Statistical Assessment of 2008 annual ambient benzene in the ambient air in the Houston Region (10 and 5 year annual trends, ending in 2008)

The City of Houston conducted a comprehensive investigation of the annual trends of benzene in the ambient air in Houston and vicinity for data collected through 2007[1] and updated the five year trend analysis with data collected during 2008. The update, presented in this document, includes analysis of the annual 2008 and 5 year trends of ambient levels of benzene concentrations conducted on seven statistical measures of benzene at 11 monitoring sites in the Houston vicinity.

The evaluation of the annual benzene data for 2008 indicates that the Lynchburg Ferry and Channelview sites continue to be ranked as "most contaminated" for seven benzene measures, while the Lake Jackson and Danciger sites remain least contaminated. Trend analysis indicated 37% of the statistical measures showed improvement in the five years ending in 2008, up from 27% of the statistical measures showing improvement in the five year period ending in 2007. Four of the 11 monitoring sites evaluated showed no improvement in any statistic for the 5 year trends.

The 2008 1-hr auto gc ambient benzene data were evaluated. Summary statistics of the data are shown in Table 1. Relative ranking and average rank of the monitors in terms of seven summary statistics of 2008 benzene concentrations are shown in Table 2. Table 3 provides a comparison of the benzene monitor ranking between 2007 and 2008. Comparison between the years indicates the monitors remain clustered in four groups in 2007 and in 2008:
1. Highest Concentration Group: Lynchburg and Channelveiw (ranks of 11)
2. Intermediate Concentration Group: Clinton, HRM-3, Cesar Chavez and Deer Park 2 (ranks of 7 to 8)
3. Lower Intermediate Concentration Group: Mustang Bayou, Milby (ranks of 6)
4. Lowest Concentration Group: Danciger, Texas City 34th, Lake Jackson and Wallisville.

The most recent ten and five year trends of the summary statistics were evaluated using the Mann Kendall test (a=0.05).   The number of summary statistics indicating improving trends in benzene at each monitor were compared with the previous year ten and five year trends (ending 2007).

Summary tables and figures:

Table1: Summary statistics of 2008 ambient benzene from Houston regional 1-hr auto GC monitors

Monitor Location		mean	median	95th upper confidence limit of mean	maximum	percent of year below 10^{-6} (0.04 ppb)	percent of year above 10^{-5} (0.4 ppb)	percent of year above 10^{-4} (4 ppb)	median of upper tail
HRM-3	Site_22_	0.40	0.24	0.41	14.60	3.21	31.30	0.23	0.66
Lynchburg	Site_23_	1.10	0.28	1.31	777.09	2.41	38.37	4.58	0.93
Wallisville	Site_24_	0.24	0.14	0.25	9.85	9.84	14.24	0.10	0.64
Tex City 34th	Site_25_	0.20	0.12	0.21	8.43	26.64	13.45	0.06	0.58
Lake Jackson	Site_26_	0.14	0.09	0.15	32.81	22.37	5.35	0.01	0.55
Mustang Bayou	Site_27_	0.30	0.13	0.32	12.42	16.04	16.51	0.65	0.76
Danciger	Site_28_	0.13	0.10	0.13	7.53	15.54	2.79	0.02	0.55
Clinton	Site_A_	0.40	0.25	0.41	8.15	1.02	27.92	0.20	0.69
Deer Park 2	Site_H_	0.39	0.19	0.40	20.55	5.17	24.09	0.66	0.75
Milby Park	Site_K_	0.30	0.17	0.31	14.83	4.40	19.47	0.16	0.68
Channelview	Site_R_	0.63	0.35	0.65	94.04	0.14	44.12	1.19	0.75
Cesar Chavez	Site_V_	0.43	0.25	0.45	7.73	1.40	30.21	0.27	0.74

concentration in ppbV

Monitor Location		standard deviation	number of data points	frequency of detect out of total	coefficient of variation	median of lower tail	minimum	count of data reported as "0" ppb
HRM-3	Site_22_	0.51	7111	0.81	1.29	0.00	0.00	149
Lynchburg	Site_23_	10.21	6773	0.77	9.26	0.00	0.00	130
Wallisville	Site_24_	0.38	7367	0.84	1.57	0.00	0.00	391
Tex City 34th	Site_25_	0.31	7165	0.82	1.50	0.00	0.00	1635
Lake Jackson	Site_26_	0.42	7255	0.83	3.00	0.00	0.00	1373
Mustang Bayou	Site_27_	0.63	7106	0.81	2.09	0.00	0.00	769
Danciger	Site_28_	0.16	6481	0.74	1.27	0.02	0.00	286
Clinton	Site_A_	0.49	6153	0.70	1.21	0.02	0.00	22
Deer Park 2	Site_H_	0.71	7093	0.81	1.82	0.02	0.00	140
Milby Park	Site_K_	0.46	6342	0.72	1.53	0.02	0.00	65
Channelview	Site_R_	1.43	7237	0.82	2.28	0.00	0.00	9
Cesar Chavez	Site_V_	0.56	7151	0.81	1.29	0.00	0.00	89

concentration in ppbV

Table 2: Relative rank and average rank of Houston regional monitors in terms of 2008 ambient benzene and 7 summary statistics

2008 Benzene	mean at 95% UCL		max		median		median of upper tail		% of year above 10^{-4} (4.0 ppb)		% of year above 10^{-5} (0.4 ppb)		% of year below 10^{-6} (0.04 ppb)		average rank
	ppb	rank	ppb	rank	ppb	rank	ppb	rank	%	rank	%	rank	%	rank	
HRM-3	0.41	8	14.60	7	0.29	9	0.66	5	0.23	7	31.30	10	3.21	8	7.7
Lynchburg	1.31	12	777.09	12	0.31	10	0.93	12	4.58	12	38.37	11	2.41	9	11.1
Wallisville	0.25	4	9.85	5	0.15	4	0.64	4	0.10	4	14.24	4	9.84	5	4.3
Tx City 34th	0.21	3	8.43	4	0.15	4	0.58	3	0.06	3	13.45	3	26.64	1	3.0
Lake Jackson	0.15	2	32.81	10	0.1	2	0.55	1	0.01	1	5.35	2	22.37	2	2.9
Mustang Bayou	0.32	6	12.42	6	0.13	3	0.76	11	0.65	9	16.51	5	16.04	3	6.1
Danciger	0.13	1	7.53	1	0.09	1	0.55	1	0.02	2	2.79	1	15.54	4	1.6
Clinton	0.41	9	8.15	3	0.31	10	0.69	7	0.20	6	27.92	8	1.02	11	7.7
Deer Park 2	0.40	7	20.55	9	0.22	7	0.75	9	0.66	10	24.09	7	5.17	6	7.9
Milby	0.31	5	14.83	8	0.2	6	0.68	6	0.16	5	19.47	6	4.40	7	6.1
Channelview	0.65	11	94.04	11	0.37	12	0.75	9	1.19	11	44.12	12	0.14	12	11.1
Cesar Chavez	0.45	10	7.73	2	0.28	8	0.74	8	0.27	8	30.21	9	1.40	10	7.9

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

Table 3: Comparison of relative rank of Houston regional monitors in terms of 2008 ambient benzene and 7 summary statistics during 2007 and 2008

Rank Order of Monitor Locations with Highest Benzene

Rank	2007	2008
1	Lynchburg	Lynchburg
2	Channelview	Channelview
3	Clinton	Deer Park 2
4	HRM-3	Cesar Chavez
5	Cesar Chavez	HRM-3
6	Deer Park 2	Clinton
7	Milby	Mustang Bayou
8	Mustang Bayou	Milby
9	Tx City 34th	Wallisville
10	Wallisville	Tx City 34th
11	Lake Jackson	Lake Jackson
12	Danciger	Danciger

ordering based on average rank of 7 statistical indicators

Table 4: Five year trend test results for ambient benzene for 8 summary statistics (2004-2008)

Mann Kendall Trend Test Results: 5 Years of Data 2004-2008

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)	2004-2008
HRM-3	Improving	No change	Improving	Improving	Improving	Improving	Improving	No change	6
Lynchburg	Improving	No change	No change	No change	No change	No change	No change	Improving	2
Wallisville	No change	No change	No change	No change	No change	No change	No change	No change	0
Tx City 34th	Improving	Improving	Improving	Improving	Improving	Improving	Improving	Improving	8
Lake Jackson	No change	No change	No change	No change	No change	No change	No change	No change	0
Mustang Bayou	Improving	No change	Improving	Improving	Improving	No change	Improving	Improving	6
Danciger	No change	No change	No change	No change	No change	No change	Improving	No change	1
Clinton	Improving	No change	Improving	Improving	Improving	Improving	Improving	No change	6
Deer Park 2	No change	No change	No change	No change	No change	No change	No change	No change	0
Milby									0
Channelview	No change	No change	No change	No change	No change	No change	No change	No change	0
Cesar Chavez	Improving	No change	Improving	Improving	No change	Improving	Improving		5
total	5	1	4	4	4	3	5	3	

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

Table 5: Ten year trend test results for ambient benzene for 8 summary statistics (1998-2007 and 1999-2008)

Mann Kendall Trend Test Results: Ten Years of Data 1998-2007 and 1999-2008

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)
1998-2007								
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
1999-2008								
Clinton	Improving	Improving	Improving	Improving	Improving	Improving	Improving	No change
Deer Park 2	Improving	No change	Improving	Improving	No change	No change	Improving	Improving

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

Table 6: Comparison of improvement detected between the two ten and five year periods

Benzene

2008 Relative Rank Order of Most Contaminated 2008	10 yr Trend 1998 to 2007	10 yr Trend 1999 to 2008	Improvement detected between the two ten year periods?	5 yr Trend 2003 to 2007	5 yr Trend 2004 to 2008	Improvement detected between the two five year periods?
Lynchburg				0/7	2/7	improvement
Channelview				0/7	0/7	no change
Deer Park 2	4/7	4/7	no change	0/7	0/7	no change
Cesar Chavez					4/7	
HRM-3				5/7	5/7	no change
Clinton	5/7	6/7	improvement	2/7	5/7	improvement
Mustang Bayou				4/7	5/7	improvement
Milby						
Wallisville				0/7	0/7	no change
Tx City 34th				6/7	7/7	improvement
Lake Jackson				0/7	0/7	no change
Danciger				2/7	1/7	decrease

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

Figure 1: Comparison of percent of statistics showing improving benzene trends at monitors from 2003-2007 and 2004-2008.
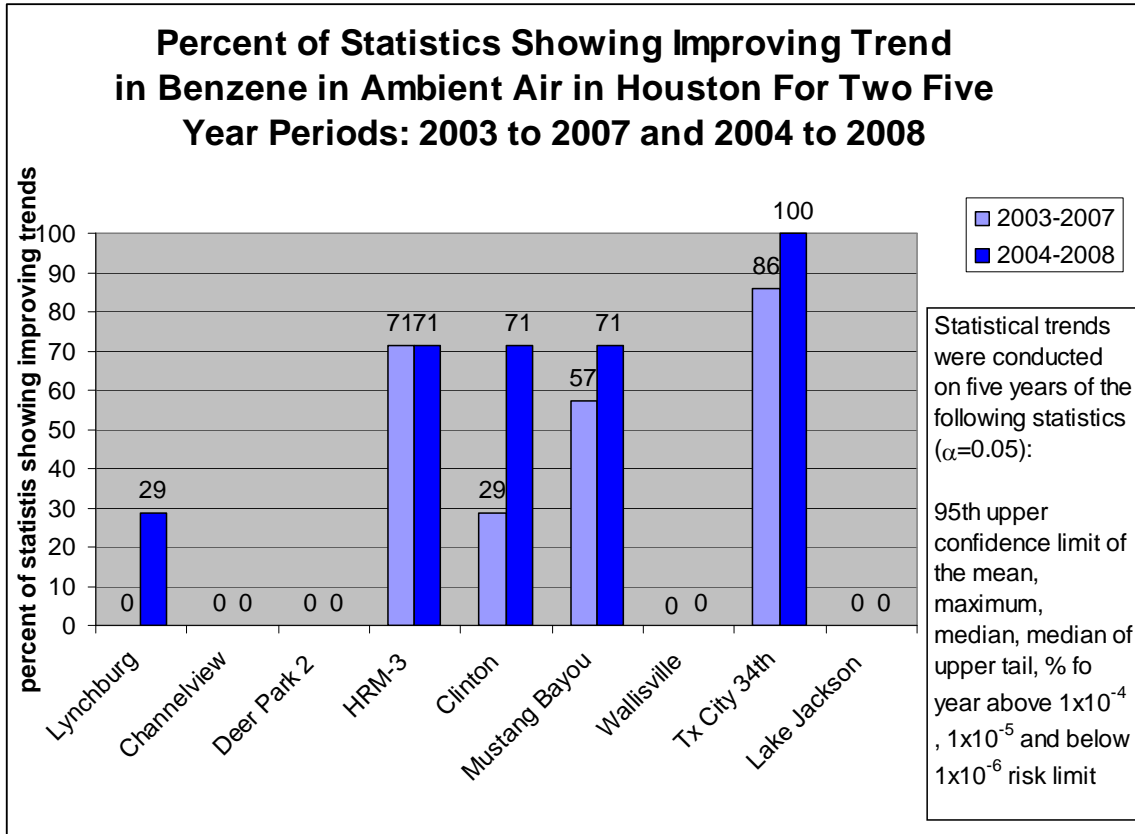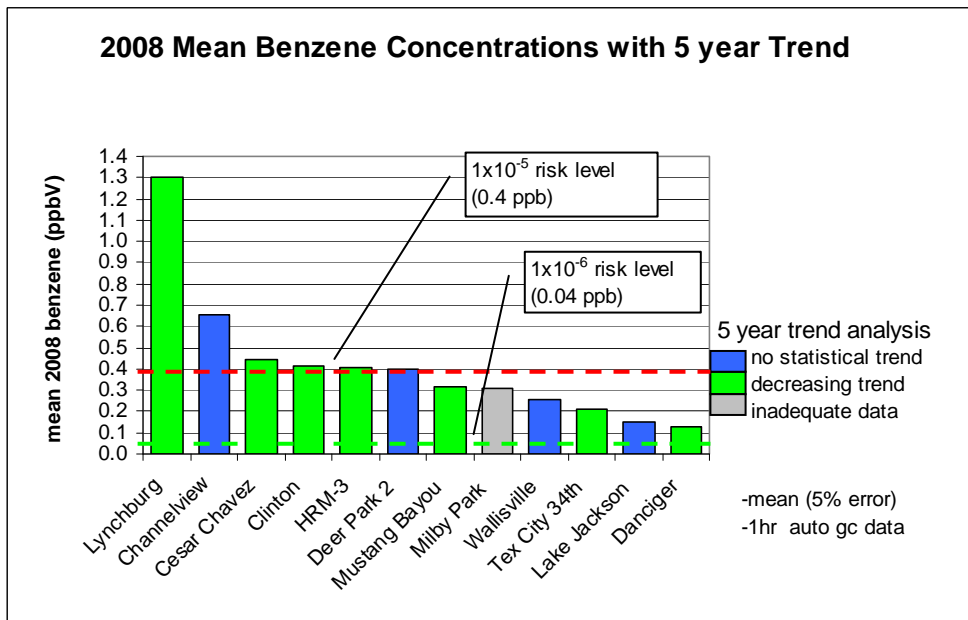

Figure 2: 2008 Mean Benzene Concentrations with 5 year trend (2004-2008)

References:

Mayor's Office of Environmental Programming. Statistical Assessment of Benzene and 1,3 Butadiene in Ambient Air in the Houston Region. 2008. Available at: http://www.greenhoustontx.gov/reports/benzeneandbutadiene.pdf. Last accessed November 21, 2008.