Texas Commission on Environmental Quality

INTEROFFICE MEMORANDUM

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Date: January 3, 2005

From: Vincent Leopold, Toxicology Section, Chief Engineer's Office

Subject: Health Effects Review of Air Monitoring Data Collected in TCEQ Region 12–Houston during 2003

Background

This memorandum conveys the Toxicology Section's evaluation of ambient air sampling conducted at monitoring network sites in Region 12–Houston during 2003. We reviewed summary results for volatile organic compounds (VOCs) from 1- and 24-hour canister samples, 1- and 24-hour carbonyl samples, and 24-hour metals samples (from $PM_{2.5}$, PM_{10}, and TSP filters). Air monitoring in 2003 is summarized below and detailed information regarding monitoring sites and target analytes is presented in Table 1.

- 1-hour canister VOC sampling at 3 sites
- 24-hour canister VOC sampling at 17 sites
- 1- and 24-hour carbonyl sampling at 3 sites
- 24-hour metals sampling at 8 sites
- 1-hour autoGC VOC monitoring at
  - 3 TCEQ sites all year, and
  - 7 Enhanced Industry-Sponsored Monitoring (EISM) sites June - December

One-hour canister VOC, autoGC VOC, and carbonyl data were evaluated for potential acute health and odor concerns. Twenty-four-hour air samples are designed to provide representative long-term average concentrations when collected over a period of time representing annual variations in meteorology. Therefore, annual averages from 24-hour samples were evaluated for potential chronic health concern. Twenty-four-hour samples do not show short-term or peak concentrations, and therefore, have limited use in evaluating the potential for acute health effects or odors.

Measured chemical concentrations were compared to TCEQ health-based and odor-based Effects Screening Levels (ESLs). An ESL is a guideline concentration which is protective of the general public including sensitive members of the population, such as the elderly, children, and persons with pre-existing health conditions. Health-based ESLs are guideline comparison levels set well below levels at which adverse health effects have been reported in the scientific literature. If an air concentration of a pollutant is below the ESL, we do not expect adverse health effects to occur. If an air concentration of a pollutant is above the health-based ESL, it is not indicative

that adverse effects will necessarily occur, but rather, that further evaluation may be warranted.

Odor-based ESLs are typically based on detection or recognition thresholds (for example, concentrations at which 50% of the tested individuals detected an odor or recognized the chemical). Therefore, the more a measured concentration exceeds an odor threshold the higher the percentage of people expected to perceive the odor. Chemical concentrations that are below an odor threshold are less likely to be odorous, but perception of their odor by some individuals cannot be ruled out.

Evaluation may include the estimation of cancer risk. This is accomplished using EPA unit risk factors to calculate *upper-bound excess lifetime cancer risk* that is estimated to result from continuous lifetime exposure to the monitored average concentration. *Upper-bound* means the true risk may be lower but is unlikely to be higher than the estimate. *Excess lifetime* risk means the additional or extra risk of developing cancer due to exposure to a toxic substance incurred over the lifetime of an individual. The highest excess cancer risk considered to be acceptable is generally between 1 in 10,000 and 1 in 1 million (or 10^{-4} to 10^{-6})[1]. The acceptable risk goal of the Toxicology Section is 1 in 100,000 (10^{-5}) for individual chemicals and 1 in 10,000 (10^{-4}) for cumulative risk. This memorandum evaluates air monitoring data on a chemical-by-chemical basis. Evaluation of the potential for cumulative effects will be presented in a later report. The Texas Department of State Health Services estimates that approximately two out of every five persons alive today (40%) will develop some type of cancer in their lifetime[2]. Lifestyle choices such as tobacco use and diet have been associated with 50-75% of cancer deaths[3] while environmental pollution has been estimated to cause a relatively small percentage of cancers. The Harvard Center for Cancer Prevention estimates 2% of cancer deaths are attributable to environmental pollution (including water, soil, and air)[4]. These are overall estimates regarding causes of cancer and may not reflect the relative importance of risk factors in select

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[1]40 CFR Ch. 1, 300.430, 7-1-98 Edition.

[2]Texas Department of State Health Services, Texas Cancer Epidemiology and Surveillance Branch. *Summary of Investigation Into the Occurrence of Cancer, Zip Codes 77531 (Clute), 77541 (Freeport), 77012, 77017 (Houston), 77520 (Baytown), 77619 (Groves), 77640/77642 (Port Arthur), and 77651 (Port Neches), Brazoria, Harris, and Jefferson County Texas, 1993-2002, September 3, 2004.*

[3]National Cancer Institute. *Cancer Progress Report - 2003 Update*. NIH, DHHS, Bethesda, MD, February 2004, http://progressreport.cancer.gov/ (accessed 12/1/04).

[4]Harvard Center for Cancer Prevention. Harvard Reports on Cancer Prevention. Volume I: Human Causes of Cancer, http://www.hsph.harvard.edu/cancer/publications/reports/vol1_summary.html (accessed 12/1/04).

subpopulations and individuals.

Evaluation

One-Hour Concentrations

Most one-hour canister VOC, autoGC VOC, and carbonyl concentrations were below their respective short-term health- and odor-based ESLs. One-hour concentrations that exceeded their respective short-term ESL and for which further evaluation determined potential for health effects or odors are discussed below.

The highest one-hour formaldehyde level measured at the Channelview site was 51 parts per billion by volume (ppbv). Exposure to this concentration may cause eye and respiratory irritation in some sensitive individuals. Some hourly autoGC VOC measurements exceeded their respective odor-based ESLs at several sites as shown below.

Site	Chemical	Number of hourly samples > odor-based ESL	Highest Concentration (ppbv)	Odor-based ESL (ppbv)
Baytown Lynchburg Ferry EISM U23 (June - Dec)	isoprene	2	11	5
	t-2-pentene	1	58	30
	styrene	23	987	25
Baytown Wallisville Rd. EISM U24 (June - Dec)	isoprene	1	8	5
Channelview (Jan - Dec)	isoprene	7	25	5
Dancigar EISM U28 (June - Dec)	isoprene	10	11	5
Houston Haden Rd. EISM U22 (June - Dec)	1-butene	1	97	69
Lake Jackson EISM U26 (June - Dec)	isoprene	1	5	5

Exposure to strong unpleasant odors can cause odor-related effects such as headache and nausea. At the Baytown Lynchburg Ferry site, 23 hourly styrene concentrations exceeded the odor-based ESL of 25 ppbv, though even the maximum styrene concentration of 987 ppbv would not be expected to cause acute health effects such as eye and skin irritation[5].

[5]ATSDR, 1992. Toxicological Profile for Styrene. Agency for Toxic Substances and Disease Registry, U.S. Public Health Service. September, 1992,

Annual Average Concentrations

Most annual average concentrations calculated for autoGC and 24-hour canister VOCs, 24-hour carbonyls, and 24-hour metals were less than their respective long-term ESLs and are not expected to pose a significant health concern. However, a few chemicals exceeded their respective long-term ESLs and/or merit further discussion below.

Benzene
The 2003 average benzene levels at Texas City-Ball Park (1.2 ppbv) and Galena Park (1.7 ppbv) exceeded the long-term benzene ESL (1 ppbv). The reported canister benzene average at Lynchburg Ferry (2.7 ppbv) was based an incomplete year of available data collected April 27 - Nov. 17. However, autoGC data collected at Lynchburg Ferry provided a 12-month (6/6/03 to 6/5/04) benzene average of 2.8 which also exceeds the ESL. The EPA has published a range of risk estimates for benzene carcinogenicity because of uncertainty in the low-dose exposure scenarios and lack of clear understanding of the mode of action. The risk estimates range from 2.2×10^{-6} to 7.8×10^{-6} risk per microgram/m^3 with each having equal scientific plausibility[6]. Assuming continuous lifetime exposure to the measured benzene levels and using the high end of the unit risk factor range, theoretical cancer risk estimates at these sites ranged from 3 in 100,000 to 7 in 100,000.

Because the Baytown Lynchburg Ferry site is not located in a residential area, additional information would be needed to better characterize potential community exposure in the surrounding areas. As shown in Figure 1, from Lynchburg Ferry looking clockwise from northwest to north to east, residential areas occur starting at distances of approximately 1 to 2 miles. A preliminary evaluation of source direction using the hourly autoGC data at this site indicates that the higher benzene levels are associated with winds blowing from the north-northwest, north-northeast, and southwest (see Figure 2). In addition, TCEQ mobile monitoring in 2002 and 2004 detected elevated benzene levels at the intersection of Battleground Road and Tidal Road. Continuing evaluation of source directionality and identification of sources is needed to determine how ambient levels in residential areas would be expected to compare with measured levels at Lynchburg Ferry. In the meantime, however, we recommend that any proposed increases in benzene emissions in this area be evaluated cautiously and that reductions be encouraged.

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http://www.atsdr.cdc.gov/toxprofiles/tp53.html (accessed 12/1/04).

[6]USEPA, 2003. Integrated Risk Information System. Benzene. Carcinogenicity Assessment for Lifetime Exposure. April 17, 2003, http://www.epa.gov/iris/subst/0276.htm#carc (accessed 12/1/04).

Formaldehyde

The 2003 average formaldehyde concentrations at Channelview (3.4 ppbv), Houston-Clinton Dr. (5.7 ppbv), and Houston-Deer Park (3.2 ppbv) exceeded the current long-term ESL (1.2 ppbv). Assuming continuous lifetime exposure to the measured levels and using the EPA unit risk factor, cancer risk estimates ranged from 5 in 100,000 to 9 in 100,000. However, the current formaldehyde unit risk factor is generally believed to substantially overestimate risk, and EPA is currently reviewing this risk factor. Use of a new risk factor[7] that incorporates more recent research regarding formaldehyde metabolism and toxicity results in insignificant risk estimates of less than 1 in 10 million for the formaldehyde levels at these sites. We expect the formaldehyde long-term ESL to increase when it is revised in order to reflect the latest scientific research.

1,3-Butadiene

Annual average 1,3-butadiene levels did not exceed the current long-term ESL (5 ppbv). However, we expect a new 1,3-butadiene ESL to be developed and published subsequent to the external expert peer review of the ESL development method in 2005. While we don't know what the new ESL will be, we expect it to be lower than the current value.

Annual average 1,3-butadiene levels at Milby Park (Figure 3) have varied between 2.1 and 4.4 ppbv since 1999, giving a five-year average of 3.1 ppbv. The highest 24-hour concentrations trended upwards from 2001-2003, though they are substantially less than the highest 24-hour levels in 1999 and 2000. The 2003 annual average 1,3-Butadiene level at Milby Park is higher than at other air toxics monitoring sites (see Figure 4).

The highest 1,3-butadiene levels measured at Milby Park are associated with winds blowing from the direction of the industrial complex (including Texas Petrochemicals, Goodyear, and Mobil) located approximately ¼ to 1¼ miles southeast of the Milby Park monitor (see Figures 5 and 6). Evaluation of source direction for 1,3-butadiene measured at the Clinton autoGC primarily points to the same industrial complex located approximately 1¾ to 2½ miles south of the Clinton monitoring site (see Figure 7).

Assuming continuous lifetime exposure to the 1,3-butadiene levels monitored in 2003 and using the EPA unit risk factor, theoretical cancer risk estimates for 1,3-butadiene at most Region 12 monitoring sites ranged from 3 in 1 million to 4 in 100,000. However, for the annual average 1,3-butadiene level (3.2 ppbv) at Milby Park, the theoretical cancer risk estimate is 2 in 10,000.

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[7] 4.77E-7 risk per 0.010 ppm (risk-conservative factor for smokers from the hockey stick-shaped dose-response model) in R. Conolly, et al., 2004. Human Respiratory Tract Cancer Risks of Inhaled Formaldehyde: Dose-Response Predictions Derived from Biologically-Motivated Computational Modeling of a Combined Rodent and Human Dataset. Toxicological Sciences 82:1, 279-296.

To put the estimated 2 in 10,000 risk in perspective, this would theoretically increase cancer incidence from a background of approximately 40% to 40.02%.

The Manchester community lies between the Clinton monitoring site and the Texas Petrochemicals/Goodyear/Mobil complex. Long-term monitoring data is not available for this community. However, the Texas Cancer Epidemiology and Surveillance (TCES) Branch of the Texas Department of State Health Services investigated the occurrence of cancer in several zip codes including 77012 (includes Manchester) and 77017 (includes Milby Park and Cesar Chavez area). Cancer cluster studies are limited by the amount and quality of available data. The TCES noted that this study was limited in its power to detect a small effect from some environmental or other type of exposure, but that a large increased risk of cancer could have been observed if it was present. Cancer incidence data from January 1, 1995–December 31, 2001 and cancer mortality data from January 1, 1993–December 31, 2002 were analyzed, and the TCES concluded that the cancer incidence and mortality data for all examined types of cancer were within normal ranges among both males and females[8]. Nevertheless, a reduction in ambient 1,3-butadiene levels is necessary because continuous lifetime exposure to the long-term 1,3-butadiene level monitored at Milby Park would represent a theoretical cancer risk that is higher than both federal limit and our acceptable risk goal.

Several air monitoring projects over the last several years have focused on characterizing ambient VOC levels, including 1,3-butadiene, in the Milby Park/Manchester/Cesar Chavez High School area. Interest in air quality in this area has been shared by local residents, local government, and legislators. Air monitoring conducted in early 2001 by the City of Houston at Cesar Chavez H.S. and Fire Station No. 29, and mobile monitoring conducted at Cesar Chavez H.S. in March 2001 by the TCEQ did not detect 1,3-butadiene levels of concern. However, mobile monitoring in April-May 2001 and in May 2002 detected 1,3-butadiene concentrations that were a potential health concern, and the health effects evaluation called for reductions. Follow-up mobile monitoring in November 2002 detected much lower butadiene concentrations than during the previous two monitoring trips. There are on-going efforts to establish a monitoring site in the Manchester neighborhood in order to better characterize ambient air quality there. The Houston Air Pilot Project that was conducted last year for the new Environmental Monitoring and Response System (EMRS) focused on highly reactive VOCs (HRVOCs) that are important in the formation of ozone. The EMRS project is focusing additional attention on 1,3-butadiene in this area. In addition to EMRS, other efforts such as the agency's HRVOC Rules, special reviews of air permit applications involving 1,3-butadiene, and

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[8]Texas Department of State Health Services, Texas Cancer Epidemiology and Surveillance Branch. *Summary of Investigation Into the Occurrence of Cancer, Zip Codes 77531 (Clute), 77541 (Freeport), 77012, 77017 (Houston), 77520 (Baytown), 77619 (Groves), 77640/77642 (Port Arthur), and 77651 (Port Neches), Brazoria, Harris, and Jefferson County Texas, 1993-2002, September 3, 2004.*

meeting with and inspections of the major 1,3-butadiene emission sources are expected to result in decreased ambient 1,3-butadiene levels.

Conclusions

- Continuous lifetime exposure to the 2003 annual average 1,3-butadiene level measured at Milby Park would be associated with a theoretical excess cancer risk of greater than 1 in 10,000. Evaluation of source direction using data from the Milby Park and Clinton monitors points toward the Texas Petrochemicals/Goodyear/Mobil industrial complex southeast of Milby Park. 1,3-Butadiene levels in the Manchester neighborhood are unknown though levels at Clinton (further downwind) are substantially lower than at Milby Park. Reductions in ambient 1,3-butadiene levels in the Milby Park area are necessary in order to meet EPA's and our target risk goals, and agency efforts such as those described above should be pursued in order to accomplish these reductions.
- Continuous lifetime exposure to the first 12-month (6/6/03 - 6/5/04) average benzene level measured at Lynchburg Ferry would be associated with a theoretical excess cancer risk of 7 in 100,000 and is of interest because it is higher than typically seen in the monitoring network. Although continuous long-term exposure would not be expected to occur at this site, these levels are noteworthy considering that this is not "fenceline" monitoring, and both industrial benzene sources and residential areas lie within 1 to 2 miles of the monitoring site. Continuing evaluation of source directionality and identification of sources is needed to determine how ambient levels in residential areas would be expected to compare with measured levels at Lynchburg Ferry. In the meantime, however, we recommend that any proposed increases in benzene emissions in this area be evaluated cautiously and that reductions be encouraged.
- Hourly levels of several VOCs (most notably, styrene at Lynchburg Ferry) exceeded their respective odor-based ESLs and could be odorous to people if they were exposed. All potentially odorous concentrations reported in 2003 would not be expected to cause direct health effects such as eye irritation. However, depending on the intensity, type, frequency and duration of the odor and the subjective experience of the affected person, an odor may cause odor-related effects such as headache and nausea.

Please contact me at 512-239-1784 or vleopold@tceq.state.tx.us if you have any questions regarding this memorandum.

Table 1. TCEQ Region 12 air monitoring sites and types of data collected.

County	AIRS Number	City, Site	Hourly AutoGC VOCs	24-hour Canister VOCs	1-hour Canister VOCs	24-hour Carbonyls	1-hour Carbonyls	24-hour Metals
Brazoria	480391003	Clute, Cobb Field	no	Yes[1,2]	no	no	no	no
	480390618	Danciger, EISM U28	Yes[1]	no	no	no	no	no
	480391016	Lake Jackson, EISM U26	Yes[1]	no	no	no	no	no
	480390619	Liverpool, Mustang Bayou, EISM U27	Yes[1]	no	no	no	no	no
Galveston	481670014	Galveston, Airport	no	Yes[1,2]	Yes[1,2]	no	no	Yes[4]
	481670005	Texas City, Ball Park	no	Yes[1,2]	no	no	no	no
	481670053	Texas City, Nessler Pool	no	Yes[1,2]	Yes[1,2]	no	no	no
	481670056	Texas City, EISM U25	Yes[1]	no	no	no	no	no
Harris	482010024	Aldine, Hambrick Jr. High School	no	Yes[1,2]	no	no	no	Yes[4]
	482010058	Baytown	no	Yes[1,2]	no	no	no	no
	482011015	Baytown, Lynchburg Ferry	no	Yes[1,2]	no	no	no	no
		Baytown, Lynchburg Ferry, EISM U23	Yes[1]	no	no	no	no	no
	482010617	Baytown, Wallisville Rd., EISM U24	Yes[1]	no	no	no	no	no
	482010026	Channelview	Yes[1]	Yes[1,2]	no	Yes[3]	Yes[3]	Yes[4]
	482010057	Galena Park	no	Yes[1,2]	no	no	no	no
	482011034	Houston East	no	no	no	no	no	Yes[7]
	482011035	Houston, Clinton Dr.	Yes[1]	Yes[1,2]	no	Yes[3]	Yes[3]	Yes[5]
	482011039	Houston, Deer Park #2	Yes[1]	Yes[1,2]	no	Yes[3]	Yes[3]	Yes[6]
	482010055	Houston, Galleria	no	Yes[1,2]	no	no	no	Yes[4]
	482010803	Houston, Haden Rd.	no	Yes[1,2]	no	no	no	no
		Houston, Haden Rd., EISM U22	Yes[1]	no	no	no	no	no
	482010069	Houston, Milby Park	no	Yes[1,2]	no	no	no	no
	482010029	Houston, Northwest Harris County	no	Yes[1,2]	Yes[1,2]	no	no	no
	482011041	La Porte, San Jacinto Monument	no	Yes[1,2]	no	no	no	no
	482010061	La Porte, Shore Acres	no	Yes[1,2]	no	no	no	no
Montgomery	483390078	Conroe, re-located	no	no	no	no	no	Yes[4]

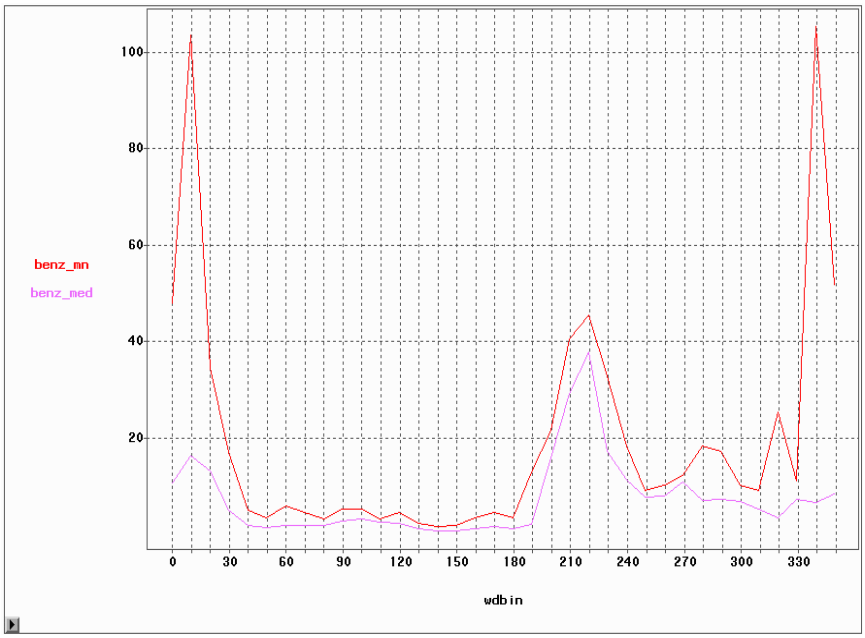
Footnotes for Table 1.

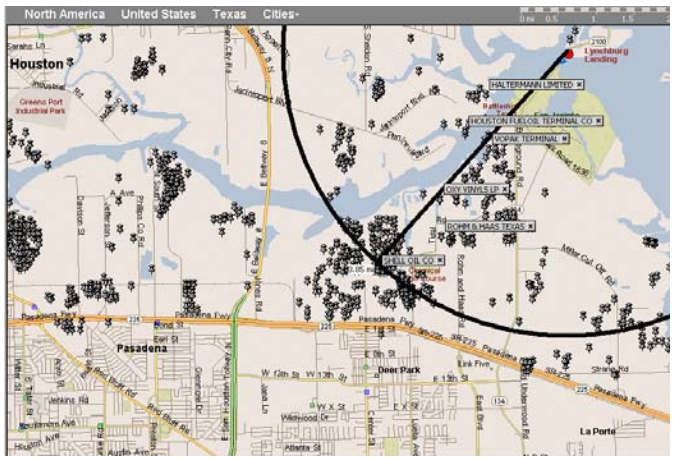
1 (autoGC & canister VOCs)		**2** (additional canister VOCs)	
1,2,3-Trimethylbenzene	Isopropylbenzene	1,1,1-Trichloroethane	Carbon Tetrachloride
1,2,4-Trimethylbenzene	Methylcyclohexane	1,1,2,2-tetrachloroethane	Chlorobenzene
1,3,5-Trimethylbenzene	Methylcyclopentane	1,1,2-Trichloroethane	Chloroform
1,3-Butadiene	Propane	1,1-Dichloroethylene	Chloroprene
1-Butene	Propylene	1,2-Dibromoethane	CIS 1,3-dichloropropylene
1-Pentene	Styrene	1,2-Dichloroethane	Cyclopentene
2,2,4-Trimethylpentane	Toluene	1,2-Dichloropropane	dichlorodifluoromethane
2,2-Dimethylbutane - Neohexane	c-2-Butene	1-Hexene+2-methyl-1-pentene	Ethyl Acetate
2,3,4-Trimethylpentane	c-2-Pentene	2-Butanone	isobutyraldehyde
2,3-Dimethylbutane	m-Diethylbenzene	2-Chloropentane	Methyl Butyl Ketone (MBK)
2,3-Dimethylpentane	m-Ethyltoluene	2-Methyl-2-Butene	methyl chloride
2,4-Dimethylpentane	n-Butane	2-methyl-3-hexanone	Methyl t-Butyl ether
2-Methylheptane	n-Decane	3-heptanone	Methylene Chloride
2-Methylhexane	n-Heptane	3-hexanone	Methylisobutylketone
2-Methylpentane - Isohexane	n-Hexane	3-Methyl-1-Butene	n-Propyl Acetate
3-Methylheptane	n-Nonane	3-pentanone	t-2-Hexene
3-Methylhexane	n-Octane	4-Methyl-1-Pentene	Tetrachloroethylene - Perchloroethylene
3-Methylpentane	n-Pentane	5-methyl-2-hexanone	trans-1-3-dichloropropylene
Acetylene	n-Propylbenzene	Bromomethane	Trichloroethylene
Benzene	n-Undecane	Butyl Acetate	Trichlorofluoromethane
Cyclohexane	o-Ethyltoluene	c-2-Hexene	Vinyl Chloride
Cyclopentane	o-Xylene		
Ethane	p-Diethylbenzene		
Ethyl Benzene	p-Ethyltoluene		
Ethylene	p-Xylene + m-Xylene		
Isobutane	t-2-Butene		
Isopentane	t-2-Pentene		
Isoprene			

3 (carbonyls)	**4** (selected metals)	**5** (selected metals)	**6** (selected metals)	**7** (selected metals)
2,5-Dimethylbenzaldehyde	Arsenic (PM2.5)	Arsenic (PM10)	Arsenic (PM2.5)	Arsenic (PM2.5)
Acetaldehyde	Cadmium (PM2.5)	Beryllium (PM10)	Cadmium (PM2.5)	Cadmium (PM2.5)
Acetone	Chromium (PM2.5)	Cadmium (PM10)	Chromium (PM2.5)	Chromium (PM2.5)
Benzaldehyde	Lead (PM2.5)	Chromium (PM10)	Lead (PM2.5)	Lead (PM2.5)
Butylaldehyde	Manganese (PM2.5)	Lead (PM10)	Manganese (PM2.5)	Manganese (PM2.5)
Crotonaldehyde - 2-Butenal	Nickel (PM2.5)	Manganese (PM10)	Nickel (PM2.5)	Nickel (PM2.5)
Formaldehyde	Mercury (PM2.5)	Nickel (PM10)	Mercury (PM2.5)	Mercury (PM2.5)
Heptaldehyde			Arsenic (PM10)	Lead (TSP)
Hexanaldehyde			Beryllium (PM10)	
Isovaleraldehyde			Cadmium (PM10)	
m-Tolualdehyde			Chromium (PM10)	
MEK/Methacrolein			Lead (PM10)	
o-Tolualdehyde			Manganese (PM10)	
p-Tolualdehyde			Nickel (PM10)	
Propanal - Propionaldehyde				
Valeraldehyde				

Figure 1. Lynchburg Ferry area.

Figure 2. Benzene at Lynchburg Ferry. Wind direction resultant versus mean and median benzene concentration. Maps showing centerline for a broad cone within which the sources are likely to lie.





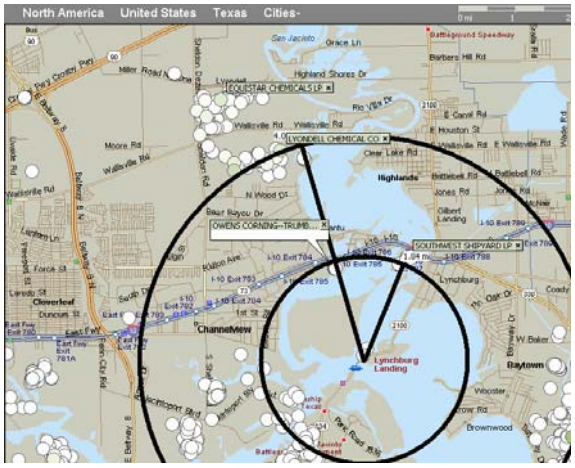


Figure 3. Annual average and highest and second highest 24-hour 1,3-butadiene levels monitored at Milby Park 1999 - 2003.

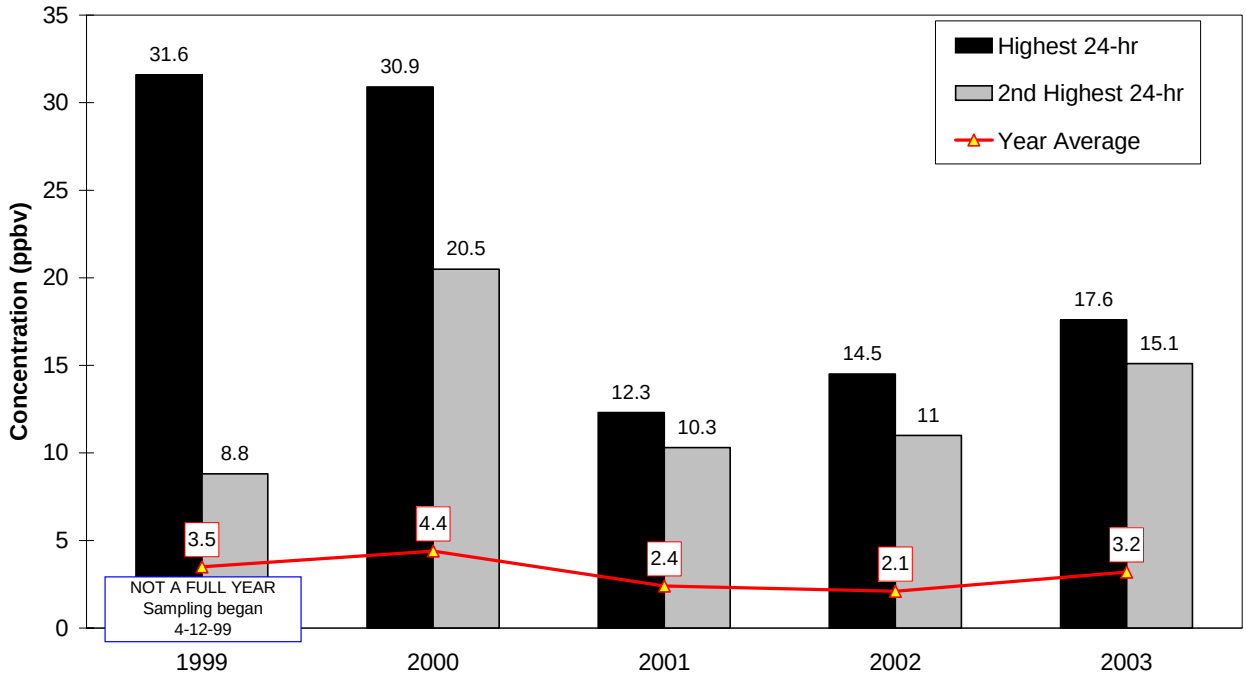


Figure 4. Annual average 1,3-butadiene levels measured at Region 12 monitoring sites in 2003.

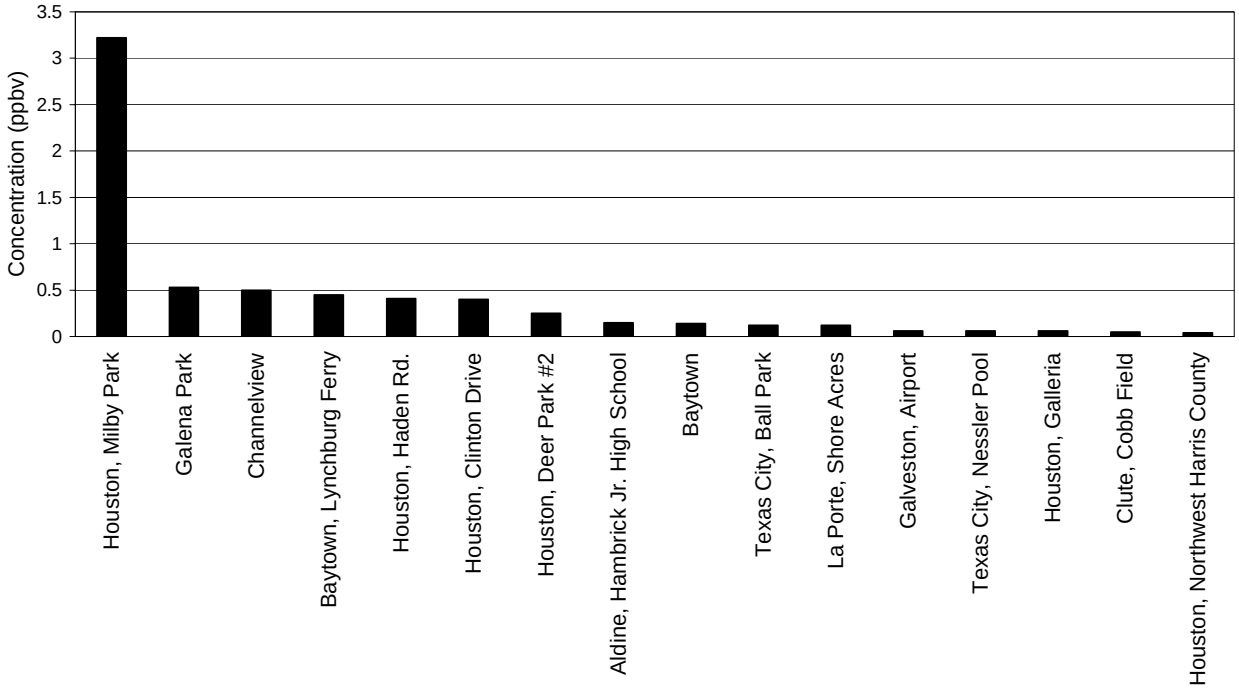
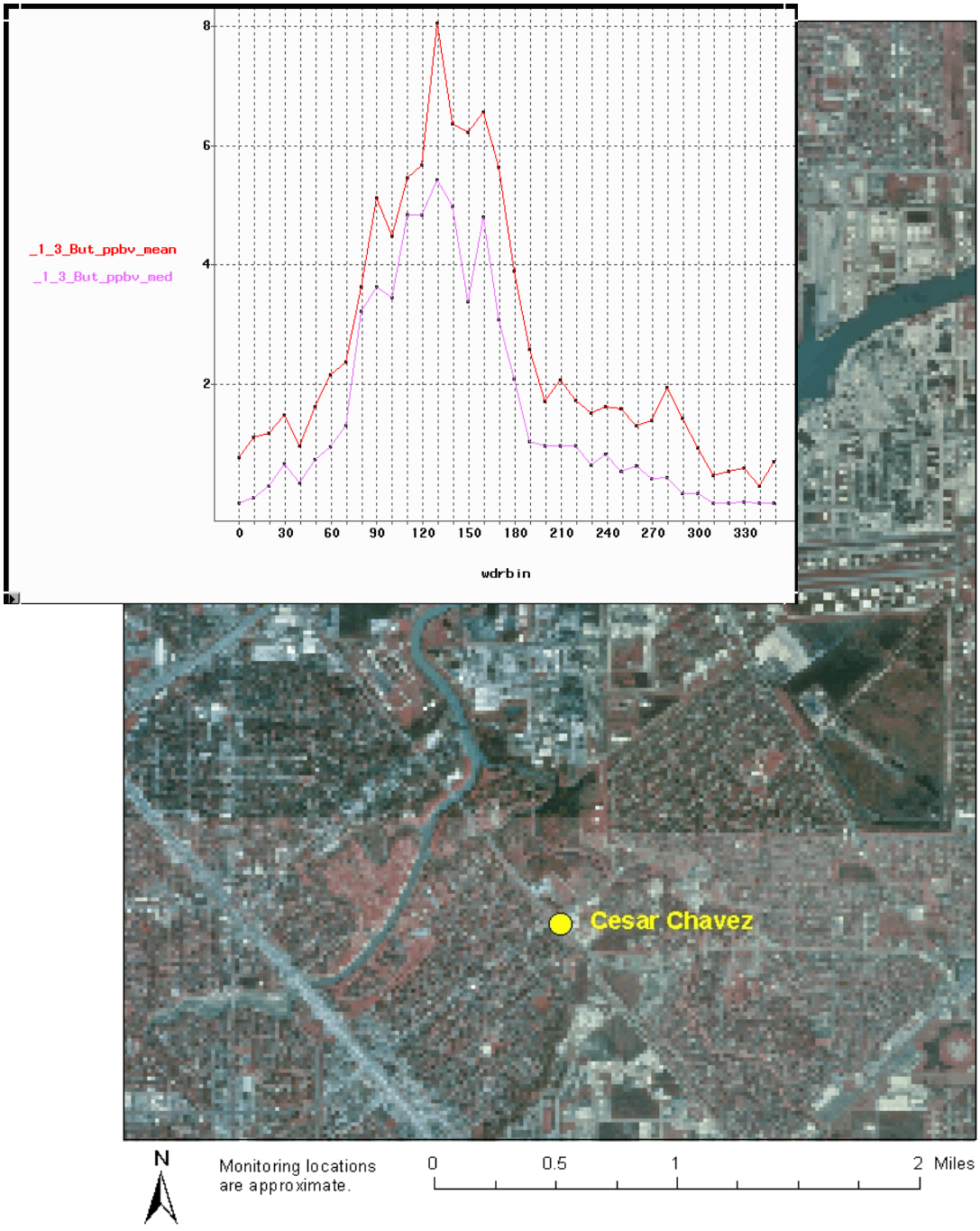
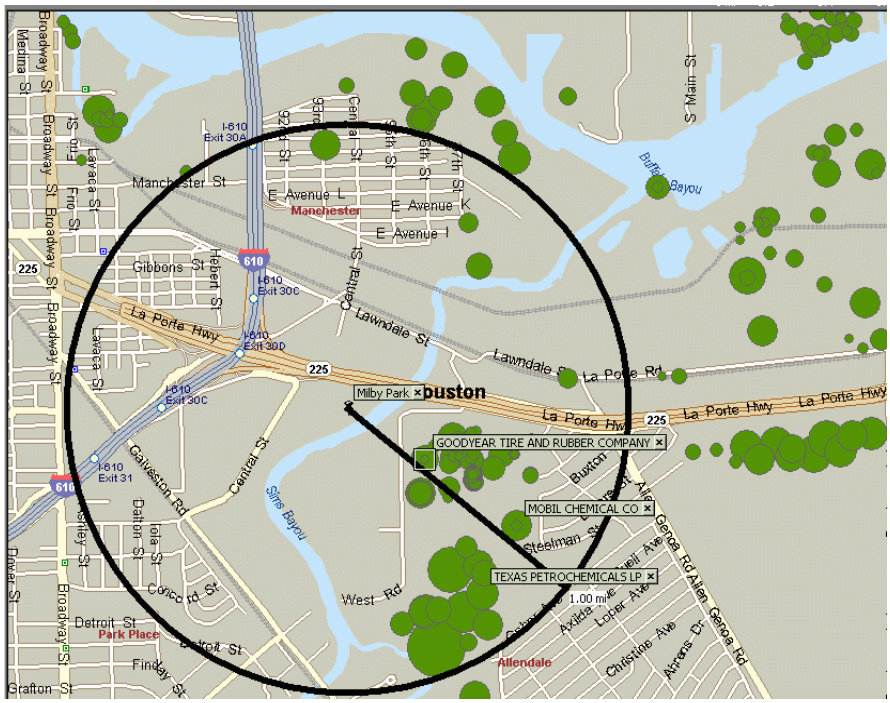


Figure 6. 1,3-Butadiene at Milby Park, Wind direction resultant versus mean and median 1,3-butadiene concentrations. Map showing centerline for a broad cone within which the sources are likely to lie.

Figure 5. Milby Park, Clinton, Cesar Chavez High School, and Manchester area.

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Manchester St
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Manchester
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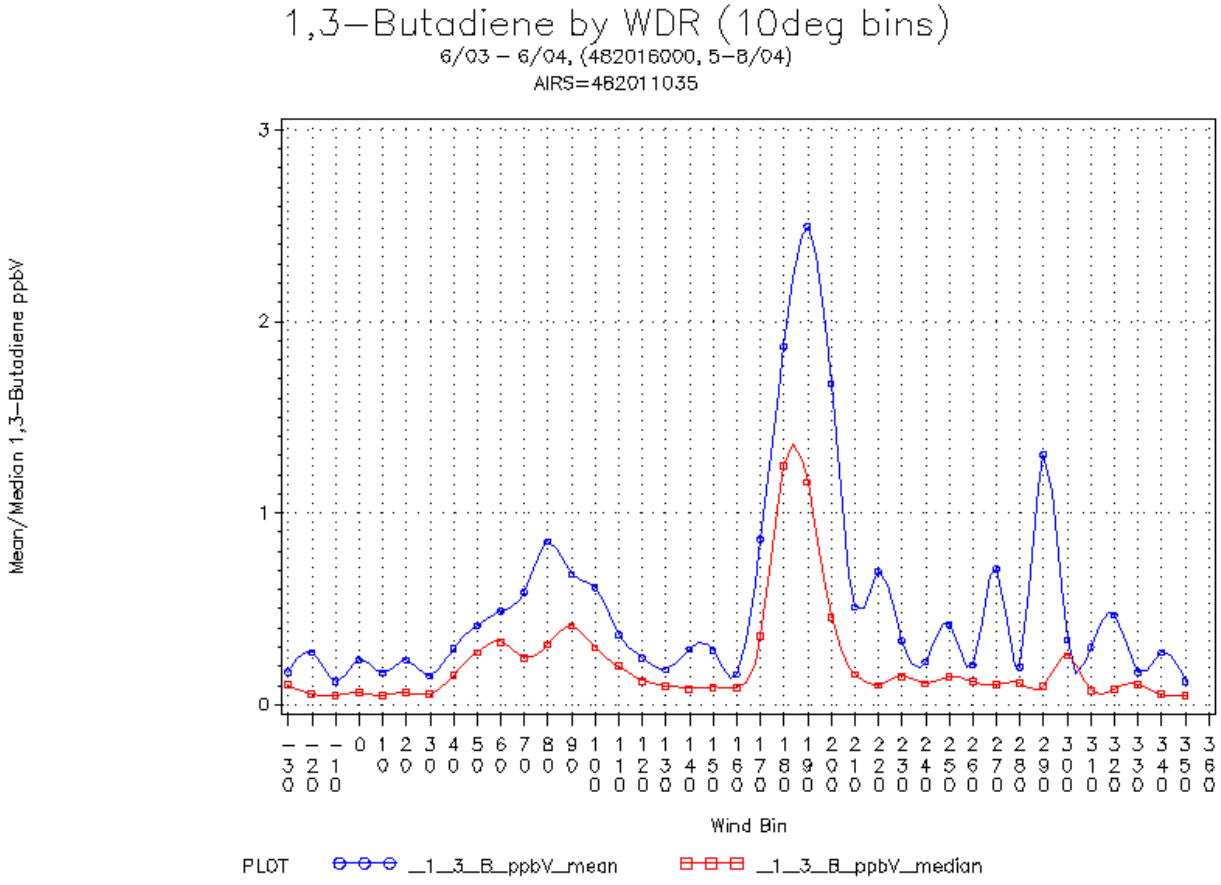
E Avenue I
S Main St
Buffalo Bayou
Gibbons St
Heiner St
610
I-610 Exit 30C
Central St
La Porte Hwy
I-610 Exit 30D
Lawndale St
225
La Porte Rd
Milby Park
buston
GOODYEAR TIRE AND RUBBER COMPANY
MOBIL CHEMICAL CO
TEXAS PETROCHEMICALS LP
1.00 mile
I-610 Exit 31
Galveston Rd
Sims Bayou
Steelman St
Genoa Rd
Allen Genoa Rd
West Rd
Detroit St
Park Place
Findlay St
Grafton St
Allendale
Christine Ave
Airdis Dr

Figure 7. 1,3-Butadiene concentrations at the TCEQ Clinton autoGC monitor. Wind direction resultant versus mean and median 1,3-butadiene concentrations.



CC: board
monitoring file

CC (via email):
Brymer, David
Eden, Dan
Henneke, Jody
Porter, Tom
Leidig, Mark
Rodriguez, Anna Maria
Ruggeri, Dom
Seal, Derek
Sidnell, Jennifer
Spaw, Steve
Steib, John
Sullivan, Dave
Toxicology Section
Wadick, Ashley K.
Wade, Brent

Arturo Blanco, City of Houston
Bob Allen, Harris County Pollution Control
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