Air Quality Along the Texas Gulf Coast

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Abstract

There are several urban and industrial regions along the Texas Gulf Coast that house some of the largest ports in the US, numerous refineries, thousands of chemical/petrochemical facilities and manufacturing plants. Given its dense population and industrial activity, monitoring and regulation of air quality in these regions is critical for protection of human health. The TCEQ has developed the largest ambient air monitoring network in the US to measure cumulative emissions in the area. In the coastal regions alone, there are more than 49 active fixed-site air monitors (2 Carbonyl, 17 AutoGCs and 30 canisters), some of which have been operational for 20 years. Acrolein, benzene, 1,3-butadiene , and formaldehyde are considered air toxics of greatest concern. To evaluate risks associated with these air toxics, we collected site-specific concentrations of these four chemicals and evaluated them from both an acute and chronic health perspective by comparing them to TCEQ health-protective values called ambient air monitoring comparison values (AMCVs). We calculated average annual concentrations measured byl-h AutoGC or 24-h canister and Dintrophenyl hadrazine (DNPH) cartridges and found that concentrations of these air toxics have steadily declined. Using long-term average concentrations of these air toxics, we calculated long-term risks to be within our acceptable risk goal (< 1 E-5) or a hazard quotient (<1) for the majority of monitoring sites. The long-term average benzene concentration at Lynchburg Ferry and Huisache monitors reached concentrations that resulted in risk (1.8 and 1.1 E-5, respectively) slightly above our risk goal. To better understand dynamics of air toxics at sites with a history of exceeding the long-term AMCV, we used 1-h AutoGC data to characterize ambient conditions contributing to exceedances. We found exceedances of the respective acute AMCVs to be rare. Instead, a few (<30%) hourly concentrations influenced the average concentration thereby causing long-term exceedances. The decline in air toxics concentrations due to improved monitoring and regulations has now resulted in air toxics at acceptable levels at all monitors in the coastal region.

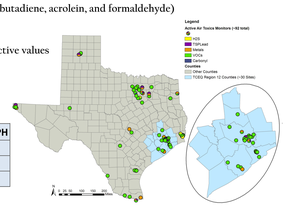
Introduction

The Texas Gulf Coast is home to a large number of industries such as chemical plants and refineries. Many of these industrial facilities are located in close proximity to neighborhoods, schools and other non-industrial entities. The TCEQ has sited (Figure 1)a large number of ambient air monitors in communities that are in near heavy industry to evaluate impacts of industrial activities on public health. This project is aimed at characterizing the risk associated with a variety of industrial chemicals within this region through the following procedure:

1. Evaluate concentrations of risk driving chemicals (benzene, 1, 3-butadiene, acrolein, and formaldehyde)
2. Determine trends in these air toxics
3. Characterize conditions that give rise to exceeding health protective values
4. Calculate long-term risk in a monitor-specific fashion

Table 1. Fixed Site Monitors in Texas Gulf Coast

TCEQ Region	City	24-h Canister	Auto-GC	24-h DNPH
10	Beaumont	8	1	—
12	Houston	14	14	2
14	Corpus Christi	3	3	—



Beaumont TCEQ Region 10 Air Toxics Trends

Beaumont is the location for several heavily industrial areas, particularly along the Sabine-Neches ship channel. Industries include refineries, chemical companies, and barges traveling along the ship channel. Monitors are placed near areas where there is concern that people might be exposed to air toxics emitted from these industries.

Table 2. Air Toxics Trends in TCEQ Region 10

Benzene										
Site Name	AQS #	Type	Number	Mean	Std. Dev.	Max.	Min.	Duration at Site	Risk or HQ
Beaumont Downtown	482450009	C	1110	0.60	0.43	7.31	0	20 Years	4.2E-06
Beaumont Downtown	482450009	A	46810	0.35	0.61	34.55	0	33 Years	2.47E-06
Beaumont Mary	482451050	C	103	0.43	0.33	2.15	0.13	3 Years	3.2E-06
Carroll St. Park	482450020	C	567	1.0	1.48	19.45	0.10	11 Years	6.5E-06
City Service Center-PA	482450019	C	820	1.15	1.61	21.92	0.1	16 Years	8.2E-06
Groves	482450014	C	987	0.85	1.25	28.6	0	20 Years	6.3E-06
Jefferson Co. Airport	482450018	C	362	0.50	0.69	8.44	0.07	7 Years	3.5E-06
Jefferson Co. Airport-1	482450018	A	2068	0.45	1.12	40.03	0	19 Years	3.1E-06
Jefferson Co. Airport-2	482450018	A	9262	0.36	0.48	22.3	0	1 Year	2.62E-06
Nederland HS C1035	482451035	A	48223	0.32	0.64	49.77	0	7 Years	2.26E-06
Port Arthur West	482450011	C	1892	0.64	0.7	14.4	0	14 Years	4.8E-06
Port Neches Ave. L	482450017	C	949	0.41	0.26	2.43	0	18 Years	2.9E-06
West Orange	483611001	C	613	0.48	0.47	8.78	0	13 Years	3.5E-06
1,3-Butadiene									
Beaumont Downtown	482450009	C	7552	0.11	0.08	89.78	0	20 Years	1.21E-07
Beaumont Downtown	482450009	A	47478	0.11	0.38	18.64	0	33 Years	7.64E-07
Beaumont Mary	482451050	C	880	0.12	0.06	1.18	0	3 Years	1.33E-07
Carroll St. Park	482450020	C	5806	0.35	0.33	10.34	0	11 Years	3.88E-07
City Service Center-PA	482450019	C	6605	0.26	0.18	9.25	0	16 Years	2.86E-07
Groves	482450014	C	7499	0.48	0.92	27.75	0	20 Years	5.27E-07
Jefferson Co. Airport	482450018	C	2898	0.17	0.16	2.53	0	7 Years	1.89E-07
Jefferson Co. Airport-1	482450018	A	9328	0.19	0.63	10.02	0	19 Years	1.37E-06
Nederland HS C1035	482451035	A	46908	0.20	0.9	37.23	0	7 Years	1.4E-06
Port Arthur West	482450011	C	7551	0.1	0.06	89.78	0	14 Years	1.06E-07
Port Neches Ave. L	482450017	C	7346	2.38	2.52	52.27	0	18 Years	2.63E-06
West Orange	483611001	C	4469	0.38	0.26	9.06	0	13 Years	4.24E-07

* C = Canister sampler; A = automatic gas chromatograph; D = Dinitrophenyl hydrazine (DNPH) cartridges

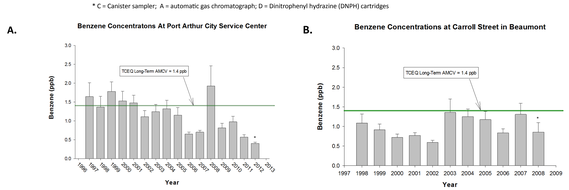
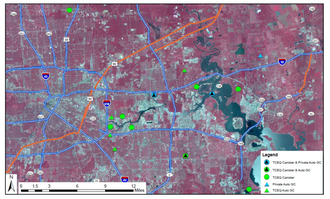


Figure 1. A) Port Arthur City Service Center monitor is located to the north of a large industrial park. Benzene levels have decreased at this site, but it still remains an area of interest due to its proximity to a local residences. **B)** The Carroll Street monitor is also stationed between industry and local community. This site is considered much improved in terms of benzene concentrations and the monitor was subsequently moved to another location. The asterisk indicates an incomplete year of data (*).

Houston TCEQ Region 12 Air Toxics Trends



Houston is the location for several heavily industrial areas, particularly along the Houston ship channel, which can be seen as a central figure in the map to the left. Industries include refineries, chemical companies, and barges traveling along the ship channel. Monitors are placed near areas where there is concern that people might be exposed to air toxics emitted from these industries. Importantly, in Houston, there are no zoning laws and sometimes communities are located in close proximity to industrial facilities.

Table 3. Air Toxics Trends in TCEQ Region 12

Benzene										
Site Name	AQS #	Type	Number	Mean	Std. Dev.	Max.	Min.	Duration at Site	Risk or HQ
Aldine	482010024	C	930	0.54	0.35	2.75	0.1	18 Years	3.8E-06
Aldine C8	482010024	A	5216	0.49	0.51	5.1	0	1 Year	3.5E-06
Allendale Subdivision	482010064	C	303	1.01	1.01	8.41	0	7 Years	6.9E-06
Bayland Park	482010055	C	788	0.38	0.32	5.83	0.04	15 Years	2.7E-06
Baytown	482010058	C	790	0.54	0.36	4.98	0.09	15 Years	3.8E-06
Cesar Chavez	482016000	A	64908	0.42	0.62	32.2	0	8 Years	2.9E-06
Channelview	482010026	C	654	0.95	0.71	7.71	0	15 Years	6.7E-06
Channelview North	482010030	C	77	0.53	0.26	1.65	0.13	3 Years	4.0E-06
Channelview C15	482010026	A	74317	0.63	1.33	133.48	0	33 Years	4.4E-06
Clinton	482011035	C	729	1.01	1.03	11.5	0	15 Years	7.3E-06
Clinton	482011035	A	100747	0.55	1.13	113.68	0	41 Years	3.9E-06
Clute	483891003	C	1062	0.39	0.39	5.53	0	21 Years	2.8E-06
Conroe Relocated	483390078	C	292	0.25	0.12	0.89	0.08	6 Years	1.7E-06
Dancinger	480390618	A	68357	0.14	0.17	11.89	0	10 Years	9.7E-07
Deer Park-2	482011039	C	1241	0.55	0.47	4.31	0.08	17 Years	3.9E-06
Deer Park-2	482011039	A	104612	0.49	0.90	41.8	0	15 Years	3.5E-06
Galena Park	482010057	C	797	1.44	1.35	12.51	0.16	16 Years	**1.0E-05**
Galleria (Bayland)	482010055	A	13912	0.38	0.48	7.65	0	3 Years	2.7E-06
Galveston 99th St.	481671034	C	298	0.17	0.1	0.65	0.03	6 Years	1.2E-06
Galveston Airport	481670014	C	589	0.27	0.53	12.08	0	12 Years	1.9E-06
HRM 7 W. Baytown	482010807	A	1159	0.56	0.46	4.47	0	2 Years	3.9E-06
HRM 3 Haden Rd.	482010803	C	1106	0.97	2.39	63.63	0	21 Years	6.8E-06
HRM 3 Haden Rd. #2	482010803	A	1370	1.18	1.09	13.64	0	21 Years	8.3E-06
HRM 3 Haden Rd. #3	482010803	A	73617	0.47	1.66	296.58	0	21 Years	3.3E-06
Jacinto Port	482010036	C	327	1.11	1.37	20.19	0.18	7 Years	8.0E-06
Lake Jackson	480391016	A	68163	0.14	0.24	32.81	0	10 Years	9.6E-07
Lynchburg Ferry	482011015	C	481	2.58	12.11	193	0.09	12 Years	**1.7E-05**
Lynchburg Ferry	482011015	A	67614	1.63	12.76	1551.92	0	10 Years	**1.1E-05**
Manchester/Central	482010307	C	397	0.63	0.55	4.85	0.13	8 Years	4.4E-06
Milby Park	482010069	C	285	0.7	0.93	12.48	0.13	7 Years	5.0E-06
Milby Park	482010069	A	57104	0.32	0.54	25.59	0	14 Years	2.2E-06
Mustang Bayou	480390619	A	48161	0.33	0.62	28.45	0	10 Years	2.4E-06
Nessler Pool	481670053	C	660	0.84	0.97	18.21	0	16 Years	6.0E-06
NW Harris County	482010029	C	782	0.43	0.32	2	0.05	15 Years	3.0E-06
Pasadena North	482011049	C	236	0.82	1.02	8.2	0.09	5 Years	5.6E-06
San Jacinto Monument	482011041	C	110	1.35	1.51	10.35	0.13	4 Years	7.3E-06
Shore Acres	482010061	C	807	0.9	1.83	41.03	0	15 Years	6.2E-06
TX City Ball Park	481670005	C	771	0.88	0.96	10.27	0.12	16 Years	6.2E-06
TX City Ball Park 34th St.	481670056	A	71078	0.49	2.97	179.24	0	10 Years	3.4E-06
Wallisville Rd.	482010617	A	69272	0.25	0.39	21.76	0	10 Years	1.7E-06
Formaldehyde									
Bayland Park	482010055	D	43	3.20	1.62	7.37	0.03	1 Year	0.36
Channelview C15	482010026	D	402	2.69	1.83	19.84	0.15	8 Years	0.30
Clinton	482011035	D	2938	4.15	3.87	41.99	0	16 Years	0.46
Deer Park-2	482011039	D	935	3.37	3.37	43.47	0.03	13 Years	0.38

1,3-Butadiene									
Site Name	AQS #	Type	Number	Mean	Std. Dev.	Max.	Min.	Duration at Site	Risk or HQ
Aldine	482010024	C	946	0.12	0.09	3.24	0	18 Years	1.38E-07
Aldine C8	482010024	A	5215	0.168	0.26	4.96	0	1 Year	1.18E-06
Allendale Subdivision	482010064	C	307	1.23	1.10	32.87	0	7 Years	1.37E-06
Bayland Park	482010055	C	800	0.06	0.06	1.94	0	15 Years	7.10E-08
Baytown	482010058	C	805	0.14	0.11	4.95	0	15 Years	1.60E-07
Cesar Chavez	482016000	A	64732	0.25	0.94	87.89	0	8 Years	1.78E-06
Channelview	482010026	C	682	0.1	0.26	6.15	0	15 Years	4.47E-07
Channelview North	482010030	C	77	0.20	0.15	1.82	0	3 Years	2.23E-07
Channelview C15	482010026	A	69375	0.34	1.38	79.26	0	33 Years	2.4E-06
Clinton	482011035	C	739	0.48	0.34	10.76	0	15 Years	5.35E-07
Clinton	482011035	A	96172	0.4	1.79	116.92	0	41 Years	2.78E-06
Clute	483891003	C	1064	0.10	0.16	11.51	0	21 Years	1.11E-07
Conroe Relocated	483390078	C	307	0.02	0.01	0.2	0	6 Years	2.42E-08
Dancinger	480390618	A	68999	0.03	0.08	8.57	0	10 Years	2.12E-07
Deer Park-2	482011039	C	899	0.16	0.14	7.03	0	17 Years	1.78E-07
Deer Park-2	482011039	A	97710	0.18	0.98	203.4	0	15 Years	1.28E-06
Galena Park	482010057	C	801	0.35	0.23	7.63	0	16 Years	3.88E-07
Galleria (Bayland)	482010055	A	13762	0.13	0.26	7.38	0	3 Years	9.28E-07
Galveston 99th St.	481671034	C	312	0.03	0.05	1.12	0	6 Years	3.50E-08
Galveston Airport	481670014	C	589	0.05	0.07	5.54	0	12 Years	5.26E-08
HRM 7 W. Baytown	482010807	A	852	4.142	9.2	87.58	0	2 Years	2.91E-05
HRM 3 Haden Rd.	482010803	C	1099	0.32	0.27	15.41	0	21 Years	3.52E-07
HRM 3 Haden Rd. #2	482010803	A	1410	0.487	1.03	16.31	0	21 Years	3.42E-06
HRM 3 Haden Rd. #3	482010803	A	70364	0.228	0.93	89.29	0	21 Years	1.6E-06
Jacinto Port	482010036	C	342	0.13	0.06	1.03	0	7 Years	1.46E-07
Lake Jackson	480391016	A	68853	0.04	0.09	4.54	0	10 Years	2.61E-07
Lynchburg Ferry	482011015	C	494	0.15	0.11	3.94	0	12 Years	1.71E-07
Lynchburg Ferry	482011015	A	67732	0.22	1.00	121.87	0	10 Years	1.53E-06
Manchester/Central	482010307	C	411	0.23	0.13	12.06	0	8 Years	2.55E-07
Milby Park	482010069	C	285	2.76	1.65	37.42	0	7 Years	3.05E-06
Milby Park	482010069	A	57802	0.85	8.2	1611.25	0	14 Years	5.96E-06
Mustang Bayou	480390619	A	47824	0.08	0.63	61.93	0	10 Years	5.6E-07
Nessler Pool	481670053	C	652	0.19	0.37	34.98	0	16 Years	2.13E-07
NW Harris County	482010029	C	798	0.03	0.02	2.83	0	15 Years	2.81E-08
Pasadena North	482011049	C	236	0.10	0.06	1.6	0	5 Years	1.1E-07
San Jacinto Monument	482011041	C	110	0.30	0.16	9.57	0	4 Years	3.30E-07
Shore Acres	482010061	C	823	0.12	0.14	6.8	0	15 Years	1.29E-07
TX City Ball Park	481670005	C	787	0.11	0.18	13.58	0	16 Years	1.19E-07
TX City Ball Park 34th St.	481670056	A	70894	0.06	0.50	49.01	0	10 Years	4.37E-07
Wallisville Rd.	482010617	A	69478	0.09	0.32	27.5	0	10 Years	5.98E-07
Acrolein									
Channelview C15	482010026	D	302	0.06	0.05	0.30	0	5 Years	0.29
Clinton	482011035	D	1223	0.07	0.05	0.34	0	8 Years	0.30
Deer Park-2	482011039	D	505	0.05	0.08	0.97	0	8 Years	0.25
Deer Park-2	482011039	C	66	0.12	0.06	0.30	0	1 Year	0.55

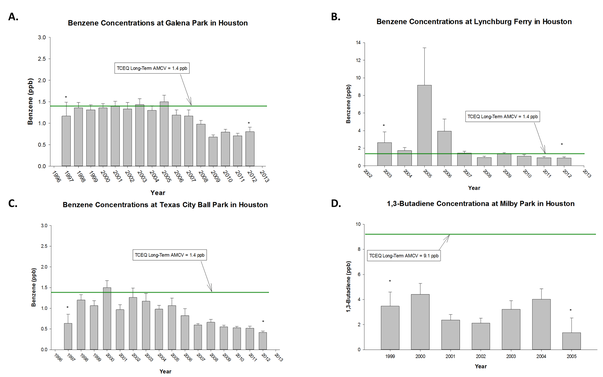


Figure 2. A) The Galena monitor is located to the north of a large industrial park. Benzene levels have decreased at this site, but it still remains an area of interest due to its proximity to a number of neighborhoods. **B)** The Lynchburg Ferry monitor is sited in an outcropping of land in the Houston Ship Channel. It is in an industrial area not skirting a local neighborhood. However, it is an area with both vehicular and nautical traffic. Benzene at this site has decreased and improvements in this area are due to large collaborative efforts to reduce emissions of this chemical. At one point, this site had the highest benzene concentrations in the state. **C)** One of the monitors at Texas City Ball Park is located to the north of the Texas City Industrial Complex and is sited within a neighborhood. While benzene levels have not had peaks that have exceeded the short-term health value at this site, concentrations of this chemical have had a higher baseline due to nearby sources. Thus, efforts were made to reduce benzene emissions in this area. **D)** The Milby Park monitor is located near one of the largest sources of 1,3-butadiene emissions in the state. There are neighborhoods and major roadways near this site south of the Houston Ship Channel. The previously utilized regulatory values used to evaluate ambient air levels of this chemical were highly conservative, resulting in exceedances at this location. Efforts to reduce 1,3-butadiene emissions were successful at this site. However, newer scientific data resulted in the derivation of a new regulatory value, which has been exceeded less frequently (previous value = 1 ppb, current value = 9.1 ppb). The asterisk indicates an incomplete year of data (*).

Corpus Christi TCEQ Region 14 Air Toxics Trends

Corpus Christi's industrial areas can be found along the ship channel. There are communities that skirt these industrial parks, demonstrating the need for monitor placement to protect public health and welfare.

Table 3. Air Toxics Trends in TCEQ Region 14

Benzene									
Site Name	AQS #	Type	Number	Mean	Std. Dev.	Max.	Min.	Duration at Site	Risk or HQ
Dona Park	483550034	C	544	0.41	0.59	10.96	0.05	11 Years	2.9E-06
Hillcrest	483550029	C	1058	0.68	1.54	40.32	0.05	15 Years	5.5E-06
Huisache	483550032	C	1740	1.88	2.47	28.54	0.06	16 Years	**1.2E-05**
Navigation	483550020	C	508	0.72	0.74	5.7	0	10 Years	5.0E-06
Oak Park	483550035	A	59221	0.47	1.44	120.16	0	9 Years	3.3E-06
Palm	483550083	A	20184	0.28	0.92	87.41	0	3 Years	2.0E-06
Poth	483550030	C	84	1.65	1.62	11.71	0.02	3 Years	9.5E-06
Solar Estates	483550041	A	56838	0.24	0.36	11.66	0	9 Years	1.7E-06
1,3-Butadiene									
Dona Park	483550034	C	560	0.02	0.03	2.93	0	11 Years	1.74E-08
Hillcrest	483550029	C	765	0.02	0.05	1.59	0	15 Years	2.28E-08
Huisache	483550032	C	1735	0.02	0.02	0.81	0	16 Years	2.51E-08
Navigation	483550020	C	493	0.04	0.04	1.57	0	10 Years	3.95E-08
Oak Park	483550035	A	59319	0.043	0.13	15.61	0	9 Years	3.01E-07
Palm	483550083	A	20107	0.03	0.05	20.27	0	3 Years	1.9E-07
Poth	483550030	C	84	0.02	0.03	0.04	0	3 Years	2.60E-08
Solar Estates	483550041	A	57738	0.043	0.43	35.73	0	9 Years	2.99E-07

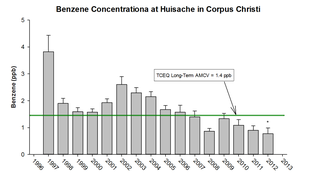


Figure 3. The Huisache monitor is located to the north of a neighborhood that is located near a heavily industrial ship channel. Benzene levels have been decreasing in the past. The asterisk indicates an incomplete year of data (*).

Conditions that Cause Exceedances

Air toxics trends identified using the automatic gas chromatography (AutoGC) method are similar to those observed in canister samplers. However, the AutoGC offers greater insight into the dynamics of air toxics and the conditions that give rise to chemical concentrations of concern. Below are histograms demonstrating the distribution of benzene concentrations at various monitors in the coastal region.

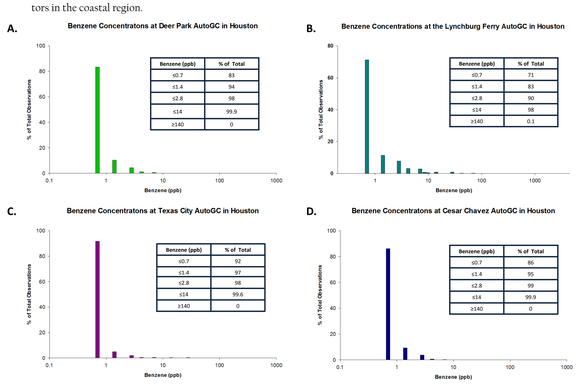


Figure 4. The above histograms show the frequency of benzene concentrations observed at various AutoGC monitors from the time of activation to present in the Houston area. At the Deer Park (**A**), Lynchburg Ferry (**B**), Texas City (**C**), and Cesar Chavez (**D**) monitors, benzene concentrations have a right skewed distribution. In the past, benzene concentrations have not been within risk management goals at Lynchburg Ferry or Texas City monitors. Both monitors appear to have a longer tail to the distribution of benzene concentration, particularly at Lynchburg Ferry. This would indicate that the exceedances of health protective values at these sites is caused by higher background benzene concentrations consistent with the presence of more sources near the monitor. In addition to a higher background level, benzene concentrations observed at the Lynchburg Ferry monitor peaked to concentrations above the short-term, health protective AMCV. Investigations revealed that these peaks were caused by mobile sources in the Houston Ship Channel. These data reveal that exceedances of the AMCV and subsequent risk management goals are generally caused by higher background levels of the chemical of concern. However, the observed annual average concentration of a given chemical may also be influenced by episodic emission events caused by an introduction of new sources near the monitor or malfunction of equipment on an industrial site.

Remedies: Permits, Programs, and Enforcement

The TCEQ has a number of potential remedies to pursue when an exceedance of a health protective value occurs. The remedy is typically selected based upon the magnitude and frequency of the exceedance.

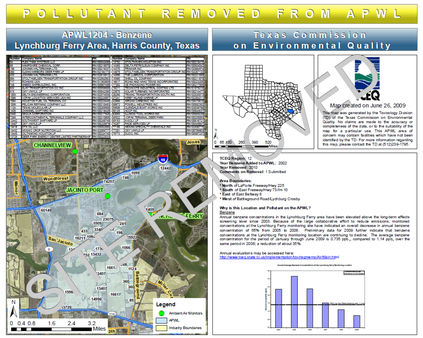
1. If exceedances of the long-term health protective value are observed repeatedly at a given site, the area may be listed upon the Air Pollutant Watch List (APWL).
2. If an area is listed on the APWL, industrial activities will fall under greater observation, including increased monitoring, more stringent air permit evaluation, and routine investigations to determine the cause of exceedances.
3. Research will be conducted to identify entities contributing to levels of concern. This includes an evaluation of emissions inventories and ambient air monitoring data.
4. Companies operating in an APWL area will not be allowed to increase emissions of chemicals exceeding the health protective value. They may also be required to provide the agency with a plan to reduce emissions.

Air Pollutant Watch List (APWL) Program

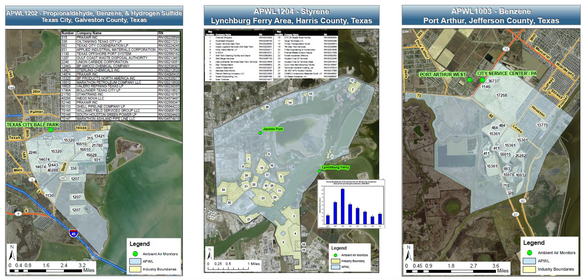
The APWL is a list of areas in Texas where specific pollutants were monitored at levels of concern for potential to cause adverse short– or long-term health effects (or both) or odor.

The purpose of the APWL is as follows:

1. Heighten awareness in areas of concern for interested parties (i.e., TCEQ staff, industry representatives, and private citizens).
2. Encourage efforts to reduce emissions
3. Help TCEQ focus resources to the areas of greatest need (facility inspections and field investigations, enforcement activities, and the prioritization and mobilization of monitoring equipment.)



Lynchburg Ferry benzene levels are an example of a site placed on the APWL that was successfully removed when levels of benzene were observed to no longer be of concern to human health and welfare. This site is still on the APWL for styrene. Other sites in the Coastal region still actively upon the APWL can be seen below.



Summary and Conclusions

1. Air toxics trends have steadily decreased throughout the Texas Coastal Region
2. Benzene continues to be the primary risk driver
3. Long-term benzene concentrations were observed to be greater than risk management goals at three sites: **Galena Park, Huisache, and Lynchburg Ferry**
4. At sites where chemical emissions became problematic to local communities the TCEQ worked with industrial entities to better regulate release of chemicals into the environment
5. The APWL Program has proven to be a very useful way to improve ambient air conditions at sites where chemical concentrations did not meet risk management goals
6. Ambient air monitors continue to be sited throughout the region to monitor potential impacts of industrial activity on air quality
7. For more information please visit the TCEQ webpages:
   APWL: http://www.tceq.texas.gov/toxicology/AirPollutantMain/APWL_index.html#general
   Monitoring: http://www.tceq.texas.gov/toxicology/regmemo/AirMain.html
   Toxicology: http://www.tceq.texas.gov/toxicology
   TCEQ Main Webpage: http://www.tceq.texas.gov/