Quality Assurance Report
for the
Gulf Coast Aerosol Research and Characterization Program (Houston Supersite)

FINAL REPORT

Cooperative Agreement No. R-82806201

between the Environmental Protection Agency and the
University of Texas at Austin

Submitted by:

Dr. David Allen
(allen@che.utexas.edu)
512-471-0049

Center for Energy and Environmental Resources
The University of Texas at Austin
10100 Burnet Road, Bldg. 133
MS R7100
Austin, Texas 78758

June, 2005

1. Introduction

The entire eastern half of Texas experiences annual average concentrations of fine particulate matter (specifically PM less than 2.5 μm in aerodynamic diameter, or $PM_{2.5}$) in the range of 10-12 μg/m^3. Superimposed on these background concentrations are regions in southeastern Texas in which industrial and urban emissions drive annual average concentrations of fine PM to approximately 15 μg/m^3. These high background concentrations, with local hot spots, located in a region of high population density (Houston is the fourth most populous city in the United States), result in high exposures to fine PM. At the time the Gulf Coast Aerosol Research and Characterization Study (GC-ARCH) study was initiated, a report performed under contract to the City of Houston estimated that approximately 2.5 million people in the Houston urban area in southeast Texas are exposed to annual average PM concentrations in excess of 15 μg/m^3 (Lurmann, et al., 1999).

In addition to being an area where $PM_{2.5}$ exposures are significant, southeastern Texas also has a unique mix of emission sources that influence $PM_{2.5}$ concentrations, including typical urban anthropogenic sources, biogenic sources, and significant industrial emissions. The Houston area is home to the largest concentration of petrochemical manufacturing facilities in the United States, and the strength of the industrial source signature in southeastern Texas is unique among large U.S. cities.

The GC-ARCH study (also referred to as the Houston PM Supersite) examined the spatial and temporal variability in fine PM source contributions and composition in Southeastern Texas, and the physical and chemical process that govern PM formation and transformation in Southeastern Texas. This was accomplished through the analysis of data collected in a 16-month field sampling program (August 2000 – November 2001). During the first six weeks of sampling, intensive measurements were collected in coordination with the Texas Air Quality Study (TexAQS). Three core sites and approximately 20 peripheral sites, jointly operated by the study team and the Texas Commission on Environmental Quality (TCEQ), were employed. A summary of the Scientific Key Findings has been reported to EPA in the Final Report dated April, 2005. For reference, the specific objectives of the study are summarized below and the hypotheses that were examined are listed in Table 1.

Objective 1: Collect physicochemical data on fine PM over a 16 month sampling period in Southeastern Texas; use the data to identify sources and to characterize spatial and temporal variability in fine PM source contributions and composition

Objective 2: Compare the spatial and temporal variability in fine PM source contributions and composition in southeastern Texas to variability throughout the United States

Objective 3: Examine the physical and chemical process that govern PM formation and transformation in Southeastern Texas

Objective 4: Develop a combined database on PM, gas phase air pollutants and meteorological variables, suitable for testing models of the formation and fate of fine PM; this objective was achieved by coordinating with a large, integrated ozone and PM field study conducted during the summer of 2000

Table 1. Hypotheses examined through the Gulf Coast Aerosol Research and Characterization Study (GC-ARCH or the Houston PM Supersite)*

Objective 1: Collect physicochemical data on fine PM over a 16 month sampling period in Southeastern Texas; use the data to identify sources and to characterize spatial and temporal variability in fine PM source contributions and composition

Hypotheses:

- Source profiles, average mass concentrations, and average compositions of PM in an upwind site, a site downwind of a heavily industrialized region and a site downwind of the urban core are substantially different, and spatial gradients in fine PM concentrations are greatest in the Ship Channel (industrial) region. (Hypothesis 1a)
- Maximum fine PM concentrations in Southeast Texas are observed in the summer, when secondary PM generation peaks. (Hypothesis 1b)
- Variations in fine PM concentration and composition on an hourly time scale will be substantial and this temporal variability will be related to, but will not identically track, variability in ozone (and other gas phase pollutant) concentrations. (Hypothesis 1c)

Objective 2: Compare the spatial and temporal variability in fine PM source contributions and composition in southeastern Texas to variability throughout the United States

Hypotheses:

- Source profiles of PM in Southeastern Texas are substantially different than those in other parts of the U.S. . (Hypothesis 2a)
- Maximum fine PM concentrations are observed in the summer, when secondary PM generation peaks. (Hypothesis 2b)

Objective 3: Examine the physical and chemical process that govern PM formation and transformation in Southeastern Texas

Hypotheses:

- In regions of high PM concentration gradients, increases in PM mass are primarily due to condensation onto existing PM, rather than formation of new particles. (Hypothesis 3a)
- Rates of condensation of organics onto hydrophobic and hydrophilic PM will vary, and the condensation rates will depend on the hydrophobic surface area available for condensation. (Hypothesis 3b)
- Rates of PM growth are highly correlated with concentrations of semivolatiles, peroxides, and acid gases and gas/particle partitioning ratios for organics will depend on the hydrophobic surface area available for condensation. (Hypothesis 3c)

Objective 4: Develop a combined database on PM, gas phase air pollutants and meteorological variables, suitable for testing models of the formation and fate of fine PM; this objective was achieved by coordinating with a large, integrated ozone and PM field study conducted during the summer of 2000 (no hypotheses)

*These hypotheses are adapted from the original Houston Supersite proposal, and while many of the hypotheses were proven to be correct, some were proven to be incorrect (see Section 2, Key Findings, for details)

2. Objective

The overall goals of the GC-ARCH program were to characterize the composition and identify the sources of particulate matter in Southeastern Texas, to develop and test new methods for characterization of fine particulate matter, and to collect data on the physical and chemical characterization of fine particulate matter that can be used to support exposure and health effects studies. The objective of this report is to review the quality assurance activities associated with datasets funded by the Houston PM Supersite.

3. Project Organization

Oversight of GC-ARCH activities was provided by the EPA Supersites Manager, Richard Scheffe. Administration was directed by the EPA Project Officer, Michael Jones. The GC-ARCH Program Management Team consisted of the PI, the co-PI, and the program manager. The PI was David Allen from the University of Texas; the co-PI was Matthew Fraser from Rice University. The PI and co-PI were responsible for budgeting, all communication with the Science Team, coordination with parallel studies, supervision of data archiving and site management, and communication with the Scientific Advisory board. The program manager, Vincent Torres, was responsible for day-to-day administration of the program and its budgets.

Quality assurance was managed by Gary McGaughey of the University of Texas, and data archiving was managed by Elena McDonald-Buller from the University of Texas. The Quality Assurance Manager (QAM) was responsible for performing technical audits on all data. These audits included assessing the quality of data submitted to the Data Management Coordinator (DMC) as well as reviewing the data before it was submitted to the NARSTO Permanent Data Archive (PDA). It is the DMC's responsibility to organize all data submitted by the individual PIs, as well as submit the data to the PDA. The individual PIs were responsible for running and maintaining their portions of the GC-ARCH study as well as performing quality assurance of field and laboratory procedures and operations.

4. Data Quality Activities

As outlined in the Quality Assurance Project Plan, GC-ARCH was committed to delivering all measurement data collected by GC-ARCH data providers to the NARSTO PDA. NARSTO requires that datasets conform to the Data Exchange Standard (DES) format. During the post-field campaign data collection efforts, it became clear that the Houston PM Supersite PIs required substantial guidance and technical assistance to generate an acceptable DES dataset. As such, the majority of the QAM's data quality activities consisted of assisting the data providers in the generation and development of DES files for submission to the NARSTO PDA.

The DES outlines the structure and formatting conventions for air quality and meteorological datasets, and consists of self-documenting ASCII comma-delimited files. The DES requires standardized reporting of all measurement data and metadata. Since the DES was undergoing substantial evolution during the 2000-2002 period, the QAM continuously served as liaison between the data providers and the NARSTO Quality Systems Science Center (QSSC) throughout the process.

The University of Texas at Austin (UT-Austin) developed software programs written in FORTRAN, MicroSoft Excel, and SAS to process and quality assure the measurement datasets received from the GC-ARCH PIs. UT-Austin staff often performed all technical work necessary to generate the DES files. Although the level of effort varied depending on the complexity of an individual dataset, typical technical tasks are summarized below:

1. The DES header table (GC-ARCH identification, PI information, dataset name, sampling interval and frequency, etc.) and site information table (assigns unique GC-ARCH site ID, site description, location, land use, coincident measurements, etc.) were constructed.
2. Study flags were uniquely mapped to the required NARSTO flags.
3. The QAM worked with each PI to establish NARSTO-approved chemical and non-chemical/physical names for all measured variables and various descriptive metadata elements. This often required consultation with QSSC to establish approved names and/or consultation with QSSC to request that new names be added to the NARSTO reference tables.
4. CAS Registry Numbers were obtained for chemical substances variables.
5. Programs were written to report measurement times and dates in both Central Standard Time (CST) and Coordinated Universal Time (UTC).
6. NARSTO requires that dates, times, flags, and measurement values follow strict format guidelines; therefore, programs were written by UT-Austin staff to modify the measurement data received from the PI to conform to the NARSTO QSSC guidance.
7. UT-Austin programs were used to verify and edit the measurement and validation flag data so that the measurement value fields contained either a measured value, a substituted detection limit, or a missing value representation.
8. Programs were written to confirm that measurement values were consistent with the reported validation flags.
9. Time series plots were generated and reviewed for all measurement variables. The visual review often identified data quality issues (e.g., outliers, missing data periods) that required significant resources to fully review and correct. The measurement data were often returned to the PI for further analysis.
10. After the raw data were converted to DES format, the QSSC Read and Verify Program was used to quality assure the datasets. The QSSC Read and Verify program generates overall statistics (e.g., minimum, maximum, mean, median, number of total observations, number of valid observations) for each reported measurement variable. These statistical metrics were reviewed for reasonableness.
11. The output of the QSSC Read and Verify Program often led to additional investigation and modification of the DES files. The process was typically an iterative one. Any remaining problematic output identified by the Read and Verify program were discussed with QSSC to establish the appropriate action.
12. In consultation with QSSC, a searchable metadata index for each DES dataset was created using the NARSTO Data and Information Sharing Tool (DIST). In parallel with this effort, the DES file was submitted to QSSC for approval. Additional clarification and editing of the DES files was sometimes required before QSSC submitted the data to the PDA.

5. GC-ARCH Measurements

Data collection occurred during a 16-month period beginning in August 2000. During the first six weeks of sampling, intensive measurements were collected in coordination with the Texas Air Quality Study (TexAQS). The GC-ARCH funded datasets that were provided to the QAM are summarized in Table 2. These datasets have been submitted to the NARSTO PDA and have received final acceptance from QSSC. These datasets were used to address one or more of the specific objectives of the GC-ARCH study described in Section 1 of this report.

6. Detection limits

The Detection Limit (DL) is defined as a statistically determined value above which the reported concentration or amount can be differentiated, at a specific probability, from a non-zero concentration or amount. Analytical procedures and sampling equipment impose specific constraints on the determination of detection limits. NARSTO requires that detection limits be provided if at all possible. The detection limits for the GC-ARCH funded datasets are summarized in Table 3.

7. Uncertainties

Measurement uncertainty is typically provided as a range of values that contains the true value, within a given statistical confidence interval. As stated in an EPA memorandum dated July 25, 2001 to Supersite Principal Investigators, Data Managers, and Research Scientists from Dr. Paul Soloman, Dennis Mikel, and Mike Jones:

"…The uncertainty of the data collected is of paramount importance. The data users will need to understand the uncertainty of the data, which will provide them confidence in their assumptions and predictions. Therefore, the EPA is strongly recommending that each Supersite Cooperative work closely with the research investigators and data managers of each Supersite to estimate and report uncertainties…"

The uncertainty information provided by the GC-ARCH PIs is summarized in Table 4. The majority of data providers chose to define uncertainties as a constant value or as a percentage of the measured value. One notable exception occurred for the near real-time nitrate data provided by Susanne Hering where uncertainties were calculated for each measurement value.

8. Data Completeness

Completeness of a dataset is determined as the percentage of the scheduled sample collections that result in validated ambient observations that meet data quality objectives. The completeness for the GC-ARCH funded datasets is provided in Table 5. Explanatory notes are provided.

9. References

Lurmann, F.W., Hall, J.V., Kleinman, M., Chinkin, L.R., Brajer, V., Meacher, D., Mummery, F., Arndt, R.L., Funk, T.H., Alcorn, S.H., and Kumar, N.. 1999. Assessment of the Health Benefits of Improving Air Quality in Houston, Texas, Final report by Sonoma Technologies to the City of Houston (STI-998460-1875-FR).

Table 2. GC-ARCH measurements.

PI	Organization	Instrument	Measurement	Monitoring Sites	Sampling Period
David Allen	University of Texas at Austin	Hering LPI (Low Pressure Impactor) and FTIR	Aliphatic HC, Carbonyl, Organonitrates, Sulfate	Aldine, HRM3, LaPorte	intensive
Don Collins	Texas A&M University	DMA (Differential Mobility Analyzer)	Particles: total count and sizes	DeerPark	16-month
				Aldine, HRM3	16-month
				LaPorte	intensive
Purnendu Dasgupta	Texas Tech University	Hantz fluorescence	Formaldehyde	HRM3	intensive
		HRP (HorseRadish Peroxidase)-catalyzed thiamine oxidation thiochrome fluorescence	Hydrogen peroxide (H_2O_2)	HRM3	intensive
Matthew Fraser	Rice University	Denuder NH3	Ammonia	Aldine, DeerPark, HRM3	16-month
		Denuder HNO3	Nitric acid	Aldine, DeerPark, HRM3	16-month
		Organic $PM_{2.5}$ Speciation	Organic compounds (69 target compounds)	Aldine, LaPorte, HRM3	intensive
Susanne Hering	Aerosol Dynamics, Inc.	Continous $PM_{2.5}$ Mass	Near real time carbon, nitrate, and sulfate	Aldine, DeerPark	16-month
			Near real time carbon, nitrate, and sulfate	LaPorte	intensive
Len Stockburger	EPA	Moudi (Micro-Orifice Uniform Deposit Impactor)	PM Mass for 8 size ranges	LaPorte, HRM3	intensive
Dave Sullivan	Texas Commission on Environmental Quality (TCEQ), formerly Texas Natural Resource Conservation Commission (TNRCC)	TEOM (Thermal Element Oscillating Microbalance)	$PM_{2.5}$	Houston/Galveston CAMS (6 sites)	intensive
Anthony Wexler	University of Delaware	RSMS (Rapid single-particle mass spectrometer)	Particle mass spectrum	HRM3	intensive

Table 3. GC-ARCH detection limits.

PI	Instrument	Measurement	Detection Limit
David Allen	Hering LPI (Low Pressure Impactor) and FTIR absolute absorbance areas for size segregated PM	Aliphatic HC, Carbonyl, Organonitrates, Sulfate	Undetermined
Don Collins	DMA (Differential Mobility Analyzer)	Particles: total count and sizes	0.015 µm
Purnendu Dasgupta	Hantz fluorescence	Formaldehyde	15 parts per trillion by volume (pptv)
	HRP (HorseRadish Peroxidase)-catalyzed thiamine oxidation thiochrome fluorescence	Hydrogen peroxide (H_2O_2)	13.5 parts per trillion by volume (pptv)
Matthew Fraser	Denuder NH3	Ammonia	0.1 µg/m^3
	Denuder HNO3	Nitric acid	0.1 µg/m^3
	Organic $PM_{2.5}$ Speciation	Organic compounds (69 target compounds)	0.01 ng/m^3
Susanne Hering	Continous $PM_{2.5}$ Mass	Near real time carbon, nitrate, and sulfate	0.5 µg/m^3
Len Stockburger	Moudi (Micro-Orifice Uniform Deposit Impactor)	PM Mass for 8 size ranges	0.3 µg/m^3
Dave Sullivan	TEOM (Thermal Element Oscillating Microbalance)	$PM_{2.5}$	Not provided
Anthony Wexler	RSMS (Rapid single-particle mass spectrometer)	Particle mass spectrum	Undetermined

Table 4. GC-ARCH measurement uncertainties.

PI	Instrument	Measurement	Uncertainty
David Allen	Hering LPI (Low Pressure Impactor) and FTIR absolute absorbance areas for size segregated PM	Aliphatic HC, Carbonyl, Organonitrates, Sulfate	factor of 2
Don Collins	DMA (Differential Mobility Analyzer)	Particles: count	10% of the reported value
		Particles: size	5% of the reported value
Purnendu Dasgupta	Hantz fluorescence	Formaldehyde	3.3 times the detection limit at very low levels or, more commonly, 5% of the reported value.
	HRP (HorseRadish Peroxidase)-catalyzed thiamine oxidation thiochrome fluorescence	Hydrogen peroxide (H_2O_2)	3.3 times the detection limit at very low levels or, more commonly, 5% of the reported value.
Matthew Fraser	Denuder NH3	Ammonia	Greater of 0.2 $\mu g/m^3$ or 12% of the reported value
	Denuder HNO3	Nitric acid	Greater of 0.2 $\mu g/m^3$ or 12% of the reported value
	Organic $PM_{2.5}$ Speciation	Organic compounds (69 target compounds)	25% of the reported value (based on precision)
Susanne Hering	Continuous $PM_{2.5}$ Mass	Near real time carbon	3 $\mu g/m^3$
		Near real time nitrate	Calculated for each reported value (range of values: 0.18 $\mu g/m^3$ - 4.65 $\mu g/m^3$)
		Near real time sulfate	Greater of 0.2 $\mu g/m^3$ or 12% of the reported value
Len Stockburger	Moudi (Micro-Orifice Uniform Deposit Impactor)	PM Mass for 8 size ranges	0.2 $\mu g/m^3$
Dave Sullivan	TEOM (Thermal Element Oscillating Microbalance)	$PM_{2.5}$	not provided
Anthony Wexler	RSMS (Rapid single-particle mass spectrometer)	Particle mass spectrum	30% of the reported value

Table 5. GC-ARCH data completeness.

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
David Allen	Carbonyl: external	Aldine	2000/08/05	2000/08/27	98	60	61.2	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Carbonyl: internal	Aldine	2000/08/05	2000/08/27	98	94	95.9	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Total aliphatic HC: external	Aldine	2000/08/05	2000/08/27	98	60	61.2	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Total aliphatic HC: internal	Aldine	2000/08/05	2000/08/27	98	94	95.9	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Organonitrates: external	Aldine	2000/08/05	2000/08/27	98	60	61.2	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Organonitrates: internal	Aldine	2000/08/05	2000/08/27	98	94	95.9	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Sulfate: external	Aldine	2000/08/05	2000/08/27	98	58	59.2	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Sulfate: internal	Aldine	2000/08/05	2000/08/27	98	92	93.9	24 hours	Grab	Expected: 14 samples * 7 size ranges
	Carbonyl: external	HRM3	2000/08/06	2000/09/13	217	182	83.9	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Carbonyl: internal	HRM3	2000/08/06	2000/09/13	217	212	97.7	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Total aliphatic HC: external	HRM3	2000/08/06	2000/09/13	217	182	83.9	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Total aliphatic HC: internal	HRM3	2000/08/06	2000/09/13	217	213	98.2	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Organonitrates: external	HRM3	2000/08/06	2000/09/13	217	182	83.9	24 hours	Grab	Expected: 31 samples * 7 size ranges

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
David Allen (continued)	Organonitrates: internal	HRM3	2000/08/06	2000/09/13	217	213	98.2	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Sulfate: external	HRM3	2000/08/06	2000/09/13	217	182	83.9	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Sulfate: internal	HRM3	2000/08/06	2000/09/13	217	213	98.2	24 hours	Grab	Expected: 31 samples * 7 size ranges
	Carbonyl: external	LaPorte	2000/08/08	2000/09/13	224	169	75.4	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Carbonyl: internal	LaPorte	2000/08/08	2000/09/13	224	217	96.9	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Total aliphatic HC: external	LaPorte	2000/08/08	2000/09/13	224	169	75.4	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Total aliphatic HC: internal	LaPorte	2000/08/08	2000/09/13	224	218	97.3	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Organonitrates: external	LaPorte	2000/08/08	2000/09/13	224	169	75.4	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Organonitrates: internal	LaPorte	2000/08/08	2000/09/13	224	219	97.8	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Sulfate: external	LaPorte	2000/08/08	2000/09/13	224	169	75.4	24 hours	Grab	Expected: 32 samples * 7 size ranges
	Sulfate: internal	LaPorte	2000/08/08	2000/09/13	224	218	97.3	24 hours	Grab	Expected: 32 samples * 7 size ranges
Don Collins	Particle size: 100 size ranges	DeerPark	2000/10/03	2001/03/01	35672	22803	63.9	Continuous	~ 6 minutes	Expected: Assumed 6-minute sampling frequency.
		DeerPark	2001/06/03	2001/10/19	4427	2946	66.5	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
Don Collins (continued)	Particle count	DeerPark	2000/10/03	2001/03/01	35672	22803	63.9	Continuous	~ 6 minutes	Expected: Assumed 6-minute sampling frequency.
		DeerPark	2001/06/03	2001/10/19	4427	2946	66.5	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency
	Particle size: 100 size ranges	Aldine	2000/08/28	2000/09/19	15230	4981	32.7	Continuous	~ 4 minutes	Expected: Assumed 4-minute sampling frequency
		Aldine	2000/09/20	2001/03/02	39143	14967	38.2	Continuous	~ 6 minutes	Expected: Assumed 6-minute sampling frequency.
		Aldine	2001/05/30	2001/10/21	6945	4916	70.8	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 30-minute sampling frequency
	Particle count	Aldine	2000/08/28	2000/09/19	15230	4981	32.7	Continuous	~ 4 minutes	Expected: Assumed 4-minute sampling frequency
		Aldine	2000/09/20	2001/03/02	39143	14967	38.2	Continuous	~ 6 minutes	Expected: Assumed 6-minute sampling frequency.
		Aldine	2001/05/30	2001/10/21	6945	4916	70.8	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 30-minute sampling frequency
	Particle size: 100 size ranges	HRM3	2000/08/18	2000/09/21	9677	3278	33.9	Continuous	~ 5 minutes	Expected: Assumed 5-minute sampling frequency
		HRM3	2000/09/28	2001/03/24	6149	3638	59.2	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
Don Collins (continued)	Particle size: 100 size ranges (continued)	HRM3	2001/06/24	2001/11/07	4363	973	22.3	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency
	Particle count	HRM3	2000/08/18	2000/09/21	9677	3278	33.9	Continuous	~ 5-minute	Expected: Assumed 5-minute sampling frequency
		HRM3	2000/09/28	2001/03/24	6149	3638	59.2	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency
		HRM3	2001/06/24	2001/11/07	4363	973	22.3	Continuous	Ranged from ~ 25 minutes to ~ 60 minutes	Expected: Assumed 45-minute sampling frequency
	Particle size: 100 size ranges	LaPorte	2000/08/21	2000/09/16	9304	4323	46.5	Continuous	~ 4 minutes	Expected: Assumed 4-minute sampling frequency
	Particle count	LaPorte	2000/08/21	2000/09/16	9304	4323	46.5	Continuous	~ 4 minutes	Expected: Assumed 4-minute sampling frequency
Purnendu Dasgupta	Formaldehyde	HRM3	2000/08/12	2000/09/25	6288	6060	96.4	3 minutes	10 minutes	
	Hydrogen peroxide (H2O2)	HRM3	2000/08/12	2000/09/25	6288	6078	96.7	3 minutes	10 minutes	
Matt Fraser	Ammonia	Aldine	2000/09/30	2001/05/22	79	77	97.5	24 hours	1 every 3 days	
		DP	2000/10/15	2001/05/22	74	68	91.9	24 hours	1 every 3 days	
		HRM3	2000/09/30	2001/05/22	79	77	97.5	24 hours	1 every 3 days	
	Nitric acid	Aldine	2000/09/30	2001/05/22	79	77	97.5	24 hours	1 every 3 days	
		DP	2000/10/15	2001/05/22	74	71	95.9	24 hours	1 every 3 days	
		HRM3	2000/09/30	2001/05/22	79	77	97.5	24 hours	1 every 3 days	

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
Matt Fraser (continued)	69 Organic compounds	Aldine	2000/08/15	2000/09/30	621	602	96.9	24 hours	Grab	Expected: 9 samples * 69 compounds
		HRM3	2000/08/15	2000/09/30	621	602	96.9	24 hours	Grab	Expected: 9 samples * 69 compounds
		LaPorte	2000/08/27	2000/09/14	345	342	99.1	24 hours	Grab	Expected: 5 samples * 69 compounds
Susanne Hering	Near real time nitrate	LaPorte	2000/08/17	2000/09/18	4611	2526	54.8	~8.5 minutes	10 minutes	
		DP	2000/09/27	2001/11/05	58108	46529	80.1	~8.5 minutes	10 minutes	
		Aldine	2000/08/15	2001/11/05	64331	36272	56.4	~8.5 minutes	10 minutes	
	Near real time sulfate	LaPorte	2000/08/12	2000/09/16	5083	3219	63.3	~8.5 minutes	10 minutes	
		DP	2000/09/23	2001/05/09	32802	19848	60.5	~8.5 minutes	10 minutes	
		Aldine	2000/08/13	2001/05/21	40425	20660	51.1	~8.5 minutes	10 minutes	
	Near real time carbon	LaPorte	2000/08/12	2000/09/16	5083	2038	40.1	~8.5 minutes	10 minutes	
		DP	2000/09/23	2001/05/09	32802	11941	36.4	~8.5 minutes	10 minutes	
		Aldine	2000/08/13	2001/05/21	40425	10371	25.7	~8.5 minutes	10 minutes	
Len Stockburger	PM Mass for 8 size ranges	LaPorte	2000/08/17	2000/09/13	224	191	85.3	~8.5 minutes	10 minutes	
		HRM3	2000/08/17	2000/09/13	224	159	71.0	~8.5 minutes	10 minutes	
Dave Sullivan	PM2.5	Houston East C1	2000/08/02	2000/09/30	17266	17241	99.9	Continuous	5 minutes	
		Channelview C15/C115	2000/08/02	2000/09/30	17279	16579	95.9	Continuous	5 minutes	
		Galveston Airport C34/C109/C152	2000/08/02	2000/09/30	17224	17166	99.7	Continuous	5 minutes	
		Houston-Deer Park 2 C35/139	2000/08/02	2000/09/30	16791	16745	99.7	Continuous	5 minutes	
		Hamshire C64	2000/08/02	2000/09/30	17272	17214	99.7	Continuous	5 minutes	
		Conroe C65	2000/08/02	2000/09/30	17280	16966	98.2	Continuous	5 minutes	

PI	Measurement	Site	Start Date (yyyy/mm/dd)	Stop Date (yyyy/mm/dd)	Expected	Valid	Percent Valid	Sampling Interval	Sampling Frequency	Notes
Anthony Wexler	particle mass spectrum	HRM3	2000/08/23	2000/09/18	variable	27314	N/A	Continuous	Highly variable	