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AMBIENT AIR QUALITY AFTER HURRICANE KATRINA

AMBIENT AIR QUALITY AFTER HURRICANE KATRINA (EPA Technical Report)

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EXECUTIVE SUMMARY

Following Hurricane Katrina (Katrina) EPA evaluated air quality to determine whether the storm damage in Louisiana and Mississippi and subsequent cleanup efforts caused air quality in the affected areas to (1) exceed screening levels and (2) change in comparison to monitored air quality prior to the storm. Ambient air quality monitoring sites were established throughout the impacted area to collect samples beginning in October 2005. Measurements of over 80 pollutants, including metals, volatile organic compounds (VOCs), carbonyl compounds, particulate matter (PM), ozone, and polycyclic aromatic hydrocarbons (PAHs) were made. Sites were operated in the New Orleans and Gulfport/Pascagoula, Mississippi, areas; not all sites measured all pollutants. This document reports on air quality data collected from October 2005 through September 2006, the first year after the hurricane. In partnership with other federal, state and local agencies, EPA monitored air quality in as many locations as possible, given limited resources. Locations included heavily populated areas, near roadways, near waste sites and in locations of remediation. EPA's goal was to provide adequate protection to the general population. The purpose of this report is to describe air quality levels across the region.

ES.1 FREQUENCY OF CONCENTRATIONS ABOVE SCREENING LEVELS

Given the large number of pollutants monitored post-Katrina, EPA used screening levels, originally established for quick review of the data, to prioritize this one-year retrospective air quality data analysis.[1] Pollutants with measurements above the screening levels received first priority for analysis. Seven of the more than 80 pollutants examined had at least one monitored concentration greater than the screening levels during the post-Katrina time period (October 2005 through September 2006). These measurements of ambient air pollutants in the affected areas of Louisiana and Mississippi indicate that screening levels were not routinely exceeded by any pollutants other than acrolein (**Table ES-1**).

- More than 50% of acrolein concentration samples at all four monitoring sites were above the screening level (0.09 $\mu g/m^3$). The concentrations observed during the first quarter post-Katrina in the affected areas were within the range of concentrations observed elsewhere in the United States during the same time period using similar measurement

[1] Screening levels were established by the EPA prior to any sample collection to provide a health-based interpretation of the ambient monitoring data collected around the recovery activity areas. The approach for setting the levels gave preference to the use of relevant air standards and regulations (e.g., the National Ambient Air Quality Standards [NAAQS]), established public health indicators (e.g., the Air Quality Index [AQI]), and EPA risk assessment guidance for air toxics. Screening levels for the criteria pollutants (e.g., $PM_{2.5}$ and PM_{10}) were set at levels designed to caution members of the public about acute effects that might result from that exposure (see <http://www.airnow.gov/index.cfm?action=aqibroch.aqi#aqipar>). Screening levels for the toxic air pollutants were set to assess the potential for longer-term exposures (e.g., on the order of a year) which may pose health risks to exposed populations and were not designed to predict the occurrence of effects. Rather, they were designed to provide longer-term (months to a year) exposure levels that would not be associated with appreciable risk of effects. Accordingly, individual sample results greater than the screening levels do not imply an immediate health threat. The levels were reviewed by the Centers for Disease Control and Prevention, the Agency for Toxic Substances and Disease Registry (ATSDR), the EPA Offices of Solid Waste and Emergency Response, and the Office of Air Quality Planning & Standards (OAQPS), EPA Regions 2, 4, and 6, and the Louisiana and Mississippi state environmental agencies.

methods. Therefore, in the context of the nationally observed concentrations, it is unlikely that the acrolein concentrations were abnormally high as a result of Katrina recovery efforts.

- Formaldehyde concentrations were above the screening level (40 $\mu g/m^3$) in six samples collected at one site in Pascagoula, Mississippi. All six samples were collected in October and November 2005; additional samples collected since that time have all been below the screening level.
- The following pollutants were above screening levels less than 1% of the time: particulate matter in two size fractions (PM_{10} and $PM_{2.5}$), nickel (total suspended particulate [TSP]), manganese [TSP], and acetonitrile.

Table ES-1. Summary of pollutant counts above screening levels in the post-Katrina time period.

Pollutant	City	No. of Sites	Post-Katrina			Pre-Katrina		
			No. of Samples Above Screening Level	Total Samples	Percent of Samples Above Screening Level	No. of Samples Above Screening Level	Total Samples	Percent of Samples Above Screening Level
Acetonitrile	Gulfport-Biloxi	1	1	246	<1	0	97	0
Acrolein	Gulfport-Biloxi	2	164	246	67	Not Measured		
Acrolein	New Orleans	1	70	99	71			
Acrolein	Pascagoula	1	67	101	66			
Formaldehyde	Pascagoula	1	6	112	5	1	110	<1
Manganese (TSP)	New Orleans	2	2	1150	<1	Not Measured		
Nickel (TSP)	New Orleans	4	6	1148	<1			
PM_{10}	New Orleans	1	1	1126	<1	0	1333	0
$PM_{2.5}$	Gulfport-Biloxi	2	8	1416	<1	13	3737	<1
$PM_{2.5}$	New Orleans	4	7	1770	<1	18	7245	<1

ES.2 COMPARISON OF MEAN CONCENTRATIONS

EPA compared pre-Katrina to post-Katrina pollutant concentrations to assess possible changes in air quality. For pollutants with concentrations observed above screening levels:

- PM_{10} and $PM_{2.5}$ concentrations in New Orleans were higher than in previous years.

- Average formaldehyde and acetonitrile concentrations in Pascagoula and Gulfport were also higher than those previously measured at the same sites.

- Acrolein concentrations had not been measured in this area previously, so no historical comparisons could be made.

Significant differences in mean concentrations between pre- and post-Katrina time periods could be caused by meteorology, emissions changes, or changes in regional background concentrations.

Among pollutants with concentrations that showed statistically significant differences were:

- Concentrations of $PM_{2.5}$, NO_2, and ozone were higher than previously measured values at the Gulfport/Pascagoula sites. These higher concentrations may be a result of increased emissions resulting from construction and demolition activities despite decreased emissions from the reduced commuter traffic. Higher NO_2 concentrations may be partly responsible for higher ozone concentrations.
- NO_2 concentrations in New Orleans post-Katrina were lower than in previous years. This may be a result of lower vehicle emissions and/or less energy production after the hurricane.
- PM_{10} and $PM_{2.5}$ concentrations in New Orleans post-Katrina were higher than in previous years. Higher PM_{10} concentrations may be a result of demolition and cleanup activities. The highest PM_{10} concentrations were seen at a monitoring site near approved local demolition, grinding, and landfill sites.

It should be noted that no adjustments were made in this analysis for meteorology, which can significantly impact concentrations of secondary pollutants such as ozone and $PM_{2.5}$. Therefore, concentrations that may have changed significantly could be the result of changing meteorological conditions and not changes in emissions.

1. INTRODUCTION

1.1 BACKGROUND

Hurricane Katrina (Katrina) was the eleventh named tropical storm, fifth hurricane, third major hurricane, and first Category 5 hurricane of the 2005 Atlantic hurricane season. It was the third most powerful storm of the season and the sixth strongest Atlantic hurricane recorded. Katrina became the Gulf Coast's strongest hurricane (Hurricane Rita broke this record later in the season). Katrina made its second landfall as a large Category 3 storm on the morning of August 29 along the Central Gulf Coast near Buras-Triumph, Louisiana.

The storm surge from Katrina caused catastrophic damage along the coastlines of Louisiana, Mississippi, and Alabama. Levees separating Lake Pontchartrain from New Orleans were breached by the surge, ultimately flooding about 80% of New Orleans, most of St. Bernard Parish, and portions of St. Tammany Parish and Plaquemines Parish.

EPA examined the effects of Katrina to determine whether associated flooding of Louisiana and Mississippi and subsequent cleanup efforts caused air quality in the affected areas to change. Air quality measurements examined here were made in the affected areas beginning in October 2005. Pollutant concentrations were compared to screening levels. Post-Katrina concentrations were also compared to concentrations in the affected areas pre-Katrina where measurements were previously available to determine if concentrations were higher or lower than those reported before Katrina. In areas where previous measurements were not available, we examined concentrations within the same state.

The damage caused by Katrina, flooding, and subsequent cleanup efforts may have caused changes in emissions of some air pollutants. The changes in emissions may be evident in ambient concentrations of pollutants in the affected areas. Changes in emissions could cause ambient concentrations to be higher or lower than those previously experienced:

- Evacuation of the affected areas, which resulted in a significant reduction in the number of cars and other vehicles operated in some of the areas, is expected to have caused a reduction of pollutants associated with gasoline-powered motor vehicles (i.e., benzene, xylenes, and ethylbenzene).
- Increased construction and demolition activity in the area may elevate concentrations of particulate matter (PM) from dust and also increase other pollutants associated with diesel emissions from on-road and non-road vehicles and equipment used in this effort (e.g., dump trucks, bulldozers).

In this report, we identify ambient pollutant concentrations that were above screening levels and identify changes in mean ambient pollutant concentrations pre- and post-Katrina. When possible, an attempt was made to evaluate the reasons for the changes (e.g., emissions or meteorological differences).

1.2 APPROACH

The objectives of the analyses were to ascertain if concentrations were above screening levels and to assess how post-Katrina ambient pollutant concentrations compared to pre-Katrina levels in the affected areas. Given the large number of pollutants monitored post-Katrina, screening levels were used to prioritize air quality data analysis.[2] After examining those pollutants with concentrations above screening levels, concentrations of other pollutants were examined.

Time series of pollutant concentrations above screening levels were examined to assess whether clear trends are evident in ambient concentrations post-Katrina. It was relatively difficult to identify trends for those pollutants with high natural temporal variability. Underlying trends in these pollutants will not be detectable without dramatic changes in concentrations or additional sophisticated analyses of the influence of meteorology and emissions on concentrations in the affected areas.

Pollutants whose concentrations were above screening levels in the Katrina-affected areas were compared to previously measured concentrations in the same areas to assess if concentrations changed as a result of Katrina recovery activities. Ideally, this analysis would be performed using data from long-term established monitors in the affected regions with consistent analytical laboratories and sampling and analytical methods. Unfortunately, only a few monitors in the affected areas measured concentrations of most of the pollutants pre-Katrina. Measurements of criteria pollutants such as ozone and $PM_{2.5}$ were available in the New Orleans and Gulfport/Pascagoula areas. However, the New Orleans area only had recent measurements (i.e., post-2000) of some air toxics such as particulate metals at one site, Breton, which is considered a rural site and may not be representative of the New Orleans area. Recent measurements of toxic volatile organic compounds (VOCs) and particulate metals were available from Gulfport, Mississippi; polycyclic aromatic hydrocarbon (PAH) measurements were not available in this area. For pollutants without concentration measurements pre-Katrina, we examined concentrations from monitors in the same state. For acrolein, even these comparisons were not possible due to changes in sampling methodology. Therefore, acrolein concentrations were compared to concentrations measured at national air toxics monitoring sites.

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[2] Screening levels were established by the EPA prior to any sample collection to provide a health-based interpretation of the ambient monitoring data collected around the recovery activity areas. The approach for setting the levels gave preference to the use of relevant air standards and regulations (e.g., the National Ambient Air Quality Standards [NAAQS]), established public health indicators (e.g., the Air Quality Index [AQI]), and EPA risk assessment guidance for air toxics. Screening levels for the criteria pollutants (e.g., $PM_{2.5}$ and PM_{10}) were set at levels designed to caution members of the public about acute effects that might result from that exposure (see <http://www.airnow.gov/index.cfm?action=aqibroch.aqi#aqipar>). Screening levels for the toxic air pollutants were set to assess the potential for longer-term exposures (e.g., on the order of a year) which may pose health risks to exposed populations and are not designed to predict the occurrence of effects. Rather, they are designed to provide longer-term (months to a year) exposure levels that would not be associated with appreciable risk of effects. Accordingly, individual sample results greater than the screening levels do not imply an immediate health threat. The levels were reviewed by the Centers for Disease Control and Prevention, the Agency for Toxic Substances and Disease Registry (ATSDR), the EPA Offices of Solid Waste and Emergency Response, and the Office of Air Quality Planning & Standards (OAQPS), EPA Regions 2, 4, and 6, and the Louisiana and Mississippi state environmental agencies.

Time series and concentration comparisons were also created for pollutants with concentrations that never exceeded the screening level. These comparisons were made to examine if any obvious temporal trends in pollutant concentrations could be attributed to post-Katrina recovery efforts or changes in emissions.

2. ACQUISITION AND TREATMENT OF DATA

2.1 POLLUTANTS AND AVAILABLE DATA

Data were acquired from the U.S. Environmental Protection Agency's (EPA) Air Quality System (AQS). These data were then organized into an Oracle 9i relational database. Pollutants with hourly or other sub-daily samples were processed to create daily metrics, such as 24-hr averages; 1-hr maximum values and 8-hr average maximum values were generated for ozone for comparison to the National Ambient Air Quality Standards (NAAQS) value. The number of daily averages available in the database is shown in **Tables 2-1 and 2-2** for Louisiana and Mississippi, respectively. Pollutants for which more than 75% of measurements were below the minimum detection limit are not shown in the tables.

As shown in Table 2-1, New Orleans only reported concentrations of criteria pollutants and metals pre-Katrina; as noted, the metals concentrations were only reported for the Breton site, a rural site that may not be representative of the New Orleans area. Therefore, we compared toxics and metals concentrations to concentrations from within the same state. As shown in Table 2-2, most pollutants were measured in Gulfport/Pascagoula pre-Katrina. Sufficient measurements of most pollutants statewide were also available in both Louisiana and Mississippi for comparison. Pollutants with no comparable measurements in the area pre-Katrina include the PAHs (not shown) and acrolein.

Pollutants are listed in the two tables, by pollutant type. The pollutant types are criteria ($PM_{2.5}$ and PM_{10} mass, ozone, NO_2, and SO_2), metals, VOCs, and PAHs. EPA working with its federal and state partners established an asbestos monitoring network that was made up of area wide (ambient measurements) as well as waste reduction and demolition specific components (emissions and personal monitoring measurements). Ambient asbestos concentrations were not above detection limits enough of the time to be shown in these tables. Screening levels were compared to 24-hr averages with the exception of ozone for which the maximum 8-hr daily average was used.

Not all pollutants were measured during the entire post-Katrina time frame. See **Tables 2-3 and 2-4** for the last sample collected in New Orleans and Gulfport/Pascagoula, respectively, by pollutant type.

Table 2-1. Available measurements of pollutants monitored in New Orleans, Louisiana, pre- and post-Katrina. (Note that pollutants without screening levels are not shown).

Pollutant	Screening Level ($\mu g/m^3$ or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples: New Orleans	No. of Daily Samples: New Orleans, 2000–2005	No. of Daily Samples: Louisiana, 2000–2005
$PM_{2.5}$	40	Criteria	1770	7245	24784
PM_{10}	150	Criteria	1226	1333	904
Ozone – 8hr	85 ppb	Criteria	1076	10291	45768
Sulfur Dioxide – 24 hr	140 ppb	Criteria	119	2033	10459
Nitrogen Dioxide – 24 hr	100 ppb	Criteria	357	4096	20774
Arsenic (TSP)	0.3	Metal	1150	–	–
Arsenic ($PM_{2.5}$)	0.3	Metal	548	408	512
Arsenic (PM_{10})	0.3	Metal	899	–	–
Lead (TSP)	1.5	Metal	1150	167	–
Lead ($PM_{2.5}$)	1.5	Metal	548	408	512
Lead (PM_{10})	1.5	Metal	899	–	–
Beryllium ($PM_{2.5}$)	0.02	Metal	548	–	–
Beryllium (PM_{10})	0.02	Metal	899	–	–
Cobalt (TSP)	0.1	Metal	1150	–	–
Cobalt ($PM_{2.5}$)	0.1	Metal	548	–	512
Cobalt PM_{10}	0.1	Metal	899	–	–
Cadmium (TSP)	0.2	Metal	1150	–	–
Nickel (TSP)	0.2	Metal	1148	–	–
Cadmium ($PM_{2.5}$)	0.2	Metal	548		512
Nickel ($PM_{2.5}$)	0.2	Metal	548	408	512
Cadmium (PM_{10})	0.2	Metal	899	–	–
Nickel (PM_{10})	0.2	Metal	899	–	–
Manganese (TSP)	0.5	Metal	1150	–	–
Manganese ($PM_{2.5}$)	0.5	Metal	548	408	512
Manganese (PM_{10})	0.5	Metal	899	–	–
Chromium (TSP)	1	Metal	1150	–	–
Chromium Vi (TSP)	1	Metal	123	–	–
Chromium ($PM_{2.5}$)	1	Metal	548	408	512
Chromium (PM_{10})	1	Metal	899	–	–
Antimony (TSP)	2	Metal	1150	–	–
Antimony ($PM_{2.5}$)	2	Metal	548	–	512

TSP=total suspended particulate matter

Table 2-1. Available measurements of pollutants monitored in New Orleans, Louisiana, pre- and post-Katrina. (Note that pollutants without screening levels are not shown).

Pollutant	Screening Level ($\mu g/m^3$ or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples: New Orleans	No. of Daily Samples: New Orleans, 2000–2005	No. of Daily Samples: Louisiana, 2000–2005
Antimony (PM_{10})	2	Metal	899	–	–
Mercury ($PM_{2.5}$)	3	Metal	548	–	512
Mercury (PM_{10})	3	Metal	899	–	–
Selenium (TSP)	20	Metal	1150	–	–
Selenium ($PM_{2.5}$)	20	Metal	548	408	512
Selenium (PM_{10})	20	Metal	899	–	–
7,12-Dimethylbenz[A]Anthracene	0.1	PAH	58	–	–
3-Methylcholanthrene	1	PAH	58	–	–
Dibenzo[A,H]Anthracene	5.8	PAH	482	–	–
Benzo[A]Pyrene	6.4	PAH	482	–	–
Benzo[A]Anthracene	64	PAH	482	–	–
Benzo[B]Fluoranthene	64	PAH	482	–	–
Benzo[K]Fluoranthene	64	PAH	482	–	–
Indeno[1,2,3-Cd]Pyrene	64	PAH	482	–	–
Naphthalene	30	PAH	1537	–	–
Carbazole	1200	PAH	479	–	–
Acrolein	0.09	VOC	99	–	–
Benzene	20	VOC	1295	–	4143
M/P-Xylene	3000	VOC	238	–	3601
O-Xylene	3000	VOC	1295	–	4143
P-Xylene	3000	VOC	1057	–	–
Toluene	5000	VOC	1295	–	4143
1,3-Butadiene	20	VOC	199	–	2749
Formaldehyde	40	VOC	107	–	798
1,2-Dichloropropane	40	VOC	1156	–	985
Vinyl Chloride	80	VOC	99	–	1039
Acetaldehyde	90	VOC	107	–	798
1,1,2,2-Tetrachloroethane	120	VOC	1156	–	985
Chloroform	200	VOC	99	–	985
Carbon Tetrachloride	200	VOC	1156	–	985
Trichloroethylene	500	VOC	1195	–	985
Dichloromethane	1000	VOC	99	–	1039

TSP=total suspended particulate matter

Table 2-1. Available measurements of pollutants monitored in New Orleans, Louisiana, pre- and post-Katrina. (Note that pollutants without screening levels are not shown).

Pollutant	Screening Level (µg/m^3 or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples: New Orleans	No. of Daily Samples: New Orleans, 2000–2005	No. of Daily Samples: Louisiana, 2000–2005
Tetrachloroethylene	1200	VOC	1195	–	985
Benzidine	0.1	VOC	10	–	–
N-Nitrosodimethylamine	0.5	VOC	10	–	–
Aniline	10	VOC	58	–	–
Trans-1,3-Dichloropropylene	14	VOC	99	–	741
Cis-1,3-Dichloropropylene	14	VOC	99	–	741
Hexachlorobenzene	15	VOC	58	–	–
Acrylonitrile	20	VOC	99	–	–
3,3'-Dichlorobenzidene	21	VOC	58	–	–
2,4-Dinitrotoluene	70	VOC	58	–	–
Chloroprene	70	VOC	99	–	–
Ethylene Dichloride	80	VOC	138	–	985
1,1-Dichloroethylene	80	VOC	99	–	985
Chlorobenzilate	90	VOC	58	–	–
Pentachloronitrobenzene	95	VOC	58	–	–
Bis(2-Ethylhexyl)Phthalate	100	VOC	58	–	–
Hexachlorocyclopentadiene	100	VOC	58	–	–
Bis (2-Chloroethyl)Ether	120	VOC	58	–	–
Bromomethane	200	VOC	99	–	985
Hexachlorobutadiene	320	VOC	157	–	959
Chloromethane	400	VOC	99	–	969
1,1,2-Trichloroethane	440	VOC	138	–	985
Ethyl Acrylate	500	VOC	99	–	–
Acetonitrile	600	VOC	97	–	–
1,4-Dichlorobenzene	600	VOC	1311	–	1039
Trans-1,2-Dichlororthylene	800	VOC	99	–	–
Pentachlorophenol	1000	VOC	58	–	–
3,3'-Dimehtylbenzidine	1800	VOC	58	–	–
N-Hexane	2000	VOC	139	–	3174
1,2,4-Trichlorobenzene	2000	VOC	1214	–	985
Methyl Tert-Butyl Ether	2500	VOC	99	–	–
Methyl Chloroform	4000	VOC	1194	–	1039

TSP=total suspended particulate matter

Table 2-1. Available measurements of pollutants monitored in New Orleans, Louisiana, pre- and post-Katrina. (Note that pollutants without screening levels are not shown).

Pollutant	Screening Level (µg/m^3 or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples: New Orleans	No. of Daily Samples: New Orleans, 2000–2005	No. of Daily Samples: Louisiana, 2000–2005
Ethylbenzene	4000	VOC	1295	–	4264
Bromoform	6400	VOC	1156	–	–
Methyl Methacrylate	7000	VOC	99	–	–
Styrene	10000	VOC	1295	–	4143
Chlorobenzene	10000	VOC	1195	–	985
Isophorone	20000	VOC	58	–	–
Propylene	30000	VOC	199	–	2860
Acetone	31000	VOC	107	–	688
Methyl Ethyl Ketone	50000	VOC	99	–	–
Hexachloroethane	60000	VOC	58	–	–
Chloroethane	100000	VOC	99	–	985

TSP=total suspended particulate matter

Table 2-2. Data available for pollutants monitored in Gulfport/Pascagoula, pre- and post-Katrina.

Pollutant	Screening Level ($\mu g/m^3$ or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples, Gulfport/ Pascagoula	No. of Daily Samples, Gulfport/ Pascagoula	No. of Daily Samples, Rest of Mississippi
$PM_{2.5}$ Mass	40	Criteria	2002	4443	11892
PM_{10} Mass – STP	150	Criteria	29	292	1000
PM_{10} Mass – Local Conditions	150	Criteria	998	9	11892
Ozone – 8hr	85 ppb	Criteria	608	7206	11537
Nitrogen Dioxide – 24 hr	100 ppb	Criteria	313	2354	1572
Sulfur Dioxide – 24 hr	140 ppb	Criteria	419	3708	2820
Arsenic ($PM_{2.5}$)	0.3	Metal	877	429	804
Arsenic (PM_{10})	0.3	Metal	1004	–	–
Lead ($PM_{2.5}$)	1.5	Metal	877	429	804
Lead (PM_{10})	1.5	Metal	1004	–	–
Cobalt (PM_{10})	0.1	Metal	1004	–	–
Cadmium ($PM_{2.5}$)	0.2	Metal	877	429	804
Nickel ($PM_{2.5}$)	0.2	Metal	877	428	804
Cadmium (PM_{10})	0.2	Metal	1004	–	–
Nickel (PM_{10})	0.2	Metal	1004	–	–
Manganese ($PM_{2.5}$)	0.5	Metal	877	429	804
Manganese (PM_{10})	0.5	Metal	1004	–	–
Chromium Vi (TSP)	1	Metal	189	–	–
Chromium ($PM_{2.5}$)	1	Metal	877	429	804
Chromium (PM_{10})	1	Metal	1004	–	–
Antimony ($PM_{2.5}$)	2	Metal	877	429	804
Antimony (PM_{10})	2	Metal	1004	–	–
Mercury (PM_{10})	3	Metal	1004	–	–
Selenium ($PM_{2.5}$)	20	Metal	877	429	804
Selenium (PM_{10})	20	Metal	1004	–	–
Benzo[A]Pyrene	6.4	PAH	258	–	–
Chrysene	640	PAH	258	–	–
Naphthalene	30	PAH	258	–	–
Acrolein	0.09	VOC	347	3	8
Benzene	20	VOC	595	230	284

Table 2-2. Data available for pollutants monitored in Gulfport/Pascagoula, pre- and post-Katrina.

Pollutant	Screening Level (µg/m^3 or ppb where noted)	Type	Post-Katrina (10/1/2005–9/30/2006)	Pre-Katrina (1/1/2000–9/30/2005)	
			No. of Daily Samples, Gulfport/ Pascagoula	No. of Daily Samples, Gulfport/ Pascagoula	No. of Daily Samples, Rest of Mississippi
M/P-Xylene	3000	VOC	595	230	284
O-Xylene	3000	VOC	595	230	284
Toluene	5000	VOC	595	230	284
Formaldehyde	40	VOC	368	205	279
Acetaldehyde	90	VOC	369	205	279
Chloroform	200	VOC	347	210	284
Carbon Tetrachloride	200	VOC	347	210	284
Dichloromethane	1000	VOC	347	210	284
Bis(2-Ethylhexyl)Phthalate	100	VOC	190	–	–
Bromomethane	200	VOC	347	210	284
Chloromethane	400	VOC	347	210	284
Acetonitrile	600	VOC	347	210	284
1,4-Dichlorobenzene	600	VOC	717	210	284
N-Hexane	2000	VOC	248	20	–
Methyl Chloroform	4000	VOC	347	210	284
Ethylbenzene	4000	VOC	595	230	284
Styrene	10000	VOC	595	230	284
Propylene	30000	VOC	595	230	284
Acetone	31000	VOC	369	205	279
Methyl Ethyl Ketone	50000	VOC	347	210	284

. Last sample date of data reported post-Katrina by site and pollutant type for the New Orleans area.

Metal ($PM_{2.5}$)	Metal (TSP)	Metal (PM_{10})	NO_2	O_3	PAH	PM_{10}	$PM_{2.5}$	SO_2	VOC
1/23/06	7/20/06	–	9/30/06	9/30/06	7/31/06	7/19/06	7/19/06	1/27/06	7/31/06
1/23/06	7/17/06	–	–	–	7/11/06	7/16/06	7/16/06	–	2/28/06
12/21/05	12/22/05	–	–	–	12/22/05	12/21/05	12/21/05	–	12/22/05
1//06	7/20/06	–	–	–	12/22/05	11/28/06	12/4/06	–	7/20/06
1/17/06	7/17/06	–	–	–	12/22/05	7/16/06	7/16/06	–	7/11/06
1/23/06	–	–	–	–	–	7/19/06	7/19/06	–	–
1/23/06	7/20/06	–	8/28/05	8/28/05	12/16/05	7/19/06	7/19/06	–	7/20/06
–	–	–	–	–	–	–	–	–	–
–	7/20/06	–	–	–	12/16/05	–	–	–	7/14/06
1/23/06	7/20/06	–	–	–	12/16/05	12/1/06	12/1/06	–	3/5/06
1/20/06	–	–	–	–	12/22/05	12/4/06	12/4/06	–	7/17/06
–	7/17/06	–	–	–	12/16/05	–	–	–	7/17/06
–	12/22/05	–	–	–	12/22/05	–	–	–	12/22/05
–	12/22/05	12/20/05	–	–	12/22/05	12/20/05	12/20/05	–	12/22/05
12/20/05	12/22/05	12/20/05	–	–	12/22/05	12/20/05	12/20/05	–	12/22/05
1/20/06	–	5/5/06	–	–	–	7/16/06	7/16/06	–	–
–	–	12/21/05	–	–	–	12/21/05	12/21/05	–	–
12/29/04	–	–	–	–	–	12/29/04	–	–	–
–	7/20/06	–	–	8/29/05	12/4/05	–	–	8/29/05	7/20/06
1/23/06	7/20/06	5/8/06	–	–	12/15/05	7/19/06	7/19/06	–	3/5/06
1/23/06	–	5/8/06	–	–	–	12/4/06	12/4/06	–	–
–	–	–	–	9/30/06	–	–	–	–	–
–	12/22/05	–	–	–	12/22/05	–	–	–	12/22/05
12/21/05	–	12/21/05	–	–	–	12/21/05	12/21/05	–	–
–	–	–	–	9/30/06	–	–	–	–	–
–	12/10/02	–	–	–	–	–	–	–	–
–	–	–	–	–	12/16/05	–	–	–	12/16/05
1/23/06	7/20/06	5/8/06	–	–	12/21/05	12/1/06	12/1/06	–	7/20/06
12/15/05	–	12/15/05	–	–	–	12/15/05	12/15/05	–	–

st sample date of data reported post-Katrina by site and pollutant type for the Gulfport/Pascagoula area.

Metal ($PM_{2.5}$)	Metal (PM_{10})	NO_2	O_3	PAH	PM_{10}	$PM_{2.5}$	SO_2	VOC
–	–	–	10/31/06	–	–	10/30/06	–	–
–	–	–	10/31/06	–	–	11/30/06	–	–
–	–	–	10/31/06	–	–	10/29/06	–	–
12/30/05	–	–	–	–	–	10/26/06	–	–
2/28/06	–	–	–	–	–	1/5/06	–	–
–	–	–	–	–	11/9/05	11/9/05	–	–
1/23/06	10/29/05	–	–	–	3/30/06	3/30/06	–	–
1/23/06	11/1/05	–	–	–	6/11/06	6/4/06	–	–
–	4/5/06	–	–	–	–	6/4/06	–	–
1/23/06	–	–	–	6/4/06	6/4/06	6/4/06	–	6/4/06
9/14/06	–	–	10/31/06	9/26/06	6/3/06	11/30/06	–	9/26/06
–	–	–	10/31/05	–	–	–	–	–
1/23/06	–	–	–	–	6/3/06	6/4/06	–	–
1/23/06	–	–	–	–	3/30/06	3/30/06	–	–
1/23/06	–	–	–	–	6/3/06	6/4/06	–	–
–	4/5/06	–	–	–	–	5/11/06	–	–
–	4/5/06	–	–	–	–	6/4/06	–	–
–	–	–	10/31/06	–	–	11/30/06	–	–
5/29/06	–	–	–	–	–	5/31/06	12/31/05	–
1/23/06	–	11/30/06	10/31/06	–	6/4/06	11/30/06	11/30/06	6/4/06
–	–	–	10/31/05	–	–	–	–	–
12/30/05	–	–	–	–	–	10/29/06	–	–
–	–	–	10/31/06	–	–	11/30/06	–	–
–	–	–	10/31/06	–	–	11/30/06	–	9/26/06
–	–	–	–	–	–	10/29/06	–	–
–	–	–	–	–	–	12/30/05	–	–
–	–	–	–	–	–	12/24/05	–	–
–	–	–	–	–	–	12/30/05	–	–

Post-Katrina measurements were made at multiple sites along the affected areas of the Gulf Coast. These monitoring locations are shown in **Figures 2-1 and 2-2.**

Figure 2-1. Map of New Orleans with monitoring site locations and highways identified. Monitoring site locations are shown as green triangles (post-Katrina measurements only) or purple circles (pre- and post-Katrina measurements) with AQS site codes next to their locations. The Breton IMPROVE site (about 100 miles south of New Orleans) is not shown.

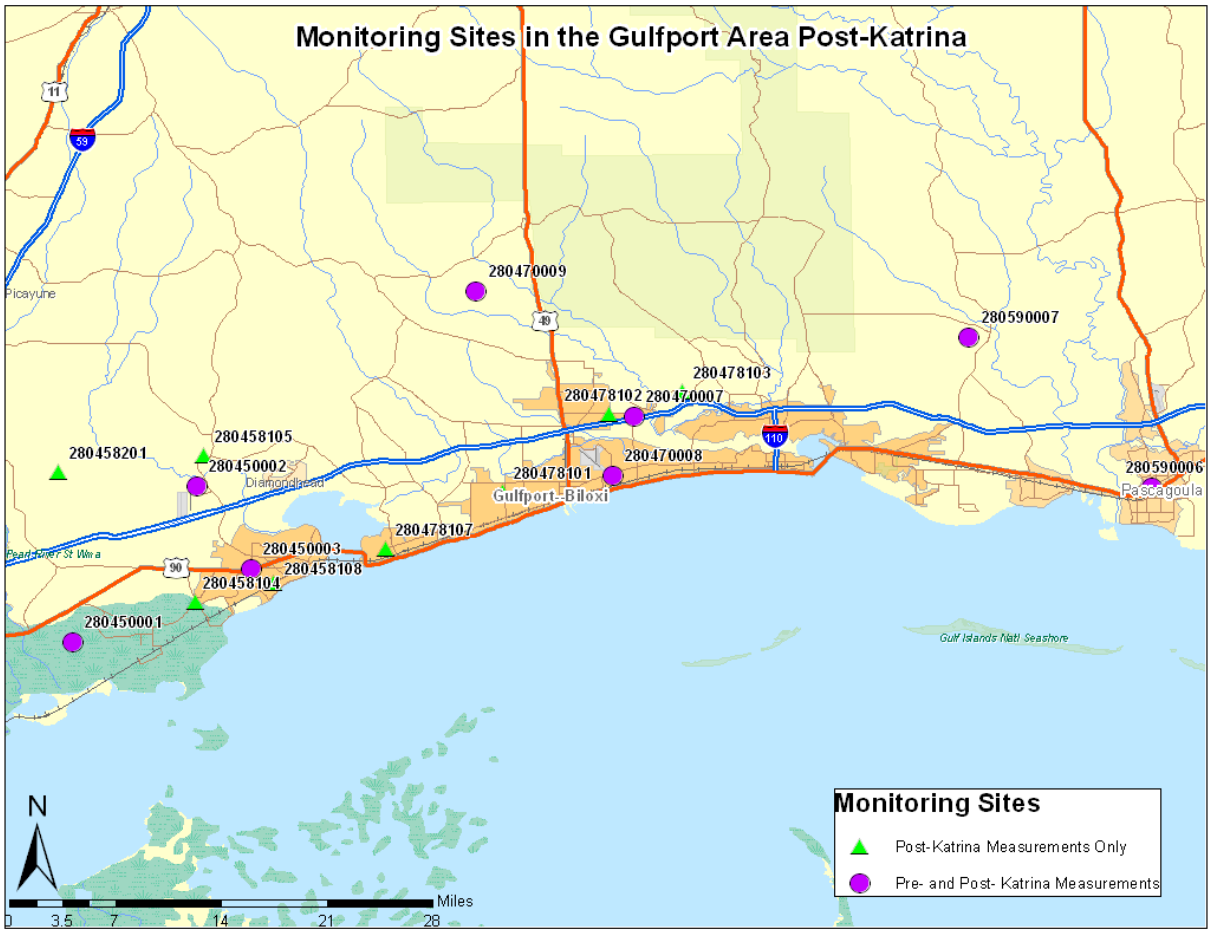

Figure 2-2. Map of the Gulfport/Pascagoula area with monitoring site locations and highways identified. Monitoring site locations are shown as green triangles (post-Katrina measurements only) or purple circles (pre- and post-Katrina measurements) with AQS site codes next to their locations.

Table 2-5 lists major sites and names and indicates which pollutant types were measured at those sites in the five years preceding Katrina. No sites in New Orleans measured toxic VOCs or PAHs pre-Katrina. In Mississippi, two sites were used to monitor VOCs and metals both pre- and post-Katrina. PAH measurements were added to one Mississippi site post-Katrina. Most monitoring sites in these areas were established post-Katrina.

Table 2-5. Site AQS codes, names, states, and descriptions of measurement types made at each site. Sites with measurements are marked with an X; those without measurements are indicated by a blank space. (Post Katrina includes October 1, 2005–September 30, 2006; Pre-Katrina includes January 1, 2000–September 30, 2005).

Site	State	Description	Criteria		Metal		PAH		VOC	
			Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina
220511001	LA	West Temple	X	X	X		X		X	
220512001	LA	Patriot Street	X	X	X		X		X	
220518105	LA	Bucktown	X		X		X		X	
220518106	LA	Lafreniere Park	X		X		X		X	
220518107	LA	Kawk Park	X		X		X		X	
220710010	LA	8801 Eagle Street	X	X	X					
220710012	LA	Florida/Orleans Avenue	X	X	X		X		X	
220710017	LA	Tulane Avenue	X							
220718104	LA	Palmer Park			X		X		X	
220718105	LA	Fire Training Academy	X		X		X		X	
220718106	LA	University of New Orleans	X		X		X		X	
220718107	LA	Jackson Square			X		X		X	
220718108	LA	U.S. Coast Guard			X		X		X	
220718109	LA	Fort Pike State Monument	X		X		X		X	
220718110	LA	Venetian Isles	X		X		X		X	
220718401	LA	Decatur and Elysian Fields	X		X					
220758400	LA	Main Street and Teal Road	X	X	X					
220759000	LA	Breton				X				
220870002	LA	Mehle Avenue		X	X		X		X	
220870004	LA	Nunez Street	X	X	X		X		X	
220878103	LA	Arabi	X		X					
220890003	LA	River Park Drive	X	X						
220890004	LA	Amelia Street			X		X		X	
220890005	LA	River Road	X	X	X					
220950002	LA	Azalea and S. Apricot	X	X						
220950003	LA	LaPlace				X				

Table 2-5. Site AQS codes, names, states, and descriptions of measurement types made at each site. Sites with measurements are marked with an X; those without measurements are indicated by a blank space. (October 1, 2005–September 30, 2006; Pre-Katrina includes January 1, 2000–September 30, 2005).

Site	State	Description	Criteria		Metal		PAH		VOC	
			Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina	Post-Katrina	Pre-Katrina
221038101	LA	Fritchie Park			X		X		X	
221038400	LA	Engineer Road and S. Range Road	X		X		X		X	
221038401	LA	Rerrace Avenue	X		X					
280450001	MS	Port Bienville Industrial Park		X						
280450002	MS	Stennis Airport	X	X						
280450003	MS	400 Baltic St		X						
280458104	MS	Lakeshore Dr and Lower Bay Rd	X		X					
280458105	MS	16148 Fire Dept Road	X		X					
280458108	MS	Central Avenue and Coleman Avenue	X							
280458201	MS	Stennis Space Center	X		X		X		X	
280470007	MS	Helen Richards Drive		X						
280470008	MS	47 Maple Street	X	X	X	X	X		X	X
280470009	MS	20121 W. Wortham Road	X	X						
280478101	MS	Klondyke Road	X		X					
280478102	MS	Dedeaux Road	X		X					
280478103	MS	Woolmarket Road	X		X					
280478107	MS	West North Street and Pirate Cove	X							
280590006	MS	County Health Department	X	X	X				X	X
280590007	MS	Highway 57 Vancleave	X	X						

2.2 TREATMENT OF DATA BELOW DETECTION

The method detection limit (MDL) is provided with the data used in this assessment. The MDL is used to determine the lowest concentration at which a substance is detected or is "present" in a sample. It is EPA policy to report concentrations at or below the MDL and above the instrument's detection limit (the lowest measurement distinguishable from instrument noise) with an appropriate quality control (QC) flag.

Data below MDL may still be useful for assessing trends in data over time and for determining that concentrations were below screening levels. Concentrations reported below the MDL were used for all analyses in this report, with the notable exception of the comparisons of ranges of concentrations shown in figures in Section 3.2. Because of the wide range of concentrations, some graphics in this report are based on a logarithmic scale; therefore, reported concentrations of zero were replaced with the lowest reported MDL value.

2.3 DATA REDUCTION APPROACH

Data that collected at sub-daily resolution (e.g., 1-hr or 3-hr samples) were used to derive daily metrics suitable for comparison to screening levels such as daily averages and 8-hr maximum values. These pollutants include NO_2, SO_2, ozone, and $PM_{2.5}$ (continuous monitors). To create daily averages from sub-daily values, we required 75% diurnal completeness. This requirement ensured adequate diurnal coverage and sample period coverage. For example, to calculate the daily average concentration value for a given day, a minimum of 18 samples for the day were required. To calculate the 8-hr maximum concentration for a given day, a minimum of 18 samples for the day and at least six of eight consecutive hours were required.

2.4 COMPARING CONCENTRATIONS PRE- AND POST-KATRINA

Concentration ranges (5th, 25th, 50th, 75th, and 95th percentile) for all pollutants measured in the New Orleans and Gulfport/Pascagoula areas as defined by core-based statistical area (CBSA or metropolitan area) post-Katrina (October 2005 through September 2006) were compared to concentration ranges from the same metropolitan area for January 2000–September 2005. For pollutants with insufficient measurements in the same area in previous years, concentration ranges were compared to data collected in the same state. The mean concentrations of post-Katrina data were also compared to mean concentrations of pre-Katrina data, with significant differences determined using the two-sample Kolmogorov-Smirnov (KS)-test. The KS-test is a non-parametric alternative to a traditional *t*-test applied when data are not normally distributed and when sample size is small ($n<100$). For pollutants with larger sample sizes (e.g., ozone, PM), a traditional *t*-test was used. The results of both the KS-test and the *t*-test indicate the probability that the difference in sample means is meaningful.

3. RESULTS AND DISCUSSION

This section discusses some of the major analyses performed, and the key results found, for pollutants measured in the Katrina-affected areas. First, we present analyses of those pollutants whose concentrations exceeded screening levels described earlier. These analyses include examining the frequency with which concentrations exceeded screening levels pre- and post-Katrina, examining site-specific time series analyses of pollutant concentrations, and comparing concentration ranges of these species pre- and post-Katrina. Then, we compared concentrations pre- and post-Katrina for pollutants that did not go above screening levels.

3.1 POLLUTANTS WITH MEASUREMENTS ABOVE SCREENING LEVELS

All pollutants measured were compared to screening levels developed by EPA. Pollutants for which there was at least one measurement above the screening level are listed in **Table 3-1**. Only 7 of the more than 80 pollutants examined had concentrations greater than screening levels. Of note, the samples of $PM_{2.5}$ mass and nickel (TSP) were above the screening level in New Orleans at two sites on the same day, which may be indicative of an event with a relatively large spatial extent, but low temporal frequency.

Table 3-1. Number of individual samples that were above screening levels in the affected areas (multiple monitors and days).

			Post-Katrina			Pre-Katrina		
Pollutant	City	No. of Sites	No. of Samples Above Screening Level	Total Samples	Percent of Samples Above Screening Level	No. of Samples Above Screening Level	Total Samples	Percent of Samples Above Screening Level
Acetonitrile	Gulfport-Biloxi	1	1	246	<1	0	97	0
Acrolein	Gulfport-Biloxi	2	164	246	67	Not Measured		
Acrolein	New Orleans	1	70	99	71			
Acrolein	Pascagoula	1	67	101	66			
Formaldehyde	Pascagoula	1	6	112	5	1	110	0.91
Manganese (TSP)	New Orleans	2	2	1150	<1	Not Measured		
Nickel (TSP)	New Orleans	4	6	1148	<1			
PM_{10}	New Orleans	1	1	1126	<1	0	1333	0
$PM_{2.5}$	Gulfport-Biloxi	2	8	1416	<1	13	3737	0.35
$PM_{2.5}$	New Orleans	4	7	1770	<1	18	7245	0.25

3.1.1 Time Series and Case Studies

Acrolein is the only pollutant that regularly exceeded screening levels (0.09 µg/m^3) in both Mississippi and Louisiana. Further evaluation showed that concentrations measured post-Katrina are similar to concentrations observed elsewhere in the United States and were not necessarily caused by Katrina or recovery-related emissions. **Figure 3-1** shows the concentration ranges of acrolein during the first year post-Katrina by EPA region and for the New Orleans and Gulfport/Pascagoula areas. Although the New Orleans and Gulfport/Pascagoula areas showed higher median concentrations than some regions, their concentrations are very similar to those in EPA Regions 4 and 6, regions that encompass these areas. The detection limit for acrolein varied by sample and was not always below the screening level. When the detection limit is greater than the screening level, and the sample concentration is reported below the detection level, it is not possible to determine with confidence whether the sample concentration is above or below the screening level. The detection limit was above the screening level for about 50% of samples collected in each region. An additional analysis of acrolein concentrations from the first quarter post-Katrina is discussed in Appendix A.

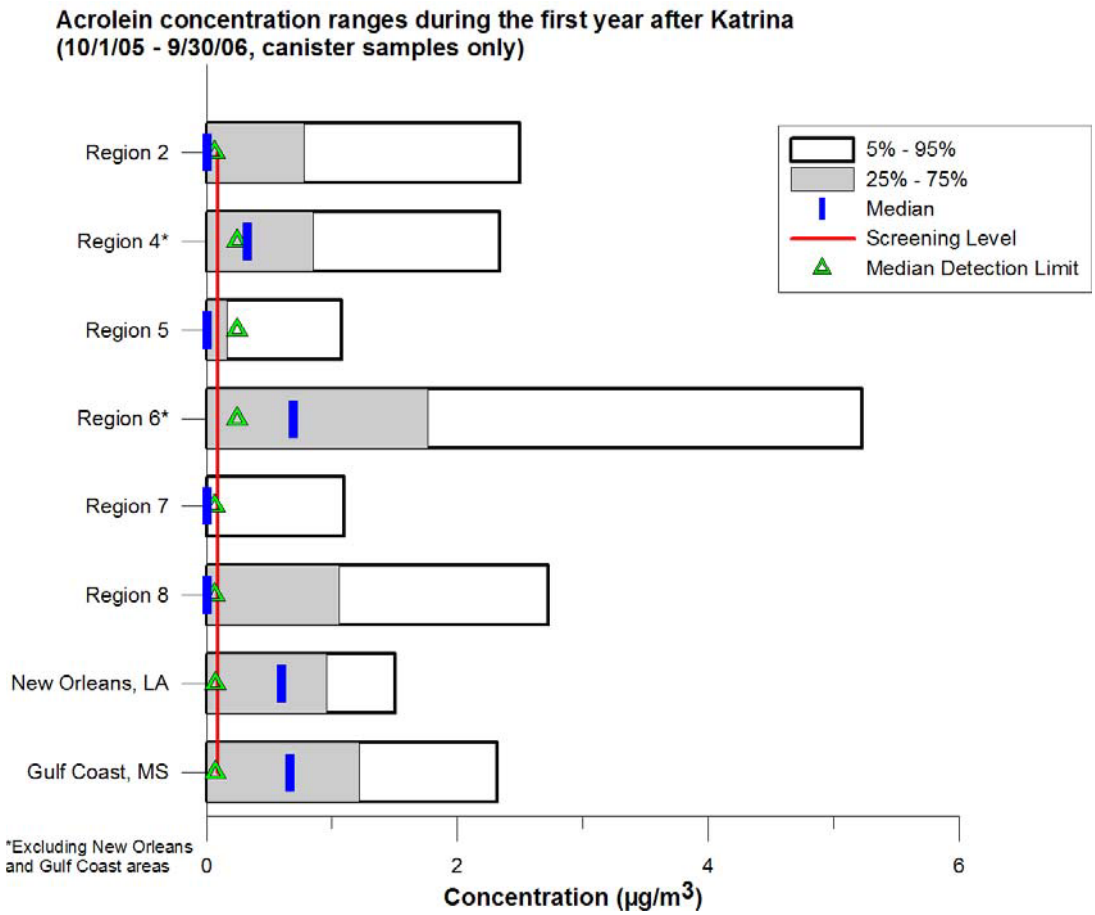

Figure 3-1. Acrolein concentration ranges by EPA region and for the New Orleans and Gulfport/Pascagoula areas post-Katrina. Note comparable data from Regions 1, 3, and 9 were not available.

EPA national-scale modeling work has separately identified acrolein as a pollutant needing attention nationally (see <http://www.epa.gov/ttn/atw/nata1999/>).

Formaldehyde concentrations were above the screening level on six days sampled post-Katrina at one monitoring site in the Pascagoula, Mississippi, area. This rate is noticeably higher than the previous rate of values above the screening level in this area (i.e., one sample above the screening level out of 110 samples). Daily concentrations of formaldehyde measured in Mississippi post-Katrina are shown in **Figure 3-2**. Concentrations of formaldehyde at the Pascagoula, Mississippi, site (Health Department on Hospital Road across from a Katrina recovery staging area) exceeded the screening level early in the post-Katrina monitoring period in October and November 2005. These high concentrations appear to be important only on a local scale, since the concentrations in Gulfport and New Orleans were not high during these months. Concentrations at the Pascagoula, Mississippi, site then dropped to levels below the screening level, although they were still typically higher than those in Gulfport or New Orleans. Formaldehyde is typically emitted from incomplete combustion processes or from photo-oxidation of other hydrocarbons. However, concentrations of other VOCs that form formaldehyde were not high enough to account for the high formaldehyde values. It is more likely that the formaldehyde concentrations were a result of direct emissions from some nearby source. Formaldehyde is also emitted from medical laboratories and mortuaries and found in products such as particle board, glue, paper product coatings, and plywood.

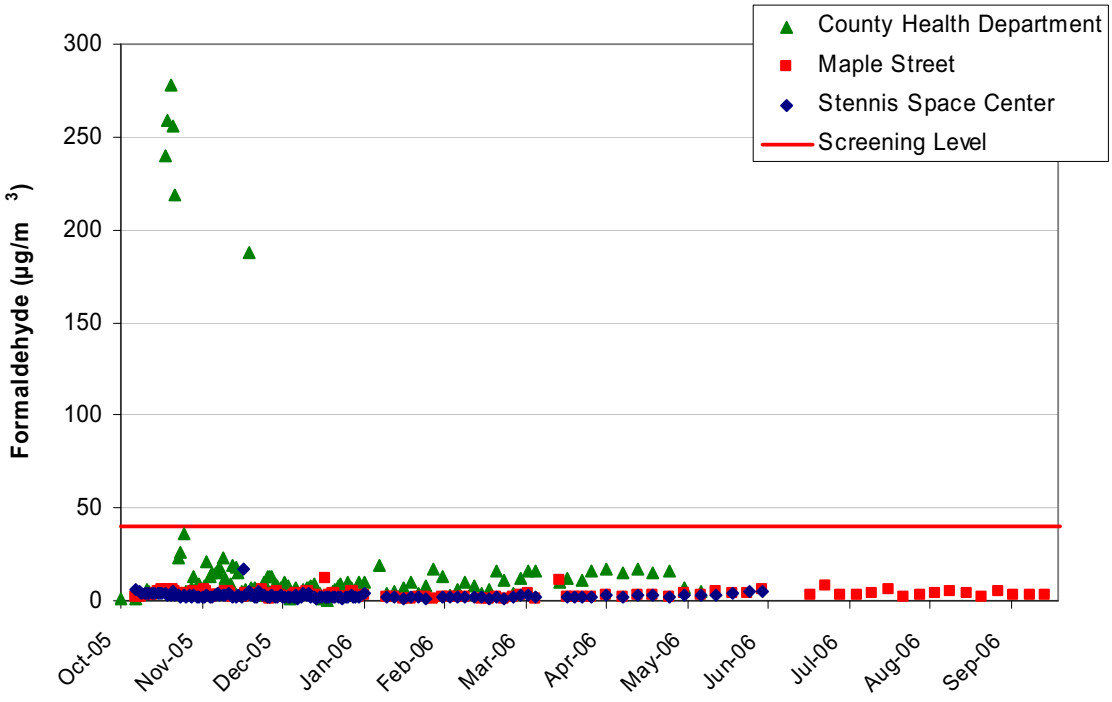

Figure 3-2. Time series of formaldehyde concentrations (µg/m^3) in Gulfport (red squares, Maple Street; blue diamonds, Stennis Space Center) and Pascagoula, Mississippi (green triangles, County Health Department), post-Katrina.

A single sample of acetonitrile collected at the Gulfport site was higher than the screening level of 600 $\mu g/m^3$. In comparison, no samples were above the screening level in Mississippi for 2000-2005 (491 samples). The single sample was significantly higher than typical concentrations in the same area (e.g., 2,031 $\mu g/m^3$ compared to a median concentration for the area of 3 $\mu g/m^3$). However, six acetonitrile samples were greater than 200 $\mu g/m^3$ in the Gulfport-Biloxi area in fourth quarter 2005, and all sites in Mississippi (including Tupelo) reported acetonitrile concentrations higher than 100 $\mu g/m^3$ both pre- and post-Katrina. These high acetonitrile concentrations may be due to sampling error introduced by the collection method. Acetonitrile is used to clean dinitrophenylhydrazine (DNPH) cartridges which are often attached to the same sampling manifold as canisters used to sample ambient air. If concentrations were real and not a sampling artifact, possible acetonitrile emissions sources include mobile sources, chemical solvents, petrochemical industry, and thermal decomposition of foam products.

$PM_{2.5}$ exceeded the screening level seven days post-Katrina in the New Orleans area and eight days in the Gulfport/Pascagoula area. PM_{10} exceeded the screening level on one day in New Orleans post-Katrina. The frequency of $PM_{2.5}$ mass exceedances was lower than the frequency of exceedances observed in Louisiana and Mississippi pre-Katrina on a percentage basis. On the other hand, PM_{10} mass had not exceeded the screening level in other areas of Louisiana in the previous five years. Concentrations of PM_{10} that exceeded the screening level at the Florida/Orleans Avenue site were higher than those at other sites in the New Orleans area (**Figure 3-3**). It is possible that concentrations were higher at this site due to the collection or grinding of debris at early collection sites in the vicinity (**Figure 3-4**). The high PM_{10} concentration was isolated spatially and is likely due to local emissions, which appeared to have little influence on other areas of New Orleans.

Concentrations of nickel (TSP) were above the screening level at the West Temple, LaFreniere, Fire Training Academy (two different POCs) and Nunez Street sites on five days. **Figure 3-5** shows concentrations of nickel (TSP) at these sites in New Orleans. All sites measured concentrations of nickel (TSP) that were typically below the MDL (and reported as zeroes), with the exception of a few events. On these days, concentrations were above both the MDL and the screening level. However, at the same sites, nickel $PM_{2.5}$ concentrations were more than two orders of magnitude lower in concentration on the same day, and were far below the screening level. All nickel $PM_{2.5}$ concentrations were below 0.01 $\mu g/m^3$, except one sample at Fire Training Academy (0.0684 on December 9, 2005). It is unclear what caused nickel (TSP) concentrations to be significantly higher at these sites without impacting nickel $PM_{2.5}$ concentrations at the same time.

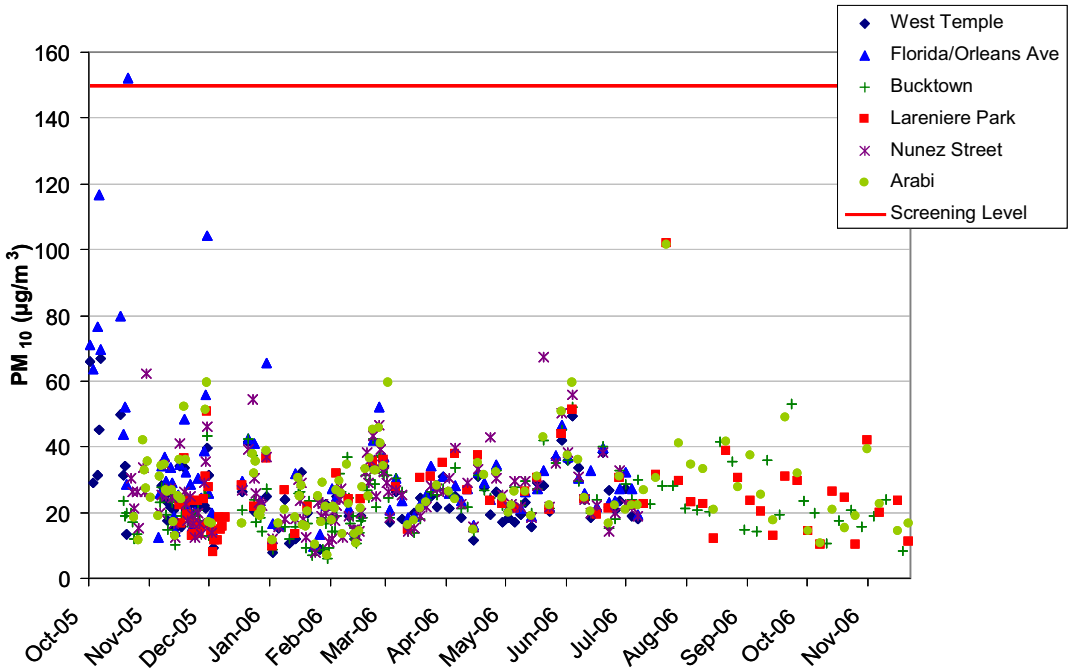

Figure 3-3. Time series of PM_{10} mass concentrations measured at sites in New Orleans. The highest concentrations were at the Florida/Orleans Avenue site in central New Orleans. Only sites with more than 75 samples are shown.

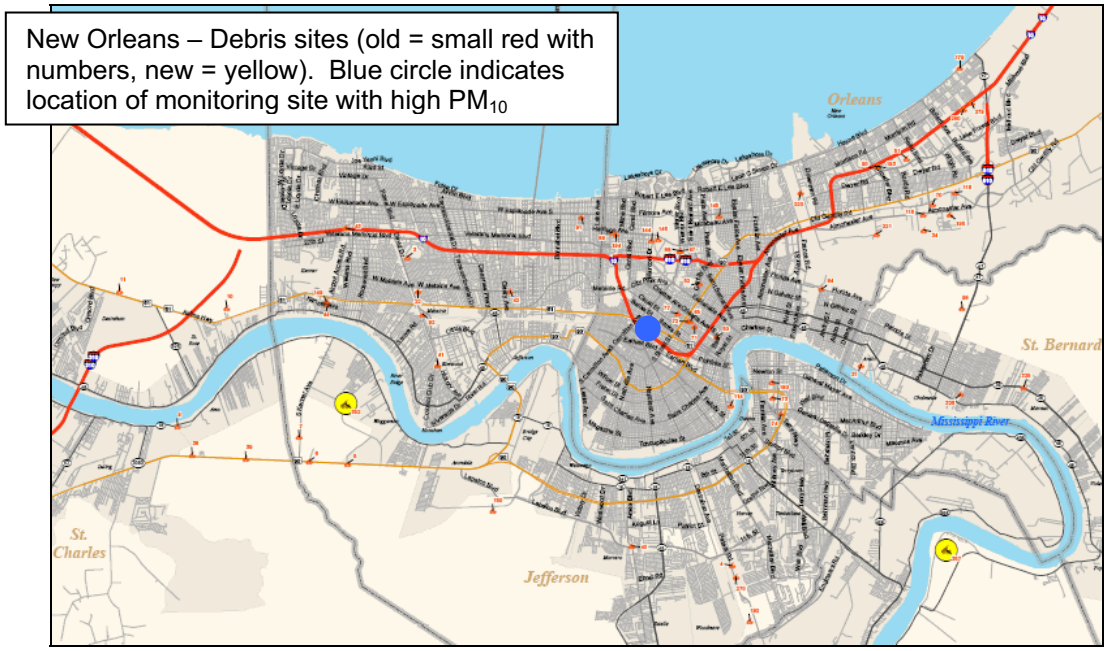

Figure 3-4. Debris collection sites approved in New Orleans (February 2006). These sites were all approved for grinding/burning/landfill activities, but not all of them were actually in use (map from Louisiana Department of Environmental Quality, <http://map.ldeq.org>).

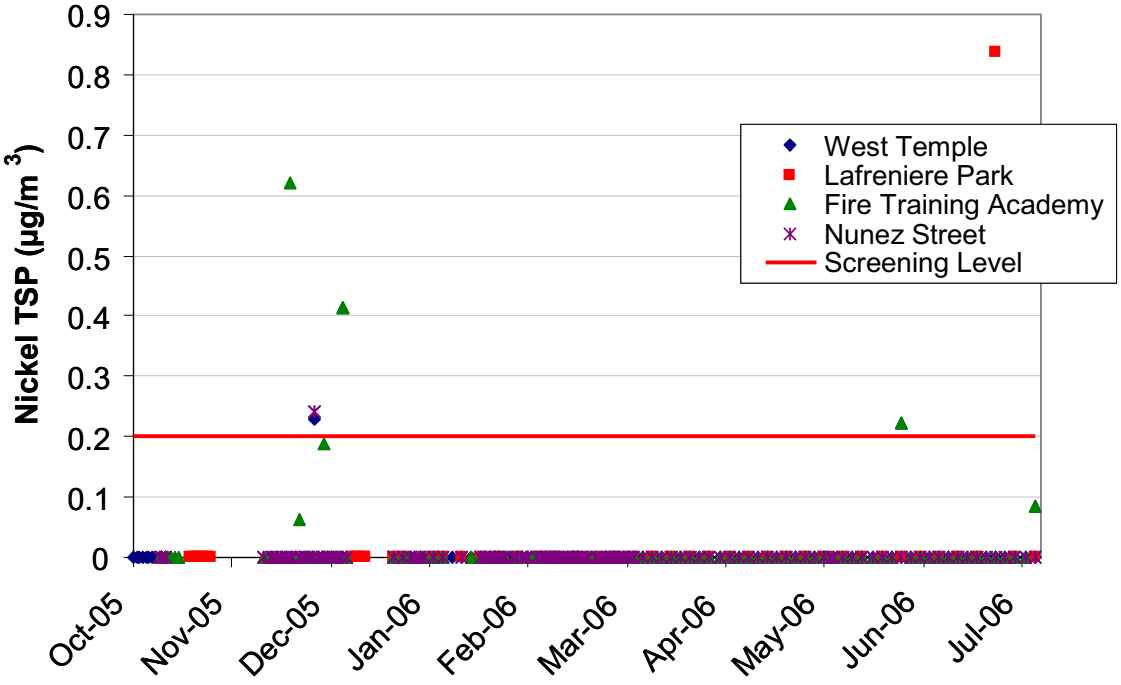

Figure 3-5. Time series of nickel (TSP) concentrations (µg/m^3) at selected sites. Most nickel (TSP) measurements were below MDL and were reported as zeroes.

Manganese (TSP) exceeded the screening level at two sites on separate dates (**Figure 3-6**). At Kawk Park, manganese (TSP) was not detected on any other days. No manganese ($PM_{2.5}$) measurements were available from either site.

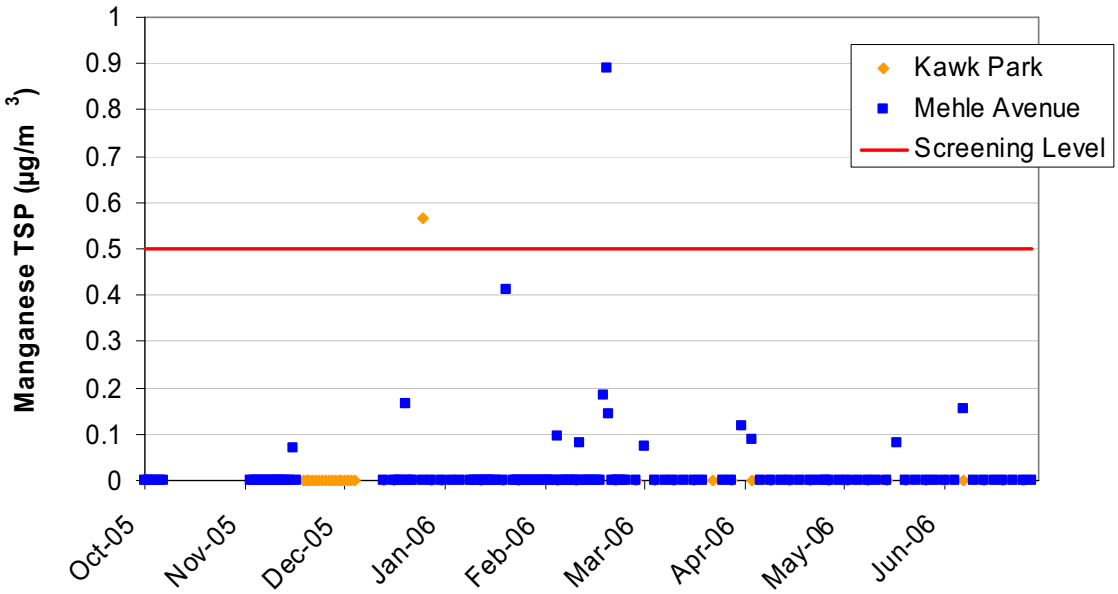

Figure 3-6. Time series of manganese (TSP) concentrations (µg/m^3) at selected sites.

3.1.2 Comparing Concentration Ranges Pre- and Post-Katrina

Table 3-2 lists comparisons of concentrations for data collected in the Gulf Coast area before and after Katrina. These tables indicate whether post-Katrina concentrations were higher, lower, or the same (i.e., indistinguishable) compared to pre-Katrina concentrations in the same area (or from the whole state if data from the same area were not available). Comparisons show whether mean concentrations (statistically significant at 95% level) and distributions of concentrations (qualitative) pre- and post-Katrina increased, decreased, or were equal or similar in the same area. Note that at least one sample of manganese (TSP), nickel (TSP) and acrolein was above the screening level in New Orleans, and at least 1 sample of acrolein was above the screening level in Gulfport/Pascagoula; however, a sufficient number of pre-Katrina samples of these species were not available for this comparison. When compared to data from the same area pre-Katrina, some differences were observed in the ranges of concentrations of criteria pollutants for both the Gulfport/Pascagoula and New Orleans areas. For example, PM_{10} and $PM_{2.5}$ concentrations in New Orleans were significantly higher post-Katrina.

Average concentrations of formaldehyde and acetonitrile were significantly higher than those previously monitored in Mississippi. As mentioned previously, acrolein was compared to concentrations at National Air Toxics Trends Stations (NATTS) during the same time period.

Table 3-2. Comparison of pollutant concentrations pre- and post-Katrina by *t*-test or KS-test and distribution for each pollutant with at least one sample with concentrations above screening levels. Orange = higher after the storm than before; no shading = similar; blank cell = no data or no comparison made.

Pollutant	Area	Type	Same Area	
			KS/*t*-test	Distribution
Formaldehyde	Gulfport/Pascagoula	VOC	Higher	Higher
Acetonitrile	Gulfport/Pascagoula	VOC	Higher	Similar
PM_{10}	New Orleans	Criteria	Higher	Higher
$PM_{2.5}$	New Orleans	Criteria	Higher	Higher
$PM_{2.5}$	Gulfport/Pascagoula	$PM_{2.5}$	Higher	Higher

3.2 EXAMINING POLLUTANTS WITH NO CONCENTRATIONS ABOVE SCREENING LEVELS

Temporal and spatial trends in concentrations may provide insight into changes in emissions in the New Orleans and Gulfport/Pascagoula areas post-Katrina. This section shows interesting time series of concentrations in the affected areas, shows comparisons of concentrations pre- and post-Katrina, and investigates pollutants with significant portions of data reported below MDLs.

3.2.1 Comparisons of Concentrations Before and After Katrina

Tables 3-3 and 3-4 provide a list of the comparisons in concentrations for data collected in the Gulf Coast area before and after Katrina. These tables indicate whether post-Katrina concentrations were higher, lower, or the same (i.e., indistinguishable) as pre-Katrina concentrations in the same area (or from the whole state if data from the same area were not available). Post-Katrina monitoring data include all available data from October 2005 through September 2006. Pre-Katrina monitoring data include all available data from January 2000 to September 2005. The data were not adjusted for meteorology, which can significantly impact some species (particularly secondary species). Therefore, changes in concentrations may be due to changes in meteorological conditions rather than changes in emissions. Species were selected based on the availability of comparable pollutants pre-Katrina in the affected areas or same state. In addition, more than 25% of measurements post-Katrina had to be above the MDL for purposes of the comparison. Some differences were observed in the ranges of concentrations of criteria pollutants for both the Gulfport/Pascagoula area and the New Orleans area, pre- and post-Katrina.

Table 3-3. Comparison of pollutant concentrations pre- and post-Katrina by *t*-test or KS-test and distribution for Gulfport/Pascagoula areas. Comparisons show whether mean concentrations (statistically significant at 95% level) and distributions of concentrations (qualitative) pre- and post-Katrina were higher, lower, or equal or similar in either Gulfport/Pascagoula or all of Mississippi. Green = lower after the storm than before; orange = higher after the storm than before; no shading = similar; blank = no data or no comparison.

Pollutant	Type	KS/*t*-test	Distribution
Ozone 1-hr max	Criteria	Higher	Similar
Ozone 8-hr max	Criteria	Equal	Similar
$PM_{2.5}$	Criteria	Higher	Higher
Nitrogen Dioxide	Criteria	Higher	Higher
Sulfur Dioxide	Criteria	Lower	Lower
Arsenic ($PM_{2.5}$)[a]	Metal	Lower	Lower
Lead ($PM_{2.5}$)	Metal	Higher	Higher
Antimony ($PM_{2.5}$)[a]	Metal	Lower	Lower
Cadmium ($PM_{2.5}$)[a]	Metal	Lower	Similar
Chromium ($PM_{2.5}$)[a]	Metal	Lower	Similar
Manganese ($PM_{2.5}$)[a]	Metal	Lower	Lower
Nickel ($PM_{2.5}$)[a]	Metal	Lower	Lower
Selenium ($PM_{2.5}$)[a]	Metal	Lower	Lower
Acrolein	VOC	Equal	Similar
Benzene	VOC	Lower	Lower
m-&p-Xylene	VOC	Lower	Lower
o-Xylene	VOC	Lower	Lower
Toluene	VOC	Lower	Lower
Acetaldehyde	VOC	Higher	Higher
Carbon Tetrachloride	VOC	Higher	Higher
Chloroform	VOC	Higher	Higher
Dichloromethane	VOC	Lower	Higher
Formaldehyde	VOC	Higher	Higher
1,4-Dichlorobenzene	VOC	Higher	Similar
2,2,4-Trimethylpentane	VOC	Lower	Lower
Acetone	VOC	Higher	Higher
Acetonitrile	VOC	Higher	Similar
Chloromethane	VOC	Higher	Higher
Ethylbenzene	VOC	Lower	Lower
Methyl Chloroform	VOC	Higher	Higher
N-Hexane	VOC	Equal	Lower
Propionaldehyde	VOC	Higher	Higher
Propylene	VOC	Lower	Lower
Styrene	VOC	Higher	Higher

[a] Possibly lower due to changes in detection limit

Table 3-4. Comparison of pollutant concentrations pre- and post-Katrina by *t*-test or KS-test and distribution for the New Orleans area. Comparisons show whether mean concentrations (statistically significant at 95% level) and distributions of concentrations (qualitative) pre- and post-Katrina were higher, lower, or equal or similar in New Orleans, all of Louisiana, or similar counties. Green = lower after the storm than before; orange = higher after the storm than before; no shading = equal; blank = no data or no comparison.

Pollutant	Type	KS/*t*-test; New Orleans	Distribution; New Orleans	KS/*t*-test; Louisiana	Distribution; Louisiana
Ozone – 1-hr	Criteria	Higher	Higher		
Ozone – 8-hr	Criteria	Higher	Higher		
PM_{10}	Criteria	Higher	Higher		
$PM_{2.5}$	Criteria	Higher	Higher		
CO	Criteria	Equal	Similar		
Nitrogen Dioxide	Criteria	Lower	Lower		
Sulfur Dioxide	Criteria	Higher	Lower		
Arsenic ($PM_{2.5}$)	Metal			Higher	Higher
Lead ($PM_{2.5}$)	Metal	Higher[a]	Higher[a]	Higher	Higher
Antimony ($PM_{2.5}$)	Metal			Lower	Similar
Cadmium ($PM_{2.5}$)	Metal			Lower	Similar
Chromium ($PM_{2.5}$)	Metal	Higher[a]	Higher[a]	Higher	Higher
Manganese ($PM_{2.5}$)	Metal	Higher[a]	Higher[a]	Higher	Higher
Mercury ($PM_{2.5}$)	Metal			Higher	
Nickel ($PM_{2.5}$)	Metal	Higher[a]	Higher[a]	Higher	Higher
Selenium ($PM_{2.5}$)	Metal	Lower[a]	Lower[a]	Lower	Lower
Benzene	VOC			Lower	Lower
M/P-Xylene	VOC			Higher	Higher
Toluene	VOC			Higher	Higher
Acetaldehyde	VOC			Higher	Higher
Dichloromethane	VOC			Higher	Higher
Formaldehyde	VOC			Equal	Higher
2,2,4-Trimethylpentane	VOC			Equal	Similar
Acetone	VOC			Lower	Lower
Chloroethane	VOC			Equal	Similar
Chloromethane	VOC			Equal	Higher
N-Hexane	VOC			Higher	Higher
Propylene	VOC			Lower	Lower

[a] Compared to Breton site only

Figures 3-7 through 3-10 show comparisons of the pre- and post-Katrina concentration distributions of pollutant types (e.g., VOCs, metals). These plots were used to qualitatively determine if the concentration distribution for a given pollutant and area had substantially changed after Katrina. Not all pollutants are shown in these figures.

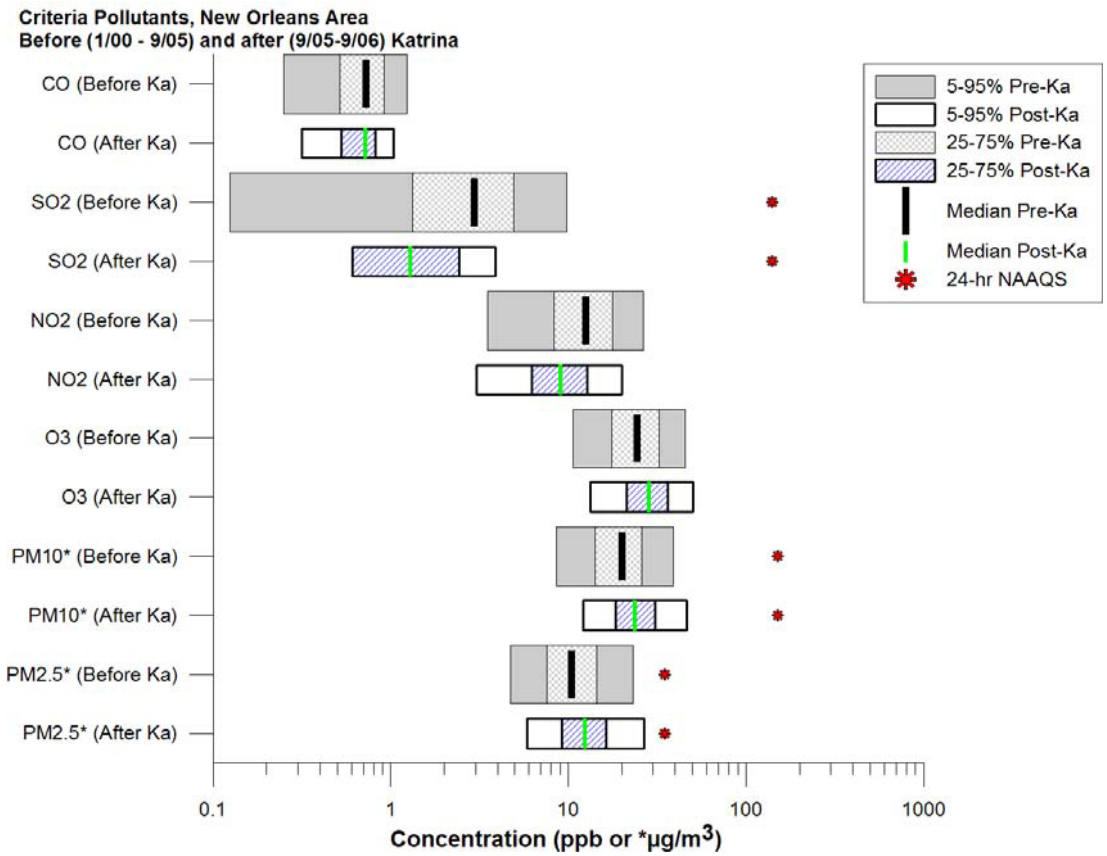

Figure 3-7. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of selected criteria pollutants in the New Orleans area. Levels of the NAAQS are shown as red asterisks. Note that this plot shows concentrations on a log scale.

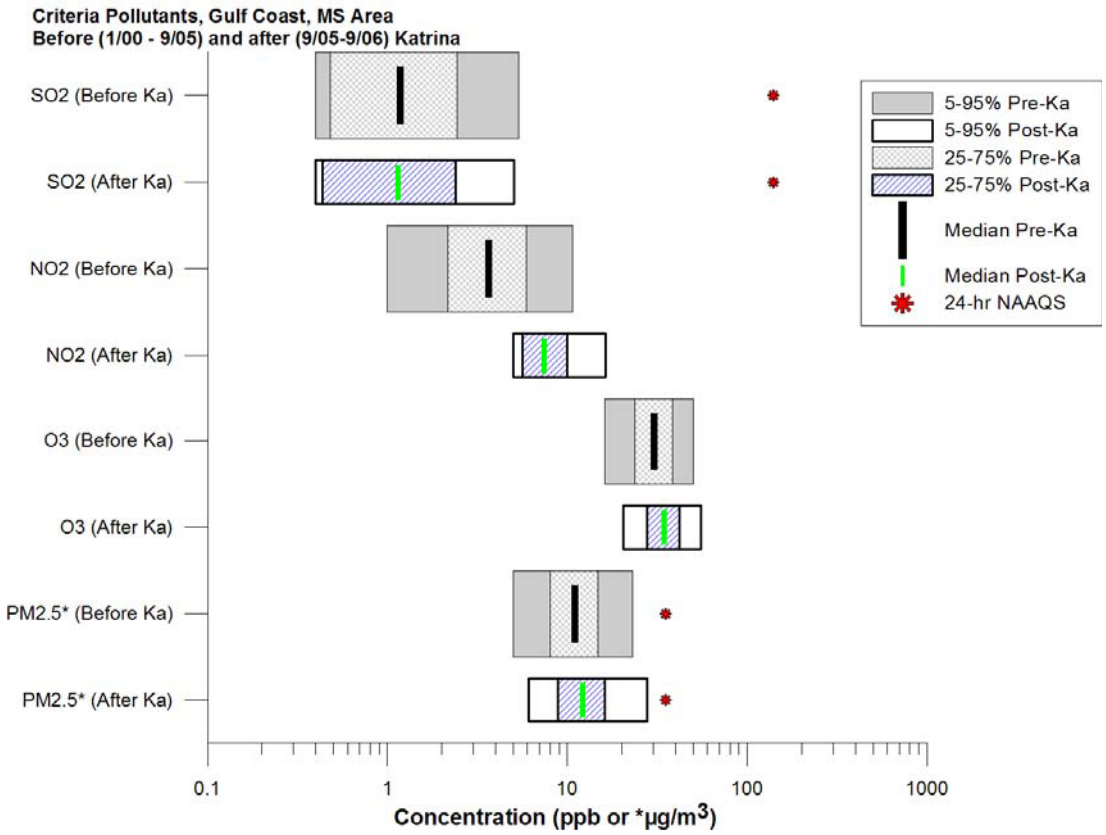

Figure 3-8. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of some criteria pollutants in the Gulfport/Pascagoula area. Levels of the NAAQS are shown as red asterisks. Note that this plot shows concentrations on a log scale.

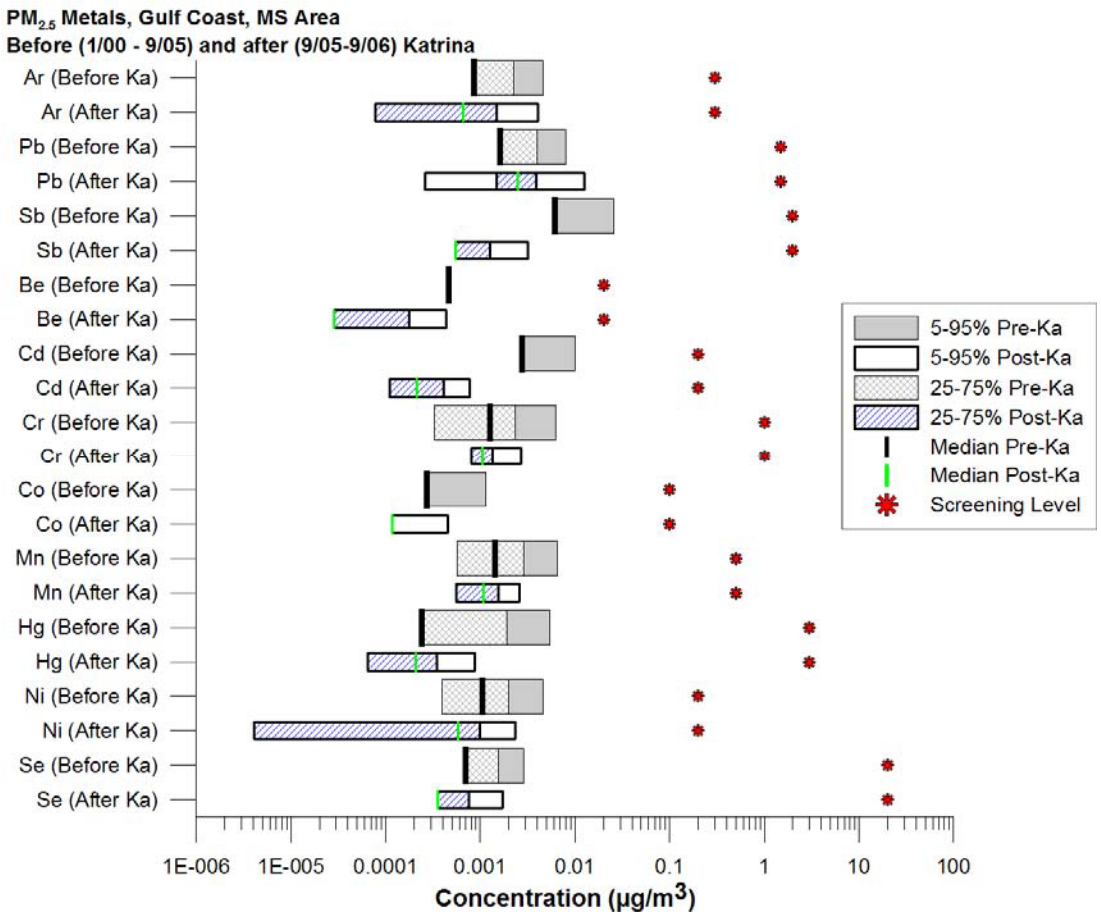

Figure 3-9. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of selected $PM_{2.5}$ metals in the Gulfport/Pascagoula area. Screening levels are shown as red asterisks. Note that this plot shows concentrations on a log scale. Also note that concentration values reported below the detection limit (as zeroes) were replaced with MDL values, which is often the lower bound for both the 5th, 25th, and median concentrations.

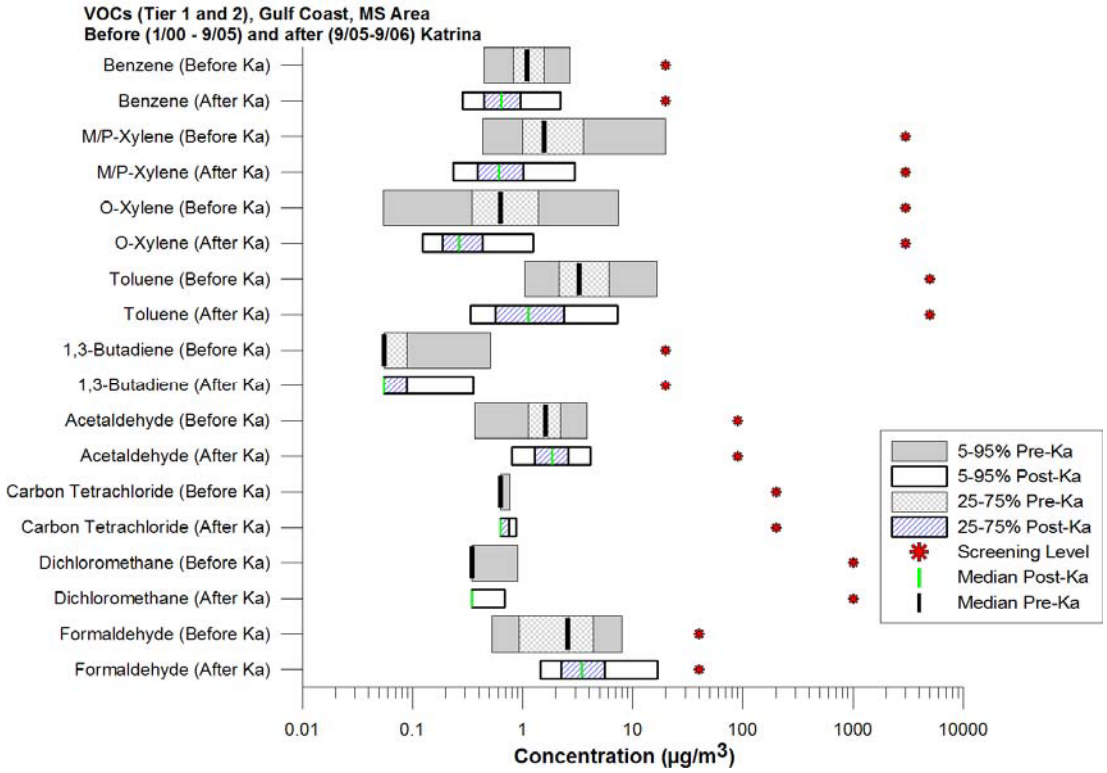

Figure 3-10. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of selected VOCs in the Gulfport/Pascagoula area. Screening levels are shown as red asterisks. Note that this plot shows concentrations on a log scale. Also note that concentration values reported below the detection limit (as zeroes) were replaced with MDL values, which is often the lower bound for both the 5th, 25th, and median concentrations.

In New Orleans, the following observations of concentrations before and after Katrina were made:

- The mean concentrations of PM_{10} and $PM_{2.5}$ mass increased relative to those in previous years. Increased concentrations of PM_{10} and $PM_{2.5}$ mass could be a result of enhanced fugitive dust emissions caused by construction and demolition equipment. Additional analysis of the composition of PM_{10} and $PM_{2.5}$ at some sites could be performed to determine how the individual components of PM have changed over time and to better understand possible sources. **Figure 3-11** shows trends in PM_{10} and $PM_{2.5}$ in New Orleans.
- Average concentrations of several VOCs, including acetaldehyde, m-&p-xylene, toluene, dichloromethane, and n-hexane were statistically significantly higher post-Katrina.
- Average concentrations of most $PM_{2.5}$ metals, including arsenic $PM_{2.5}$, lead $PM_{2.5}$, chromium $PM_{2.5}$, mercury $PM_{2.5}$ and nickel $PM_{2.5}$ were statistically significantly higher post-Katrina.
- NO_2 showed statistically significant decreases in average concentration post-Katrina. Decreased concentrations of NO_2 could be a result of reduced vehicle traffic.

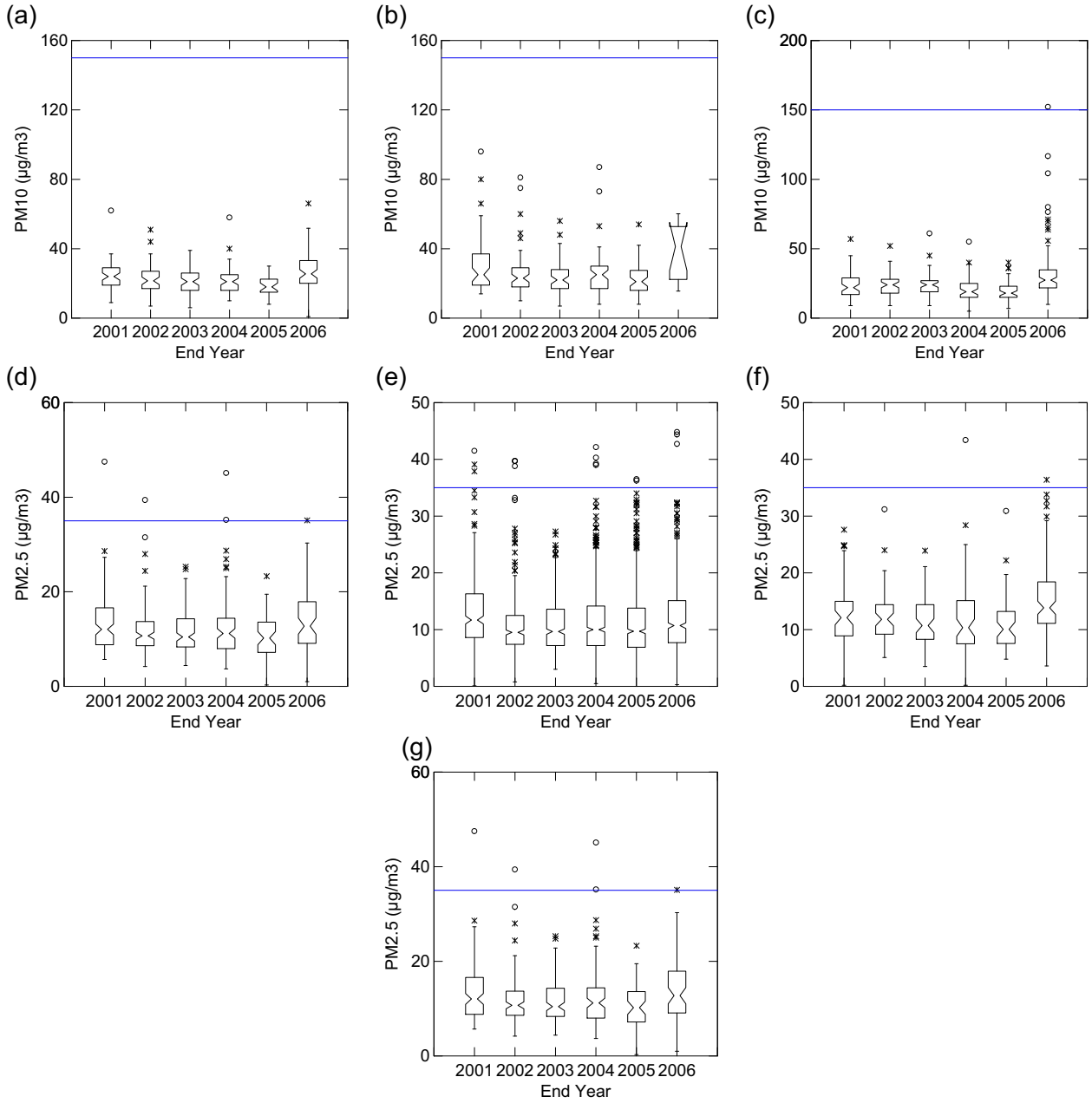

Figure 3-11. Trends in measured concentrations of PM_{10} or $PM_{2.5}$ at (a) Eagle Street, (b) River Road, (c) Florida/Orleans Avenue, (d) Eagle Street, (e) West Temple, (f) Patriot Street, and (g) Nunez Street. Blue lines show the daily average NAAQS for PM_{10} (150 µg/m^3) and $PM_{2.5}$ (35 µg/m^3). Each box represents 12 months of data ending September 30 of the year shown; for example, the first notched box in each plot represents data from October 1, 2000–September 30, 2001. Note that the NAAQS are not based on a single exceedance.

The following observations were made about concentrations reported at sites in the Gulfport/Pascagoula area:

- The concentrations of NO_2, $PM_{2.5}$ mass, and ozone 1-hr maximum were higher post-Katrina than in previous years. The increases in NO_2 may be explained by an increase in diesel vehicle emissions related to cleanup and construction activities.
- Concentrations of lead were higher after Katrina. Lead is usually emitted from metal industries (e.g., lead smeltering). More information about industrial activity in the New Orleans area should be investigated to explore the higher lead concentrations.
- Several carbonyl compound concentrations were higher post-Katrina, including acetaldehyde and formaldehyde.
- Concentrations of carbon tetrachloride were higher, but the increase may actually be due to issues of reporting previous measurements. Carbon tetrachloride concentrations were largely dominated by background concentrations (McCarthy et al., 2006).[3] Remote background concentrations of carbon tetrachloride did not dip below 0.5 $\mu g/m^3$ from 2000 through 2005, but concentrations were often reported as zero $\mu g/m^3$, (i.e., no concentration was detected). These concentrations appear to be a result of an MDL too high to accurately measure carbon tetrachloride.
- Concentrations of $PM_{2.5}$ metals decreased on average. However, this apparent decrease is likely due to the lower detection limits post-Katrina.

3.2.2 Comparisons to Other Sites Within the State

Concentrations of non-criteria pollutants were not measured in the New Orleans area from 2000 through 2005; therefore, post-Katrina data were compared to concentrations measured elsewhere in Louisiana (mostly Baton Rouge, see **Figures 3-12** and **3-13**). While concentrations may have increased or decreased relative to those in other areas, these comparisons should only be considered a qualitative assessment of relative concentrations due to possible spatial differences of emissions and ambient concentrations. Concentration ranges were relatively similar for New Orleans and the rest of Louisiana; most concentrations were within about a factor of two.

Detection limits for metals were lower in fourth quarter 2005 than previously reported at Mississippi sites. For pollutants that were generally at or below detection, direct comparison was not available.

[3] McCarthy M.C., Hafner H.R., and Montzka S.A. (2006) Background concentrations of 18 air toxics for North America. *J. Air & Waste Manage. Assoc.* **56**, 3-11 (STI-903550-2589).

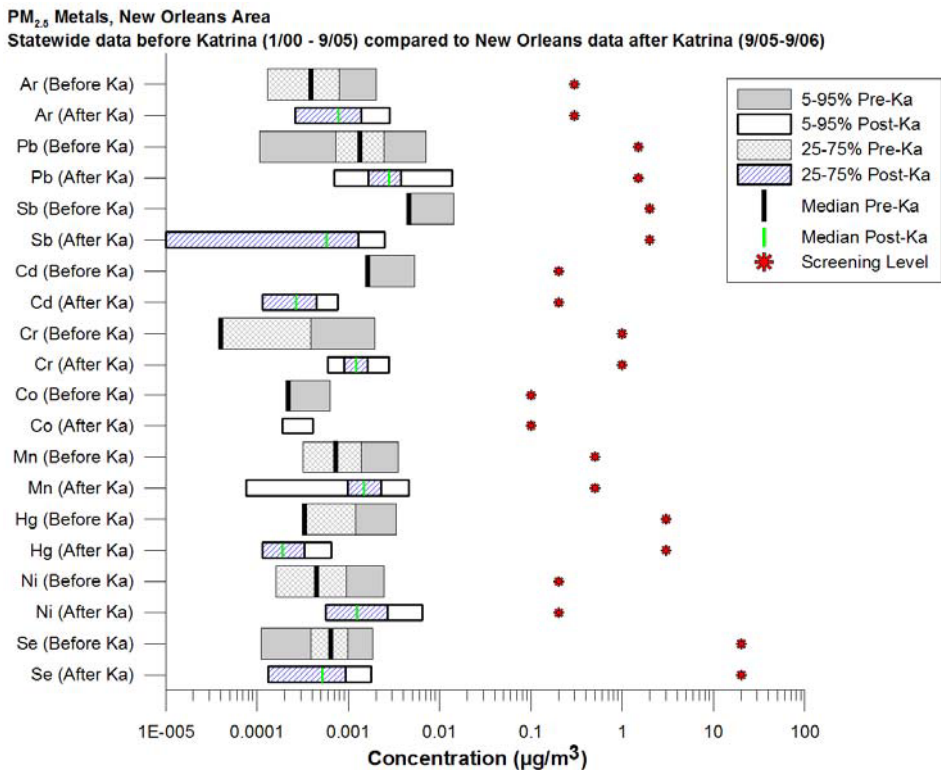

Figure 3-12. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of selected $PM_{2.5}$ metals in New Orleans. Screening levels are shown as red asterisks. Note that this plot shows concentrations on a log scale. Also note that concentration values reported below the detection limit (as zeroes) were replaced with MDL values, which is often the lower bound for both the 5th, 25th, and median concentrations.

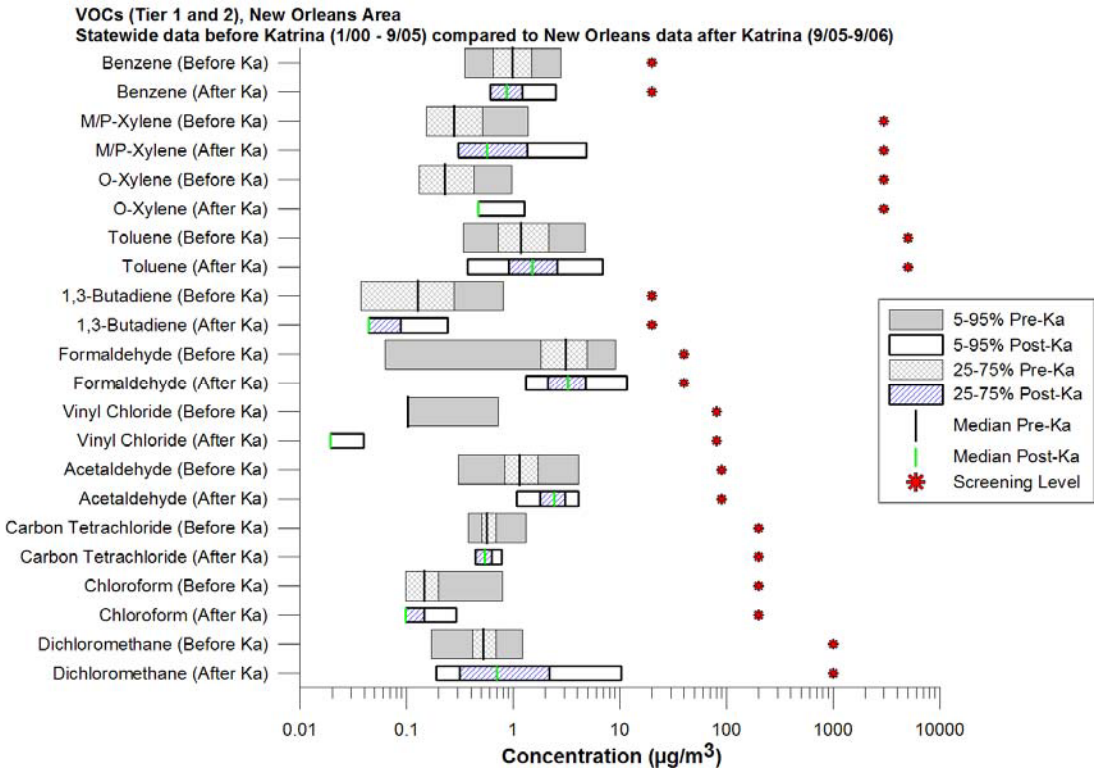

Figure 3-13. Comparison of before (wide bars) and after (narrow bars) Katrina concentration ranges of selected VOCs in New Orleans. Screening levels are shown as red asterisks. Note that this plot shows concentrations on a log scale. Also note that concentration values reported below the detection limit (as zeroes) were replaced with MDL values, which is often the lower bound for both the 5th, 25th, and median concentrations.

4. CONCLUSIONS

Air quality in the New Orleans and Gulfport/Pascagoula areas was examined for the first year after Hurricane Katrina to determine if the flooding and cleanup efforts in these areas had an impact on air quality. Multiple sites sampled for criteria pollutants, metals, VOCs, and PAHs, including several sites established immediately after Hurricane Katrina. Concentrations of these pollutants were first compared to screening levels (established by EPA). Screening levels were designed to provide longer-term (months to a year) exposure levels that would not be associated with appreciable risk of effects. Accordingly, individual sample results greater than the screening levels do not imply an immediate health threat. Only 7 pollutants, out of over 80 pollutants measured, had at least one sample with concentrations above the screening level in one or both of the areas of interest. Acrolein was the only pollutant to regularly exceed the screening level; however, concentrations of acrolein in the Katrina-affected areas were similar to concentrations seen throughout the region and do not appear to be driven by Katrina-related activities. Formaldehyde concentrations exceeded the screening level 6 times (5 percent of all samples) at one site in what appears an isolated event. The other pollutants that exceeded the screening level—acetonitrile, PM_{10} mass, $PM_{2.5}$ mass, manganese (TSP), and nickel (TSP)—did so in less than 1 percent of samples.

Only a few sites in each area measured these pollutants before Katrina. When available, these measurements were compared to samples collected after Katrina. In the Gulfport/Pascagoula area, $PM_{2.5}$ mass, NO_2, and ozone concentrations were all higher after Katrina (compared to data collected in the same area from January 2000–September 2005), which could reflect an increase in construction and demolition activities in the area. In New Orleans, NO_2 concentrations were lower after Katrina than previously measured, possibly due to decreased mobile source emissions in the area. As in the Gulfport/Pascagoula area, the higher $PM_{2.5}$ and PM_{10} mass concentrations in New Orleans after Katrina could also reflect demolition activity in the area.

APPENDIX A

KATRINA SPECIAL STUDIES

A.1 PERCENT OF DATA BELOW DETECTION LIMITS

Tables A-1 and A-2 detail the counts of pollutants and the percent of data reported below detection limits by quarter. Many pollutants were below detection limits a large percent of the time and are highlighted with increasingly warmer colors (yellow, orange, red).

Many of the data reported post-Katrina were composed of concentrations below the MDL for a given chemical species. Analyzing the percent of data reported below detection (usually as zeroes) for some pollutants provides nearly as much information about changes in concentration as analyzing the concentrations above detection. We compared the percent of data reported below detection for each post-Katrina period to assess whether concentrations had changed significantly for some species with large percents of data below detection.

Table A-1. Percent of data below detection post-Katrina (by quarter) for New Orleans area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Page 1 of 5

Pollutant	Type	Percent Below Detection in New Orleans Post-Katrina	Percent Below Detection in New Orleans 2000–2005	Percent Below Detection in Louisiana 2000–2005
Ozone	Criteria	5	7	6
PM_{10}	Criteria	0	0	0
$PM_{2.5}$	Criteria	0	0	0
Carbon Monoxide	Criteria	25	28	29
Nitrogen Dioxide	Criteria	2	6	9
Sulfur Dioxide	Criteria	52	34	38
Arsenic ($PM_{2.5}$)	Metal	44	41	35
Arsenic (TSP)	Metal	98		
Arsenic PM_{10}	Metal	42		
Lead ($PM_{2.5}$)	Metal	2	5	13
Lead (TSP)	Metal	100	18	18
Lead PM10	Metal	3		
Antimony ($PM_{2.5}$)	Metal	54		86
Antimony (TSP)	Metal	100		
Antimony PM_{10}	Metal	42		
Beryllium ($PM_{2.5}$)	Metal	100		
Beryllium PM_{10}	Metal	100		

Table A-1. Percent of data below detection post-Katrina (by quarter) for New Orleans area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection in New Orleans Post-Katrina	Percent Below Detection in New Orleans 2000–2005	Percent Below Detection in Louisiana 2000–2005
Cadmium ($PM_{2.5}$)	Metal	20		91
Cadmium (TSP)	Metal	100		
Cadmium PM_{10}	Metal	13		
Chromium ($PM_{2.5}$)	Metal	3	62	61
Chromium (TSP)	Metal	95		
Chromium PM_{10}	Metal	6		
Chromium Vi (TSP)	Metal	36		
Cobalt ($PM_{2.5}$)	Metal	81		93
Cobalt (TSP)	Metal	100		
Cobalt PM_{10}	Metal	62		
Manganese ($PM_{2.5}$)	Metal	8	22	26
Manganese (TSP)	Metal	98		
Manganese PM_{10}	Metal	2		
Mercury ($PM_{2.5}$)	Metal	95		81
Mercury PM_{10}	Metal	95		
Nickel ($PM_{2.5}$)	Metal	16	9	28
Nickel (TSP)	Metal	99		
Nickel PM_{10}	Metal	13		
Selenium ($PM_{2.5}$)	Metal	43	0	32
Selenium (TSP)	Metal	95		
Selenium PM_{10}	Metal	38		
3-Methylcholanthrene	PAH	100		
7,12-Dimethylbenz[A]Anthracene	PAH	100		
Acenaphthene	PAH	98		
Acenaphthylene	PAH	100		
Anthracene	PAH	100		
Benzo[A]Anthracene	PAH	100		
Benzo[A]Pyrene	PAH	100		
Benzo[B]Fluoranthene	PAH	100		
Benzo[G,H,I]Perylene	PAH	100		
Benzo[K]Fluoranthene	PAH	100		
Chrysene	PAH	100		
Dibenzo[A,H]Anthracene	PAH	100		
Fluoranthene	PAH	99		

Table A-1. Percent of data below detection post-Katrina (by quarter) for New Orleans area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection in New Orleans Post-Katrina	Percent Below Detection in New Orleans 2000–2005	Percent Below Detection in Louisiana 2000–2005
Fluorene	PAH	98		
Indeno[1,2,3-Cd]Pyrene	PAH	100		
Phenanthrene	PAH	96		
Pyrene	PAH	99		
Carbazole	PAH	100		
Dibenzofuran	PAH	99		
Naphthalene	PAH	97		
Acrolein	VOC	29		
Benzene	VOC	71		1
M/P-Xylene	VOC	15		18
O-Xylene	VOC	84		21
P-Xylene	VOC	81		
Toluene	VOC	43		1
1,1,2,2-Tetrachloroethane	VOC	100		95
1,2-Dichloropropane	VOC	100		99
1,3-Butadiene	VOC	76		40
Acetaldehyde	VOC	0		10
Carbon Tetrachloride	VOC	91		52
Chloroform	VOC	79		81
Dichloromethane	VOC	3		21
Formaldehyde	VOC	0		2
Tetrachloroethylene	VOC	97		89
Trichloroethylene	VOC	99		58
Vinyl Chloride	VOC	91		86
1,1,2-Trichloroethane	VOC	100		97
1,1-Dichloroethylene	VOC	100		100
1,2,4-Trichlorobenzene	VOC	100		78
1,4-Dichlorobenzene	VOC	95		72
2,2,4-Trimethylpentane	VOC	29		20
2,4,5-Trichlorophenol	VOC	100		
2,4,6-Trichlorophenol	VOC	100		
2,4-Dinitrophenol	VOC	100		
2,4-Dinitrotoluene	VOC	100		

Table A-1. Percent of data below detection post-Katrina (by quarter) for New Orleans area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection in New Orleans Post-Katrina	Percent Below Detection in New Orleans 2000–2005	Percent Below Detection in Louisiana 2000–2005
2-Acetylaminofluorene	VOC	100		
3,3'-Dichlorobenzidene	VOC	100		
3,3'-Dimehtylbenzidine	VOC	100		
4-Dimethylaminoazobenzene	VOC	100		
4-Nitrophenol	VOC	100		
Acetone	VOC	0		0
Acetonitrile	VOC	14		
Acetophenone	VOC	93		
Acrylonitrile	VOC	94		
Aniline	VOC	100		
Benzidine	VOC	100		
Benzyl Chloride	VOC	100		91
Bis (2-Chloroethyl)Ether	VOC	100		
Bis(2-Ethylhexyl)Phthalate	VOC	97		
Bromoform	VOC	100		
Bromomethane	VOC	83		70
Chlorobenzene	VOC	100		77
Chlorobenzilate	VOC	100		
Chloroethane	VOC	74		92
Chloromethane	VOC	0		4
Chloroprene	VOC	95		
Cis-1,3-Dichloropropylene	VOC	100		100
Dimethyl Phthalate	VOC	100		
Ethyl Acrylate	VOC	100		
Ethylbenzene	VOC	83		21
Ethylene Dibromide	VOC	100		99
Ethylene Dichloride	VOC	94		73
Hexachlorobenzene	VOC	100		
Hexachlorobutadiene	VOC	100		82
Hexachlorocyclopentadiene	VOC	100		
Hexachloroethane	VOC	98		
Isophorone	VOC	100		
Isopropylbenzene	VOC	100		77
Methyl Chloroform	VOC	94		54

Table A-1. Percent of data below detection post-Katrina (by quarter) for New Orleans area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection in New Orleans Post-Katrina	Percent Below Detection in New Orleans 2000–2005	Percent Below Detection in Louisiana 2000–2005
Methyl Ethyl Ketone	VOC	36		
Methyl Isobutyl Ketone	VOC	97		
Methyl Methacrylate	VOC	99		
Methyl Tert-Butyl Ether	VOC	92		
N-Hexane	VOC	6		4
N-Nitrosodimethylamine	VOC	100		
O-Toluidine	VOC	100		
Pentachloronitrobenzene	VOC	100		
Pentachlorophenol	VOC	100		
Propionaldehyde	VOC	0		
Propylene	VOC	0		2
Styrene	VOC	93		36
Trans-1,2-Dichlororthylene	VOC	100		
Trans-1,3-Dichloropropylene	VOC	100		98

Table A-2. Percent of data below detection post-Katrina (by quarter) for Gulfport/Pascagoula area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection Post-Katrina	Percent Below Detection in Gulfport/Pascagoula 2000-2005	Percent Below Detection in Mississippi 2000-2005
Ozone	Criteria	2	4	4
PM_{10}	Criteria	0	0	0
$PM_{2.5}$	Criteria	0	0	0
Nitrogen Dioxide	Criteria	30	50	44
Sulfur Dioxide	Criteria	55	54	56
Arsenic ($PM_{2.5}$)	Metal	50	78	78
Arsenic PM10	Metal	68		
Lead ($PM_{2.5}$)	Metal	9	80	78
Lead PM10	Metal	10		
Antimony ($PM_{2.5}$)	Metal	55	92	92
Antimony PM10	Metal	55		
Beryllium ($PM_{2.5}$)	Metal	100	100	100
Cadmium ($PM_{2.5}$)	Metal	23	93	94
Cadmium PM10	Metal	24		
Chromium ($PM_{2.5}$)	Metal	8	65	68
Chromium PM10	Metal	3		
Chromium Vi(TSP)	Metal	71		
Cobalt ($PM_{2.5}$)	Metal	82	98	98
Cobalt PM10	Metal	66		
Manganese ($PM_{2.5}$)	Metal	16	62	58
Manganese PM10	Metal	7		
Mercury ($PM_{2.5}$)	Metal	94	92	92
Mercury PM10	Metal	96		
Nickel ($PM_{2.5}$)	Metal	39	61	74
Nickel PM10	Metal	38		
Potassium PM10	Metal	2		
Selenium ($PM_{2.5}$)	Metal	57	91	93
Selenium PM10	Metal	70		
Sodium PM10	Metal	2		
3-Methylcholanthrene	PAH	100		
7,12-Dimethylbenz[A]Anthracene	PAH	100		
Acenaphthene	PAH	38		

Table A-2. Percent of data below detection post-Katrina (by quarter) for Gulfport/Pascagoula area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection Post-Katrina	Percent Below Detection in Gulfport/Pascagoula 2000-2005	Percent Below Detection in Mississippi 2000-2005
Acenaphthylene	PAH	64		
Anthracene	PAH	72		
Benzo[A]Anthracene	PAH	66		
Benzo[A]Pyrene	PAH	93		
Benzo[B]Fluoranthene	PAH	76		
Benzo[G,H,I]Perylene	PAH	85		
Benzo[K]Fluoranthene	PAH	80		
Chrysene	PAH	64		
Dibenzo[A,H]Anthracene	PAH	99		
Fluoranthene	PAH	36		
Fluorene	PAH	33		
Indeno[1,2,3-Cd]Pyrene	PAH	90		
Phenanthrene	PAH	31		
Pyrene	PAH	43		
Carbazole	PAH	100		
Dibenzofuran	PAH	43		
Naphthalene	PAH	19		
Acrolein	VOC	34	67	64
Benzene	VOC	0	1	1
M/P-Xylene	VOC	1	2	3
O-Xylene	VOC	6	12	12
Toluene	VOC	0	0	0
1,1,2,2-Tetrachloroethane	VOC	100	100	100
1,2-Dichloropropane	VOC	100	100	100
1,3-Butadiene	VOC	79	80	79
Acetaldehyde	VOC	0	0	0
Carbon Tetrachloride	VOC	0	60	57
Chloroform	VOC	71	98	97
Dichloromethane	VOC	33	79	72
Formaldehyde	VOC	0	0	0
Tetrachloroethylene	VOC	84	97	94
Trichloroethylene	VOC	100	99	99
Vinyl Chloride	VOC	99	100	99
1,1,2-Trichloroethane	VOC	100	100	100

Table A-2. Percent of data below detection post-Katrina (by quarter) for Gulfport/Pascagoula area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection Post-Katrina	Percent Below Detection in Gulfport/Pascagoula 2000-2005	Percent Below Detection in Mississippi 2000-2005
1,1-Dichloroethylene	VOC	100	100	100
1,2,4-Trichlorobenzene	VOC	100	100	100
1,4-Dichlorobenzene	VOC	62	89	87
2,2,4-Trimethylpentane	VOC	62	20	20
2,4,5-Trichlorophenol	VOC	100		
2,4,6-Trichlorophenol	VOC	100		
2,4-Dinitrophenol	VOC	100		
2,4-Dinitrotoluene	VOC	100		
2-Acetylaminofluorene	VOC	100		
3,3'-Dichlorobenzidene	VOC	100		
3,3'-Dimehtylbenzidine	VOC	100		
4-Dimethylaminoazobenzene	VOC	99		
4-Nitrophenol	VOC	100		
Acetone	VOC	0	0	0
Acetonitrile	VOC	24	53	36
Acetophenone	VOC	46		
Acrylonitrile	VOC	99	97	94
Aniline	VOC	97		
Benzidine	VOC	100		
Benzyl Chloride	VOC	100	100	100
Bis (2-Chloroethyl)Ether	VOC	100		
Bis(2-Ethylhexyl)Phthalate	VOC	44		
Bromoform	VOC	100	100	100
Bromomethane	VOC	92	100	100
Chlorobenzene	VOC	99	100	100
Chlorobenzilate	VOC	100		
Chloroethane	VOC	86	100	99
Chloromethane	VOC	0	1	0
Chloroprene	VOC	100	100	100
Cis-1,3-Dichloropropylene	VOC	100	100	100
Dimethyl Phthalate	VOC	99		
Ethyl Acrylate	VOC	100	100	100
Ethylbenzene	VOC	8	15	17
Ethylene Dibromide	VOC	100	100	100

Table A-2. Percent of data below detection post-Katrina (by quarter) for Gulfport/Pascagoula area. Red > 75% ; orange > 50% and <75%; yellow >25% and <50%.

Pollutant	Type	Percent Below Detection Post-Katrina	Percent Below Detection in Gulfport/Pascagoula 2000-2005	Percent Below Detection in Mississippi 2000-2005
Ethylene Dichloride	VOC	99	96	98
Hexachlorobenzene	VOC	100		
Hexachlorobutadiene	VOC	100	100	100
Hexachlorocyclopentadiene	VOC	100		
Hexachloroethane	VOC	99		
Isophorone	VOC	100		
Isopropylbenzene	VOC	99	100	100
Methyl Chloroform	VOC	24	98	98
Methyl Ethyl Ketone	VOC	63	36	37
Methyl Isobutyl Ketone	VOC	83	99	99
Methyl Methacrylate	VOC	99	100	100
Methyl Tert-Butyl Ether	VOC	99	80	69
N-Hexane	VOC	3	0	0
N-Nitrosodimethylamine	VOC	100		
O-Toluidine	VOC	100		
Pentachloronitrobenzene	VOC	100		
Pentachlorophenol	VOC	99		
Propionaldehyde	VOC	0	11	14
Propylene	VOC	0	2	1
Styrene	VOC	36	68	69
Trans-1,2-Dichlororthylene	VOC	100	100	100
Trans-1,3-Dichloropropylene	VOC	100	100	99

A.2 ANALYSIS OF SELECTED EVENTS

Time series plots of concentrations were examined to assess possible trends in ambient concentrations and to identify "high concentrations" or other abrupt changes in ambient concentrations for pollutants with concentrations below screening levels. Of particular interest in this analysis, we examined pollutants for which there was at least one sampled concentration above the screening level. Overall, most sites exhibited similar concentrations across the New Orleans, Gulfport, and Pascagoula sites on most days. Concentrations from only a few sites showed large deviation from typical regional concentrations. This may indicate that changes in meteorology throughout the area were influencing region-wide concentrations of most pollutants examined. Changes in meteorology may explain the day-to-day changes in most of these concentrations. Only those sites displaying significant deviation from other sites are likely to be heavily influenced by local emissions. Observations and a few example figures are provided in

the following subsections. These examples comprise individual examinations of the data for the fourth quarter of 2005 and first half of 2006; some may not show the entire set of available data.

A.2.1 New Orleans Area

A spike in lead concentrations was observed at most sites around December 11, 2005, as shown in **Figure A-1**. Individual sites reported concentrations as high as 0.0665 μg/m^3. However, the concentrations are still well below the screening level for lead.

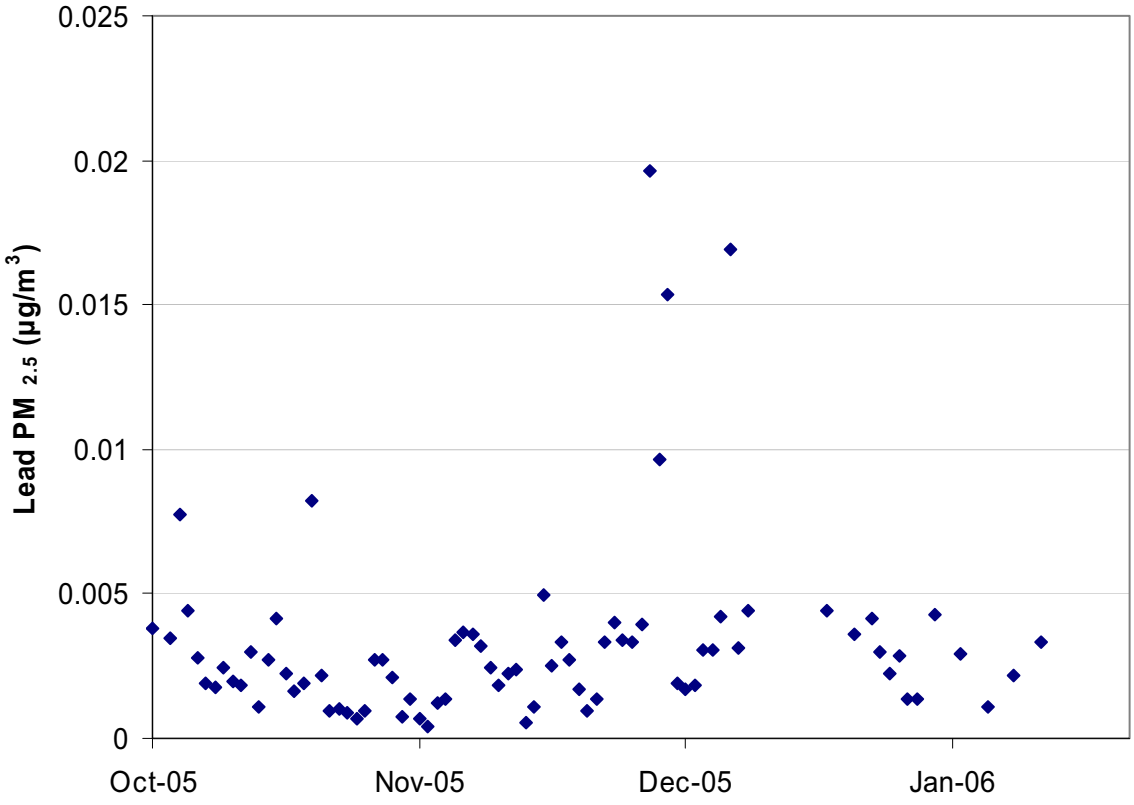

Figure A-1. Time series of daily lead $PM_{2.5}$ concentrations (μg/m^3) in New Orleans, averaged across all sites.

A PAH event during which most PAH concentrations were elevated was observed in mid-February (for example, **Figure A-2**). Pollutants that exhibited this pattern included acenaphthene, pyrene, fluorene, dibenzofuran, phenol, and chrysene. Although none of the compounds was measured above the screening level, the concentrations were unusually high and the cause of such an event may warrant additional investigation. PAHs were measured from October 1, 2005–January 1, 2006 at multiple sites and from January 1, 2006–August 1, 2006 at the West Temple site but the PAHs observed in this event were not detected at any site during the entire time period. Fingerprint plots of PAH concentrations examined for days during and before/after this event. Although most of the same pollutants were observed in all plots, some pollutants are only present during the episode and the ratios of the various pollutants changed substantially during the event (**Figure A-3**).

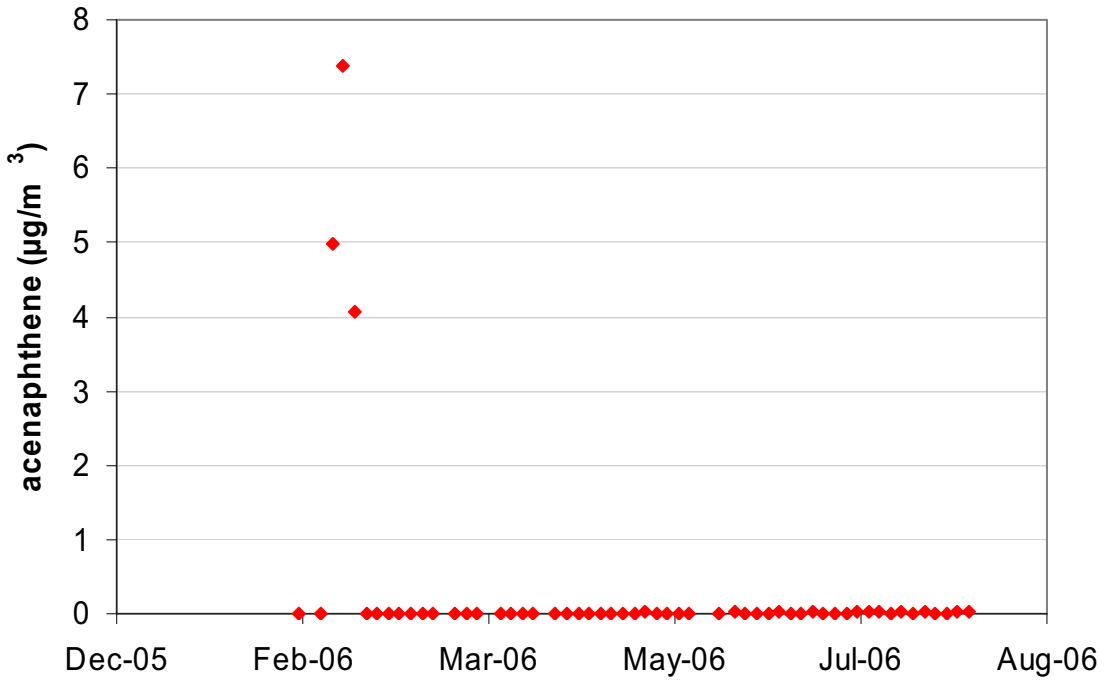

Figure A-2. Acenaphthene concentrations, in New Orleans, post-Katrina (site: West Temple). Zeroes indicate data below detection.

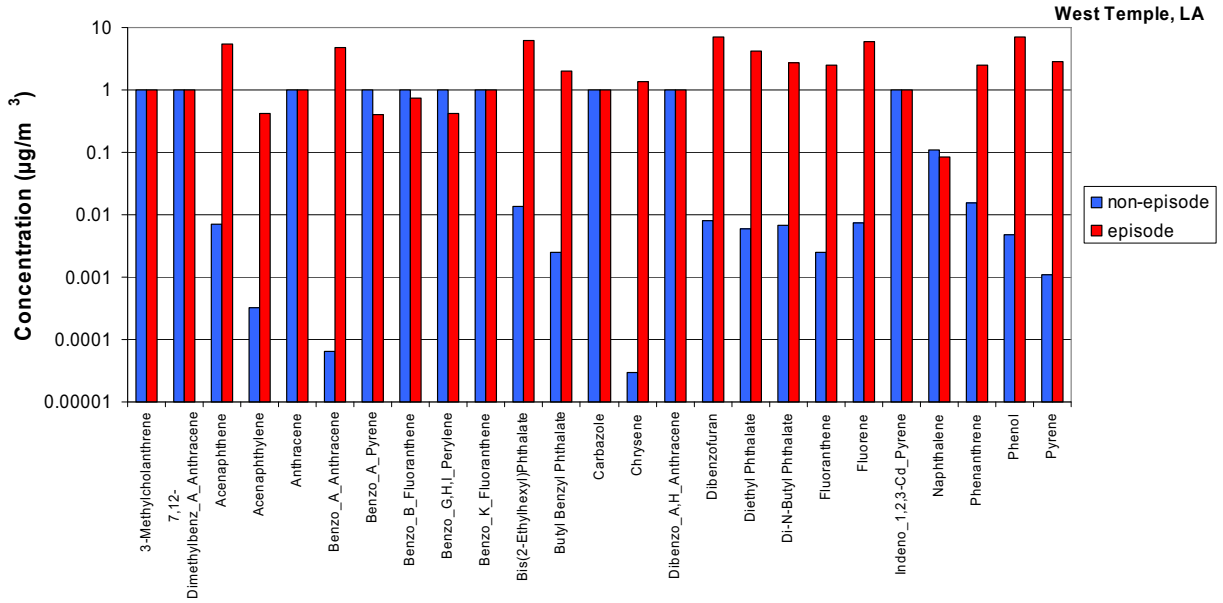

Figure A-3. Fingerprint plot of average PAH concentrations (µg/m^3) on episode days and non-episode days; first quarter 2006, New Orleans area. Concentrations of some PAHs were more than three orders of magnitude higher (note log-scale) during episodes.

Concentrations of multiple aldehyde species increased from December 15, 2005, through January 26, 2006, at the West Temple site (see example, **Figure A-4**). Pollutants that exhibited this pattern included formaldehyde, propionaldehyde, valeraldehyde, hexanaldehyde, benzaldehyde, and tolualdehyde. Acrolein and acetone did not exhibit the same pattern. Scatter plots between species included in this event showed a clear difference between "episode days" and "non-episode days". For example, the slope between acetaldehyde and formaldehyde is less than 1 on non-event days and almost 4 on event days (see **Figure A-5**). Some species, such as hexanaldehyde, showed no correlation with other carbonyls on non-event days but had an R^2 value at or above 0.9 on event days. It is possible that a distinct common source of aldehydes near this site impacted concentrations during the six week "episode". However, it is unclear what source would emit only aldehydes and not emit other hydrocarbons or carbonyls at an increased rate. All these species concentrations remained below screening levels during the episode.

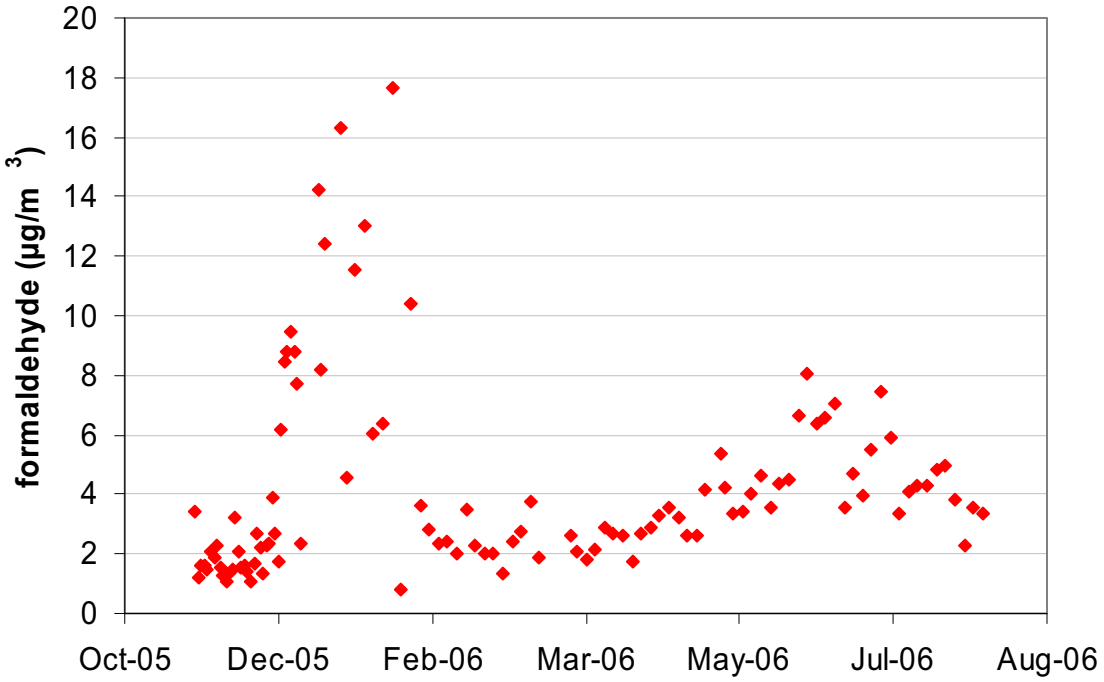

Figure A-4. Daily average formaldehyde concentrations at the West Temple site in New Orleans.

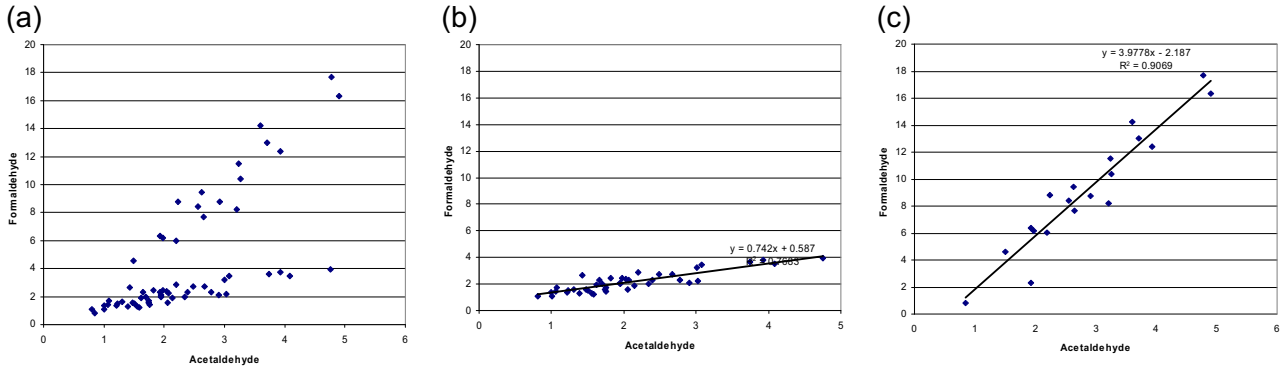

Figure A-5. Acetaldehyde vs. formaldehyde scatter plots: (a) all days sampled in first quarter 2006; (b) days not during carbonyl episode; (c) days during carbonyl episode (December 15, 2005–January 26, 2006). Concentrations are in $\mu g/m^3$.

Elevated benzene concentrations occurred on several days at various sites in the New Orleans area. The first event occurred at the Florida/Orleans Avenue site in October 2005, with concentrations about three to five times the average concentrations for five samples (blue dots, **Figure A-6**). There were also elevated concentrations of a few samples at the Nunez and Kawk Park sites at the end of November/beginning of December 2005 (Nunez = open purple circle, Kawk Park = grey asterisk, Figure A-6). These concentrations were higher during the first event. At the end of June 2006, the Kenner/West Temple monitoring site had benzene concentrations again elevated three to five times the average concentration (red diamonds, Figure A-6). It should be noted that these concentrations were much lower than their respective screening levels (in many cases several orders of magnitude lower). Each event was localized, with elevated concentrations seen only at one site.

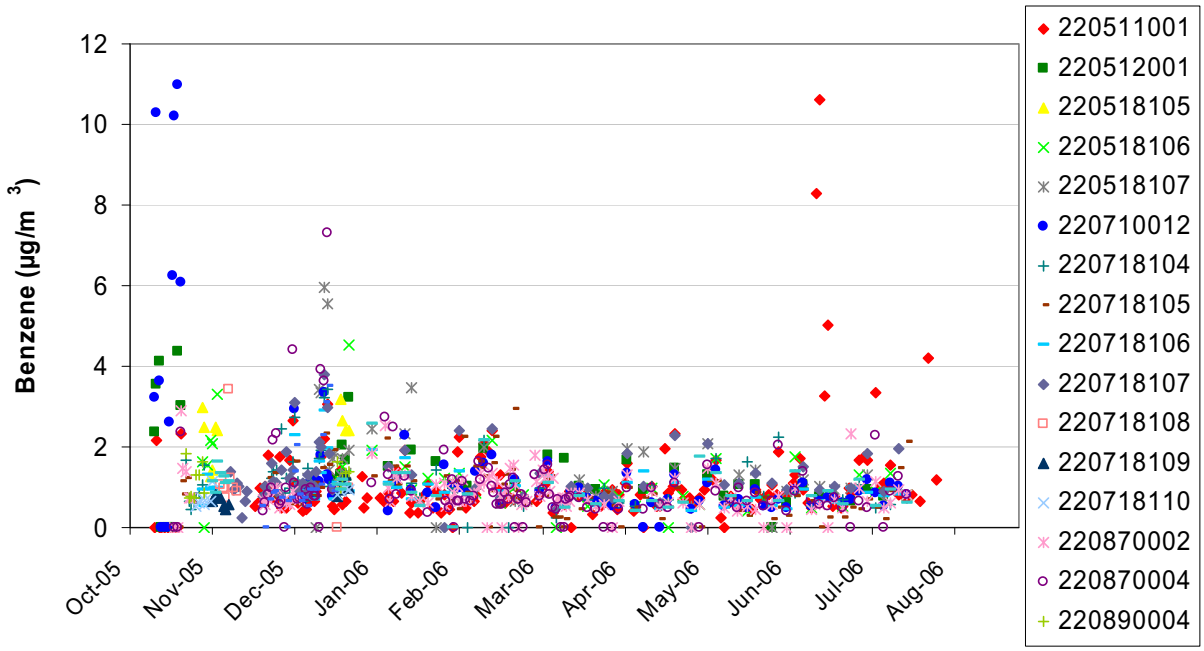

Figure A-6. Daily benzene concentrations (µg/m^3) in New Orleans. All concentrations were well below the screening level of 20 µg/m^3.

Several carbonyl compounds displayed an increasing trend beginning around April 2006 in New Orleans (see **Figure A-7**). This trend is consistent with the expected seasonal variations in carbonyl compound concentrations. Higher concentrations could also be indicative of a regional change in background concentrations, as many of these species showed similar trends at sites in Gulfport/Pascagoula. Unfortunately, past year carbonyl species concentration data are not available for New Orleans so a comparison to previous seasonal trends cannot be performed. Again, these concentrations were still well below screening levels.

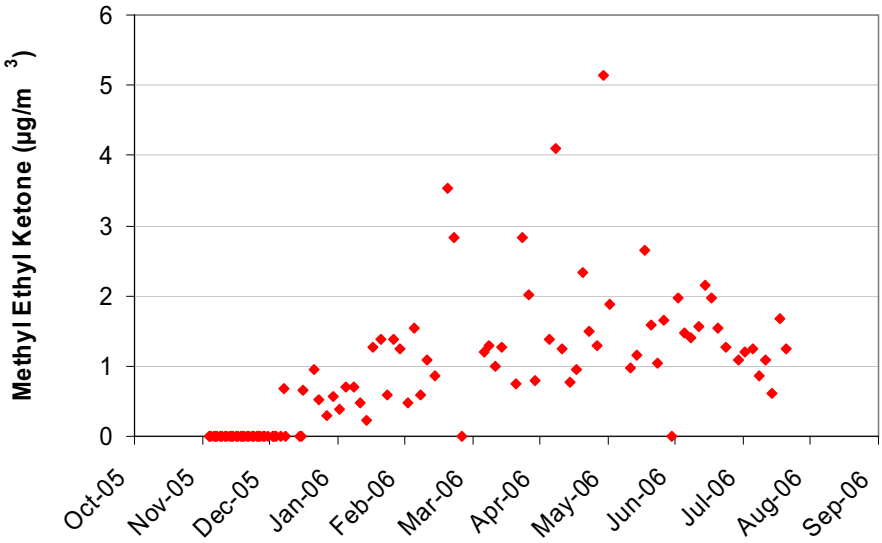

Figure A-7. Daily methyl ethyl ketone concentrations (µg/m^3) at the West Temple site in New Orleans. The screening level for methyl ethyl ketone is 50,000 µg/m^3.

A.2.2 Gulfport/Pascagoula Area

Overall, concentrations at the Gulfport and Pascagoula sites were generally consistent, despite being 30 miles apart. In addition, most pollutants at these sites exhibited similar concentration time series with the peak concentration declining over time (e.g., see **Figures A-8 and A-9**). We suspect this pattern is a function of meteorology or background concentration changes, rather than daily changes in emissions. The following are significant observations about individual species:

- Formaldehyde concentrations were consistently higher at the Pascagoula County Health Department site than at the Gulfport site. We believe this spatial pattern is due to differences in local emissions.
- Only one site, Maple Street, reported $PM_{2.5}$ metals in Gulfport/Pascagoula after January 2006. The concentrations reported after January 2006 were much higher than concentrations reported previously and any site for most $PM_{2.5}$ metals, including cadmium, chromium, manganese, mercury, and selenium (see **Figure A-10** for example). These concentrations were still well below the screening levels of the species. Other sites had large increases in the detection limit after January 2006 (and therefore did not have any detects) or did not continue monitoring $PM_{2.5}$ metals.
- Several spikes in $PM_{2.5}$ cobalt concentrations in October and late December at both Mississippi sites were observed. Sources of cobalt include steel and alloy manufacturing. Major sources are typically automotive repair shops or steel manufacturing.
- Elevated PAH concentrations were observed in February at the Mississippi sites, similar to those seen in New Orleans. PAH concentrations are usually associated with

combustion and mobile sources, although the concentrations observed are orders of magnitude higher than those observed elsewhere in the United States.

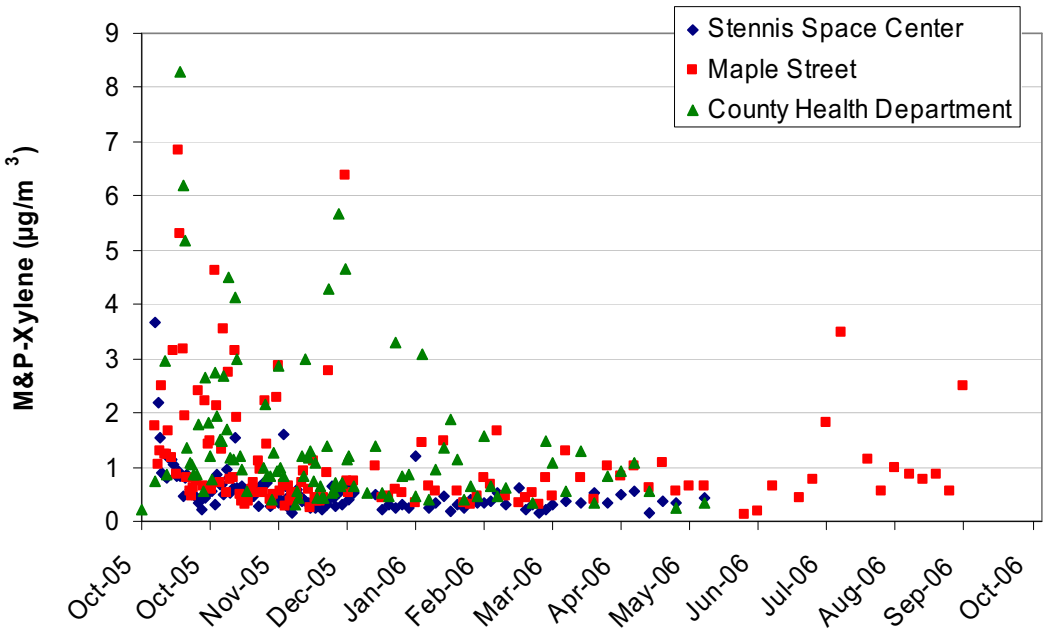

Figure A-8. Time series of m-&p-xylene concentrations (µg/m^3) at Gulfport (red squares, Maple Street; blue diamonds, Stennis Space Center) and Pascagoula, Mississippi (green triangles, County Health Department) post-Katrina. These concentrations are well below the screening level.

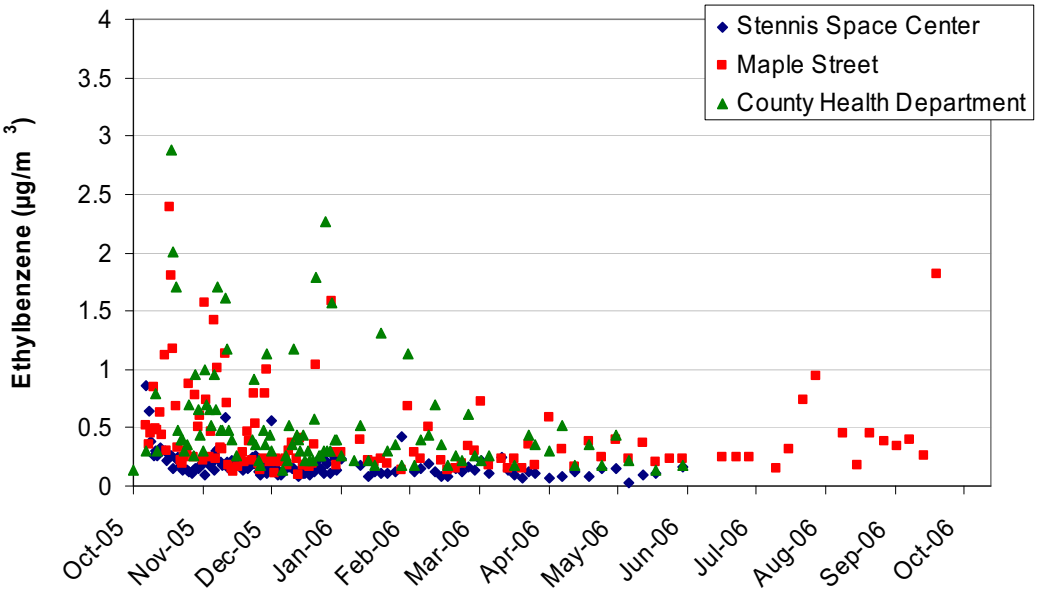

Figure A-9. Daily ethylbenzene concentrations (µg/m^3) at sites in Gulfport (red squares, Maple Street; blue diamonds, Stennis Space Center) and Pascagoula,

Mississippi (green triangles, County Health Department) post-Katrina. The screening level for ethylbenzene is 4,000 μg/m^3.

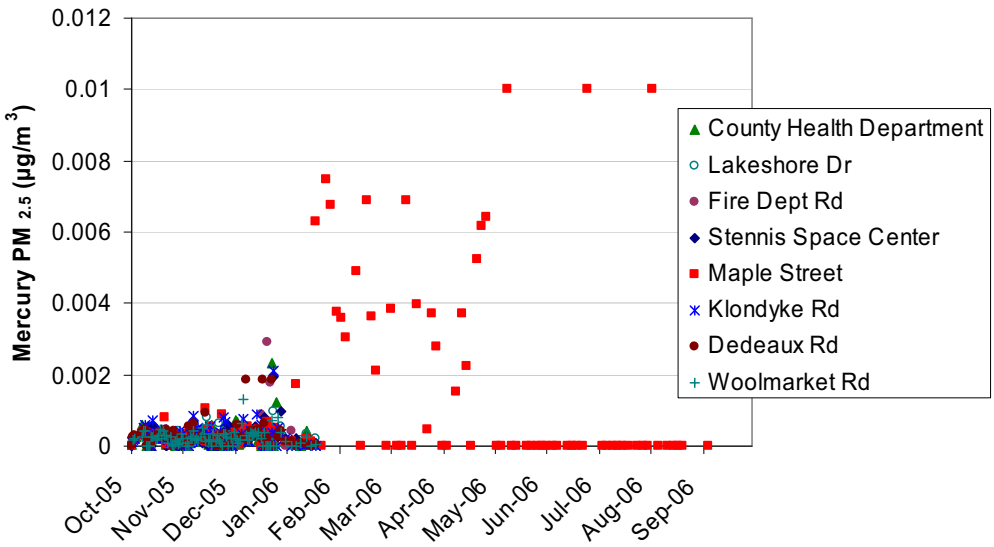

Figure A-10. Daily mercury $PM_{2.5}$ concentrations (μg/m^3) in Gulfport/ Pascagoula. Note that only the Maple Street site reported concentrations after January 2006. The screening level for mercury is 3 μg/m^3.

A.3 METEOROLOGICAL ANALYSIS

A preliminary analysis was conducted on several meteorological variables, including temperature, pressure, precipitation, and wind speed to compare pre-Katrina and post-Katrina meteorology. A significant difference in meteorological variables could increase and/or decrease pollutant concentrations in the area, masking any concentration changes due to emissions or other factors. Meteorological values from fourth quarter 2005 were compared to average values from fourth quarters 2000 through 2004 for the New Orleans and Gulfport/Pascagoula areas using a Student's *t*-test. Of the meteorological variables examined, only barometric pressure showed a statistically significant difference from the typical climatology of the previous five years in either area.

In Gulfport/Pascagoula, the average temperature and the distribution of temperatures for fourth quarter 2005 and fourth quarters 2000-2005 were nearly identical (see **Table A-3**). Wind speed values for these time periods were also very similar. There was no statistically significant difference in either temperature or wind speed. The barometric pressure was slightly lower in fourth quarter 2005, possibly as a result of a large-scale system covering the Southeast. The difference in pressure did not affect the other meteorological variables and would most likely not have affected pollutant concentrations.

In the New Orleans area, the average temperature and the distribution of temperatures were nearly identical in fourth quarter 2005 and fourth quarters 2000-2005 (see **Table A-4**). The average wind speed was slightly higher during fourth quarter 2005 (p=0.003), but the median

wind speed was the same in fourth quarter 2005 and fourth quarters 2000-2005. As in Gulfport/ Pascagoula, the barometric pressure was slightly lower, but this likely did not affect other parameters.

Table A-3. Comparison of meteorological variables, Gulfport/Pascagoula area.

	Temperature (°C)		Barometric Pressure (mb)		Precipitation (inches)		Wind Speed (m/s)	
	2000-2004	2005	2000-2004	2005	2000-2004	2005	2000-2004	2005
Minimum	-6	-1	1001.8	1004.6	0	0	0	0
Maximum	32	32	1035.9	1031.2	1.39	0.96	26	22
Median	16	16	1019.6	1018.3	0	0.01	5	5
Mean	15.6	15.7	1019.5	1018.2	0.0	0.1	5.5	5.6
StDev	7.3	7.4	5.4	5.5	0.1	0.2	4.4	4.4

Table A-4. Comparison of meteorological variables, New Orleans area.

	Temperature (°C)		Barometric Pressure (mb)		Precipitation (inches)		Wind Speed (m/s)	
	2000-2004	2005	2000-2004	2005	2000-2004	2005	2000-2004	2005
Minimum	-3	2	1002.4	1004.6	0	0	0	0
Maximum	32	32	1036.6	1032.5	1.77	0.6	33	27
Median	18	17	1019.8	1018.75	0	0.01	7	7
Mean	17.2	17.2	1019.7	1018.8	0.0	0.0	7.1	7.4
StDev	6.7	6.8	5.5	5.5	0.1	0.1	4.6	4.6

A.4 ACROLEIN CONCENTRATIONS, FIRST QUARTER AFTER KATRINA

Concentrations of acrolein measured with the same sampling method elsewhere in the United States are, on average, somewhat lower than those measured in the Katrina-affected areas, with the exception of sites in Austin, Texas (all Texas sites are located in Austin, see **Figure A-11)**. The data from the Gulfport/Pascagoula area and New Orleans are usually close to or within the first standard deviation (shown as a dashed line) of the average concentration measured elsewhere and are very similar to concentrations at Tupelo (TUMS), Mississippi (which was not affected by Katrina). These data imply that the observed concentrations are not abnormally high for sites in the southeastern United States. Acrolein is emitted in industrial processes as a chemical intermediate, in incomplete combustion processes such as vehicle exhaust and forest fires, and as a photo-oxidation product of 1,3-butadiene.

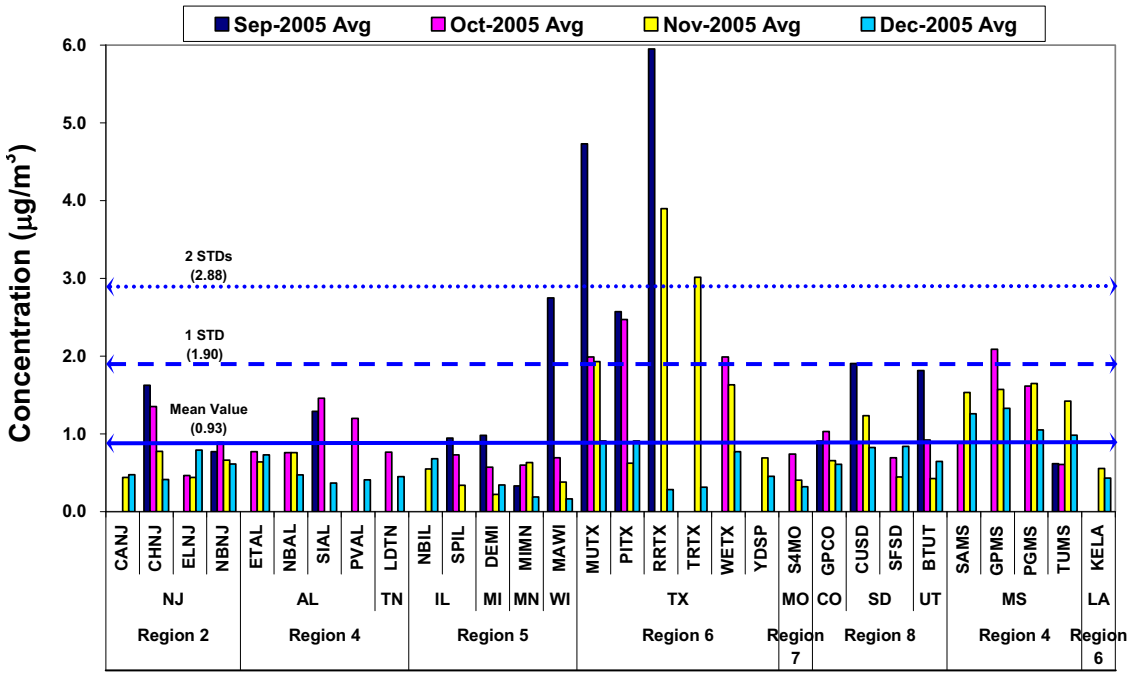

Figure A-11. Monthly average concentrations of acrolein measured at all sites in the United States, September through December 2005. Sites are differentiated with a two-letter site code concatenated with the two-letter state abbreviation; Mississippi and Louisiana sites are on the far right. (Figure created by Kina McCanns at EPA Region 4.)