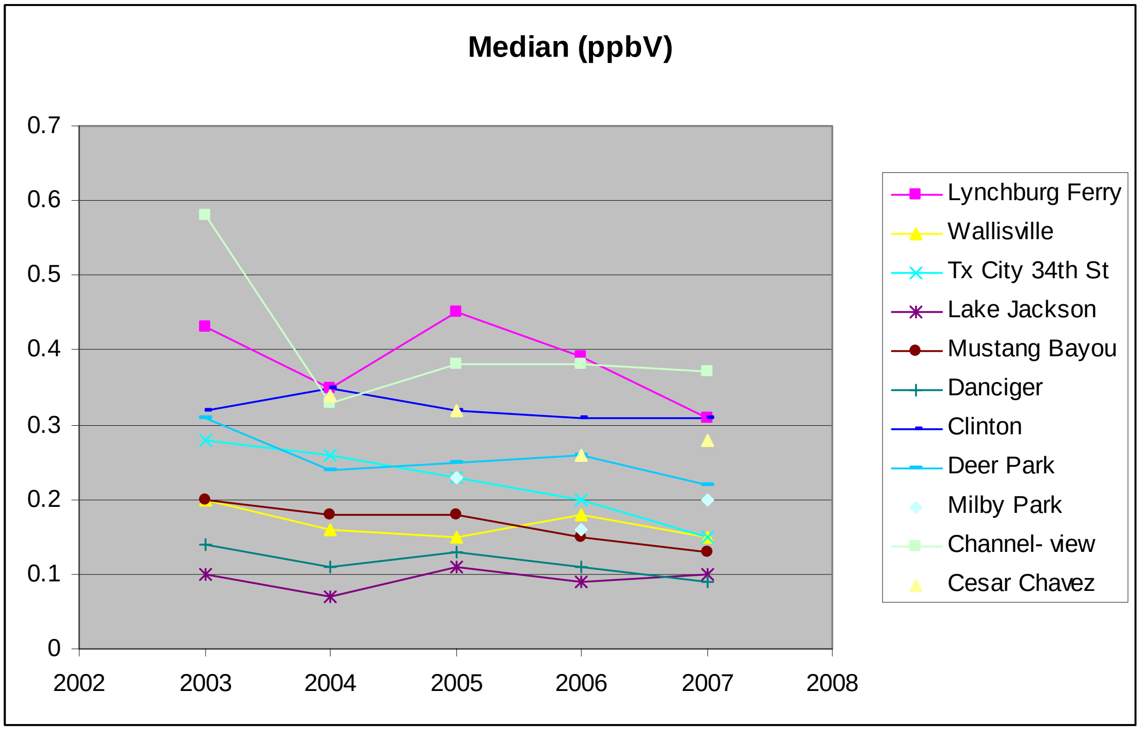
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1.11		0.74	0.65	0.64	0.58	0.46
Lynchburg Ferry						2.84	2.23	3.02	2.27	1.44
Wallisville						0.32	0.24	0.24	0.29	0.23
Tx City 34th St						1.04	1.55	0.74	0.39	0.25
Lake Jackson						0.17	0.15	0.18	0.14	0.15
Mustang Bayou						0.45	0.37	0.33	0.31	0.29
Danciger						0.18	0.15	0.17	0.15	0.12
Clinton	0.69	0.71	0.79	0.65	0.57	0.57	0.64	0.57	0.50	0.54
Deer Park	0.64	0.75	0.46	0.53	0.63	0.58	0.45	0.54	0.49	0.44
Milby Park								0.47	0.31	0.35
Channel-view				0.85	0.66	0.93	0.57	0.71	0.64	0.61
Cesar Chavez							0.64	0.56	0.45	0.46

This statistic is the the annual sample mean of the hourly automatic gas chromatograph data without confidence. It is used in conjunction with the number of samples collected and the standard deviation of the samples to calculate the upper confidence limit of the true mean.

red	= $1x10^{-4}$ risk, 4.0 ppbV, or greater
orange	=$1x10^{-5}$ risk, 0.4 ppbV, or greater
yellow	=$1x10^{-6}$ risk, 0.04 ppbV, or greater
green	=less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure D-1. Benzene median



Benzene Median ppbV

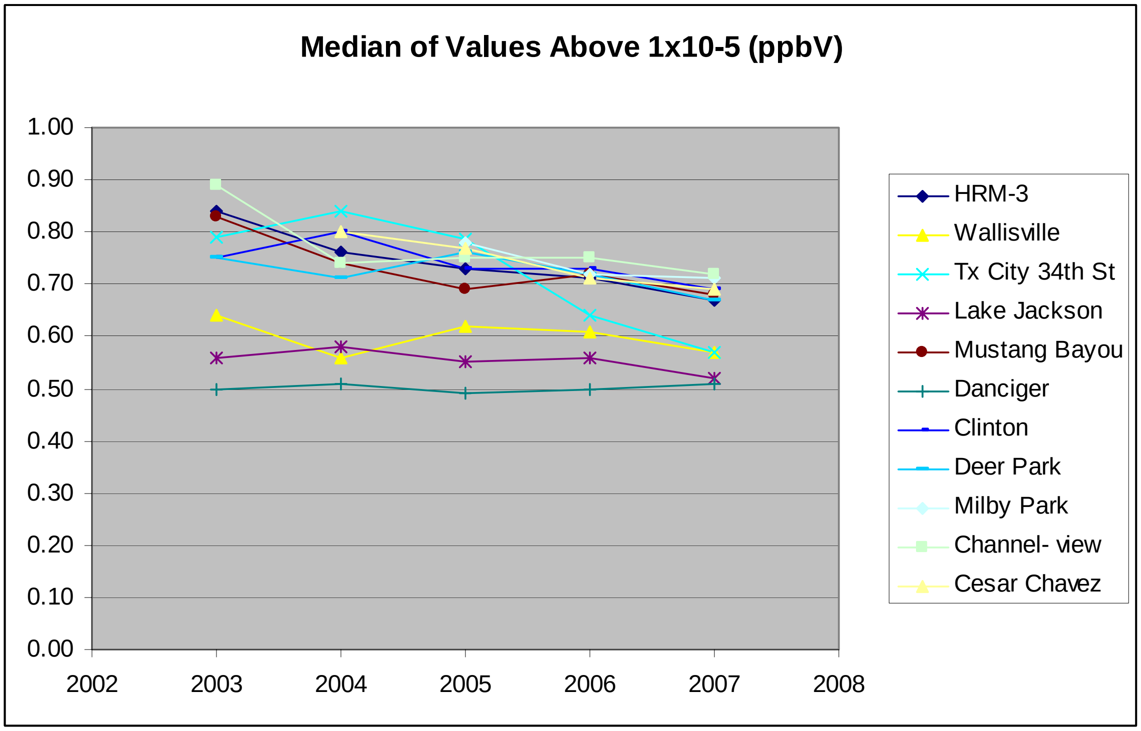
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.83		0.44	0.39	0.39	0.29	0.29
Lynchburg Ferry						0.43	0.35	0.45	0.39	0.31
Wallisville						0.2	0.16	0.15	0.18	0.15
Tx City 34th St						0.28	0.26	0.23	0.2	0.15
Lake Jackson						0.1	0.07	0.11	0.09	0.1
Mustang Bayou						0.2	0.18	0.18	0.15	0.13
Danciger						0.14	0.11	0.13	0.11	0.09
Clinton	0.41	0.37	0.5	0.37	0.31	0.32	0.35	0.32	0.31	0.31
Deer Park	0.38	0.37	0.29	0.26	0.37	0.31	0.24	0.25	0.26	0.22
Milby Park								0.23	0.16	0.2
Channel-view				0.54	0.49	0.58	0.33	0.38	0.38	0.37
Cesar Chavez							0.34	0.32	0.26	0.28

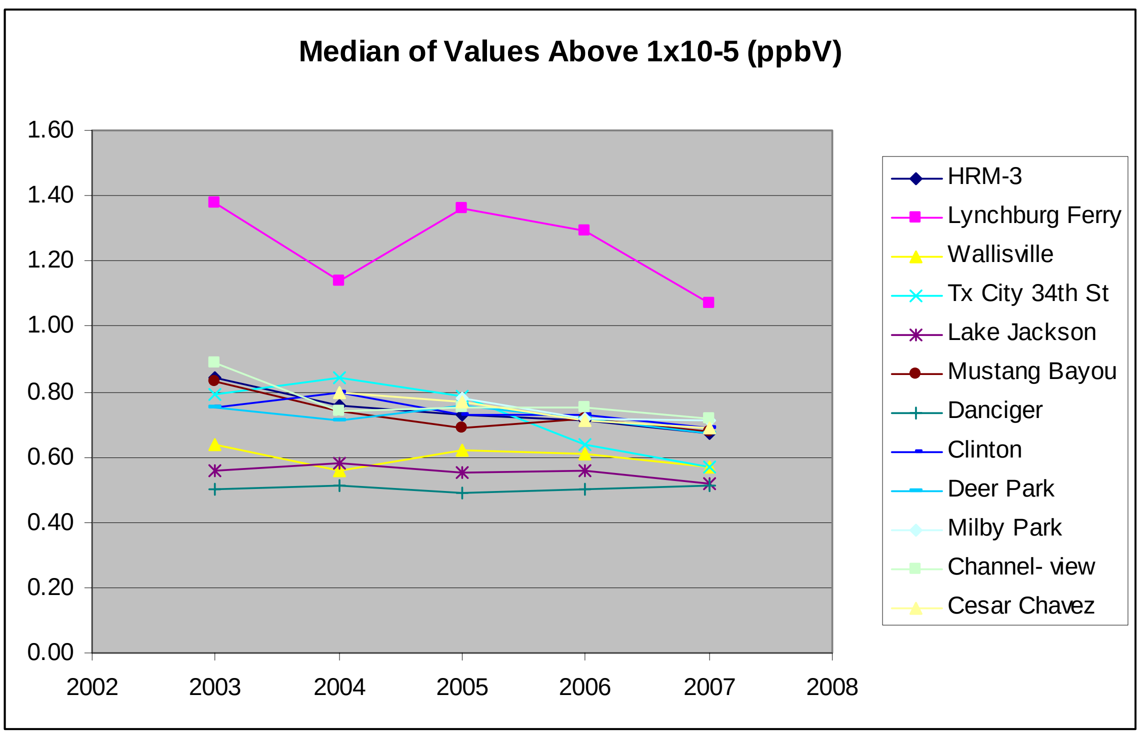
This statistic is the middle 50% of the data. It is a better indicator of central tendancy of the data distribution than the mean for skewed environmental datasets.

red	= $1x10^{-4}$ risk, 4.0 ppbV, or greater
orange	=$1x10^{-5}$ risk, 0.4 ppbV, or greater
yellow	=$1x10^{-6}$ risk, 0.04 ppbV, or greater
green	=less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure E-1. Benzene median of concentrations above 1 x 10^{-5} risk





Benzene Median of Concentrations above $1x10^{-5}$ risk ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1.10		0.84	0.76	0.73	0.71	0.67
Lynchburg Ferry						1.38	1.14	1.36	1.29	1.07
Wallisville						0.64	0.56	0.62	0.61	0.57
Tx City 34th St						0.79	0.84	0.79	0.64	0.57
Lake Jackson						0.56	0.58	0.55	0.56	0.52
Mustang Bayou						0.83	0.74	0.69	0.72	0.68
Danciger						0.50	0.51	0.49	0.50	0.51
Clinton	0.77	0.80	0.73	0.78	0.78	0.75	0.80	0.73	0.73	0.69
Deer Park	0.70	0.80	0.69	0.76	0.73	0.75	0.71	0.76	0.72	0.67
Milby Park								0.78	0.72	0.71
Channel-view				0.84	0.68	0.89	0.74	0.75	0.75	0.72
Cesar Chavez							0.80	0.77	0.71	0.69

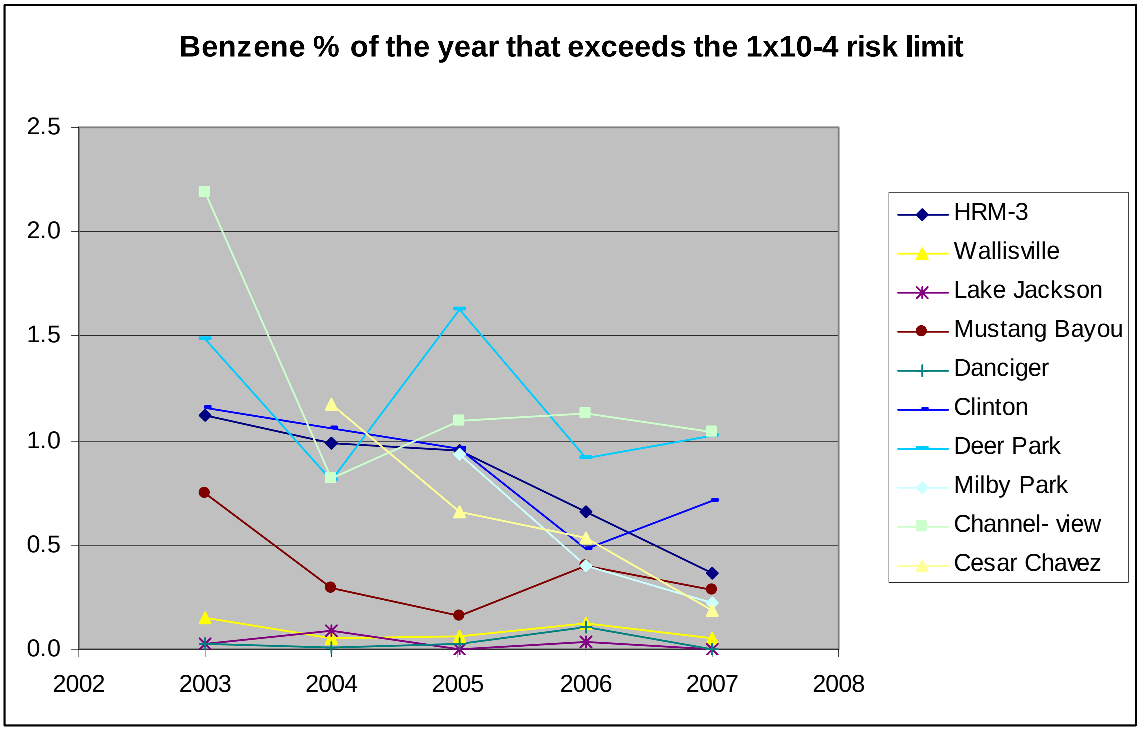
This statistic is the middle 50% of the data which exceeds the $1x10^{-5}$ risk limit. It is an indicator of the severity to which the concentrations exceed the limit.

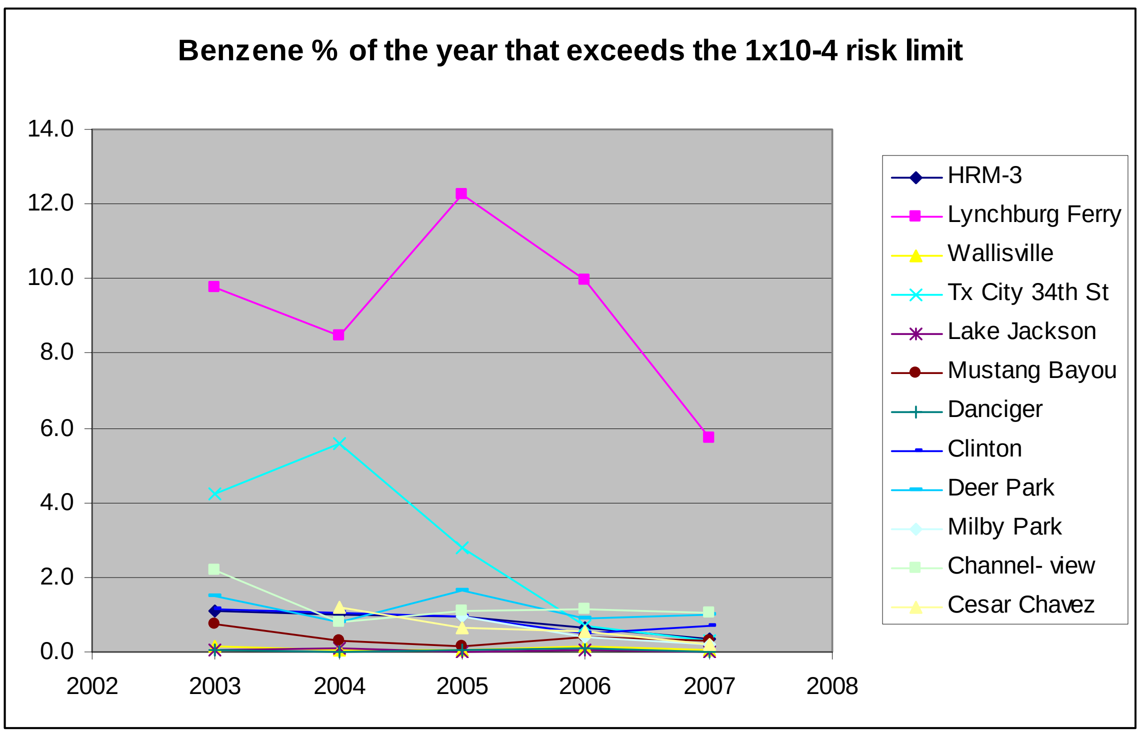
pink = concentrations are 3x the $1x10^{-5}$ risk, 1.2 ppbV, or greater

rose = concentrations are 2x the $1x10^{-5}$ risk, 0.8 ppbV, or greater

blank cells indicate no data were reported for the time frame

Figure F-1. Benzene % of the year that exceeds $1x10^{-4}$ risk limit





Benzene % of the year that exceeds the 1x10^{-4} risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				2		1	1	1	1	0
Lynchburg Ferry						10	8	12	10	6
Wallisville						0	0	0	0	0
Tx City 34th St						4	6	3	1	0
Lake Jackson						0	0	0	0	0
Mustang Bayou						1	0	0	0	0
Danciger						0	0	0	0	0
Clinton	1	2	2	1	1	1	1	1	0	1
Deer Park	1	3	1	1	1	1	1	2	1	1
Milby Park								1	0	0
Channel-view				2	1	2	1	1	1	1
Cesar Chavez							1	1	1	0

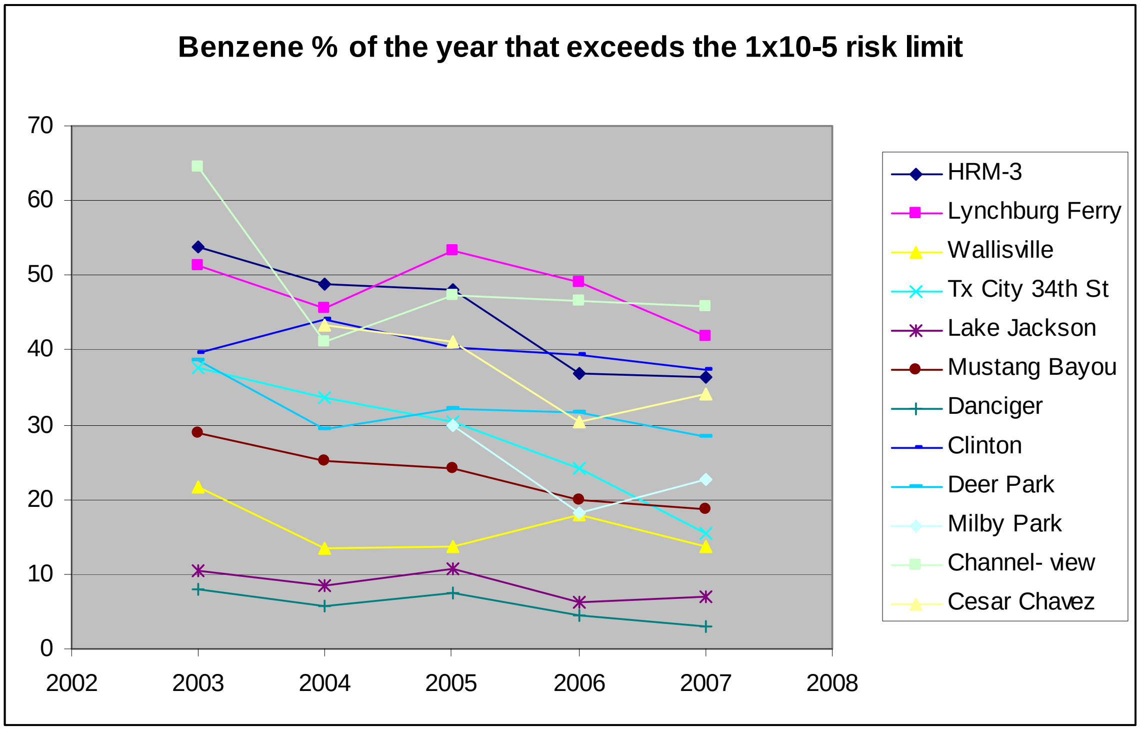
This statistic is the percent of the year that hourly concentrations exceeded the 1x10^{-4} risk limit. This is an indicator of how often very extreme values were experienced.

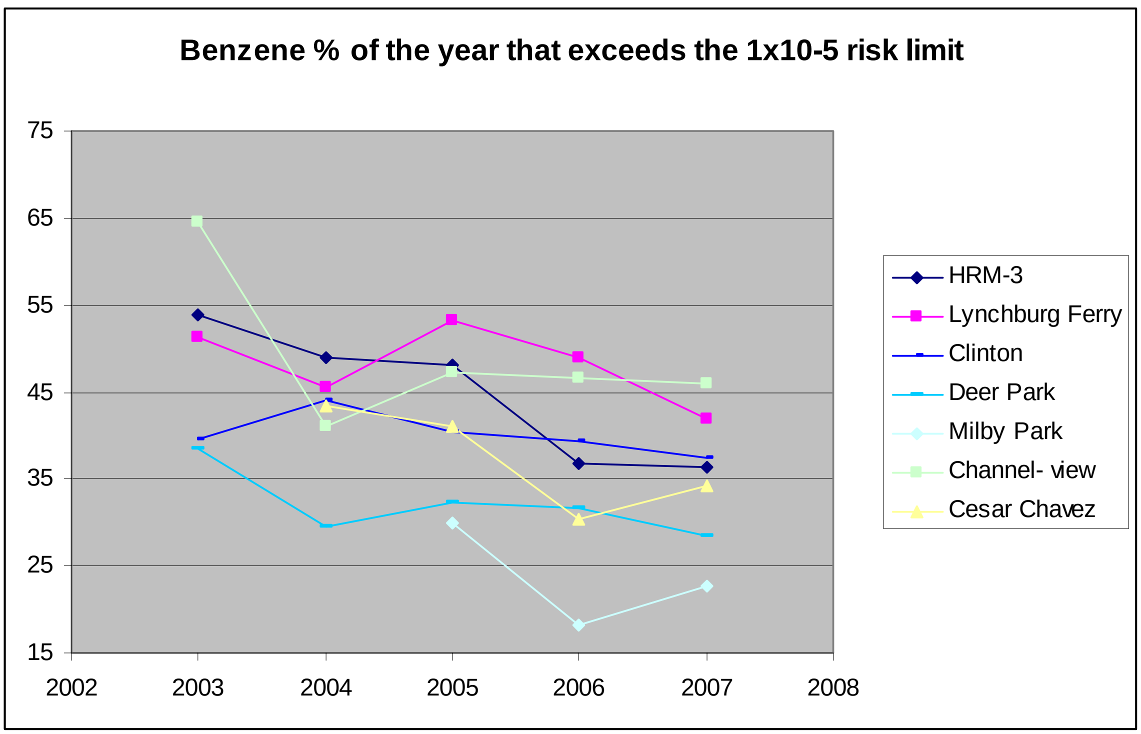
dk gray = percent of year with 10% or greater extreme values

lt gray = percent of year with 5% or greater extreme values

blank cells indicate no data were reported for the time frame

Figure G-1. Benzene % of the year that exceeds $1x10^{-5}$ risk limit





Benzene % of the year that exceeds the 1x10^{-5} risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				77		54	49	48	37	36
Lynchburg Ferry						51	46	53	49	42
Wallisville						22	13	14	18	14
Tx City 34th St						38	34	30	24	15
Lake Jackson						11	9	11	6	7
Mustang Bayou						29	25	24	20	19
Danciger						8	6	7	5	3
Clinton	50	47	61	47	39	40	44	40	39	37
Deer Park	47	46	34	35	45	39	29	32	32	28
Milby Park								30	18	23
Channel-view				61	61	65	41	47	47	46
Cesar Chavez							43	41	30	34

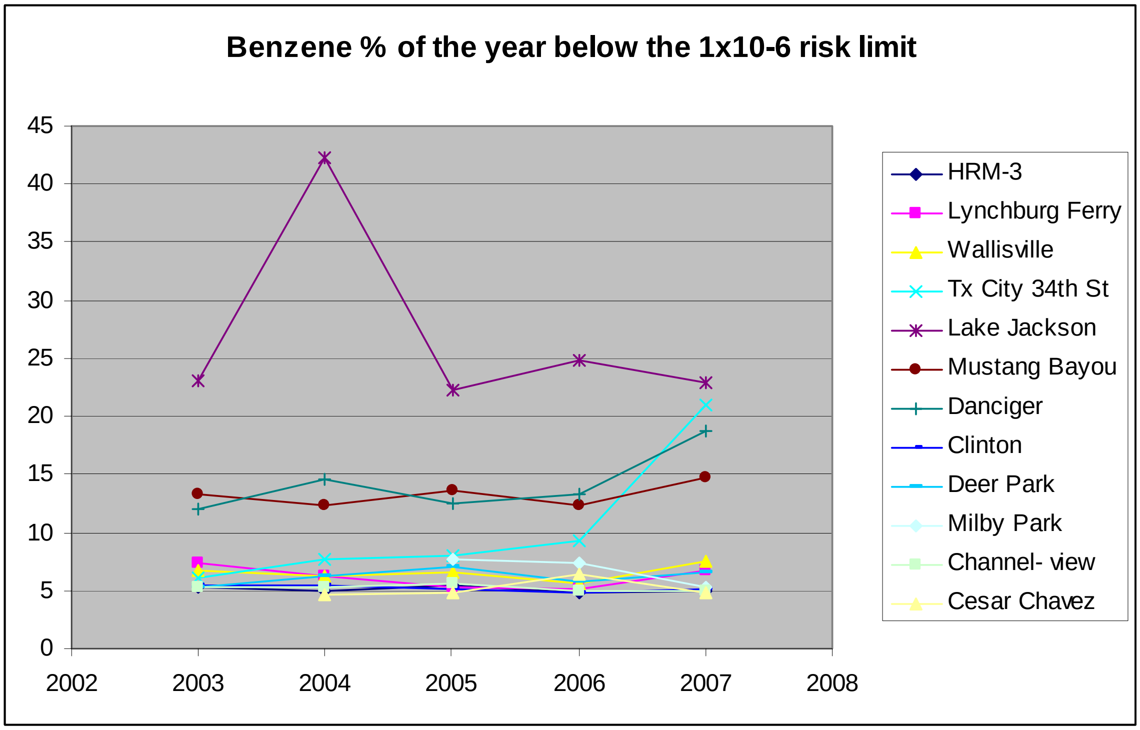
This statistic is the percent of the year that hourly concentrations exceeded the 1x10^{-5} risk limit. This is an indicator of how often extreme values were experienced.

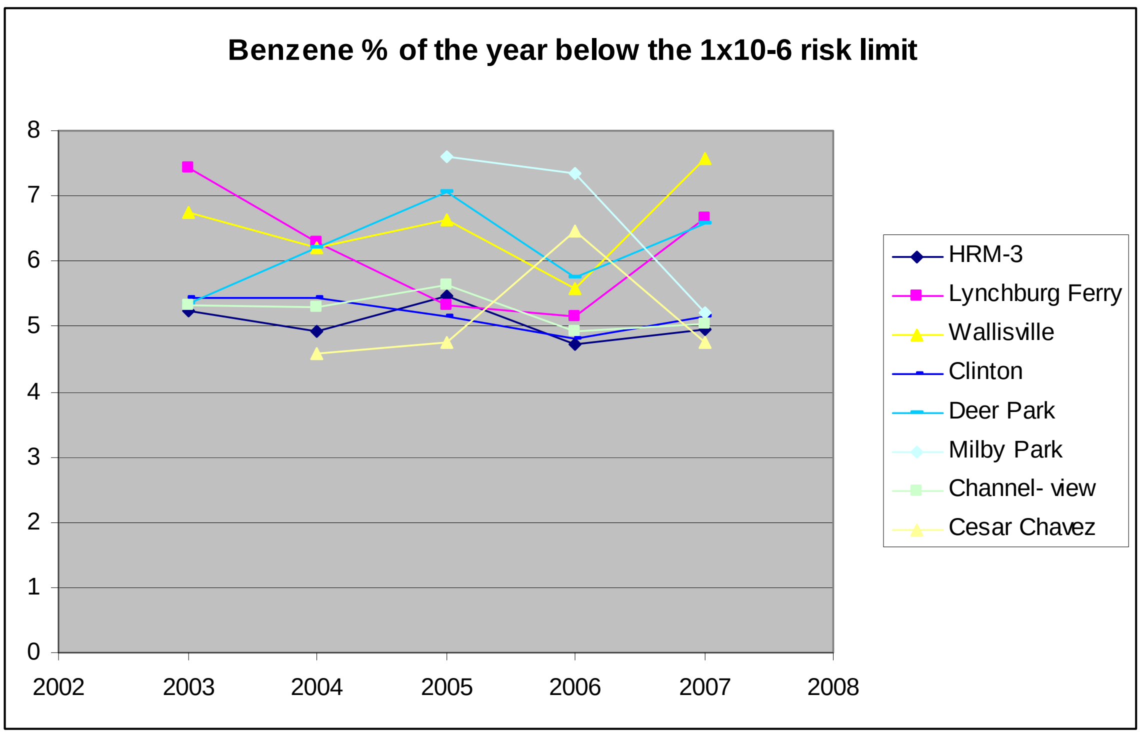
dk orange = percent of year with 50% or greater extreme values

lt orange = percent of year with 30% or greater extreme values

blank cells indicate no data were reported for the time frame

Figure H-1. Benzene % of the year below 1x10^{-6} risk limit


Benzene % of the year below the 1x10-6 risk limit
45
40
35
30
25
20
15
10
5
0
2002
2003
2004
2005
2006
2007
2008
HRM-3
Lynchburg Ferry
Wallisville
Tx City 34th St
Lake Jackson
Mustang Bayou
Danciger
Clinton
Deer Park
Milby Park
Channel- view
Cesar Chavez


Benzene % of the year below the 1x10-6 risk limit
8
7
6
5
4
3
2
1
0
2002
2003
2004
2005
2006
2007
2008
HRM-3
Lynchburg Ferry
Wallisville
Clinton
Deer Park
Milby Park
Channel- view
Cesar Chavez

Benzene % of the year below the 1x10^{-6} risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				6		5	5	5	5	5
Lynchburg Ferry						7	6	5	5	7
Wallisville						7	6	7	6	8
Tx City 34th St						6	8	8	9	21
Lake Jackson						23	42	22	25	23
Mustang Bayou						13	12	14	12	15
Danciger						12	15	12	13	19
Clinton	5	5	5	5	5	5	5	5	5	5
Deer Park	7	5	6	5	5	5	6	7	6	7
Milby Park								8	7	5
Channel-view				0	10	5	5	6	5	5
Cesar Chavez							5	5	6	5

This statistic is the percent of the year that hourly concentrations are below the 1x10^{-6} risk limit. This is an indicator of how often accetable values were experienced.

dk orange = percent of year with 30% or greater acceptable values

lt orange = percent of year with 10% or greater acceptable values

blank cells indicate no data were reported for the time frame

Figure I-1. Descriptive statistics: 10 years of data 1998-2007

		HRM-3 Site_22_	Lynchburg Site_23_	Wallisville Site_24_	Tex City 34th Site_25_	Lake Jackson Site_26_	Mustang Bayou Site_27_	Danciger Site_28_	Clinton Site_A_	Deer Park 2 Site_H_	Milby Park Site_K_	Channelview Site_R_	Cesar Chavez Site_V_
Standard Deviation	1998								1.79	1.06			
	1999								1.75	1.30			
	2000								1.40	0.64			
	2001	1.10							1.15	0.97		1.51	
	2002								0.85	0.87		0.78	
	2003	1.00	19.56	0.42	4.57	0.24	0.72	0.20	0.99	0.95		1.66	
	2004	0.97	21.02	0.29	7.07	0.38	0.61	0.17	1.63	0.82		0.95	1.04
	2005	2.17	19.35	0.34	3.38	0.22	0.49	0.19	1.05	1.11	0.88	2.61	0.73
	2006	4.12	12.62	0.38	1.25	0.24	0.58	0.22	0.61	0.86	0.65	1.07	0.82
	2007	0.82	12.59	0.29	0.50	0.18	0.54	0.12	1.16	0.96	0.55	0.96	0.65
% of Samples Below Limit	1998								4	5			
	1999								4	3			
	2000								4	3			
	2001	1							4	4		1	
	2002								4	4		4	
	2003	2	3	2	3	2	3	2	4	4		4	
	2004	4	5	4	4	4	5	4	4	4		4	3
	2005	4	4	4	4	4	4	4	4	5	4	4	4
	2006	4	4	4	4	4	4	4	4	4	4	4	4
	2007	4	4	4	4	4	4	4	4	4	4	4	4
Number of Samples	1998								7487	6653			
	1999								6384	5351			
	2000								7662	5699			
	2001	1445							5883	6549		1839	
	2002								6416	6658		3524	
	2003	4551	4433	4503	4653	3476	3485	3821	6118	6847		7303	
	2004	7683	6879	7567	7937	6788	7202	7799	7164	6917		6111	5025
	2005	6736	7297	6403	7742	6985	7332	7375	7197	6387	6294	6311	7711
	2006	8020	7726	6346	7607	7565	7518	7227	7706	7216	7550	7371	7361
	2007	7657	7895	7655	7632	7890	7484	7694	7546	7656	7740	7494	7860
Coefficient of Variation	1998								2.61	1.66			
	1999								2.45	1.74			
	2000								1.77	1.38			
	2001	0.99							1.77	1.84		1.76	
	2002								1.50	1.39		1.18	
	2003	1.36	6.89	1.33	4.40	1.40	1.62	1.11	1.74	1.65		1.77	
	2004	1.51	9.43	1.24	4.56	2.53	1.64	1.08	2.55	1.82		1.67	1.63
	2005	3.39	6.41	1.41	4.57	1.22	1.49	1.10	1.84	2.04	1.88	3.68	1.30
	2006	7.05	5.56	1.33	3.21	1.64	1.84	1.40	1.22	1.77	2.06	1.66	1.83
	2007	1.76	8.76	1.29	2.00	1.19	1.89	1.00	2.18	2.17	1.58	1.58	1.41
Frequency of Detect	1998								85%	76%			
	1999								73%	61%			
	2000								87%	65%			
	2001	16%							67%	75%		21%	
	2002								73%	76%		40%	
	2003	52%	51%	51%	53%	40%	40%	44%	70%	78%		83%	
	2004	87%	78%	86%	90%	77%	82%	89%	82%	79%		70%	57%
	2005	77%	83%	73%	88%	80%	84%	84%	82%	73%	72%	72%	88%
	2006	92%	88%	72%	87%	86%	86%	83%	88%	82%	86%	84%	84%
	2007	87%	90%	87%	87%	90%	85%	88%	86%	87%	88%	86%	90%

		HRM-3 Site_22_	Lynchburg Site_23_	Wallisville Site_24_	Tex City 34th Site_25_	Lake Jackson Site_26_	Mustang Bayou Site_27_	Danciger Site_28_	Clinton Site_A_	Deer Park 2 Site_H_	Milby Park Site_K_	Channelview Site_R_	Cesar Chavez Site_V_
95th Upper Confidence Lin	1998								0.72	0.66			
	1999								0.75	0.78			
	2000								0.82	0.47			
	2001	1.16							0.68	0.55		0.91	
	2002								0.58	0.64		0.68	
	2003	0.76	3.32	0.33	1.15	0.18	0.47	0.19	0.59	0.60		0.97	
	2004	0.66	2.65	0.24	1.68	0.16	0.38	0.16	0.67	0.46		0.59	0.66
	2005	0.68	3.39	0.25	0.80	0.18	0.34	0.18	0.59	0.57	0.49	0.76	0.57
	2006	0.66	2.51	0.29	0.41	0.15	0.32	0.16	0.52	0.50	0.33	0.66	0.46
	2007	0.48	1.67	0.23	0.26	0.15	0.30	0.13	0.56	0.46	0.36	0.63	0.48
Maximum	1998								113.68	32.56			
	1999								77.59	27.03			
	2000								52.19	13.37			
	2001	13.64							43.53	25.68		44.31	
	2002								23.82	15.63		17.75	
	2003	25.37	525.58	9.28	115.86	4.31	10.15	4.49	27.52	17.03		70.95	
	2004	31.74	1551.92	7.39	177.01	19.92	13.51	6.83	73.54	16.2		23.84	20.93
	2005	153.96	770.78	7.22	179.24	3.79	8.19	6.23	26.09	23.6	25.59	133.48	15
	2006	296.58	418.98	8.88	57.95	8.9	15.52	5.4	8.52	20.85	21.1	26.57	32.21
	2007	44.12	912.74	10.67	14.14	3.5	13.83	2.68	66.93	41.8	21.03	25.68	17.44
Mean	1998								0.69	0.64			
	1999								0.71	0.75			
	2000								0.79	0.46			
	2001	1.11							0.65	0.53		0.85	
	2002								0.57	0.63		0.66	
	2003	0.74	2.84	0.32	1.04	0.17	0.45	0.18	0.57	0.58		0.93	
	2004	0.65	2.23	0.24	1.55	0.15	0.37	0.15	0.64	0.45		0.57	0.64
	2005	0.64	3.02	0.24	0.74	0.18	0.33	0.17	0.57	0.54	0.47	0.71	0.56
	2006	0.58	2.27	0.29	0.39	0.14	0.31	0.15	0.50	0.49	0.31	0.64	0.45
	2007	0.46	1.44	0.23	0.25	0.15	0.29	0.12	0.54	0.44	0.35	0.61	0.46
Median	1998								0.41	0.38			
	1999								0.37	0.37			
	2000								0.5	0.29			
	2001	0.83							0.37	0.26		0.54	
	2002								0.31	0.37		0.49	
	2003	0.44	0.43	0.2	0.28	0.1	0.2	0.14	0.32	0.31		0.58	
	2004	0.39	0.35	0.16	0.26	0.07	0.18	0.11	0.35	0.24		0.33	0.34
	2005	0.39	0.45	0.15	0.23	0.11	0.18	0.13	0.32	0.25	0.23	0.38	0.32
	2006	0.29	0.39	0.18	0.2	0.09	0.15	0.11	0.31	0.26	0.16	0.38	0.26
	2007	0.29	0.31	0.15	0.15	0.1	0.13	0.09	0.31	0.22	0.2	0.37	0.28
Median of Lower Tail	1998								0	0.01			
	1999								0	0.015			
	2000								0.035	0			
	2001	0							0.015	0			
	2002								0.005	0.025		0.02	
	2003	0	0	0	0	0	0	0.01	0	0		0.005	
	2004	0	0	0	0	0	0	0.02	0	0		0.01	0.005
	2005	0	0	0	0	0	0	0	0	0	0	0.005	0
	2006	0.015	0	0	0	0	0.01	0.01	0	0.01	0.005	0.025	0
	2007	0	0	0	0	0	0	0.02	0.005	0	0	0	0.015
Median of Upper Tail	1998								0.77	0.7			
	1999								0.8	0.8			
	2000								0.73	0.69			
	2001	1.1							0.78	0.76		0.84	
	2002								0.78	0.73		0.68	
	2003	0.84	1.38	0.64	0.79	0.56	0.83	0.5	0.75	0.75		0.89	
	2004	0.76	1.14	0.56	0.84	0.58	0.74	0.51	0.8	0.71		0.74	0.8
	2005	0.73	1.36	0.62	0.785	0.55	0.69	0.49	0.73	0.76	0.78	0.75	0.77
	2006	0.71	1.29	0.61	0.64	0.56	0.72	0.5	0.73	0.72	0.72	0.75	0.71
	2007	0.67	1.07	0.57	0.57	0.52	0.68	0.51	0.69	0.67	0.71	0.72	0.69
Percent of Year Above 10-4 (4 ppb)	1998								1.24	1.41			
	1999								1.54	2.64			
	2000								1.51	0.60			
	2001	2.08							1.00	1.04		1.96	
	2002								0.81	1.31		0.85	
	2003	1.12	9.75	0.16	4.23	0.03	0.75	0.03	1.16	1.49		2.19	
	2004	0.99	8.48	0.05	5.57	0.09	0.29	0.01	1.06	0.81		0.82	1.17
	2005	0.95	12.24	0.06	2.80	0.00	0.16	0.03	0.96	1.63	0.94	1.09	0.66
	2006	0.66	9.94	0.13	0.70	0.04	0.40	0.11	0.48	0.91	0.40	1.13	0.53
	2007	0.37	5.71	0.05	0.29	0.00	0.28	0.00	0.72	1.02	0.22	1.04	0.19
Percent of Year Above 10-5 (.4 ppb)	1998								50.29	47.00			
	1999								46.51	46.37			
	2000								61.08	33.76			
	2001	77.09							47.03	34.66		61.39	
	2002								38.58	45.21		61.49	
	2003	53.90	51.25	21.79	37.65	10.56	28.84	7.88	39.60	38.59		64.54	
	2004	48.89	45.52	13.47	33.74	8.52	25.08	5.76	44.05	29.49		41.04	43.44
	2005	48.13	53.27	13.60	30.35	10.64	24.20	7.40	40.36	32.19	29.92	47.31	41.05
	2006	36.87	48.99	17.87	24.27	6.35	19.82	4.55	39.29	31.68	18.13	46.59	30.34
	2007	36.40	41.96	13.76	15.45	6.97	18.56	2.90	37.33	28.37	22.61	45.93	34.21
Percent of Year Below 10-6 (0.04 ppb)	1998								5.18	6.51			
	1999								5.33	5.03			
	2000								4.78	5.74			
	2001	5.54							5.25	5.05		0.00	
	2002								5.08	5.08		9.62	
	2003	5.23	7.44	6.75	6.02	22.99	13.26	11.96	5.44	5.36		5.31	
	2004	4.93	6.29	6.21	7.67	42.34	12.37	14.53	5.43	6.20		5.30	4.60
	2005	5.48	5.32	6.62	7.96	22.32	13.67	12.49	5.14	7.06	7.61	5.64	4.76
	2006	4.73	5.16	5.58	9.36	24.86	12.29	13.24	4.80	5.75	7.34	4.92	6.45
	2007	4.95	6.66	7.56	20.90	22.95	14.67	18.69	5.14	6.57	5.21	5.04	4.75

Figure J-1. Mann-Kendall trend test results: 10 years of data 1998-2007

Mann Kendall Trend Test Results: Ten Years of Data 1998-2007

benzene	95th ucl	max	mean	median	median of upper tail	% of year above 10^{-4} (4 ppb)	% of year above 10^{-5} (.4 ppb)	% of year below 10^{-6} (0.04 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	-27	-21	-27	-28	-18	-29	-27	-3
Deer Park 2	-23	1	-23	-29	-8	-5	-31	19
Milby								
Channelview								
Cesar Chavez								

S= or >19 or S<-19 is significant, +S= upward, -S=downward at 5% error rate

Figure K-1. Benzene Improvements: 10 years of data 1998-2007

Mann Kendall Trend Test Results: Ten Years of Data 1998-2007

benzene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4} (1.5 ppb)	% of year above 10^{-5} (0.15 ppb)	% of year below 10^{-6} (0.015 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	Improving	Improving	Improving	Improving	No change	Improving	Improving	No change
Deer Park 2	Improving	No change	Improving	Improving	No change	No change	Improving	Improving
Milby								
Channelview								
Cesar Chavez								

Figure L-1. Mann-Kendall trend test results: 7 years of data 2001-2007

Mann Kendall Trend Test S-Statistic: 7 Years of Data 2001-2007

benzene	95th ucl	max	mean	median	median of upper tail	% of year above 10^{-4} (4 ppb)	% of year above 10^{-5} (.4 ppb)	% of year below 10^{-6} (0.04 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	-9	-1	-9	-9	-13	-9	-9	-5
Deer Park 2	-11	7	-11	-10	-10	-1	-13	15
Milby								
Channelview	-9	1	-9	-10	-4	-3	-9	-3
Cesar Chavez								

S= or >12 or S<-12 is significant, +S= upward, -S=downward at 5% error rate

Figure M-1. Benzene Improvements: 7 years of data 2001-2007

Mann Kendall Trend Test S-Statistic: 7 Years of Data 2001-2007

benzene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4} (1.5 ppb)	% of year above 10^{-5} (0.15 ppb)	% of year below 10^{-6} (0.015 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	No change	No change	No change	No change	Improving	No change	No change	No change
Deer Park 2	No change	No change	No change	No change	No change	No change	Improving	Improving
Milby								
Channelview	No change	No change	No change	No change	No change	No change	No change	No change
Cesar Chavez								

Improving:	statistically signifcant improvement in air quality
Worsening:	statistically significant degradation of air quality
No Change:	no statistically significant change in air quality

5% Type I error rate

Figure N-1. Mann-Kendall trend test results: 5 years of data 2003-2007

5 years of data	S= or >7 or S<-7 is significant, +S= upward, -S=downward							
benzene	95th ucl	max	mean	median	median of upper tail	% of year above 10^{-4} (4 ppb)	% of year above 10^{-5} (.4 ppb)	% of year below 10^{-6} (0.04 ppb)
HRM-3	-8	6	-10	-8	-10	-10	-10	-2
Lynchburg	-6	0	-4	-4	-6	-2	-4	-4
Wallisville	-4	2	-4	-5	-4	-4	0	0
Tx City 34th	-8	-4	-8	-10	-8	-8	-10	10
Lake Jackson	-4	-4	-2	1	-5	-3	-4	-2
Mustang Bayou	-10	4	-10	-9	-8	-4	-10	2
Danciger	-6	-4	-6	-7	2	0	-8	6
Clinton	-4	-2	-4	-6	-7	-8	-6	-6
Deer Park 2	-6	6	-6	-4	-4	0	-6	4
Milby								
Channelview	-4	-2	-4	-3	-5	-2	-4	-4
Cesar Chavez								

Figure O-1. Benzene Improvements: 5 years of data 2003-2007

Mann Kendall Trend Test Results: 5 Years of Data 2003-2007

benzene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4}	% of year above 10^{-5}	% of year below 10^{-6}
HRM-3	Improving	No change	Improving	Improving	Improving	Improving	Improving	No change
Lynchburg	No change	No change	No change	No change	No change	No change	No change	No change
Wallisville	No change	No change	No change	No change	No change	No change	No change	No change
Tx City 34th	Improving	No change	Improving	Improving	Improving	Improving	Improving	Improving
Lake Jackson	No change	No change	No change	No change	No change	No change	No change	No change
Mustang Bayou	Improving	No change	Improving	Improving	Improving	No change	Improving	No change
Danciger	No change	No change	No change	Improving	No change	No change	Improving	No change
Clinton	No change	No change	No change	No change	Improving	Improving	No change	No change
Deer Park 2	No change	No change	No change	No change	No change	No change	No change	No change
Milby								
Channelview	No change	No change	No change	No change	No change	No change	No change	No change
Cesar Chavez								

Improving:	statistically signifcant improvement in air quality
Worsening:	statistically significant degradation of air quality
No Change:	no statistically significant change in air quality

5% Type I error rate

Figure P-1. Average statistical ranks

2007	Mean at 95% upper conf		max		median		median of upper tail		% of year above 10^{-4} (4		% of year above 10^{-5} (.4		percent of year below 10^{-6} (0.04		average rank
Benzene	ppb	rank	ppb	rank	ppb	rank	ppb	rank	%	rank	%	rank	%	rank	
HRM-3	0.48	9	44.12	10	0.29	9	0.67	5	0.37	8	36.40	9	4.95	11	8.7
Lynchburg	1.67	12	912.74	12	0.31	10	1.07	12	5.71	12	41.96	11	6.66	6	10.7
Wallisville	0.23	3	10.67	3	0.15	4	0.57	3	0.05	3	13.76	3	7.56	5	3.4
Tx City 34th	0.26	4	14.14	5	0.15	4	0.57	3	0.29	7	15.45	4	20.90	2	4.1
Lake Jackson	0.15	2	3.50	2	0.1	2	0.52	2	0.00	1	6.97	2	22.95	1	1.7
Mustang Bayou	0.30	5	13.83	4	0.13	3	0.68	7	0.28	6	18.56	5	14.67	4	4.9
Danciger	0.13	1	2.68	1	0.09	1	0.51	1	0.00	1	2.90	1	18.69	3	1.3
Clinton	0.56	10	66.93	11	0.31	10	0.69	8	0.72	9	37.33	10	5.14	9	9.6
Deer Park 2	0.46	7	41.80	9	0.22	7	0.67	5	1.02	10	28.37	7	6.57	7	7.4
Milby	0.36	6	21.03	7	0.2	6	0.71	10	0.22	5	22.61	6	5.21	8	6.9
Channelview	0.63	11	25.68	8	0.37	12	0.72	11	1.04	11	45.93	12	5.04	10	10.7
Cesar Chavez	0.48	8	17.44	6	0.28	8	0.69	8	0.19	4	34.21	8	4.75	12	7.7

concentrations in ppbV
rank is the rank order of the statistic
high ranks correspond to higher concentrations or higher precentages with the following exception
in the category of "percent of year below 10^{-6}", high ranks correspond to lower precentages

Figure Q-1. Benzene % of samples below detection limit

Benzene Percent of Samples Below Limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1		2	4	4	4	4
Lynchburg Ferry						3	5	4	4	4
Wallisville						2	4	4	4	4
Tx City 34th St						3	4	4	4	4
Lake Jackson						2	4	4	4	4
Mustang Bayou						3	5	4	4	4
Danciger						2	4	4	4	4
Clinton	4	4	4	4	4	4	4	4	4	4
Deer Park	5	3	3	4	4	4	4	5	4	4
Milby Park								4	4	4
Channel-view				1	4	4	4	4	4	4
Cesar Chavez							3	4	4	4

This statistic is the number of samples where the concentration was below the detection limit. These samples were replaced with 1/2 the detection limit for statistical calculations.

Figure R-1. Benzene frequency of detection

Benzene Frequency of Detect

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				16%		52%	87%	77%	92%	87%
Lynchburg Ferry						51%	78%	83%	88%	90%
Wallisville						51%	86%	73%	72%	87%
Tx City 34th St						53%	90%	88%	87%	87%
Lake Jackson						40%	77%	80%	86%	90%
Mustang Bayou						40%	82%	84%	86%	85%
Danciger						44%	89%	84%	83%	88%
Clinton	85%	73%	87%	67%	73%	70%	82%	82%	88%	86%
Deer Park	76%	61%	65%	75%	76%	78%	79%	73%	82%	87%
Milby Park								72%	86%	88%
Channel-view				21%	40%	83%	70%	72%	84%	86%
Cesar Chavez							57%	88%	84%	90%

This statistic is the number of samples where a concentration was detected out of the total number of samples available.

Figure S-1. Benzene number of samples

Benzene Number of Samples

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1445		4551	7683	6736	8020	7657
Lynchburg Ferry						4433	6879	7297	7726	7895
Wallisville						4503	7567	6403	6346	7655
Tx City 34th St						4653	7937	7742	7607	7632
Lake Jackson						3476	6788	6985	7565	7890
Mustang Bayou						3485	7202	7332	7518	7484
Danciger						3821	7799	7375	7227	7694
Clinton	7487	6384	7662	5883	6416	6118	7164	7197	7706	7546
Deer Park	6653	5351	5699	6549	6658	6847	6917	6387	7216	7656
Milby Park								6294	7550	7740
Channel-view				1839	3524	7303	6111	6311	7371	7494
Cesar Chavez							5025	7711	7361	7860

Figure T-1. Benzene coefficient of variation

Benzene Coefficient of Variation

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.99		1.36	1.51	3.39	7.05	1.76
Lynchburg Ferry						6.89	9.43	6.41	5.56	8.76
Wallisville						1.33	1.24	1.41	1.33	1.29
Tx City 34th St						4.40	4.56	4.57	3.21	2.00
Lake Jackson						1.40	2.53	1.22	1.64	1.19
Mustang Bayou						1.62	1.64	1.49	1.84	1.89
Danciger						1.11	1.08	1.10	1.40	1.00
Clinton	2.61	2.45	1.77	1.77	1.50	1.74	2.55	1.84	1.22	2.18
Deer Park	1.66	1.74	1.38	1.84	1.39	1.65	1.82	2.04	1.77	2.17
Milby Park								1.88	2.06	1.58
Channel-view				1.76	1.18	1.77	1.67	3.68	1.66	1.58
Cesar Chavez							1.63	1.30	1.83	1.41

This statistic may indicate non-normality if it exceeds 1.2.

Figure A-2. 1,3-Butadiene mean with 95% confidence

1,3-Butadiene Mean (with 95% Confidence) ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.50		0.50	0.44	0.37	0.21	0.18
Lynchburg Ferry						0.59	0.44	0.37	0.19	0.15
Wallisville						0.15	0.17	0.10	0.07	0.08
Tx City 34th St						0.11	0.13	0.09	0.04	0.06
Lake Jackson						0.05	0.06	0.07	0.04	0.04
Mustang Bayou						0.14	0.12	0.10	0.07	0.08
Danciger						0.05	0.05	0.04	0.04	0.03
Clinton	1.19	0.60	0.64	0.36	0.41	0.39	0.62	0.32	0.30	0.23
Deer Park	0.30	0.25	0.16	0.16	0.17	0.30	0.22	0.20	0.24	0.22
Milby Park								1.53	1.65	1.03
Channel- view				0.53	0.48	0.54	0.40	0.46	0.38	0.26
Cesar Chavez							0.56	0.46	0.26	0.24

This statistic is the upper 95th confidence limit of the annual mean of the hourly automatic gas chromatograph data. Although the true mean cannot be known without analyzing all of the air, the probability that the true mean is higher than this number is held to 5%.

red	$=1x10^{-4}$ risk, 1.5 ppbV, or greater
orange	$=1x10^{-5}$ risk, 0.15 ppbV, or greater
yellow	$= 1x10^{-6}$ risk, 0.015 ppbV rounded to 0.02 ppbV, or greater
green	$=$less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure B-2. 1,3-Butadiene maximum

1,3-Butadiene Maximum ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				16.31		39.67	57.13	84.72	89.29	10.91
Lynchburg Ferry						43.54	55.77	121.87	17.11	20.11
Wallisville						7.95	14.67	8.99	24.33	27.5
Tx City 34th St						41.66	26.07	49.01	5.79	9.13
Lake Jackson						4.13	2.27	3.89	4.54	4.55
Mustang Bayou						38.12	33.29	38.74	29.25	47.97
Danciger						6.88	1.3	2.23	2.27	8.57
Clinton	112.24	35.79	48.82	24.41	23.41	15.92	35.54	54.98	116.92	25.72
Deer Park	45.52	12.89	8.33	43.1	18.67	72.24	23.39	8.05	11.28	203.4
Milby Park								82.25	1611.25	73.93
Channel-view				79.26	49.53	36.04	24.36	54.47	53.23	32.89
Cesar Chavez							37.02	52.47	53.96	31.08

This statistic is the maximum concentration of the 1 hour annual data.

red	$=1 \times 10^{-4}$ risk, 1.5 ppbV, or greater
orange	$=1 \times 10^{-5}$ risk, 0.15 ppbV, or greater
yellow	$= 1 \times 10^{-6}$ risk, 0.015 ppbV rounded to 0.02 ppbV, or greater
green	=less than 1×10^{-6} risk

blank cells indicate no data were reported for the time frame

Figure C-2. 1,3-Butadiene mean

1,3-Butadiene Mean ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.46		0.46	0.42	0.34	0.19	0.18
Lynchburg Ferry						0.55	0.41	0.34	0.18	0.14
Wallisville						0.14	0.16	0.09	0.06	0.07
Tx City 34th St						0.10	0.12	0.07	0.04	0.06
Lake Jackson						0.04	0.05	0.06	0.03	0.04
Mustang Bayou						0.10	0.11	0.09	0.06	0.07
Danciger						0.05	0.05	0.04	0.03	0.03
Clinton	1.10	0.56	0.60	0.34	0.38	0.36	0.58	0.30	0.27	0.22
Deer Park	0.28	0.24	0.15	0.14	0.16	0.25	0.21	0.19	0.24	0.17
Milby Park								1.45	1.24	1.00
Channel- view				0.43	0.45	0.50	0.37	0.42	0.35	0.24
Cesar Chavez							0.52	0.43	0.24	0.23

This statistic is the the annual sample mean of the hourly automatic gas chromatograph data without confidence. It is used in conjunction with the number of samples collected and the standard deviation of the samples to calculate the upper confidence limit of the true mean.

red	$=1x10^{-4}$ risk, 1.5 ppbV, or greater
orange	$=1x10^{-5}$ risk, 0.15 ppbV, or greater
yellow	$= 1x10^{-6}$ risk, 0.015 ppbV rounded to 0.02 ppbV, or greater
green	=less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure D-2. 1,3-Butadiene median

1,3-Butadiene Median ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.2		0.13	0.12	0.11	0.08	0.08
Lynchburg Ferry						0.24	0.15	0.1	0.08	0.06
Wallisville						0.06	0.1	0.05	0.03	0.03
Tx City 34th St						0.03	0.05	0.02	0.02	0.03
Lake Jackson						0.03	0.04	0.03	0.02	0.02
Mustang Bayou						0.01	0.02	0.02	0	0.02
Danciger						0.02	0.03	0.02	0.02	0.02
Clinton	0.18	0.16	0.1	0.13	0.11	0.11	0.14	0.11	0.11	0.1
Deer Park	0.08	0.08	0.04	0.03	0.05	0.05	0.08	0.08	0.17	0.07
Milby Park								0.19	0.14	0.22
Channel- view				0.1	0.08	0.12	0.07	0.06	0.08	0.04
Cesar Chavez							0.08	0.12	0.08	0.09

This statistic is the middle 50% of the data. It is a better indicator of central tendancy of the data distribution than the mean for skewed environmental datasets.

red	$=1x10^{-4}$ risk, 1.5 ppbV, or greater
orange	$=1x10^{-5}$ risk, 0.15 ppbV, or greater
yellow	$= 1x10^{-6}$ risk, 0.015 ppbV rounded to 0.02 ppbV, or greater
green	=less than $1x10^{-6}$ risk

blank cells indicate no data were reported for the time frame

Figure E-2. 1,3-Butadiene median of concentrations above 1 x 10^{-5} risk

1,3-Butadiene Median of Concentrations above 1x10^{-5} risk ppbV

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				0.40		0.38	0.37	0.35	0.29	0.28
Lynchburg Ferry						0.28	0.28	0.31	0.29	0.28
Wallisville						0.31	0.24	0.27	0.26	0.26
Tx City 34th St						0.25	0.25	0.26	0.24	0.23
Lake Jackson						0.23	0.23	0.24	0.22	0.22
Mustang Bayou						0.34	0.32	0.30	0.29	0.28
Danciger						0.26	0.24	0.23	0.23	0.23
Clinton	0.48	0.42	0.47	0.37	0.45	0.36	0.44	0.34	0.33	0.32
Deer Park	0.36	0.36	0.33	0.31	0.30	0.39	0.31	0.31	0.26	0.30
Milby Park								0.97	0.65	0.85
Channel- view				0.38	0.43	0.47	0.48	0.41	0.34	0.36
Cesar Chavez							0.47	0.43	0.35	0.35

This statistic is the middle 50% of the data which exceeds the 1x10^{-5} risk limit. It is an indicator of the severity to which the concentrations exceed the limit.

pink	= concentrations are 3x the 1x10^{-5} risk, 0.45 ppbV, or greater
rose	= concentrations are 2x the 1x10^{-5} risk, 0.3 ppbV, or greater

blank cells indicate no data were reported for the time frame

Figure F-2. 1,3-Butadiene % of the year that exceeds $1x10^{-4}$ risk limit

1,3-Butadiene % of the year that exceeds the $1x10^{-4}$ risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				5		6	5	3	1	1
Lynchburg Ferry						6	4	3	1	1
Wallisville						1	1	0	0	0
Tx City 34th St						0	1	0	0	0
Lake Jackson						0	0	0	0	0
Mustang Bayou						1	1	1	0	0
Danciger						0	0	0	0	0
Clinton	12	7	8	4	5	5	8	3	2	1
Deer Park	3	3	1	1	1	3	2	2	1	1
Milby Park								22	13	19
Channel- view				4	6	7	6	5	4	3
Cesar Chavez							8	5	2	2

This statistic is the percent of the year that hourly concentrations exceeded the $1x10^{-4}$ risk limit. This is an indicator of how often very extreme values were experienced.

dk gray	= percent of year with 10% or greater extreme values
lt gray	= percent of year with 5% or greater extreme values

Figure G-2. 1,3-Butadiene % of the year that exceeds $1x10^{-5}$ risk limit

1,3-Butadiene % of the year that exceeds the $1x10^{-5}$ risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				57		44	43	38	27	28
Lynchburg Ferry						80	47	33	22	21
Wallisville						19	28	11	8	9
Tx City 34th St						10	11	7	3	6
Lake Jackson						5	6	7	2	3
Mustang Bayou						10	13	10	8	7
Danciger						5	3	4	3	2
Clinton	54	51	39	44	41	41	46	38	40	35
Deer Park	31	29	21	19	23	21	26	27	54	23
Milby Park								53	49	55
Channel- view				39	36	43	32	31	33	21
Cesar Chavez							36	43	32	35

This statistic is the percent of the year that hourly concentrations exceeded the $1x10^{-4}$ risk limit. This is an indicator of how often extreme values were experienced.

dk orange = percent of year with 50% or greater extreme values

lt orange = percent of year with 30% or greater extreme values

blank cells indicate no data were reported for the time frame

Figure H-2. 1,3-Butadiene % of the year below 1x10^{-6} risk limit

1,3-Butadiene % of the year below the 1x10^{-6} risk limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				6		7	6	8	5	4
Lynchburg Ferry						6	7	7	5	11
Wallisville						7	6	6	32	21
Tx City 34th St						25	6	34	28	12
Lake Jackson						35	40	33	38	34
Mustang Bayou						58	45	48	57	49
Danciger						33	10	41	36	32
Clinton	9	5	7	6	9	10	5	6	5	6
Deer Park	12	19	36	46	21	18	6	7	5	5
Milby Park								13	7	8
Channel- view				9	11	8	13	27	12	24
Cesar Chavez							6	6	23	19

This statistic is the percent of the year that hourly concentrations are below the 1x10^{-6} risk limit. This is an indicator of how often accetable values were experienced.

dk orange	= percent of year with 30% or greater acceptable values
lt orange	= percent of year with 10% or greater acceptable values

blank cells indicate no data were reported for the time frame

Figure I-2. Descriptive statistics: 10 years of data 1998-2007

		HRM-3	Lynchburg	Wallisville	Tx City 34th	Lake Jackson	Mustang Bayou	Danciger	Clinton	Deer Park 2	Milby	Channelview	Cesar Chavez	Aldine	HRM-7	Bayland
		22	23	24	25	26	27	28	a	h	k	r	v	q	s	m
95th Upper Confidence Lin	1998								1.19	0.30						0.16
	1999								0.60	0.25						0.13
	2000								0.64	0.16				0.18		0.09
	2001	0.50							0.36	0.16		0.53		0.16	4.33	
	2002								0.41	0.17		0.48				
	2003	0.50	0.59	0.15	0.11	0.05	0.14	0.05	0.39	0.30		0.54				
	2004	0.44	0.44	0.17	0.13	0.06	0.12	0.05	0.62	0.22		0.40	0.56			
	2005	0.37	0.37	0.10	0.09	0.07	0.10	0.04	0.32	0.20	1.53	0.46	0.46			
	2006	0.21	0.19	0.07	0.04	0.04	0.07	0.04	0.30	0.24	1.65	0.38	0.26			
	2007	0.18	0.15	0.08	0.06	0.04	0.08	0.03	0.23	0.22	1.03	0.26	0.24			
Maximum	1998								112.24	45.52						7.38
	1999								35.79	12.89						4.5
	2000								48.82	8.33				2.7		4.89
	2001	16.31							24.41	43.1		79.26		4.96	87.58	
	2002								23.41	18.67		49.53				
	2003	39.67	43.54	7.95	41.66	4.13	38.12	6.88	15.92	72.24		36.04				
	2004	57.13	55.77	14.67	26.07	2.27	33.29	1.3	35.54	23.39		24.36	37.02			
	2005	84.72	121.87	8.99	49.01	3.89	38.74	2.23	54.98	8.05	82.25	54.47	52.47			
	2006	89.29	17.11	24.33	5.79	4.54	29.25	2.27	116.92	11.28	1611.25	53.23	53.96			
	2007	10.91	20.11	27.5	9.13	4.55	47.97	8.57	25.72	203.4	73.93	32.89	31.08			
Mean	1998								1.10	0.28						0.16
	1999								0.56	0.24						0.13
	2000								0.60	0.15				0.16		0.09
	2001	0.46							0.34	0.14		0.43		0.16	3.84	
	2002								0.38	0.16		0.45				
	2003	0.46	0.55	0.14	0.10	0.04	0.10	0.05	0.36	0.25		0.50				
	2004	0.42	0.41	0.16	0.12	0.05	0.11	0.05	0.58	0.21		0.37	0.52			
	2005	0.34	0.34	0.09	0.07	0.06	0.09	0.04	0.30	0.19	1.45	0.42	0.43			
	2006	0.19	0.18	0.06	0.04	0.03	0.06	0.03	0.27	0.24	1.24	0.35	0.24			
	2007	0.18	0.14	0.07	0.06	0.04	0.07	0.03	0.22	0.17	1.00	0.24	0.23			
Median	1998								0.18	0.08						0.07
	1999								0.16	0.08						0.06
	2000								0.10	0.04				0.07		0.03
	2001	0.20							0.13	0.03		0.10		0.07	0.57	
	2002								0.11	0.05		0.08				
	2003	0.13	0.24	0.06	0.03	0.03	0.01	0.02	0.11	0.05		0.12				
	2004	0.12	0.15	0.10	0.05	0.04	0.02	0.03	0.14	0.08		0.07	0.08			
	2005	0.11	0.10	0.05	0.02	0.03	0.02	0.02	0.11	0.08	0.19	0.06	0.12			
	2006	0.08	0.08	0.03	0.02	0.02	0.00	0.02	0.11	0.17	0.14	0.08	0.08			
	2007	0.08	0.06	0.03	0.03	0.02	0.02	0.02	0.10	0.07	0.22	0.04	0.09			
Median of Lower Tail	1998								0.00	0.00						0.00
	1999								0.00	0.00						0.00
	2000								0.00	0.00				0.00		0.00
	2001	0.00							0.00	0.00		0.00		0.01	0.00	
	2002								0.00	0.00		0.00				
	2003	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00		0.00				
	2004	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00			
	2005	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	2006	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
	2007	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			
Median of Upper Tail	1998								0.48	0.36						0.31
	1999								0.42	0.36						0.30
	2000								0.47	0.33				0.32		0.29
	2001	0.40							0.37	0.31		0.38		0.31	1.87	
	2002								0.45	0.30		0.43				
	2003	0.38	0.28	0.31	0.25	0.23	0.34	0.26	0.36	0.39		0.47				
	2004	0.37	0.28	0.24	0.25	0.23	0.32	0.24	0.44	0.31		0.48	0.47			
	2005	0.35	0.31	0.27	0.26	0.24	0.30	0.23	0.34	0.31	0.97	0.41	0.43			
	2006	0.29	0.29	0.26	0.24	0.22	0.29	0.23	0.33	0.26	0.65	0.34	0.35			
	2007	0.28	0.28	0.26	0.23	0.22	0.28	0.23	0.32	0.30	0.85	0.36	0.35			
Percent of Year Above 10-4 (4 ppb)	1998								11.53	3.30						0.86
	1999								7.33	2.97						0.44
	2000								7.90	1.32				0.71		0.60
	2001	5.31							4.02	1.06		3.57		0.47	35.95	
	2002								5.28	1.15		6.45				
	2003	5.65	6.36	1.11	0.47	0.05	0.59	0.05	4.88	2.63		7.09				
	2004	5.29	3.99	0.55	0.60	0.01	1.09	0.00	7.88	2.00		5.82	7.64			
	2005	3.05	3.27	0.37	0.33	0.11	0.58	0.01	3.01	1.59	21.64	5.29	5.46			
	2006	0.85	1.44	0.20	0.16	0.08	0.33	0.04	1.77	0.64	13.24	3.78	2.25			
	2007	1.00	0.69	0.22	0.05	0.05	0.36	0.04	1.31	0.72	19.23	3.33	1.85			
Percent of Year Above 10-5 (.4 ppb)	1998								53.88	30.74						22.87
	1999								51.05	29.16						19.63
	2000								38.71	21.07				28.50		12.11
	2001	56.62							44.25	19.47		39.44		27.92	65.25	
	2002								40.63	22.93		35.78				
	2003	44.04	79.61	18.88	10.21	5.19	9.56	5.19	41.13	21.16		43.45				
	2004	43.26	47.31	27.88	11.12	5.92	12.93	3.02	46.49	25.51		31.62	36.13			
	2005	38.16	32.87	10.71	6.64	7.28	10.37	4.37	38.49	27.45	53.33	30.87	43.04			
	2006	27.31	22.49	7.57	3.09	2.11	8.15	2.70	40.23	54.49	48.53	32.52	32.14			
	2007	28.32	20.81	8.99	5.59	3.11	7.18	2.43	34.72	23.45	55.32	20.99	35.03			
Percent of Year Below 10-6 (0.04 ppb)	1998								9.41	11.55						6.05
	1999								5.24	18.64						9.40
	2000								6.99	36.37				12.21		36.22
	2001	6.39							5.92	46.01		8.89		13.24	10.35	
	2002								9.06	20.98		10.64				
	2003	6.69	5.53	6.97	24.87	34.66	58.25	32.79	9.58	17.63		7.73				
	2004	6.14	6.56	6.22	6.50	40.14	45.28	10.15	5.23	6.43		13.38	6.05			
	2005	7.63	6.81	6.37	34.07	32.75	47.85	41.39	6.26	6.86	12.55	26.73	5.63			
	2006	5.12	4.76	32.29	28.39	37.82	56.91	36.25	5.38	5.46	7.14	11.91	23.35			
	2007	4.00	10.54	21.50	11.93	34.46	49.26	31.72	5.87	4.94	8.23	24.47	19.11			

		HRM-3	Lynchburg	Wallisville	Tx City 34th	Lake Jackson	Mustang Bayou	Danciger	Clinton	Deer Park 2	Milby	Channelview	Cesar Chavez	Aldine	HRM-7	Bayland
		22	23	24	25	26	27	28	a	h	k	r	v	q	s	m
Standard Deviation	1998								4.74	1.02						0.32
	1999								1.63	0.59						0.23
	2000								2.03	0.41				0.27		0.24
	2001	1.01							0.82	0.83		2.74		0.26	8.93	
	2002								1.00	0.47		1.53				
	2003	1.48	1.47	0.34	0.76	0.10	1.05	0.13	0.92	1.70		1.55				
	2004	1.37	1.75	0.40	0.72	0.09	0.58	0.06	1.73	0.63		1.12	1.65			
	2005	1.59	1.85	0.28	0.75	0.13	0.62	0.08	0.99	0.38	3.58	1.99	1.54			
	2006	1.14	0.57	0.39	0.15	0.10	0.38	0.07	1.43	0.32	22.00	1.50	0.85			
	2007	0.40	0.38	0.37	0.14	0.09	0.65	0.11	0.55	2.36	2.11	1.03	0.58			
% of Samples Below Limit	1998								4.13	4.93						2.35
	1999								3.58	3.05						4.11
	2000								4.18	2.84				1.07		2.32
	2001	0.88							3.57	3.57		1.26		2.28	0.75	
	2002								3.63	3.86		3.87				
	2003	2.44	2.68	2.43	2.56	2.19	2.83	2.39	3.53	3.95		3.96				
	2004	4.25	4.63	4.84	4.36	4.38	4.53	4.32	3.98	4.26		3.70	2.63			
	2005	4.08	4.05	3.56	4.19	4.26	4.09	4.33	4.13	4.70	4.00	4.05	4.09			
	2006	4.30	4.03	3.72	4.19	4.19	4.05	4.10	4.13	4.38	4.05	4.14	4.10			
	2007	3.05	3.09	3.09	3.17	3.05	2.97	2.99	3.05	3.28	3.14	3.03	3.07			
Number of Samples	1998								7494	6509						3721
	1999								6408	5349						7285
	2000								7086	5543				1695		3526
	2001	1487							5865	6514		1879		3815	918	
	2002								4844	6162		6571				
	2003	4321	4448	4492	4660	4008	2898	4083	3749	4367		4953				
	2004	7511	6967	7617	7944	6701	7272	7883	7043	5939		4551	5024			
	2005	6727	7311	6454	7623	7032	7601	7374	6976	6047	6413	5675	7712			
	2006	8022	7689	6342	7502	7626	7524	7341	7753	7137	7573	7081	7378			
	2007	7580	7798	7563	7587	7777	7436	7663	7543	7536	7797	7021	7665			
Coefficient of Variation	1998								4.31	3.62						2.02
	1999								2.89	2.49						1.79
	2000								3.39	2.76				1.61		2.70
	2001	2.18							2.40	5.79		6.42		1.63	2.32	
	2002								2.61	3.00		3.42				
	2003	3.23	2.66	2.39	7.96	2.28	10.05	2.93	2.56	6.72		3.08				
	2004	3.28	4.29	2.51	6.22	1.69	5.26	1.23	2.97	2.99		3.00	3.16			
	2005	4.74	5.48	2.94	10.22	1.96	6.97	2.14	3.28	1.98	2.46	4.72	3.60			
	2006	6.14	3.16	6.01	3.71	3.09	6.31	2.06	5.22	1.36	17.80	4.28	3.53			
	2007	2.26	2.76	5.13	2.62	2.47	9.34	3.52	2.51	13.63	2.12	4.31	2.47			
Frequency of Detect	1998								86%	74%						42%
	1999								73%	61%						83%
	2000								81%	63%				19%		40%
	2001	17%							67%	74%		21%		44%	10%	
	2002								55%	70%		75%				
	2003	49%	51%	51%	53%	46%	33%	47%	43%	50%		57%				
	2004	86%	79%	87%	90%	76%	83%	90%	80%	68%		52%	57%			
	2005	77%	83%	74%	87%	80%	87%	84%	80%	69%	73%	65%	88%			
	2006	92%	88%	72%	86%	87%	86%	84%	89%	81%	86%	81%	84%			
	2007	87%	89%	86%	87%	89%	85%	87%	86%	86%	89%	80%	88%			

Figure J-2. Mann-Kendall trend test results: 10 years of data 1998-2007

Mann Kendall Trend Test Results: Ten Years of Data 1998-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4} (1.5 ppb)	% of year above 10^{-5} (0.15 ppb)	% of year below 10^{-6} (0.015 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	-31	-3	-31	-20	-33	-31	-25	-9
Deer Park 2	-1	1	-5	10	-24	-23	5	-25
Milby								
Channelview								
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

S= or >19 or S<-19 is significant, +S= upward, -S=downward at 5% error rate

Figure K-2. 1,3-Butadiene Improvements: 10 years of data 1998-2007

Mann Kendall Trend Test Results: Ten Years of Data 1998-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4}	% of year above 10^{-5}	% of year below 10^{-6}
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	Improving	No change	Improving	Improving	Improving	Improving	Improving	No change
Deer Park 2	No change	No change	No change	No change	Improving	Improving	No change	Worsening
Milby								
Channelview								
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

Improving: statistically signifcant improvement in air quality

Worsening: statistically significant degradation of air quality

No Change: no statistically significant change in air quality

5% Type I error rate

Figure L-2. Mann-Kendall trend test results: 7 years of data 2001-2007

Mann Kendall Trend Test Results: 7 Years of Data 2001-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4} (1.5 ppb)	% of year above 10^{-5} (0.15 ppb)	% of year below 10^{-6} (0.015 ppb)
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	-11	9	-11	-9	-15	-11	-11	-5
Deer Park 2	7	-1	5	13	-7	-5	13	-19
Milby								
Channelview	-15	-7	-13	-12	-5	-9	-13	11
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

S= or >12 or S<-12 is significant, +S= upward, -S=downward at 5% error rate

Figure M-2. 1,3-Butadiene Improvements: 7 years of data 2001-2007

Mann Kendall Trend Test S-Statistic: 7 Years of Data 2001-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4}	% of year above 10^{-5}	% of year below 10^{-6}
HRM-3								
Lynchburg								
Wallisville								
Tx City 34th								
Lake Jackson								
Mustang Bayou								
Danciger								
Clinton	No change	No change	No change	No change	Improving	No change	No change	No change
Deer Park 2	No change	No change	No change	Worsening	No change	No change	Worsening	Worsening
Milby								
Channelview	Improving	No change	Improving	Improving	No change	No change	Improving	No change
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

Improving:	Improving: statistically signifcant improvement in air quality
Worsening:	Worsening: statistically significant degradation of air quality
No Change:	No Change: no statistically significant change in air quality

5% Type I error rate

Figure N-2. Mann-Kendall trend test results: 5 years of data 2003-2007

Mann Kendall Trend Test S-Statistic: 5 Years of Data 2003-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4} (1.5 ppb)	% of year above 10^{-5} (0.15 ppb)	% of year below 10^{-6} (0.015 ppb)
HRM-3	-10	2	-10	-9	-10	-8	-8	-6
Lynchburg	-10	-2	-10	-10	1	-10	-10	4
Wallisville	-6	8	-6	-7	-3	-8	-6	4
Tx City 34th	-6	-4	-6	-2	-6	-8	-6	0
Lake Jackson	-2	6	-2	-6	-3	2	-2	-2
Mustang Bayou	-8	2	-6	1	-10	-6	-6	0
Danciger	-10	4	-8	-2	-7	0	-8	0
Clinton	-8	4	-8	-5	-8	-8	-6	-2
Deer Park 2	-4	0	-6	3	-7	-8	4	-8
Milby								
Channelview	-8	0	-8	-6	-6	-10	-6	4
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

S= or >7 or S<-7 is significant, +S= upward, -S=downward

Figure O-2. 1,3-Butadiene Improvements: 5 years of data 2003-2007

Mann Kendall Trend Test Results: 5 Years of Data 2003-2007

1,3 butadiene	mean (95th ucl)	max	mean	median	median of upper tail	% of year above 10^{-4}	% of year above 10^{-5}	% of year below 10^{-6}
HRM-3	Improving	No change	Improving	Improving	Improving	Improving	Improving	No change
Lynchburg	Improving	No change	Improving	Improving	No change	Improving	Improving	No change
Wallisville	No change	Worsening	No change	Improving	No change	Improving	No change	No change
Tx City 34th	No change	No change	No change	No change	No change	Improving	No change	No change
Lake Jackson	No change	No change	No change	No change	No change	No change	No change	No change
Mustang Bayou	Improving	No change	No change	No change	Improving	No change	No change	No change
Danciger	Improving	No change	Improving	No change	Improving	No change	Improving	No change
Clinton	Improving	No change	Improving	No change	Improving	Improving	No change	No change
Deer Park 2	No change	No change	No change	No change	Improving	Improving	No change	Worsening
Milby								
Channelview	Improving	No change	Improving	No change	No change	Improving	No change	No change
Cesar Chavez								
Aldine								
HRM-7								
Bayland								

Improving: Improving: statistically signifcant improvement in air quality

Worsening: Worsening: statistically significant degradation of air quality

No Change: No Change: no statistically significant change in air quality

5% Type I error rate

Figure P-2. Average statistical ranks

2007	Mean at 95% upper conf		max		median		median of upper tail		% of year above 10^{-4} (1.5		% of year above 10^{-5} (.15		percent of year below 10^{-6}		average rank
1,3 butadiene	ppb	rank	ppb	rank	ppb	rank	ppb	rank	%	rank	%	rank	%	rank	
HRM-3	0.18	7	10.91	4	0.08	9	0.28	5	1.00	8	28.32	9	4.00	12	7.7
Lynchburg	0.15	6	20.11	5	0.06	7	0.28	5	0.69	6	20.81	6	10.54	8	6.1
Wallisville	0.08	4	27.5	7	0.03	4	0.26	4	0.22	4	8.99	5	21.50	5	4.7
Tx City 34th	0.06	3	9.13	3	0.03	4	0.23	2	0.05	3	5.59	3	11.93	7	3.6
Lake Jackson	0.04	2	4.55	1	0.02	1	0.22	1	0.05	2	3.11	2	34.46	2	1.6
Mustang Bayou	0.08	5	47.97	10	0.02	1	0.28	5	0.36	5	7.18	4	49.26	1	4.4
Danciger	0.03	1	8.57	2	0.02	1	0.23	2	0.04	1	2.43	1	31.72	3	1.6
Clinton	0.23	9	25.72	6	0.1	11	0.32	9	1.31	9	34.72	10	5.87	10	9.1
Deer Park 2	0.22	8	203.4	12	0.07	8	0.3	8	0.72	7	23.45	8	4.94	11	8.9
Milby	1.03	12	73.93	11	0.22	12	0.85	12	19.23	12	55.32	12	8.23	9	11.4
Channelview	0.26	11	32.89	9	0.04	6	0.36	11	3.33	11	20.99	7	24.47	4	8.4
Cesar Chavez	0.24	10	31.08	8	0.09	10	0.35	10	1.85	10	35.03	11	19.11	6	9.3

concentrations in ppbV

rank is the rank order of the statistic

high ranks correspond to higher concentrations or higher precentages with the following exception

in the category of "percent of year below 10^{-6}", high ranks correspond to lower precentages

Figure Q-2. 1,3-Butadiene % of samples below detection limit

1,3-Butadiene Percent of Samples Below Limit

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1		2	4	4	4	3
Lynchburg Ferry						3	5	4	4	3
Wallisville						2	5	4	4	3
Tx City 34th St						3	4	4	4	3
Lake Jackson						2	4	4	4	3
Mustang Bayou						3	5	4	4	3
Danciger						2	4	4	4	3
Clinton	4	4	4	4	4	4	4	4	4	3
Deer Park	5	3	3	4	4	4	4	5	4	3
Milby Park								4	4	3
Channel- view				1	4	4	4	4	4	3
Cesar Chavez							3	4	4	3

This statistic is the percent of samples where the concentration was below the detection limit out of the total number of samples available. These samples were replaced with 1/2 the detection limit for statistical calculations.

Figure R-2. 1,3-Butadiene frequency of detection

1,3-Butadiene Frequency of Detect

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				17%		49%	86%	77%	92%	87%
Lynchburg Ferry						51%	79%	83%	88%	89%
Wallisville						51%	87%	74%	72%	86%
Tx City 34th St						53%	90%	87%	86%	87%
Lake Jackson						46%	76%	80%	87%	89%
Mustang Bayou						33%	83%	87%	86%	85%
Danciger						47%	90%	84%	84%	87%
Clinton	86%	73%	81%	67%	55%	43%	80%	80%	89%	86%
Deer Park	74%	61%	63%	74%	70%	50%	68%	69%	81%	86%
Milby Park								73%	86%	89%
Channel- view				21%	75%	57%	52%	65%	81%	80%
Cesar Chavez							57%	88%	84%	88%

This statistic is the number of samples where a concentration was detected out of the total number of samples available.

Figure S-2. 1,3-Butadiene number of samples

1,3-Butadiene Number of Samples

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				1487		4321	7511	6727	8022	7580
Lynchburg Ferry						4448	6967	7311	7689	7798
Wallisville						4492	7617	6454	6342	7563
Tx City 34th St						4660	7944	7623	7502	7587
Lake Jackson						4008	6701	7032	7626	7777
Mustang Bayou						2898	7272	7601	7524	7436
Danciger						4083	7883	7374	7341	7663
Clinton	7494	6408	7086	5865	4844	3749	7043	6976	7753	7543
Deer Park	6509	5349	5543	6514	6162	4367	5939	6047	7137	7536
Milby Park								6413	7573	7797
Channel- view				1879	6571	4953	4551	5675	7081	7021
Cesar Chavez							5024	7712	7378	7665

This statistic is the number of samples where a concentration was detected.

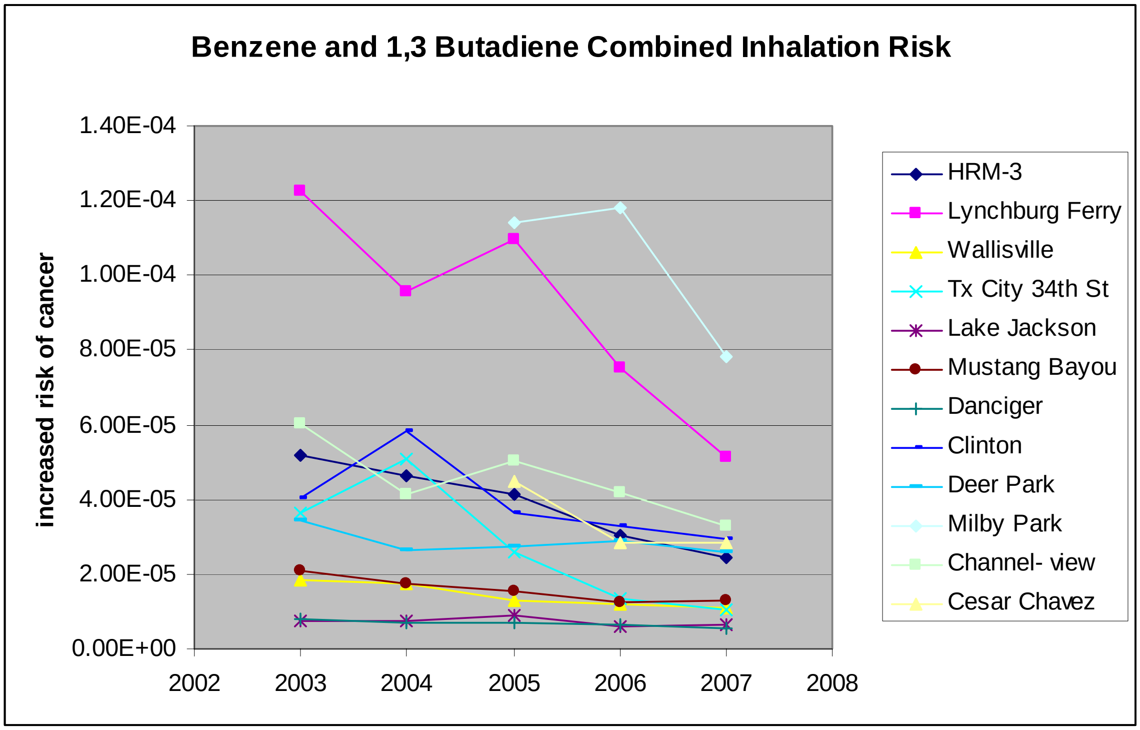
Figure T-2. 1,3-Butadiene coefficient of variation

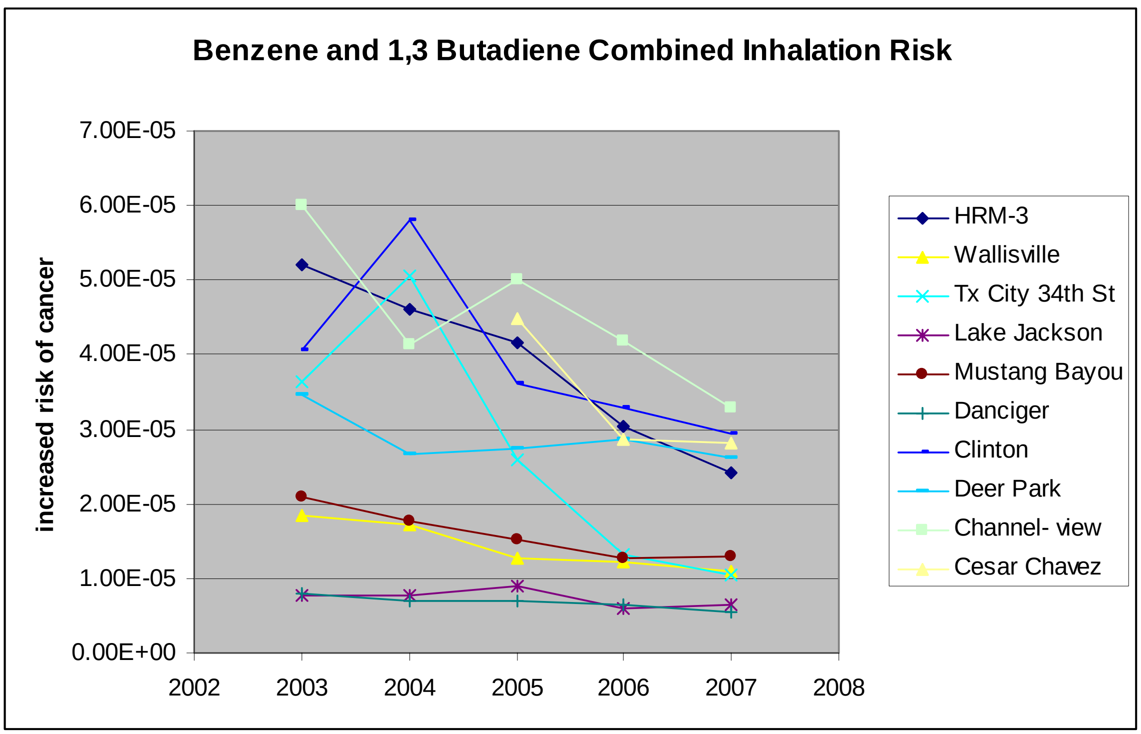
1,3-Butadiene Coefficient of Variation

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HRM-3				2.18		3.23	3.28	4.74	6.14	2.26
Lynchburg Ferry						2.66	4.29	5.48	3.16	2.76
Wallisville						2.39	2.51	2.94	6.01	5.13
Tx City 34th St						7.96	6.22	10.22	3.71	2.62
Lake Jackson						2.28	1.69	1.96	3.09	2.47
Mustang Bayou						10.05	5.26	6.97	6.31	9.34
Danciger						2.93	1.23	2.14	2.06	3.52
Clinton	4.31	2.89	3.39	2.40	2.61	2.56	2.97	3.28	5.22	2.51
Deer Park	3.62	2.49	2.76	5.79	3.00	6.72	2.99	1.98	1.36	13.63
Milby Park								2.46	17.80	2.12
Channel- view				6.42	3.42	3.08	3.00	4.72	4.28	4.31
Cesar Chavez							3.16	3.60	3.53	2.47

This statistic may indicate non-normality if it exceeds 1.2.

Figure A-3. Benzene and 1, 3-Butadiene Combined Inhalation Risk





ATTACHMENT C

Houston Refining
Complaint/Enforcement History

HOUSTON REFINING COMPLAINT / ENFORCEMENT HISTORY

Complaint History

Summary of complaints received by the three regulatory agencies in the Houston area as follows:

Complaints Received by the City of Houston Bureau of Air Quality Control

From October 2005 – September 2008 the City of Houston Bureau of Air Quality Control (BAQC) received 8 Odor Complaints involving odors and health impacts in the area of the Houston Refining-LP (Refinery), formerly Lyondell-Citgo Refining LP (HR). The complaints alleged that chemical odors were causing, headaches, dizziness, breathing trouble and nausea to the citizens in the area. All these complaints have been unconfirmed because they usually happen at night or on weekends. A summary of the complaints that alleged chemical odors causing headaches, dizziness, breathing trouble and nausea follows:

Benzene	1
Chemical Odor	2
Very Nasty Odor	1
Rotten Eggs	1
Sulfur	1
Lighter Fluid	1
Light Brown Cloud	1
Total	**8**

Complaints Received by Harris County Public Health and Environmental Services

From April 2005 – September 2008 Harris County Public Health and Environmental Services (HCPHES) received 7 Odor Complaints involving odors and health impacts in the area of the HR. The complaints alleged that strong Phosphorus / Phenol / Sulfate odors, Flare Emissions, and chemical odors were causing breathing trouble, headaches and nausea to the citizens in the area. A summary of the complaints that alleged chemical odors causing breathing trouble, headaches and nausea follows:

Sulfur Dioxide	1
Phosphorus / Phenol / Sulfate	1
Rotten Eggs	1
Chemical Odor	1
Total	**4**

Complaints Received by the Texas Commission on Environmental Quality

From June 2005 – September 2008 the Texas Commission on Environmental Quality (TCEQ) received 3 complaints involving odors and health impacts in the area of the HR Plant. Investigations Nos.: 395267, 418788 and 458725.
Total number of complaints 3.

<u>Total number of complaints received by BAQC, HCPHES and TCEQ agencies from 2005 to Present = 15 complaints</u>

PRIOR ENFORCEMENT HISTORY

NOVs issued to HR by BAQC

BAQC issued a notice of violation (NOV) to HR on September 18, 2007, alleging the following violations:

- BAQC Cited Violation 30 TAC 101.201(a)(1)(B) – HR failed to submit ten (10) initial notification reports of the reportable emissions events to the BAQC during the period from June 15, 2006 through June 22, 2007.

- BAQC Cited Violation 30 TAC 101.201(c) – HR failed to submit fifteen (15) final records of reportable emissions events to the BAQC during the period from June 15, 2006 through June 22, 2007.

- BAQC Cited Violation 30 TAC 101.201(b)(1)(G) – HR failed to identify the descriptive type of all individually listed compounds or mixtures of air contaminants or identify compounds and mixtures as "other" in the final record for seven (7) emissions events.

- BAQC Cited Violation 30 TAC 101.201(b)(1)(H) – HR failed to identify in the final record the permit authorization for four emissions events.

- BAQC Cited Violation 30 TAC 101.201(b)(1)(H) – HR reported the reportable quantity (RQ) instead of the authorized emissions limit in the final record for five emissions events.

BAQC resolved this NOV based on a response from HR dated October 9, 2007 and a meeting between HR and BAQC on November 14, 2007 where HR indicated they would comply in the future with the noted requirements. Subsequent emissions event initial notifications and final records also demonstrated compliance with the above noted requirements.

NOVs issued to HR by HCPHES

6/5/02 HCPHES Cited Violation 30 TAC 101.4 – HCPHES determined that HR was causing a Nuisance in the area.

9/5/02 HCPHES Cited Violation 30 TAC 116.715(a) and Flexible Air Permit No. 2167, Condition No. 1 - HCPHES determined that HR released unauthorized emissions.

10/17/05 HCPHES Cited Violation 30 TAC 116.715(a) and Flexible Air Permit No. 2167, Condition No. 1 - HCPHES determined that HR released 1,890 lbs of ethylene via PSV-0029 and 268 lbs of ethylene via PSV-003. These emissions were released via emissions points that were not listed in the table entitled Emission Sources-Emissions Caps and Individual Emissions Limitations.

6/1/06 HCPHES Cited Violation - 30 TAC 116.715(a), 115.722(c)(1) and Flexible Air Permit No. 2167, Condition No. 1 - HCPHES determined that HR operators failed to take all appropriate precautions in response to a high level alarm associated with the ethylene receiver in the Para-Xylene Unit, releasing 3,800 lbs of ethylene on 3/20/06.

8/14/08 HCPHES Cited Violation - 30 TAC 116.115(c), 30 TAC 116.115(b)(2)(f), 30 TAC 116.115(b)(2)(H)(i), 30 TAC 116.115(b) and Tex. Health & Safety Code 382.085(b) - HCPHES determined that an HR operator inadvertently opened the wrong valve on the manifold during a two way transfer of amine. This resulted in elevated levels of hydrogen sulfide in the Refinery's off–gases fuel system and elevated emissions of sulfur oxide.

SUMMARY – NOVs and TCEQ AGREED ORDERS ISSUED TO HR FROM FEBRUARY 2002 TO AUGUST 2008:

Total Agreed Orders (AO)	**16**
Pending AO	**5**
NOVs (Includes 7 NOVs issued by BAQC and HCPHES)	**30**
NOEs	**28**
Total Penalties Amount	**$ 876,631**

TCEQ Agreed Orders details as follows:

2001-0072-AIR-E Agenda Date: **08/07/2002** Penalty Amount: **$12,700.00:**
This agreed order covers two NOEs (issued on September 6 and November 14, 2000).

- TCEQ determined that HR failed to install a Continuous Opacity Monitoring System (COMS) in the fluid catalytic cracking unit regeneration stack to continuously monitor and record opacity of emissions from October 1995 through March 2000, in violation of 30 TAC 101.20(1)(2), 30 TAC 111.111(a)(2)(c), 40 CFR 60.105(a)(1), 40 CFR 60.105(a)(1) and Tex. Health & Safety Code 382.085(b).

- TCEQ determined that HR Failed to use the appropriate daily calibration gas on the low and high spans for the Continuous Emissions Monitoring System (CEMS), in violation of 30 TAC 101.20(2), 40 CFR 60.13(d)(1) and Tex. Health & Safety Code 382.085(b).

- TCEQ determined that HR failed to properly calibrate the Predictive Emissions Monitoring System (PEMS) on crude unit F1 heater, in violation 30 TAC 116.115(c), and Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 15.

2002-1040-AIR-E Agenda Date: **07/23/2003** Penalty Amount**: $3,350.00:**
This agreed order covers one NOE (issued on May 29, 2002). TCEQ determined thatduring the 2001 calendar year, HR failed to monitor 368 valves in the Benzene Toluene Unit (BTU) in Volatile Organic compound (VOC) service that were difficult to monitor, in violation of 30 TAC 101.20(1), Tex. Health & Safety Code 382.085(b) and 40 CFR 60.482-7(h)(3).

2003-1418-AIR-E Agenda Date: **06/09/2004** Penalty Amount: **$8,200.00:**
This agreed order covers one NOE (issued on March 10, 2003). TCEQ determined that HR allowed an unauthorized release of SO_2, H_2S, and SO_3 from the Sulfur Recovery System. This emissions event occurred on December 19, 2002, which resulted in excess emissions of 85,000 lbs of SO_2, 1,869 lbs of H_2S and 2,426 lbs of SO_3, in violation of 30 TAC 116.715(a), Flexible Permit No. 2167 and Tex. Health & Safety Code 382.085(b).

2004-0866-AIR-E Agenda Date: **03/23/2005** Penalty Amount: **$9,100.00:**
This agreed order covers one NOE (issued on June 1, 2004). TCEQ determined that HR failed to prevent an unplanned shutdown of two cooling tower's electric water pumps which resulted in the release of the following unauthorized emissions from the 732 Fluid Catalytic Cracking Unit (FCCU) on May 8, 2003: 315 lbs of butane, 38 lbs of ethylene, 2,540 lbs of isobutene, 11 lbs of pentene, 25,878 lbs of propane and 76,832 lbs of propylene, in violation of 30 TAC 116.715(a), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.1 and Tex. Health & Safety Code 382.085(b).

2004-2002-AIR-E Agenda Date: **07/27/2005** Penalty Amount: **$26,325.00:**
This agreed order covers two NOEs (issued on November 24, and December 8, 2004).

- TCEQ determined that HR failed to comply with permitted emissions limits on March 3, 2004, as a result of an emission event that resulted from operator error. HR reported that the No. 3 flare and No. 4 flare in the 737 Coker Unit emitted 47,876 lbs of sulfur dioxide, 2,239 lbs of carbon monoxide, 520 lbs of hydrogen sulfide, 310 lbs of nitrogen oxides, 7.6 lbs of ammonia and 2,639 of volatile organic compounds over a period of 3 hours and 53 minutes.

- TCEQ also determined that on September 1, 2004, an initial emission event was not timely reported, the No.: 2 Flare Stack in the 636 Cat Feed Hydrotreater Unit emitted 10,245 lbs of sulfur dioxide and 113 lbs of Hydrogen Sulfide for a period of 48 minutes, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), 30 TAC 101.201(a)(1)(B), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.1 and Tex. Health & Safety Code 382.085(b).

2005-0359-AIR-E Agenda Date: **02/08/2006** Penalty Amount: **$131,670.00:**
This agreed order covers one NOE (issued on February 2, 2005).

- TCEQ determined that HR failed to limit the hydrogen sulfide (H2S) concentration in the fuel gas to no more than 160 parts per million (ppm) on a three hour rolling average basis, in violation of 30 TAC 116.715(a), 30 TAC 101.20(1) and (3), 40 CFR 60.104(a)(1), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.1 and Tex Health & Safety Code 382.085(b).

- TCEQ determined that HR Failed to operate the Wet Gas Scrubber at the minimum pressure drop across the scrubber of 0.91 lbs per square inch (psi) and at a minimum liquid-to-gas ratio (L/G) of 16.0 gallons per 1,000 actual cubic feet, in violation of 30 TAC 116.715(a), 30 TAC 101.20(1) and (3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.1 and Tex. Health Safety Code 382.085(b).

- TCEQ determined that HR failed to maintain the hourly average carbon monoxide (CO) concentration below 500 parts per million by volume (ppmv) from the Catalyst Regenerator Stack (FCCU) in violation of 30 TAC 116.715(a), 30 TAC 101.20(1) and (3), 40 CFR 60.103(a), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.2 and Tex. Health Safety Code 382.085(b).

- TCEQ determined that HR failed to note daily flare observations in the Flare Observation Log and failed to maintain monitoring records for a flare's pilot flame, in violation of 30 TAC 111.111(a)(4)(A)(ii), 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit

No. 2167/PSD-TX-985, Special Condition No. 47; and Tex. Health & Safety Code 382.085(b).

- TCEQ determined that HR failed to repair three valves within 15 days of leak detection, in violation of 30 TAC 101.20(2), 30 TAC 101.20(3), 30 TAC 115.352(2), 30 TAC 116.715(a), 40 CFR 63.171(a), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 14.1 and Tex. Health & Safety Code 382.085(b).

- TCEQ determined that HR failed to maintain the sulfur dioxide (SO2) concentration in the exhaust gas of the No. 435 and No. 440 Tail Gas Thermal Oxidizers below 235 ppmv on a one-hour average basis, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 37 and Tex. Health & Safety Code 382.085(b).

- TCEQ determined that HR failed to conduct required inspections of three storage tanks, in violation of 30 TAC 115.114(a)(1), 30 TAC 115.114(a)(2), 30 TAC 116.715(a), 30 TAC 101.20(3), 40 CFR 63.120(a)(2)(i), 40 CFR 63.120(b)(1)(iii), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.4 and Tex. Health & Safety Code 382.085(b).

2005-0754-AIR-E Agenda Date: **01/25/2006** Penalty Amount: **$16,400.00:**
This agreed order covers two NOEs (issued on August 4, 2003 and May 8, 2005).

- TCEQ determined that HR failed to comply with permitted emissions limits on January 16, 2003, from the No.2 plant flare in the Sulfur Recovery Complex. HR reported 11,851 lbs of sulfur dioxide, 128.5 lbs of hydrogen sulfide, 371 lbs of carbon monoxide and 3.3 lbs of nitrogen oxide were released over a 40-minute period during the event, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 1 and Tex. Health & Safety Code 382.085(b)

- Also, HR reported that on November 4, 2004, their plant heater in the Sulfur Recovery Complex emitted 4,864 lbs of sulfur dioxide, 54 lbs of hydrogen sulfide over a one-hour 44-minute period. TCEQ determined that because these emissions events could have been avoided by good design, operation, and maintenance practices, the emissions do not meet the demonstrations in 30 TAC 101.222 and are not subject to an affirmative defense under 30 TAC 101.222(b)(1-11).

2005-1172-AIR-E Agenda Date: **11/30/2005** Penalty Amount: **$7,075.00:**
This agreed order covers one NOE (issued on June 25, 2005). TCEQ determine that HR failed to comply with permitted emissions limits on December 29, 2004, for the No. 3 plant flare in the 737 Coker Unit and the No.4 plant flare in the 737 Coker Unit. HR reported 924 lbs of sulfur dioxide and 10 lbs of hydrogen sulfide from the No. 3 plant flare and 7,465 lbs of sulfur dioxide and 93 lbs of hydrogen sulfide from the No.4 plant flare during an emissions event that lasted 40 minutes, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 1 and Tex. Health & Safety Code 382.085(b). TCEQ determined that because these emissions events could have been avoided by good design, operation, and maintenance practices, the emissions do not meet the demons- trations in 30 TAC 101.222 and are not subject to an affirmative defense under 30 TAC 101.222(b)(1-11).

2005-1985-AIR-E Agenda Date: **05/17/2006** Penalty Amount: **$10,000.00:**

This agreed order covers one NOE (issued on October 31, 2005). TCEQ determined that HR failed to prevent unauthorized emissions of 13,909 pounds of sulfur dioxide , beginning on April 21, 2005 at the Thermal Oxidizer in the Sulfur Recovery Complex over for six hours and 30 minutes, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3); Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No. 1, and Tex. Health & Safety Code 382.085(b).

2005-2073-AIR-E Agenda Date: **05/31/2006** Penalty Amount: **$10,000.00:**
This agreed order covers one NOE (issued on December 6, 2005). During an investigation on September 1, 2005, TCEQ staff documented that HR failed to prevent unauthorized emissions of 2,158 pounds of ethylene during an emissions event, which occurred on July 2, 2005 at the Propane Recovery Unit (PRU) and lasted 30 minutes, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.: 1 and Tex. Health & Safety Code 382.085(b).

2006-0811-AIR-E Agenda Date: **01/24/2007** Penalty Amount: **$20,000.00:**
This agreed order covers two NOEs (issued on June 20, and July 5, 2006).

- During a record review on April 3, 2006, TCEQ staff documented that during an avoidable emissions event which started on November 7, 2005 in the 434 Claus Thermal Rector Unit and lasted for one hour and 10 minutes, HR released 5,239 pounds of sulfur oxide, 190 lbs of carbon monoxide, 134 lbs of sulfur trioxide, 58 lbs of hydrogen sulfide and 27 lbs of nitrogen dioxide from the No.: 2 plant flare, as well as 368 lbs of sulfur dioxide from the 435 stack.

- During a records review on May 22, 2006, TCEQ staff documented that during an avoidable emissions event which started on March 22, 2006 in the Para-Xylene Recovery unit (PRU) and lasted for six minutes, HR released 3,800 lbs of the Highly Reactive Volatile Organic Compound (HRVOC) Ethylene from the Pressure Safety Valve (PSV) feedline to Aftercoolers, in violation of 30 TAC 116.715(a), 30 TAC 101.20(3), Flexible Air Permit No. 2167/PSD-TX-985, Special Condition No.: 1 and Tex. Health & Safety Code 382.085(b). TCEQ determined that HR failed to meet the demonstration criteria for an affirmative defense under 30 TAC 101.222.

2006-1948-AIR-E Agenda Date: **12/05/2007** Penalty Amount**: $49,800.00:**
This agreed order covers a total of four NOEs issued by TCEQ between September 12, 2006 and February 7, 2007. TCEQ determined that Emissions Event Incident Nos.: 59951, 77384, 77611, 78767 and 82077 were avoidable and HR failed to meet the demonstration criteria for an affirmative defense under 30 TAC 101.222.

2007-0440-AIR-E Agenda Date**: 7/25/2007** Penalty Amount**: $50,453.00:**
This agreed order covers a total of five NOEs (three issued on March 21, 2007 for emissions event Tracking Nos.: 85631, 85858, 86059 and two issued on April 4, 2007 for emissions event Tracking Nos.: 87866 and 87948). TCEQ determined that HR failed to meet the demonstration criteria for an affirmative defense under 30 TAC 101.222.

2007-0713-AIR-E Agenda Date: **09/19/2007** Penalty Amount: **$20,453.00:**
This agreed order covers a total of two NOEs (issued on May 9, 2007 and June 3, 2007 for emissions event Tracking Nos.: 89245 and 90267). TCEQ determined that HR failed to meet the demonstration criteria for an affirmative defense under 30 TAC 101.222.

2007-1954-AIR-E Agenda Date**: 07/09/2008** Penalty Amount: **$20,000.00:**

This agreed order covers one NOE issued by TCEQ on October 24, 2007. TCEQ determined that for Emissions Event Incident No. 99225 HR failed to meet the demonstration criteria for an affirmative defense under 30 TAC 101.222.

2008-0674-AIR-E Agenda Date**: 06/30/2008** Penalty Amount: **$481,105.00:**
This agreed order is for a multimedia inspection that resulted in numerous air and water violations. The alleged violations, included, but were not limited to, having open ended lines, failing to properly operate the FCCU wet gas scrubber, failing to properly operate a carbon canister control device, failing to keep run-time records for certain equipment, failing to inspect storage tanks, failing to comply with fugitive monitoring requirements including monitoring, recordkeeping and repair, failing to prevent visible emissions and unauthorized emissions on several occasions, failing to conduct cooling tower HRVOC monitoring, failing to conduct SO2 analyzer checks, failing to demonstrate proper flare operation, improper emissions events reporting and failing to test HRVOC analyzers. .

TCEQ PENDING AGREED ORDERS AGAINST HR

There are five additional pending enforcement actions against HR, Docket Numbers as follows:

2007-0473-AIR-E
2007-1069-AIR-E
2007-1836-AIR-E
2008-0790-AIR-E
2008-0894-AIR-E

TCEQ's Consolidated Compliance and Enforcement Data System (CCEDS) Investigation History

From September 2005 – August 2008, TCEQ has conducted 194 investigations at HR

TCEQ HAS RATED HR COMPLIANCE HISTORY AS "AVERAGE"

Please see the following chart on next page:

HOUSTON REFINING VS HARRIS COUNTY EMISSIONS EVENTS COMPARISON

Houston Refining (HR) Vs Harris County (HC) 2004-2008 Emission Events Summary

	2004	2005	2006	2007	2008 (Jan-Jun)
Contaminant	**Quantity Released per Year (Pounds)**				
Benzene (HR)[1]	357.0	25.9	13.93	1.00	0.00
Benzene (HC)	13,726.3	53,101.9	36,279.8	7,518.2	6,660.0
Benzene (%HR/HC)	2.60%	0.05%	0.04%	0.01%	0.00%
Sulfur Dioxide (HR)	71,374.3	52,616.2	110,790.3	68,818.0	10,899.0
Sulfur Dioxide (HC)	1,327,727.9	2,180,518.6	694,356.4	580,567.0	120,924.8
Sulfur Dioxide (%HR/HC)[2]	5.38%	2.41%	15.96%	11.85%	9.01%
VOC's (HR)	13,806.00	60,338.5	14,191.0	124,787.7	1,902.0
VOC's (HC)	1,535,362.7	2,924,350.2	2,033,389.4	1,165,141.8	550,984.5
VOC's (%HR/HC)[3]	0.90%	2.06%	0.70%	10.71%	0.35%
Emissions reported in violation without speciation of compounds (HR)	1,579.0	3,561.2	803.6	37,439.7	44.8
Emissions reported in violation without speciation of compounds (HC)	334,158.2	228,533.6	131,596.49	148,704.89	174,889.4
Emissions reported in violation without speciation of compounds (%HR/HC)[4]	0.47%	1.56%	0.61%	25.18%	0.03%
Total Pollutant from all Emission Events (HR)	90,231.4	148,116.8	146,613.6	209,216.4	14,131.4
Total Pollutant from all Emission Events (HC)	5,097,185.3	7,982,920.2	4,964,924.6	49,018,460.6	900,465.6
Total Pollutant from all Emission Events (%HR/HC)	1.77%	1.86%	2.95%	0.43%	1.57%
Number of Emission Events (HR)	56	83	190	87	50
Number of Emission Events (HC)	4,876	4,320	4,676	3,807	1,018
Number of Emission Events (%HR/HC)[5]	1.15%	1.92%	4.06%	2.29%	4.91%

1 During calendar year 2007, HR reported that they released only one pound of benzene from 87 emissions events. While all the facilities in Harris County (HC) reported 7,518.21 lbs of benzene released from 3,807 emissions events. HR has reported that they have released 0 pounds of benzene from 50 emissions events during the present calendar year 2008 ytd.

2 During the calendar year 2007, 15.96% of all the Sulfur Dioxide emissions released in HC during emissions events were released by HR. During the calendar year 2008, 9.01 % of all the Sulfur Dioxide emissions released in HC during emissions events were released by HR.

3 During calendar year 2007, 10.71% of all the Volatile Organic Compounds (VOCs) released in HC during emissions events were released by HR.

4 During calendar year 2007, 25.18% of emissions event emissions that were reported in violation without speciation of compounds in HC were released by HR. .

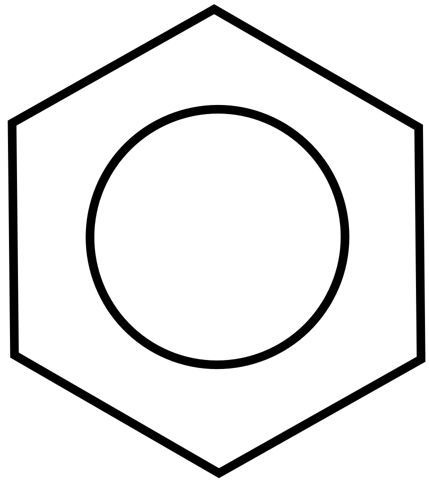
- These emissions were reported by HR as VOCs, hydrocarbons, C4-12, C5 and C6 plus, C7 – C13 in the final emissions events record. Reporting "VOCs, hydrocarbons, C4-12, C5 and C6 plus, C7 – C12 does not comply with the requirement of 30 TAC 101.201(b)(1)(G), to report the compound descriptive type of all individually listed compounds or mixtures of air contaminants from the definition of reportable quantity in 30 TAC 101.1.
- In reference to the definition of reportable quantity, "hydrocarbons, C4-12, C5 and C6 plus, C7 – C13" are not an individual air contaminant compound or a mixture specifically listed in 40 CFR 302, Table 302.4, 40 CFR 355, Appendix A or 30 TAC 101.1(84)(A)(i)(III).

5 During calendar year 2006, 4.06 % of all the emissions events releases in HC were from HR. During calendar year 2008 ytd, the percentage of emissions events in HC from HR was 4.91 % .

ATTACHMENT D

Houston Regional Benzene
Air Pollution Reduction:
A Voluntary Plan for
Major Sources Houston Refining, LP

Houston Regional Benzene Air Pollution Reduction:
A Voluntary Plan for Major Sources



Report prepared by

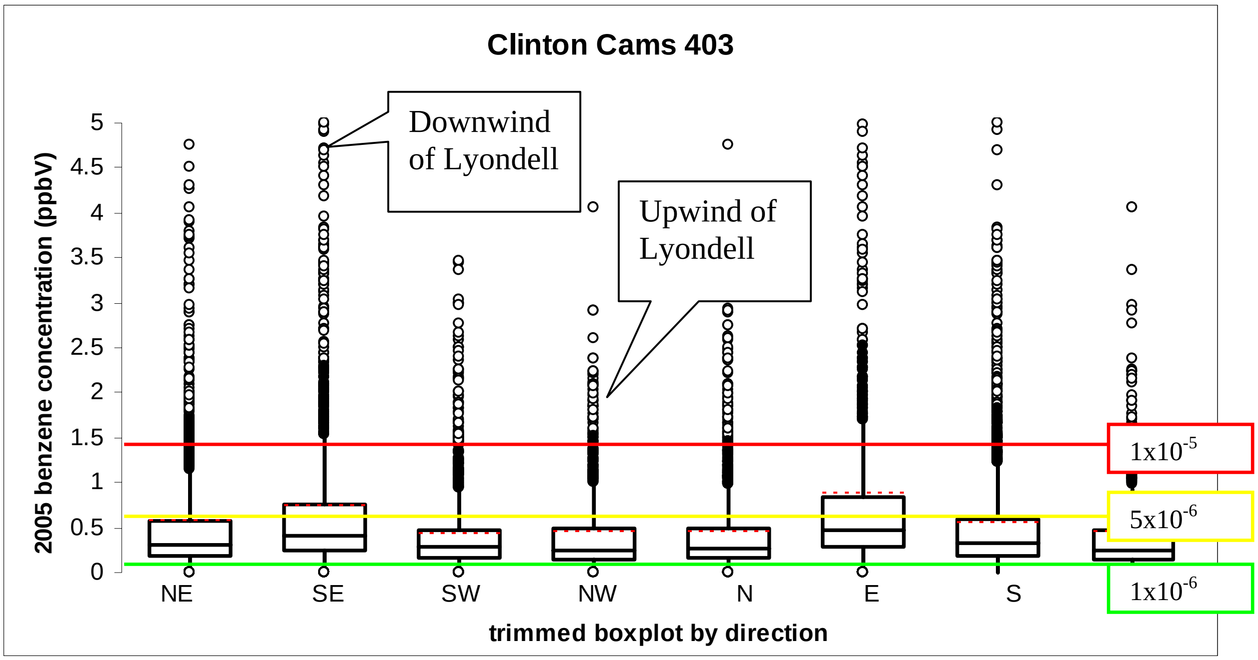
City of Houston
Mayor's Office of Environmental Programming
Department of Health and Human Services
Bureau of Air Quality Control

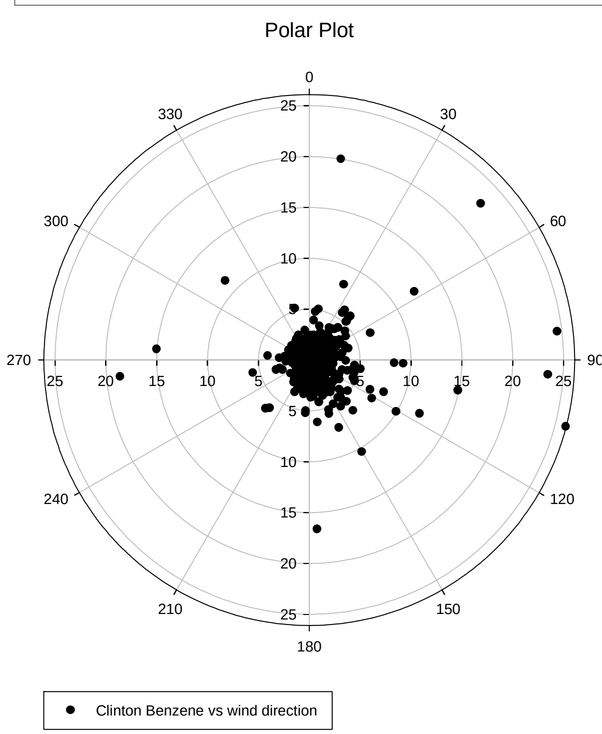
February 2007

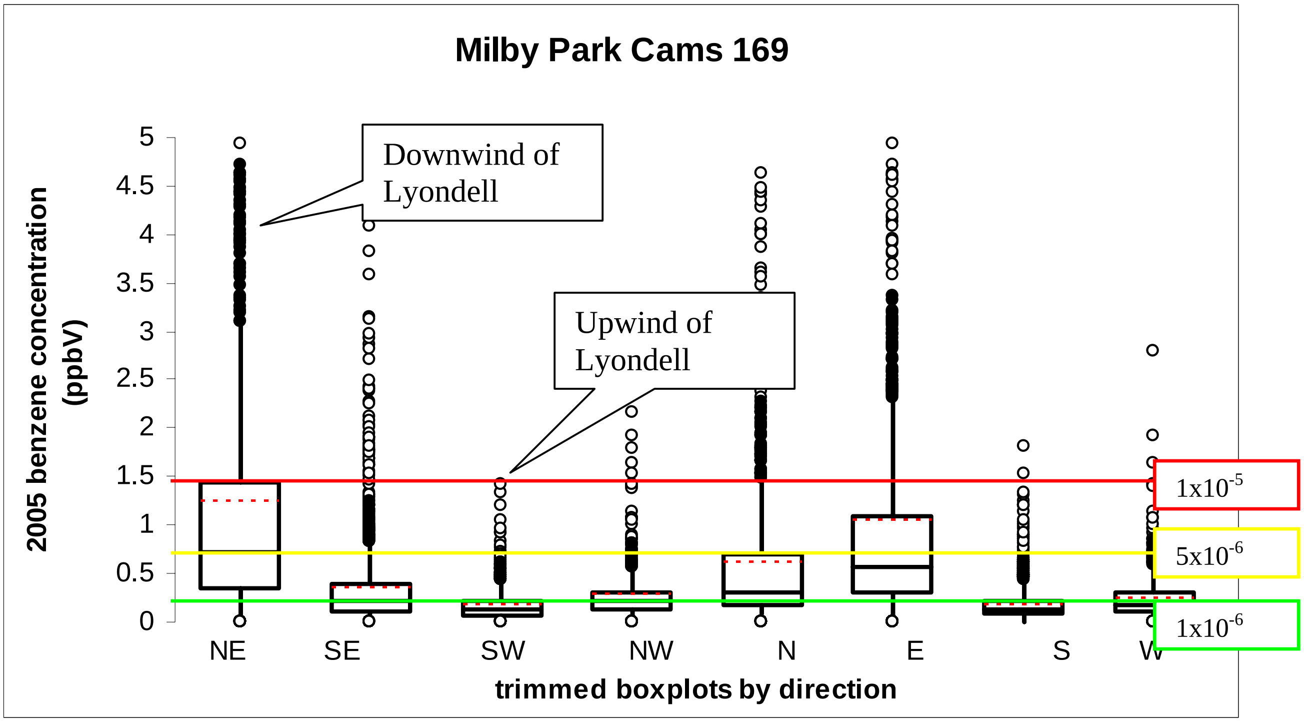
LYONDELL HOUSTON REFINING LP

SIC Code: 2911-Petroleum Refining
Nearest City, County: Houston, Harris
Total Benzene Emission (TPY)= 41.8
Benzene Risk Rank in Region= 1

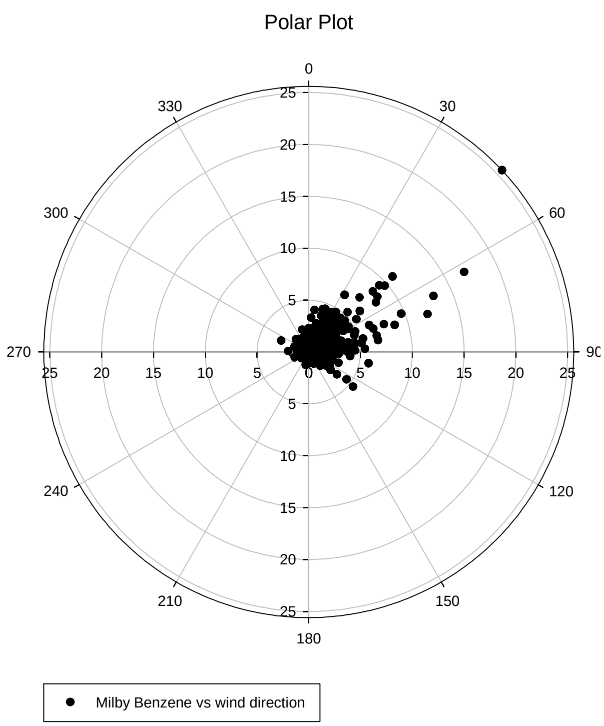
Intra-monitor comparison of benzene concentrations upwind and downwind



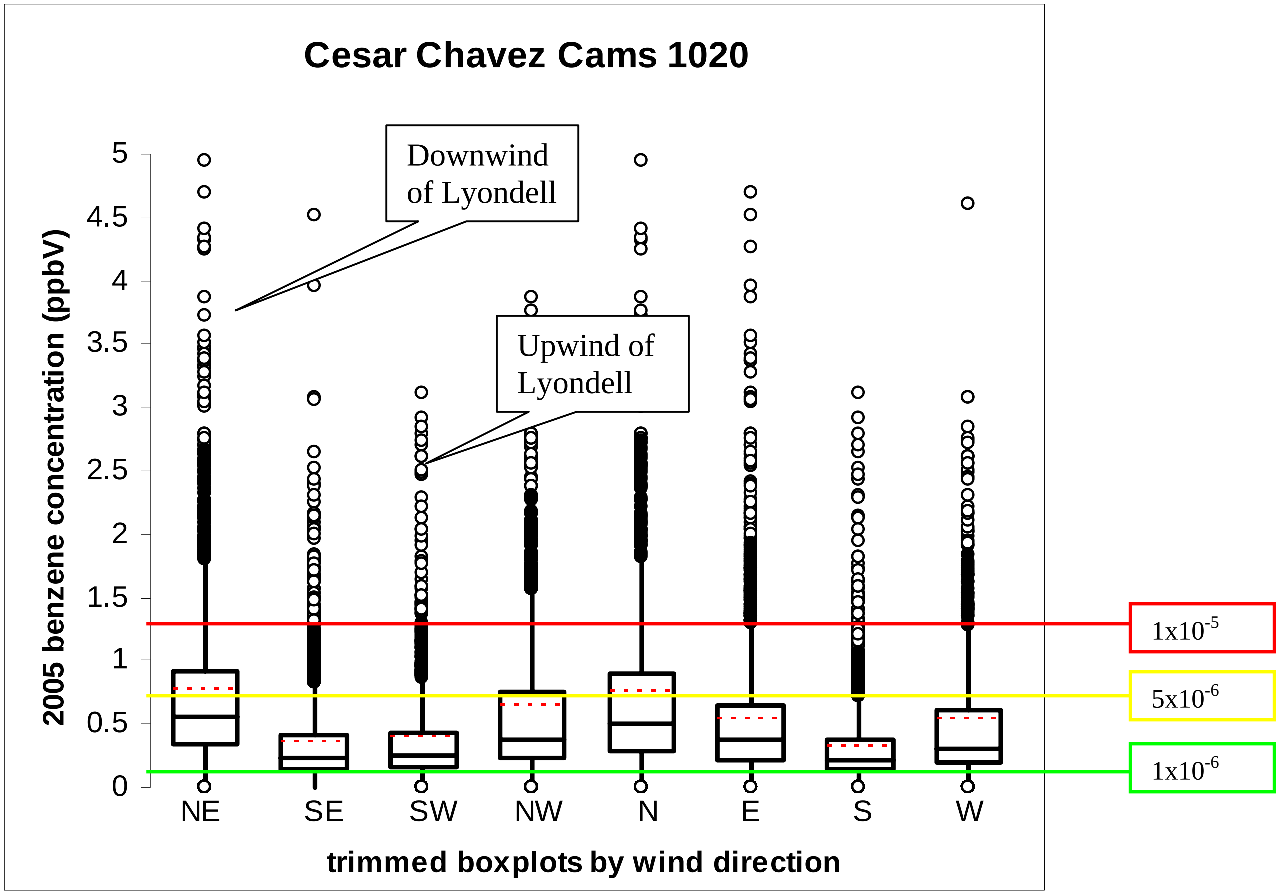




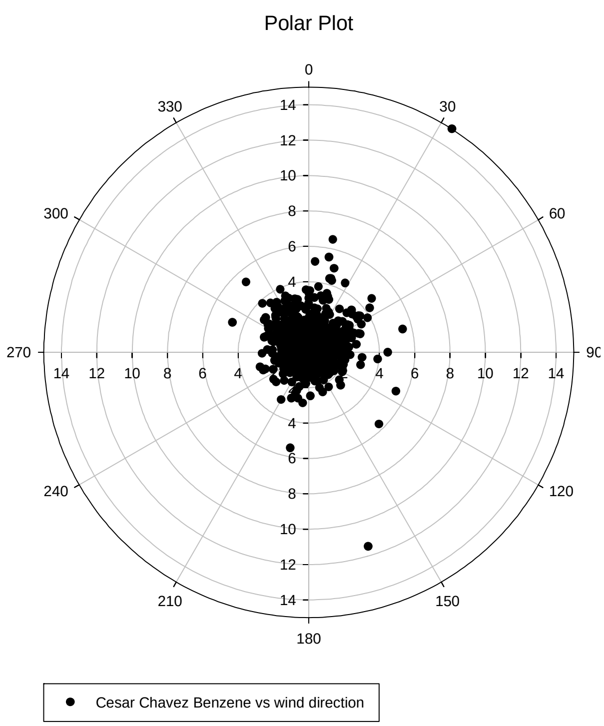
Milby Park Cams 169
Downwind of Lyondell
Upwind of Lyondell
2005 benzene concentration (ppbV)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
NE
SE
SW
NW
N
E
S
W
1x10-5
5x10-6
1x10-6
trimmed boxplots by direction



Polar Plot
0
30
60
90
120
150
180
210
240
270
300
330
25
20
15
10
5
Milby Benzene vs wind direction



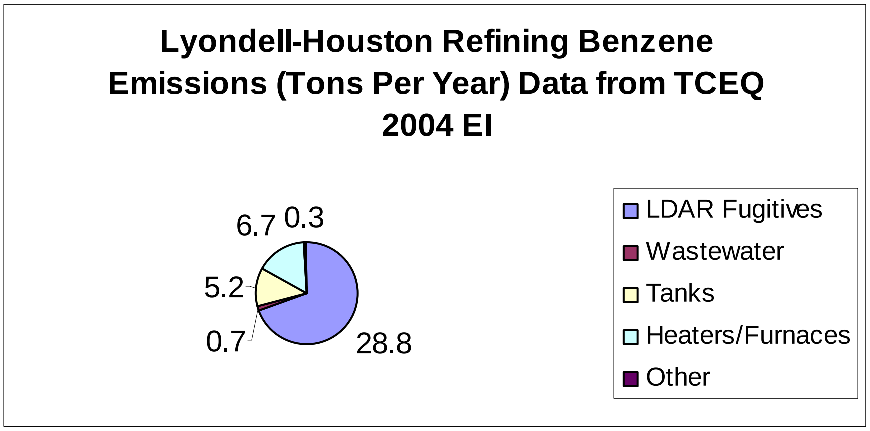
Cesar Chavez Cams 1020
2005 benzene concentration (ppbV)
Downwind of Lyondell
Upwind of Lyondell
1x10-5
5x10-6
1x10-6
NE
SE
SW
NW
N
E
S
W
trimmed boxplots by wind direction



Polar Plot
Cesar Chavez Benzene vs wind direction

Site-specific Reduction Control Strategy:

The pie chart below indicates the benzene emission sources (tons/yr) as reported at this facility in the TCEQ 2004 Emission Inventory. The corresponding emission reduction plans for these sources are provided in the table.



Year	Site-specific Plan: LYONDELL HOUSTON REFINING LP
	Heaters and Furnaces
2006	Develop a Benzene Combustion Minimization Plan (BCMP) to prevent combustion of gases containing benzene during normal operations, by recovering benzene from fuel gas systems. The BCMP will include a schedule to implement the plan.
2011	Implement BCMP to reduce benzene emissions from heaters and furnaces.
	Tanks
2007	Develop a plan to upgrade or install controls on tanks, selecting the facilities for control based on measured benzene emissions impacts and the feasibility of the controls.
2010	Implement plans to upgrade or install controls on tanks with benzene emissions.
	LDAR Fugitive
2007	Accept a 100-ppm leak threshold definition for monitored fugitive components that contain benzene, which are part of an existing leak detection and repair program and make first repair attempts within one day of leak detection for leaks from monitored fugitive components that contain benzene.
2007	Initiate an investigation to find and correct contributing conditions within four hours of measuring a significant net impact from the site. The significance threshold will depend on the baseline ambient monitoring data, and will be reduced over the five year period as monitoring verifies reductions over time.

Year	Site-specific Plan: LYONDELL HOUSTON REFINING LP
2008	Utilize a passive optical gas imaging instrument to perform startup and quarterly site-wide surveys of leak detection and repair program components, tanks, vents, wastewater collection and treatment facilities and loading and unloading operations. Leaks detected with the passive optical gas-imaging instrument must be confirmed with tradition leak detection methods (Method 21) and/or seal inspections, and the leaks must be corrected according to applicable leak repair time frames. If there is not an applicable leak repair time frame, a leak repair plan must be developed and implemented so that the leak will be repaired within a reasonable amount of time.
Quantifiable and Verifiable Reductions: Monitoring	
2008	Initiate monitoring at locations along or adjacent to the north and south or northwest and southeast property lines to verify emissions reductions and measure impacts.
2008	Make benzene monitoring data available through a web-based application (such as the TCEQ's monitoring data internal web page) and provide an automated email notification to the City of Houston when the hourly average net benzene impact from the site exceeds the current significance threshold.
2008	Submit an annual report to the City of Houston, within 60 days after the end of each calendar year in the five-year period. The annual report must include the estimated amount of benzene emissions that were reduced during the year compared to a designated baseline year as a result of participation, the estimated net annual average benzene impact from the site in ppb (through modeling and using the fence line monitoring data once fence line monitoring has been implemented), a description of projects implemented during the year, dates that each project was implemented and a schedule for each project that has not yet been implemented. If all required reductions have not been implemented by the end of the fourth year of the agreement, a final report will be due after one complete calendar year where no emissions reduction projects were implemented.