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Pacific Northwest
National Laboratory
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Joint Urban 2003: Study Overview and Instrument Locations

K. J. Allwine
J. E. Flaherty

August 2006

Prepared for the U.S. Department of Homeland Security under a Related Services Agreement with the U.S. Department of Energy under contract DE-AC05-76RL01830

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

Quality-assured meteorological and tracer data sets are vital for establishing confidence that indoor and outdoor dispersion models used to simulate dispersal of potential toxic agents in urban atmospheres are giving trustworthy results. The U.S. Department of Defense-Defense Threat Reduction Agency and the U.S. Department of Homeland Security joined together to conduct the Joint Urban 2003 atmospheric dispersion study to provide this critically-needed high-resolution dispersion data. This major urban study was conducted from June 28 through July 31, 2003, in Oklahoma City, Oklahoma, with the participation of over 150 scientists and engineers from over 20 U.S. and foreign institutions. Through mid-2006 over 125 papers and presentations have been given on scientific findings and model evaluations based on the field study results.

The Joint Urban 2003 lead scientist was Jerry Allwine (Pacific Northwest National Laboratory) who oversaw study design, logistical arrangements and field operations with the help of Joe Shinn (Lawrence Livermore National Laboratory), Marty Leach (Lawrence Livermore National Laboratory), Ray Hosker (Atmospheric Turbulence and Diffusion Division), Leo Stockham (Northrop Grumman Information Technology) and Jim Bowers (Dugway Proving Ground).

This report gives a brief overview of the field campaign, describing the scientific objectives, the dates of the intensive observation periods, and the instruments deployed. The data from this field study is available to the scientific community through an on-line database that is managed by Dugway Proving Ground. This report will be included in the database to provide its users with some general information about the field study, and specific information about the instrument coordinates. Appendix A of this document provides the definitive record of the instrument locations during this field campaign, and Appendix B lists all the study principal investigators and participants.

Acronyms

AGL	above ground level
ANL	Argonne National Laboratory
ARL	Army Research Laboratory
ARLFRD	Air Resources Laboratory Field Research Division
ARO	Army Research Office
ASU	Arizona State University
ASOS	Automated Surface Observing System
ATDD	Atmospheric Turbulence and Diffusion Division
CBD	central business district
CBNP	Chemical Biological National Security Program (DOE)
CDC	Center for Disease Control
CDT	central daylight time
CFD	computational fluid dynamics
CFU	Central Florida University
DARPA	Defense Advanced Research Projects Agency
DEQ	Oklahoma Department of Environmental Quality
DHS	U.S. Department of Homeland Security
DOE	U.S. Department of Energy
DOY	day of year
DPG	Dugway Proving Ground
DSTL	Defense Science and Technology Laboratory
DTRA	Defense Threat Reduction Agency
ECBC	Edgewood Chemical Biological Center
FM-CW	Frequency Modulated Continuous Wave Radar Profiler
GIS	geographic information system
IOP	intensive observation period
IR	infrared
ITT	ITT Industries
IU	Indiana University
LANL	Los Alamos National Laboratory

LBNL	Lawrence Berkley National Laboratory
LLNL	Lawrence Livermore National Laboratory
NEPA	National Environmental Policy Act
NGIT	Northrop Grumman Information Technology
NIOSH	National Institute for Occupational Safety and Health
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
OCS	Oklahoma Climatological Survey
OKC	Oklahoma City
OU	University of Oklahoma
PNNL	Pacific Northwest National Laboratory
TGA	Trace Gas Analyzer
TP9	U.S. Department of Defense Technical Panel 9
TTCP	The Technical Cooperation Program
TTU	Texas Tech University
UH	University of Houston
USGS	United States Geological Survey
UU	University of Utah
WSU	Washington State University

Acknowledgments

This research was supported in part by the U.S. Department of Homeland Security under a Related Services Agreement with the U.S. Department of Energy (DOE) under Contract DE-AC05-76RL01830. Pacific Northwest National Laboratory (PNNL) is operated for DOE by Battelle Memorial Institute.

Joint Urban 2003 would not have been possible without the support of Oklahoma City (OKC), the University of Oklahoma Health Sciences Center, private land owners, and the general public. The OKC Public Works Department provided considerable help by allowing study participants to use some of their facilities for staging areas, allowed instrumentation to be placed on streets and public facilities, and provided parking downtown for study staff during experimental periods. Mr. Paul Brum, OKC City Engineer, and Mr. JC Reiss of the Public Works Department were instrumental in all aspects of logistical arrangements for conducting the study. Mr. Leon Ashford of the Oklahoma Department of Environmental Quality (DEQ) arranged for some elements of the study to be staged from DEQ facilities. Additionally, the University of Oklahoma Health Sciences Center was very generous in providing laboratory and meeting space within their facilities in OKC. Dr. Jeff Basara and Ms. Cerry Leffler of the Oklahoma Climatological Survey provided invaluable support in producing identification badges for all study participants and in arranging for many Oklahoma Climatological Survey and University of Oklahoma students to help with the field operations. Mr. Ron Rocke of Maccini Construction Co. arranged for the installation of several instrument systems in OKC and also arranged with Allied Steel Construction Co. for the receiving, shipping and storage of equipment needed for the study.

The success of Joint Urban 2003 was critically dependent on many individuals, not the least of whom were the scientists, engineers, technicians, students, and contractors from the participating organizations and companies. Project participants would like to thank several individuals who played key roles during various stages of planning and conducting the study. Ms. Jennifer Reichert of the U.S. DOE's Chemical Biological National Security Program (CBNP) was the CBNP program manager for the project and was instrumental in coordinating and integrating CBNP objectives with Defense Threat Reduction Agency (DTRA) objectives. Ms. Leslie Burchett followed-on for Ms. Reichert and ensured that DOE objectives were met in the field and also facilitated the smooth transition of Joint Urban 2003 from DOE to the new Department of Homeland Security (DHS), where the final DHS portion of Joint Urban 2003 was under the guidance of Ms. Teresa Lustig. Mr. John Pace was the DTRA Urban Modeling Program manager responsible for integrating DTRA objectives with CBNP objectives for Joint Urban 2003. Mr. Richard Fry was the DTRA program manager responsible for the DTRA portion of Joint Urban 2003.

The National Environmental Policy Act (NEPA) documentation for the study was prepared by Ms. Regan Weeks of PNNL and Mr. Geoff Harvey, PNNL, served as the lead public affairs contact for Joint Urban 2003. Ms. Cheri Abdelnour and Major Linda Ritchie were responsible for the public affairs on Joint Urban 2003 for DTRA, and Ms. Michelle Petrovich was responsible for DHS public affairs. Ms. Cerry Leffler of the Oklahoma Climatological Survey was the local public affairs contact for the study.

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1.0 Introduction

Air motions in and around cities are very complicated and the increasing threat of toxic agent releases into urban atmospheres makes advancing the state-of-science of understanding and modeling atmospheric flows in and around cities essential. Quality-assured meteorological and tracer data sets are vital for establishing confidence that indoor and outdoor dispersion models used to simulate dispersal of potential toxic agents in urban atmospheres are giving trustworthy results. To provide this critically-needed high-resolution dispersion data, the U.S. Department of Defense – Defense Threat Reduction Agency (DTRA) and the U.S. Department of Homeland Security (DHS) joined in an effort to conduct the Joint Urban 2003 atmospheric dispersion study in Oklahoma City (OKC), Oklahoma (Figure 1.1) during July, 2003. Numerous investigators from government laboratories, universities, and private companies conducted the multi-million dollar OKC study. Additionally, investigators from several other U.S. federal agencies and foreign government agencies participated in the study.

Figure 1.1. OKC Looking East in Top Panel and Looking South in Bottom Panel

This major urban study was conducted from June 28 through July 31, 2003. It included several integrated scientific components necessa2ry to describe and understand the physical processes governing dispersion within and surrounding an urban area and into and within building environments. The components included characterizing:

1) the urban boundary layer and the development of the urban boundary layer within the atmospheric boundary layer,
2) flows within and downwind of the tall-building core,
3) flows within a street canyon including the effects of traffic on turbulence,
4) surface energy balance within an urban area,

5) dispersion of tracer into, out of, and within buildings, and

6) dispersion of tracer throughout the tall-building core and out to four kilometers downwind from the release.

The scientific elements of the study were accomplished using state-of-the-art meteorological and tracer instruments including lidars, sodars, radars, sonic anemometers, airplane-based meteorological sensors, fast-response tracer analyzers, and helicopter-based remote tracer detectors. Winds and other meteorological quantities were measured continuously at nearly 100 locations in and around downtown OKC.

Ten main intensive observation periods (IOPs) of 8-hours each were completed during the 34-day study period where detailed meteorological, turbulence and tracer measurements were made. Sulfur hexafluoride (SF_6) tracer was released in downtown OKC and sampled in and around downtown and as far as four kilometers downwind. During four of the ten IOPs, the infiltration of tracer into four downtown buildings was studied with detailed measurements of tracer and flows within and surrounding some buildings. Tracer was sampled using over 200 integrated samplers and 25 fast response analyzers. Vertical measurements of tracer were made by placing samplers on the tops of nearly 20 buildings and by sampling tracer at 7 levels on a 90-m crane.

An overview of the Joint Urban 2003 field study is presented, identifying scientific objectives and the deployment of instruments to accomplish the scientific objectives. Study participants, experimental periods and meteorological conditions during the study period are briefly discussed.

2.0 Scientific Objective

The primary objective of the Joint Urban 2003 field study was to collect meteorological and tracer data resolving atmospheric dispersion at scales-of-motion ranging from flows in and around a single city block, in and around several blocks in the downtown Central Business District (CBD), and into the suburban OKC area a few kilometers from the CBD. Indoor tracer and flow measurements within four downtown study buildings were also made in conjunction with detailed outdoor measurements investigating the outdoor-indoor exchange rates and mechanisms. The movement of tracer within the study buildings was also investigated.

The tracer and meteorological data collected in OKC are being used to evaluate and improve existing indoor and outdoor dispersion models, including fine-scale computational fluid dynamics (CFD) models, mesoscale numerical weather prediction models with sub-grid scale urban parameterizations, and fast-response dispersion models that typically rely on empirical or semi-empirical relationships describing atmospheric processes. The data will lead to improved algorithms and parameterizations within these models. If fact, through mid-2006 over 125 papers and presentations have been given on scientific findings and model evaluations based on the Joint Urban 2003 field study results.

Specific objectives of this field study included

- Use state-of-the-art remote sensing instruments (e.g., radar profilers, lidars, sodars) to continuously measure the detailed wind and turbulence characteristics of the urban atmosphere from the ground through several kilometers above the ground. These relatively new instruments, when applied in a dense network, give a view of the three-dimensional flow in and above cities that has not been possible in the past.

- Collect tracer data at various distances from specified release points to provide data for validating a variety of urban dispersion models. Networks of sampling capabilities and meteorological instruments were deployed to observe the concentrations at the various distances downwind, and to simultaneously investigate the physical processes that govern the dispersion.

- Use state-of-the-art in-situ meteorological instruments (e.g., sonic anemometers, infrared [IR] thermometers) to observe the winds and turbulence within the urban canopy layer. Together with time-resolved in-situ tracer sampling, these observations provide data necessary not only for validating current dispersion models, but also for improving current and formulating new dispersion algorithms and relationships.

- Conduct urban canyon experiments with high resolution wind and turbulence measurements together with tracer data to investigate the processes that disperse material within the canyon and the exchange of material between the canyon and the overall urban circulation.

- Conduct indoor experiments designed to investigate the exchange of tracer material through a building envelope. Tracer samplers and sonic anemometers were deployed inside the building and immediately outside the building in high-density configuration to estimate the exchange rate. Perfluorocarbon tracers were released and sampled inside the building to estimate transport within the building.

- Provide an archived data set that has been quality-controlled and consistency-checked based on a detailed data management plan.

The Joint Urban 2003 experimental objectives have been accomplished, to the credit of all study participants, and the data has been submitted to the data archive, which is managed by Dugway Proving Ground. The secure data archive, available via the internet, was accessible only to study participants until January 31, 2005. Since then, the archive has been made publicly available for investigators and modelers to perform analyses and validation of urban dispersion models. An account for accessing the database may be requested by visiting https://ju2003-dpg.dpg.army.mil/. The back-up database site, https://ju2003-slc.dpg.army.mil/, may also be utilized when the main site is under maintenance. As of January 2006, there were over 140 database users from 25 states and 6 countries (Halvorson et al, 2006).

3.0 Organization

The Joint Urban 2003 field study was a major effort, bringing together over 150 scientists, engineers, technicians and students from over 20 U.S. and foreign organizations to accomplish the study objectives. Participating organizations included six from the U.S. Department of Defense, five U.S. Department of Energy and Homeland Security national laboratories, two U.S. National Oceanic and Atmospheric Administration laboratories, eight U.S. universities, and other U.S. federal agencies and private companies. The U.S. organizations participating were

Department of Defense:
- Defense Threat Reduction Agency (DTRA)
- Army Research Laboratory (ARL)
- Army Research Office (ARO)
- Edgewood Chemical Biological Center (ECBC)
- Dugway Proving Ground (DPG)
- Defense Advanced Research Projects Agency (DARPA)

Departments of Homeland Security & Energy:
- Argonne National Laboratory (ANL)
- Los Alamos National Laboratory (LANL)
- Lawrence Berkley National Laboratory (LBNL)
- Lawrence Livermore National Laboratory (LLNL)
- Pacific Northwest National Laboratory (PNNL)

National Oceanic and Atmospheric Administration:
- Air Resources Laboratory - Field Research Division (ARLFRD)
- Air Resources Laboratory - Atmospheric Turbulence and Diffusion Division (ATDD)
- Department of Transportation – Volpe Center
- Center for Disease Control/National Institute for Occupational Safety and Health (CDC/NIOSH)
- National Severe Storms Laboratory (NSSL)

Universities:
- Arizona State University (ASU)
- Central Florida University (CFU)
- Texas Tech University (TTU)
- Indiana University (IU)
- University of Houston (UH)
- University of Oklahoma (OU)
- University of Utah (UU)
- Washington State University (WSU)

State of Oklahoma:
- Oklahoma Climatological Survey (OCS)
- Department of Environmental Quality (DEQ)

Private Companies:
- Northrop Grumman Information Technology
- ITT Industries, Advanced Engineering & Sciences
- Maccini Construction Company
- Allied Steel Construction Company

Other Federal Organizations:

Foreign participants were the United Kingdom Defense Science and Technology Laboratory (DSTL) and the Defense Research and Development Canada who participated in Joint Urban 2003 under the auspices of the U.S. Department of Defense Technical Panel 9 (TP9) of The Technical Cooperation Program (TTCP) Chemical, Biological and Radiological Defense (CBD) Group. Appendix B lists the study participants.

The Joint Urban 2003 lead scientist was Jerry Allwine (PNNL) who oversaw study design, logistical arrangements and field operations with the help of Joe Shinn (LLNL), Marty Leach (LLNL), Ray Hosker (ATDD), Leo Stockham (Northrop Grumman Information Technology [NGIT]) and Jim Bowers (DPG). Planning for Joint Urban 2003 was very extensive and began nearly two years prior to conducting the

study in July 2003. As part of the planning, preliminary meteorological studies were conducted during the summer of 2002 to help determine the tracer release locations and the tracer sampler locations based on the predominant wind directions. Historically, the winds in OKC during July are predominantly from the south during both night and day, and this pattern was confirmed during the preliminary meteorological studies.

Further refinement of the tracer sampling network during the design phases of Joint Urban 2003 was accomplished using results from wind tunnel studies performed by the Meteorological Institute, University of Hamburg (Leitl et al, 2003), and from preliminary modeling studies performed by LLNL and CFD Research Corporation, Huntsville, Alabama (Coirier and Reich, 2003). These reports are available from the Dugway Proving Ground database website. The design-phase wind tunnel and modeling studies were very useful in finalizing the locations and sampling intervals of the tracer samplers.

4.0 Study Overview

The Joint Urban 2003 study fielded many instruments in OKC and the surrounding area for the outdoor dispersion component of the study. Instrumentation from the indoor component that investigated the exchange of material into and within buildings will not be presented here. Details about instruments for the indoor component may be found on the DPG database site. Outdoor instruments consisted of tracer samplers, tracer analyzers, sonic anemometers, meteorological stations, and a variety of remote sensing instruments. Additionally, the Oklahoma Climatological Survey collected meteorological data from its Oklahoma Mesonet. The following list summarizes all the instrumentation, categorized by instrument type. Instruments that operated continuously throughout the study are labeled "(Cont)" below, while instruments that were only operational during the IOPs are marked with "(IOP)."

- 194 tracer bag samplers (IOP)
  - 134 ARLFRD
  - 44 LLNL
  - 16 Volpe
- 25 fast-response tracer analyzers (IOP)
  - 10 ARLFRD
  - 10 LLNL
  - 5 ITT
- 1 WSU seven-level tracer profile system (IOP)
- airborne remote sensing tracer instruments and met sensors (IOP)
  - ECBC helicopter
  - ATDD airplane
- 2 lidars (IOP)
  - ARL
  - ASU
- 3 radiosondes (IOP)
  - ANL
  - ARL
  - PNNL
- 2 tethersondes (IOP)
  - DPG
  - UU
- 7 2-D sonic anemometers (IOP)
  - 5 LANL
  - 2 Volpe
- 33 PNNL temperature sensors (Cont)
- 3 ceilometers (Cont)
- 106 3-D sonic anemometers (Cont)
  - 12 ARL
  - 4 ASU
  - 8 ATDD
  - 20 DPG
  - 7 DSTL[(d)]
  - 11 ITT[(d)]
  - 9 IU
  - 6 LANL
  - 8 LLNL
  - 10 OU
  - 11 UU
- 8 surface energy stations (Cont)
  - 1 ASU
  - 3 ATDD
  - 4 IU
- 29 surface meteorological stations (Cont)
  - 15 DPG
  - 5 PNNL
  - 3 NWS[(a)] ASOS[(b)]
  - 6 OK Mesonet
- 9 sodars (Cont)
  - 4 ANL
  - 1 ARLFRD
  - 1 DPG
  - 1 UH
  - 1 PNNL
  - 1 UU
- 4 weather stations (Cont)
  - NWS WSR-88D
- 4 radar profilers (3 with RASS) (Cont)
  - ANL
  - OU
  - PNNL
  - DPG FM-CW[(c)]
- Traffic study, mobile air temperatures, microbarograph study (Cont)

(a) NWS = National Weather Service
(b) ASOS = Automated Surface Observing System
(c) FM-CW = Frequency Modulated Continuous Wave Radar Profiler: gives high temporal and spatial resolution of vertical structure, specifically mixing depth. Does not give winds.
(d) These instruments collected data only during the IOPs

A complete listing of the instrumentation deployed by each participating institution, along with coordinates and maps of their locations, can be found in Appendix A to this document. Additionally, the Dugway Proving Ground database contains geographic information system (GIS) shapefiles that may be downloaded and viewed with GIS software. These shapefiles were created with ArcView version 9.0. A free GIS data viewer, called ArcExplorer, may be downloaded from the ESRI website (http://www.esri.com/software/arcexplorer/download.html) for viewing the instrument locations.

The majority of the meteorological and tracer instruments were sited within or near the CBD with some tracer and meteorological measurements extending out to approximately six kilometers from the CBD. Figure 4.1 presents an overview of the meteorological instruments covering the study region. As stated in the Scientific Objectives section, this field study also aimed to study scales-of-motion as small as within a single city block. Therefore, a single street canyon along Park Avenue between Robinson and Broadway Avenues was selected for a large number of surface and profile meteorological instruments. Figure 4.2 shows the instrumentation that was deployed in the Park Avenue street canyon.

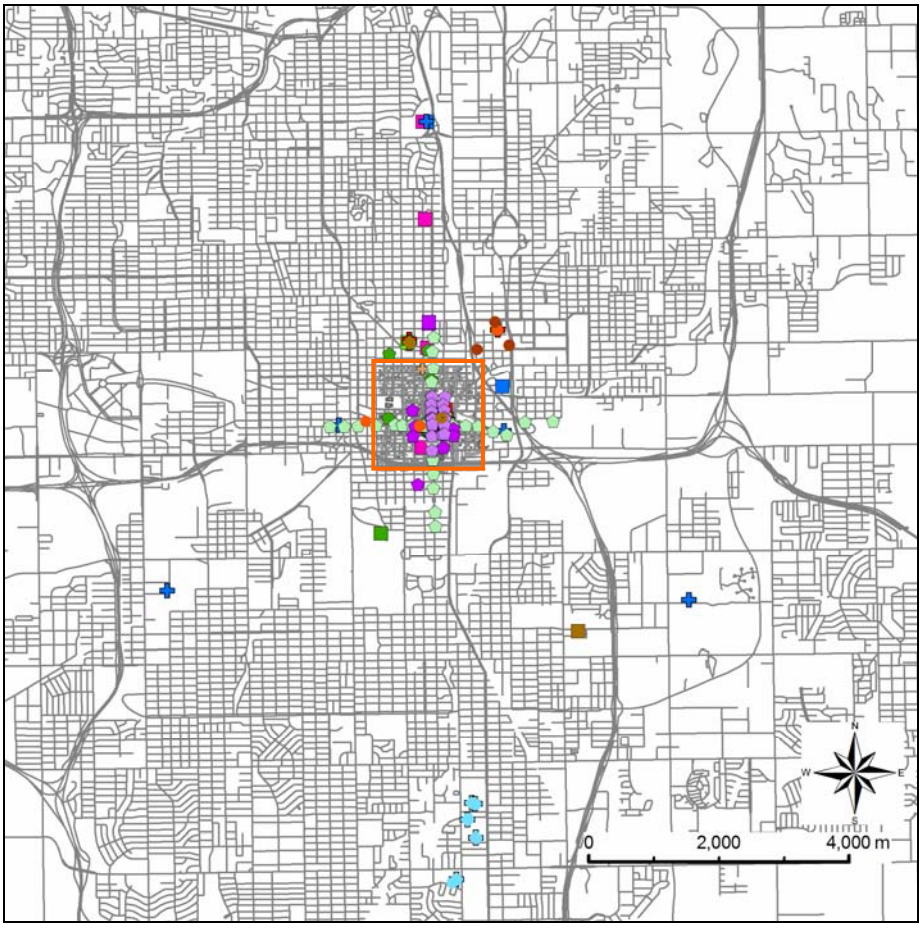

Figure 4.1. Overview of Meteorological Measurement Sites Around OKC. The orange rectangle encloses the central business district. The symbols indicate coverage of all of the meteorological instruments. For location information on specific instruments, see Appendix A.

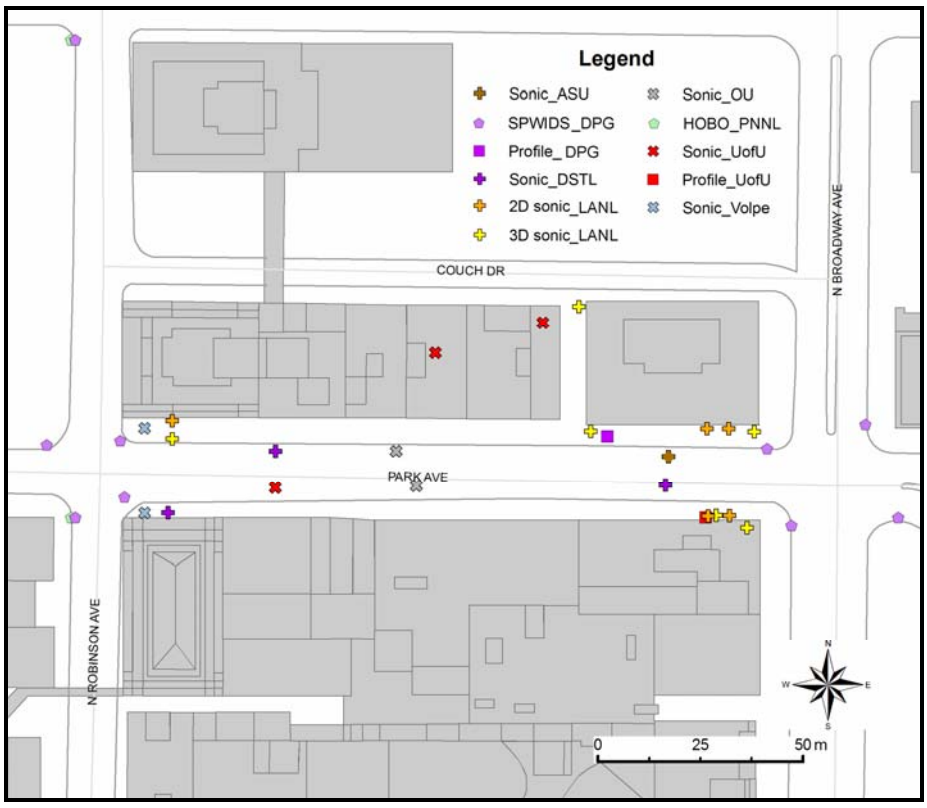

Figure 4.2. Instruments that were Located in the Park Ave Street Canyon. The instruments that appear in this figure were deployed at these locations for each IOP. Many of these instruments also remained at the measurement locations for the duration of the field campaign. (The two profile sites, the 2D sonics from LANL, and the sonics from Volpe were only operational during IOPs.)

Sulfur hexafluoride tracer was released as puffs and continuous releases from one of three release locations (Figure 4.3) during the 10 main IOPs. The release location was chosen dependent on the wind direction and building configuration. The "Westin" release was used when the winds were expected from the S through SSE and the "Botanical" release was used when the winds were expected from the S through SSW. During the first IOP, there were busses parked at the Westin release location, so the release was conducted across the street, and is indicated as Westin East. The "Park" release was used when studying the Park Avenue urban street canyon effects in more detail. A "mini" IOP (labeled "5a" in Tables 4.1. and 4.2) was conducted when the expected wind direction was from the SW. The full suite of tracer instruments was not deployed for the mini IOP; however, the 7-level tracer profiler collected tracer data. The release location during each IOP is identified in Figure 4.3 and Table 4.1.

The first six IOPs occurred during daylight hours, typically beginning at 0900 CDT and ending 8 hours later at 1700 CDT. The last four IOPs occurred during the night, typically beginning at 2300 CDT and ending at 0700 CDT. During each IOP typically seven near ground-level point releases occurred – three continuous releases of ½ hour duration and four instantaneous releases where balloons filled with tracer were popped. Table 4.2 summarizes the times and rates of the tracer releases.

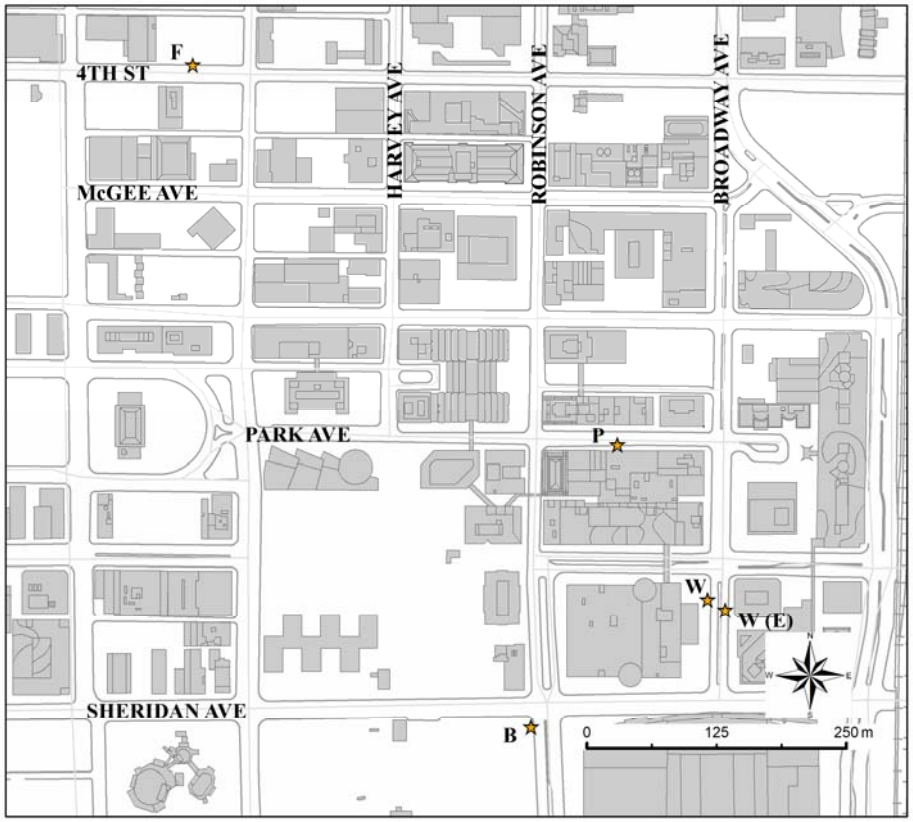

Figure 4.3. Tracer Release Locations. W (E) = Westin East, W = Westin, B=Botanical, P=Park, and F = Fourth

Table 4.1. Summary of Intensive Observation Periods (IOPs). DOY = day of year, Release Locations are W (E) = Westin East, W = Westin, B=Botanical, P=Park, and F = Fourth. See Fig 4.3 for a map with release locations.

IOP #	Begin Date 2003	Begin DOY	Beg / End Time (CDT)	Day/ Night	In-door	Release Location	# Releases; Puff (P)/ Continuous (C)
1	6/29 - Sun	180	09 / 15[(a)]	D		W (E)	8; P,P,P,P,P,P,C,C
2	7/02 - Wed	183	09 / 17	D		W	7; P,P,P,P,C,C,C
3	7/07 - Mon	188	09 / 17	D		B	7; P,P,P,P,C,C,C
4	7/09 - Wed	190	09 / 17	D	I	B	6; P,P,P,C,C,C
5	7/13 - Sun	194	09 / 17	D	I	B	7; C,C,C,P,P,P,P
5a	7/15 - Tue	196	12 / 14	D		F	3; C,C,C
6	7/16 - Wed	197	09 / 17	D	I	B	7; C,C,C,P,P,P,P
7	7/18 - Fri	199	23 / 07	N	I	B	7; C,C,C,P,P,P,P
8	7/24 - Thu	205	23 / 07	N		W	7; C,C,C,P,P,P,P
9	7/26 - Sat	207	23 / 07	N		P	7; C,C,C,P,P,P,P
10	7/28 - Mon	209	21 / 04[(a)]	N		P	6; C,C,C,P,P,P
(a) Stopped early because of wind shift off sampling grid.							

Meteorological conditions during the July 2003 study period are summarized in Figure 4.4. The period of each IOP is identified, showing the wind directions primarily from the SSW through SSE during IOPs. The SF_6 tracer samplers and analyzers were deployed in different configurations depending on the release location. Figure 4.5 shows all the sampler configurations used for all the IOPs. More detailed images of tracer instrumentation deployed by each group during each IOP can be found in Appendix A.

Table 4.2. Summary of IOP Tracer Release Rates and Times.

IOP	Date	Release Type	Start (CDT)	Release Amount
1	6/29/03	Puff	0900	1000
		Puff	0910	1003
		Puff	0920	1000
		Puff	0930	1000
		Puff	0945	500
		Puff	1000	508
		30-Min	1100	4.9
		30-Min	1300	4.8
2	7/2/03	Puff	0900	1001
		Puff	0920	1010
		Puff	0940	1000
		Puff	1000	1041
		30-Min	1100	5.0
		30-Min	1300	5.0
		30-Min	1500	5.0
3	7/7/03	Puff	0900	1000
		Puff	0920	1005
		Puff	0940	1000
		Puff	1000	1004
		30-Min	1100	5.0
		30-Min	1300	3.0
		30-Min	1500	3.0
4	7/9/03	Puff	0900	996
		Puff	0920	1002
		Puff	0940	504
		30-Min	1100	3.1
		30-Min	1300	3.0
		30-Min	1500	3.0
5	7/13/03	30-Min	0900	2.2
		30-Min	1100	3.0
		30-Min	1300	3.1
		Puff	1500	499
		Puff	1520	500
		Puff	1540	500
		Puff	1600	500
5a	7/15/03	20-Min	1200	8.0
		20-Min	1230	5.0
		20-Min	1300	3.0

IOP	Date	Release Type	Start (CDT)	Release Amount
6	7/16/03	30-Min	0900	3.0
		30-Min	1100	3.2
		30-Min	1300	3.0
		Puff	1500	498
		Puff	1520	499
		Puff	1540	510
		Puff	1600	500
7	7/18/03	30-Min	2300	3.0
		30-Min	0100	2.0
		30-Min	0300	2.0
		Puff	0500	303
		Puff	0520	300
		Puff	0540	304
		Puff	0600	298
8	7/24/03	30-Min	2300	3.1
		30-Min	0100	3.0
		30-Min	0300	3.0
		Puff	0500	500
		Puff	0520	500
		Puff	0540	300
		Puff	0600	305
9	7/26/03	30-Min	2300	2.0
		30-Min	0100	2.0
		30-Min	0300	2.1
		Puff	0500	300
		Puff	0520	300
		Puff	0540	300
		Puff	0600	300
10	7/28/03	30-Min	2100	2.2
		30-Min	2300	1.9
		30-Min	0100	2.2
		Puff	0300	300
		Puff	0320	300
		Puff	0340	300

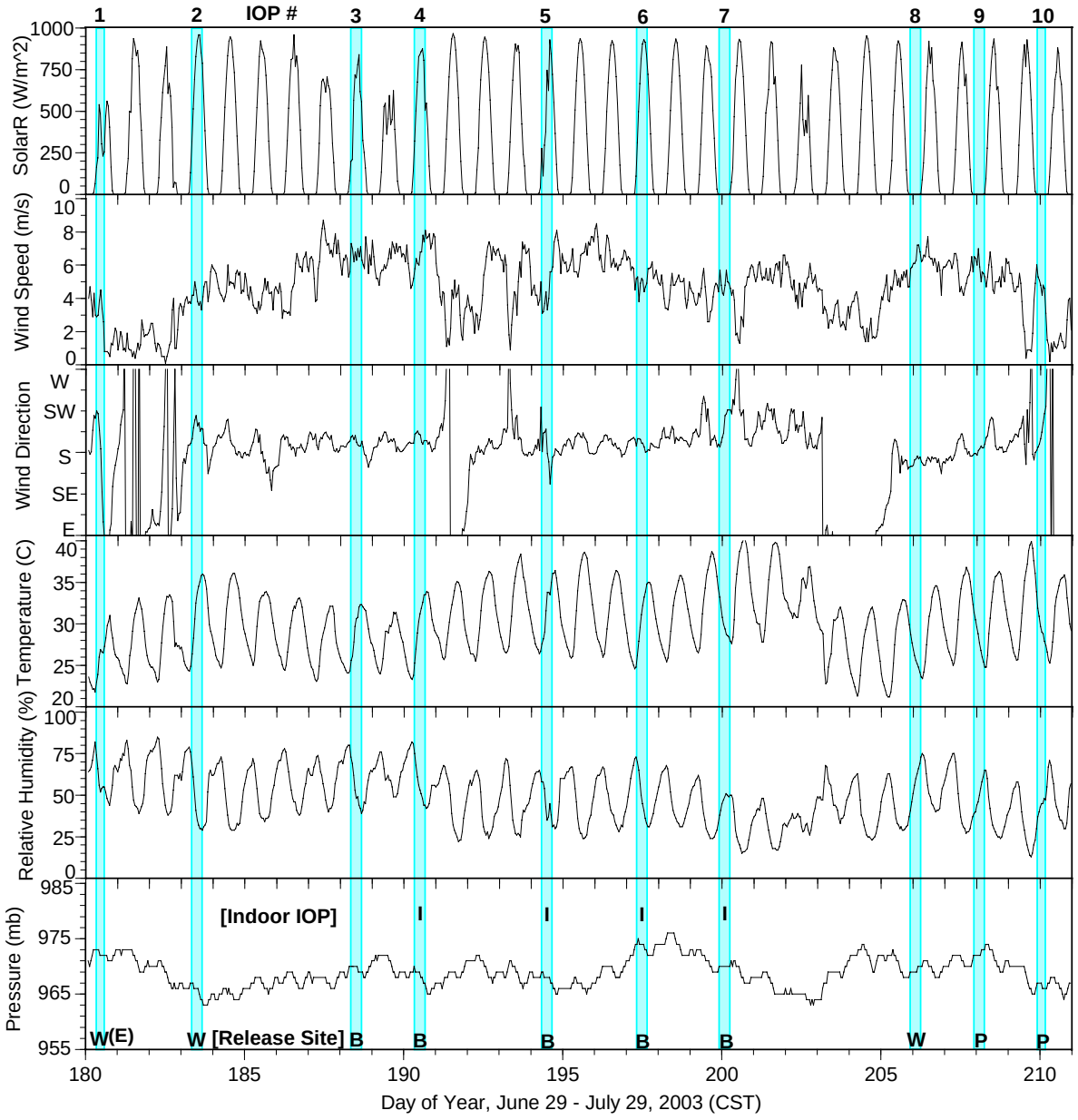

Figure 4.4. Hourly Averaged Meteorological Conditions for July 2003 Measured at 3 m Above the Rooftop on a 42-m-high Building with Unobstructed Exposure to the Winds. The weather station was located on St. Anthony's hospital (NW 10th & Dewey) approximately 1 ½ km NW of downtown OKC. The atmospheric pressure is from a weather station on the rooftop of the 34-m-high Civic Center Music Hall (Colcord & Lee) just west of downtown OKC. The blue lines indicate the times of the IOPs during which tracers were released. The labels "W (E)," "W," "B," and "P" (Westin East, Westin, Botanical and Park) identify the tracer release location for each IOP (see Figure 4.3 and Table 4.1).

The release locations and "indoor study" IOPs are also identified in Figure 4.4. An indoor component to this study was conducted during IOPs 4-7. The four buildings studied as part of the indoor component of Joint Urban 2003 were located near the intersections of Park & Broadway and McGee & Harvey. During indoor IOPs the release location was chosen such that the tracer plume would move in the direction of the indoor study buildings based on the forecast wind directions. The Joint Urban 2003 database website contains information and data from the indoor study; however, the indoor instrumentation will not be described in this report. All of the outdoor tracer sampler and analyzer instrumentation deployed during this study are presented in Figure 4.5.

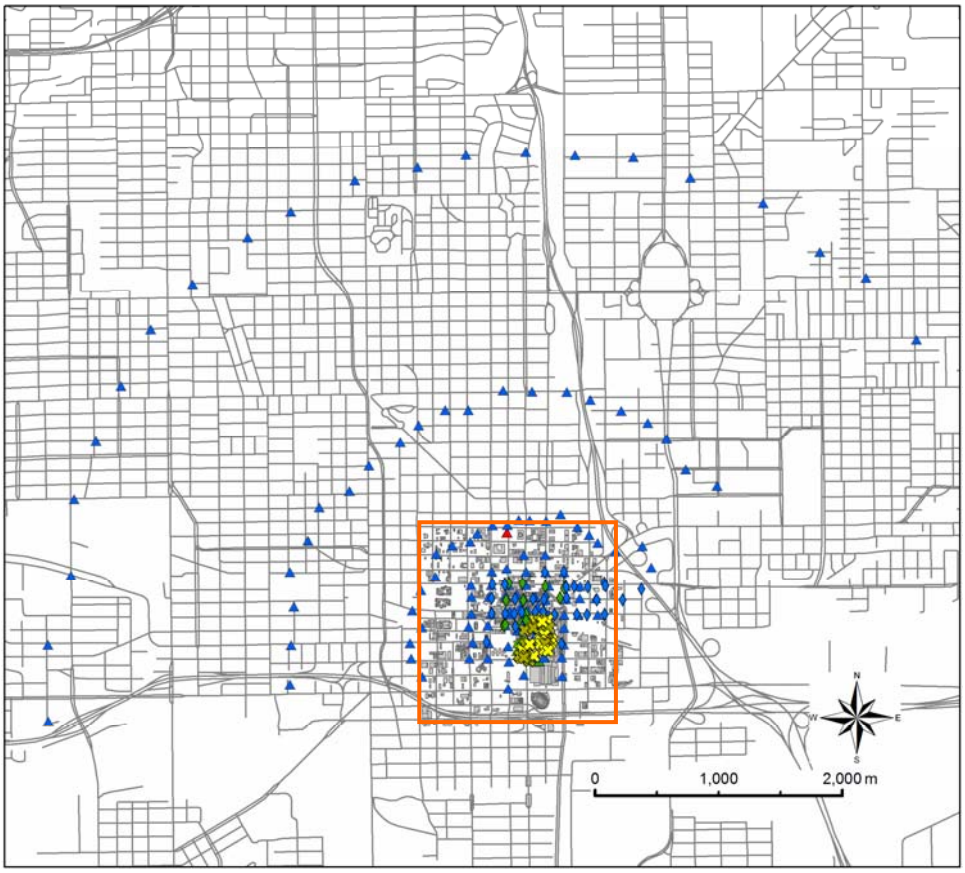

Figure 4.5. Overview of Tracer Sampler and Analyzer Instrument Locations. The orange box encloses the central business district of OKC. For location information on specific instruments, see Appendix A.

5.0 References

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Appendix A

This section contains information concerning the locations of all of the instrumentation deployed during the Joint Urban 2003 field campaign. The instruments are presented in alphabetical order by the institution responsible for the instruments. The instrument coordinates are presented in both geodetic coordinates (latitude and longitude) and Universal Transverse Mercator (UTM) coordinates in meters. Latitude values are north of the equator and longitude values are west of the prime meridian. UTM coordinates are generally projected to zone 14N with the 1983 North American Datum. The exception to this is the Tulsa radar site, which was in zone 15N.

The instrument coordinates presented in this section are a result of extensive investigation. It was discovered that the instrument positions that were provided with the data were not always an accurate representation of the true instrument location. Therefore, each instrument location was examined carefully using a variety of information sources, including instrument ReadMe files, instrument photos, and aerial images from the United States Geological Survey (USGS) and Google Earth. This information was used to position each instrument within the urban landscape, which was defined primarily by the building shapefile (Dr. May Yuan, OU Dept. of Geography). Curblines were also available for the central business district, and streetlines were available for the whole of Oklahoma City. These shapefiles were not as reliable as the building shapefile, and were used with caution. The coordinates presented in this document are the definitive positions of the instruments with respect to the GIS-defined urban landscape. When there are discrepancies between the information provided with the data from the Dugway Proving Ground database site and the tables in this section, the information in this document should be used.

A.1 Argonne National Laboratory

The Argonne National Laboratory deployed profile instrumentation at four sites. Table A.1 presents the coordinates of the instrumentation at each of these sites, while Figures A.1 and A.2 show the locations on a map. Data collected from ANL can also be found at their website: http://www.atmos.anl.gov/OKC/.

Table A.1. ANL Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
profiler/RASS	First Christian Church	35.50999	97.51726	634463	3930612
minisodar	First Christian Church	35.50999	97.51726	634463	3930612
rawindsonde	First Christian Church	35.50999	97.51726	634463	3930612
minisodar	Botanical Gardens	35.46474	97.51822	634451	3925592
sodar	Goodholm Park	35.49634	97.51713	634497	3929098
minisodar	10^{th} and Harvey	35.47866	97.51707	634532	3927137

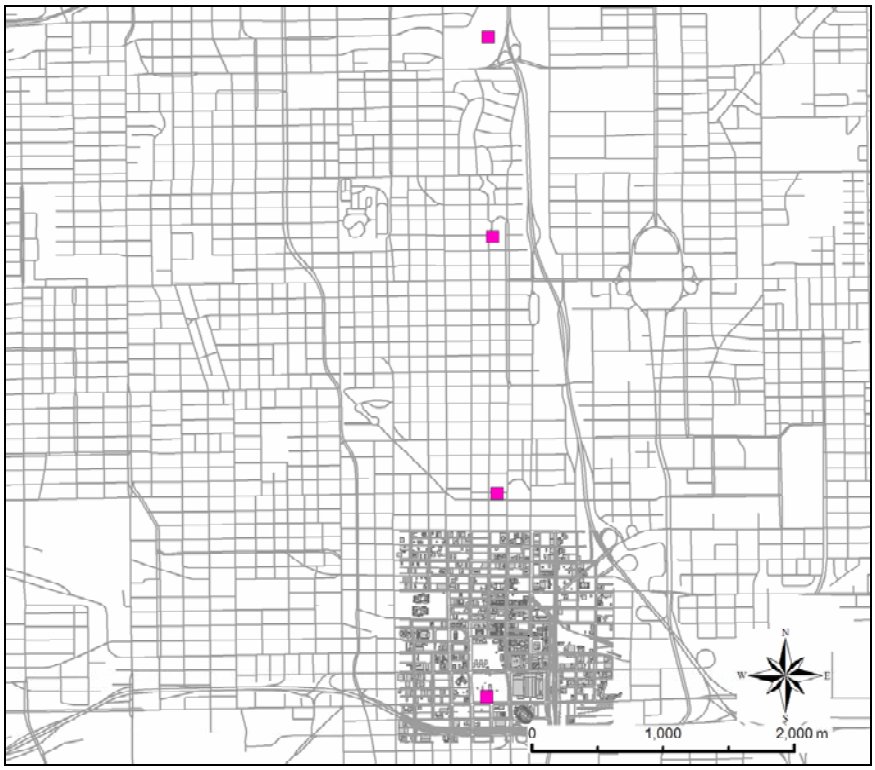

Figure A.1. Overview of ANL Instrument Locations

Figure A.2. ANL Instrument Locations: (a) Botanical, (b) 10th and Harvey Site, (c) Goodholm Park, and (d) First Christian Church

A.2 Army Research Laboratory

The Army Research Laboratory deployed instrumentation at six separate sites around Oklahoma City. Five of these sites had towers with 3D sonic anemometers mounted at 10 m and 5 m above ground level, while two of the towers (numbered 2 and 3 in Table A.2) had an additional sonic anemometer at 2.5 m above ground level. The instrument coordinates are presented in Table A.2 and locations are shown in Figures A.3 and A.4.

Table A.2. ARL Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Sonic tower 1	SW 18th & S Miller	35.44529	97.56171	630536	3923376
Sonic tower 2	E Sheridan & S Byers (near Bricktown Ballpark)	35.46684	97.50418	635721	3925844
Sonic tower 3	2300 SE 22nd. Park Maintenance	35.44295	97.47329	638565	3923237
Sonic tower 4	NW 36th & Walker. First Christian Church	35.50994	97.51657	634525	3930608
Sonic tower 5	W Main & N Klein	35.46800	97.53217	633180	3925934
rawindsonde	NW 36th & Walker. First Christian Church	35.50994	97.51657	634525	3930608
Lidar / radiometer	On parking garage at 655 Research Parkway [~10m agl]	35.47308	97.50443	635688	3926536

Figure A.3. Overview of ARL Instrument Locations

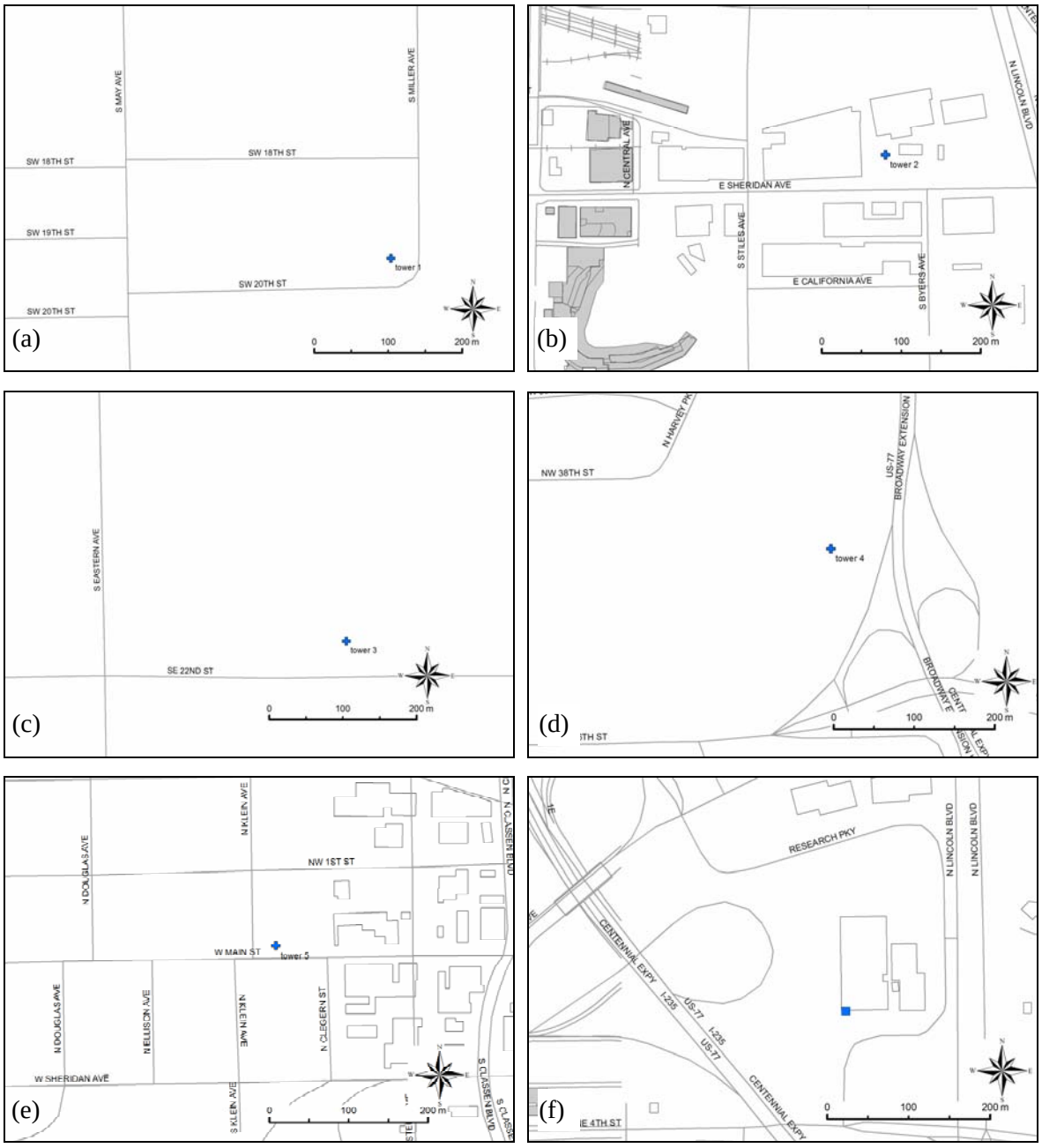

Figure A.4. ARL Instrument Locations for (a) Tower 1, (b) Tower 2, (c) Tower 3, (d) Tower 4 and Rawindsonde, (e) Tower 5, and (f) Lidar and Radiometer

A.3 NOAA Air Resources Laboratory—Field Research Division

The NOAA Air Resources Laboratory Field Research Division deployed a large number of SF_6 tracer samplers and analyzers throughout Oklahoma City. The tracer samplers, known as Programmable Integrating Gas Samplers (PIGS) and a newer version Super-PIGS (S-PIGS), were placed within the central business district and in 1-, 2-, and 4-km arcs from the central business district. The PIGS and S-PIGS were deployed in different arrangements during each IOP, depending on the expected wind direction. The sampler positions used during this field study are presented in Table A.3 and in Figures A.5, A.6, and A.7. Trace Gas Analyzers (TGAs) measured instantaneous concentrations of SF_6, and were deployed in one mobile and nine stationary vans in the central business district. The coordinates of the stationary vans during each IOP are presented in Table A.4 and the locations are shown in Figure A.8.

Additionally, the tracer dissemination for this field study was performed by ARLFRD. The tracer dissemination site consisted of a release tube (for continuous releases), a release balloon (for instantaneous releases), a 3D sonic anemometer, and a temperature/RH sensor. The coordinates of the five tracer release locations that were used during this field study are presented in Table A.5 and the locations are shown in Figure A.9. Finally, a sodar was deployed at the Oklahoma School of Science and Mathematics. The coordinates of this sodar are given in Table A.6 and the position is shown on a map in Figure A.10.

Table A.3. ARLFRD Tracer Sampler Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
[003]	CBD - Reno & Harvey	35.46436	97.51795	634476	3925550
[014]	CBD - Robinson between Reno & Sheridan	35.46532	97.51652	634604	3925659
[017]	CBD - Santa Fe between Reno & Sheridan	35.46518	97.51312	634913	3925648
[021]	CBD - Sheridan & Walker	35.46657	97.52136	634163	3925790
[022]	CBD - Sheridan & Hudson	35.46656	97.51973	634311	3925792
[023]	CBD - Sheridan between Hudson & Robinson	35.46630	97.51783	634484	3925765
[024]	CBD - Sheridan & Robinson	35.46655	97.51657	634598	3925795
[025]	CBD - Sheridan between Robinson & Broadway	35.46655	97.51530	634713	3925797
[026]	CBD - Sheridan & Broadway	35.46656	97.51469	634768	3925798
[027]	CBD - Sheridan & Santa Fe	35.46656	97.51310	634912	3925801
[031]	CBD - Main & Walker	35.46772	97.52107	634187	3925919
[032]	CBD - Main & Hudson	35.46767	97.51963	634318	3925915
[033]	CBD - Main & Harvey (Parking Lot)	35.46742	97.51789	634476	3925890
[034]	CBD - Main & Robinson	35.46760	97.51614	634635	3925912
[036]	CBD - Main & Broadway	35.46756	97.51431	634801	3925910
[037]	CBD - Main & Santa Fe	35.46749	97.51293	634926	3925904
[041]	CBD - Walker btwn Colcord & Couch	35.46890	97.52138	634157	3926049
[042]	CBD – Park & Hudson	35.46895	97.51966	634313	3926057
[043]	CBD – Park & Harvey	35.46892	97.51810	634455	3926056
[044]	CBD – Park & Robinson (NE corner)	35.46885	97.51656	634595	3926050
[045]	CBD – Park between Robinson & Broadway	35.46869	97.51550	634691	3926034
[046]	CBD – Park & Broadway	35.46882	97.51462	634771	3926049
[047]	CBD – Park & Santa Fe	35.46870	97.51288	634929	3926038

Table A.3. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
[051]	CBD – Kerr & Walker	35.46983	97.52111	634180	3926152
[052]	CBD – Kerr & Hudson	35.46980	97.51938	634337	3926152
[053]	CBD – Kerr & Harvey	35.46977	97.51783	634478	3926150
[054]	CBD – Kerr & Robinson	35.46975	97.51630	634617	3926150
[055]	CBD - S side Kerr between Robinson & Broadway (Kerr Parking Top)	35.46972	97.51542	634697	3926148
[056]	CBD - Kerr & Broadway (Broadway Kerr Parking Garage)	35.46970	97.51426	634802	3926147
[057]	CBD – Kerr & Santa Fe	35.46963	97.51286	634929	3926142
[058]	CBD – Kerr between Santa Fe & Oklahoma	35.46964	97.51158	635045	3926144
[059]	CBD – Kerr between Oklahoma & Walnut	35.46960	97.50983	635204	3926142
[061]	CBD - McGee & Walker	35.47106	97.52109	634180	3926289
[062]	CBD - McGee & Hudson	35.47105	97.51954	634321	3926290
[063]	CBD - McGee & Harvey	35.47099	97.51800	634460	3926285
[064]	CBD - McGee & Robinson	35.47095	97.51644	634602	3926283
[065]	CBD - McGee between Robinson & Broadway	35.47093	97.51542	634695	3926282
[066]	CBD - McGee & just E of Broadway	35.47072	97.51448	634780	3926260
[067]	CBD - McGee & Santa Fe	35.47079	97.51263	634948	3926270
[068]	CBD - McGee between Santa Fe & Oklahoma	35.47083	97.51144	635056	3926277
[069]	CBD - McGee between Oklahoma & Walnut	35.47080	97.51001	635186	3926275
[071]	CBD - N 4th & Walker	35.47192	97.52111	634177	3926384
[072]	CBD - N 4th & Hudson	35.47190	97.51929	634342	3926385
[073]	CBD - N 4th & Harvey	35.47186	97.51777	634480	3926382
[074]	CBD - N 4th & Robinson	35.47185	97.51620	634622	3926383
[076]	CBD - N 4th & Broadway	35.47176	97.51419	634805	3926376
[077]	CBD - N 4th btwn Broadway & RR tracks	35.47173	97.51262	634947	3926375
[078]	CBD - N 4th between RR tracks & Oklahoma	35.47172	97.51138	635060	3926375
[082]	CBD - N 5th & Hudson	35.47293	97.51926	634343	3926499
[083]	CBD - N 5th & Harvey	35.47310	97.51791	634465	3926520
[084]	CBD - N 5th & Robinson	35.47286	97.51617	634623	3926495
[086]	CBD - N 5th & Broadway	35.47279	97.51443	634781	3926490
[087]	CBD - N 5th btwn Broadway & RR tracks	35.47278	97.51278	634931	3926491
[094]	CBD - N 6th & Robinson	35.47410	97.51637	634603	3926632
[096]	CBD - N 6th & Broadway	35.47405	97.51445	634777	3926630
[401]	Tunnel - Broadway between Sheridan & Main	35.46724	97.51435	634798	3925874
[402]	Tunnel - Broadway btwn Main & Park (W of Bank One Bldg)	35.46824	97.51422	634808	3925985
[403]	Tunnel - Kerr & Broadway	35.46970	97.51452	634778	3926147
[404]	Tunnel - Kerr & Harvey	35.46996	97.51765	634494	3926172
[501]	1 km Arc- California & Shartel	35.46532	97.52561	633779	3925646
[502]	1 km Arc- Sheridan & Shartel	35.46663	97.52657	633690	3925790
[503]	1 km Arc- Main btwn Fred Jones & Shartel	35.46777	97.52664	633682	3925916
[504]	1 km Arc- Colcord & Shartel	35.46888	97.52557	633777	3926041
[505]	1 km Arc- Kerr & Shartel	35.47011	97.52640	633700	3926176
[506]	1 km Arc- Shartel btwn N 3rd & N 4th	35.47160	97.52559	633771	3926343
[507]	1 km Arc- Lee btwn N 4th & N 5th	35.47258	97.52430	633886	3926453

Table A.3. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
[508]	1 km Arc- Lee btwn N 5th & N 6th	35.47426	97.52418	633894	3926640
[509]	1 km Arc- Dewey btwn N 6th & N 7th	35.47485	97.52275	634023	3926707
[510]	1 km Arc- N 7th & Walker	35.47512	97.52115	634168	3926739
[511]	1 km Arc- btwn N 7th & N 8th and Walker & Hudson	35.47571	97.52049	634227	3926805
[512]	1 km Arc- N 8th & Hudson	35.47630	97.51912	634350	3926873
[513]	1 km Arc- N 8th & Harvey	35.47631	97.51780	634470	3926876
[514]	1 km Arc- btwn N 8th & N 9th and Harvey & Robinson	35.47667	97.51677	634563	3926917
[515]	1 km Arc- btwn N 8th & N 9th and Robinson & Broadway	35.47661	97.51580	634651	3926912
[516]	1 km Arc- Broadway btwn N 8th & N 9th	35.47653	97.51432	634785	3926905
[517]	1 km Arc- N 9th btwn Broadway & RR tracks	35.47702	97.51303	634901	3926961
[518]	1 km Arc- N 8th btwn RR tracks & Oklahoma	35.47608	97.51154	635038	3926859
[519]	1 km Arc- Oklahoma btwn N 7th & N 8th	35.47547	97.51050	635133	3926792
[520]	1 km Arc- N 7th btwn Oklahoma & Walnut	35.47490	97.50977	635201	3926730
[521]	1 km Arc- On overpass (Harrison) btwn 6th & 7th	35.47423	97.50820	635344	3926658
[522]	1 km Arc- Stiles btwn N 6th & N 7th	35.47461	97.50578	635563	3926704
[523]	1 km Arc- N 5th btwn Stiles & Geary	35.47304	97.50498	635638	3926530
[531]	2km Arc - California & McKinley	35.46489	97.53744	632707	3925582
[532]	2km Arc - Main & McKinley	35.46773	97.53726	632718	3925898
[533]	2km Arc - McKinley btwn N 2nd & N 3rd	35.47052	97.53696	632741	3926208
[534]	2km Arc - N 5th & McKinley	35.47309	97.53725	632710	3926492
[535]	2km Arc - Brauer btwn Linwood & N 7th	35.47539	97.53562	632854	3926749
[536]	2km Arc - N 9th & Douglas	35.47780	97.53457	632946	3927018
[537]	2km Arc - N 19th & Klein	35.47895	97.53186	633190	3927149
[538]	2km Arc - N 11th & Western	35.48078	97.53009	633347	3927355
[539]	2km Arc - N 13th & Francis	35.48249	97.52724	633603	3927548
[540]	2km Arc - N 14th & Shartel	35.48371	97.52559	633751	3927686
[541]	2km Arc - N 15th btwn Lee & Dewey	35.48480	97.52320	633966	3927810
[542]	2km Arc - N 15th btwn Walker & Hudson	35.48477	97.52114	634153	3927810
[543]	2km Arc - N 16th btwn Hudson & Harvey	35.48617	97.51798	634437	3927969
[544]	2km Arc - N 16th & Robinson	35.48603	97.51540	634671	3927957
[545]	2km Arc - N 16th btwn Broadway & RR tracks	35.48598	97.51232	634951	3927956
[546]	2 km Arc- N 16th btwn Oklahoma & Walnut	35.48538	97.51023	635141	3927892
[547]	2 km Arc- N 15th btwn Walnut & Stiles	35.48455	97.50748	635392	3927804
[548]	2 km Arc- N 14th btwn Stiles & Lincoln	35.48363	97.50513	635607	3927705
[549]	2 km Arc- N 13th & Lincoln	35.48244	97.50345	635761	3927575
[550]	2 km Arc- SL Young & Lindsay	35.48015	97.50180	635915	3927324
[551]	2 km Arc- Philips btwn N 10th & SL Young	35.47892	97.49903	636168	3927191
[561]	4km Arc - S 2nd & Linn	35.46247	97.55904	630750	3925285
[562]	4km Arc - Main & Linn	35.46802	97.55898	630747	3925901
[563]	4km Arc - General Pershing & Villa	35.47307	97.55682	630935	3926464
[564]	4km Arc - N 10th & Villa	35.47866	97.55646	630958	3927084
[565]	4km Arc - N 13th & Billan	35.48290	97.55440	631138	3927557
[566]	4km Arc - N 17th & Youngs	35.48690	97.55211	631340	3928004

Table A.3. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
[567]	4km Arc - N 21st & Barnes	35.49098	97.54939	631580	3928460
[568]	4km Arc - N 23rd & Virginia	35.49424	97.54558	631920	3928827
[569]	4km Arc - N 27th & Florida	35.49760	97.54061	632365	3929206
[570]	4km Arc - N 29th & McKinley	35.49944	97.53672	632715	3929416
[571]	4km Arc - N 31st & Lake	35.50166	97.53094	633236	3929670
[572]	4km Arc - N 32nd & Shartel	35.50255	97.52535	633741	3929776
[573]	4km Arc - Hill & Walker	35.50342	97.52101	634133	3929878
[574]	4km Arc - N 33rd & Robinson	35.50355	97.51564	634620	3929900
[575]	4km Arc - Hill btwn Santa Fe & Walnut	35.50328	97.51125	635019	3929876
[576]	4 km Arc- Hill btwn Walnut & Lincoln	35.50308	97.50606	635490	3929861
[577]	4 km Arc- N 31st & Lindsay	35.50150	97.50098	635953	3929693
[578]	4 km Arc- N 29th & Kelley	35.49955	97.49450	636544	3929485
[579]	4 km Arc- N 25th & Lottie	35.49591	97.48953	637001	3929089
[580]	4 km Arc- Madison & Prospect	35.49398	97.48545	637375	3928880
[581]	4 km Arc- N 20th & Rhode Island	35.48938	97.48101	637785	3928376
[940]	Rooftop - Park between Harvey & Robinson (Oklahoma Tower Roof – 117m agl)	35.46855	97.51708	634548	3926016
[945]	Rooftop - Park btwn Robinson & Broadway (Chamber of Commerce roof – 17m agl)	35.46889	97.51546	634694	3926056
[946]	Rooftop – NW corner of Park & Broadway (Sonic Building Roof – 47m agl)	35.46891	97.51470	634763	3926059
[950]	Rooftop – NE corner of Kerr & Robinson (39m agl)	35.47001	97.51609	634635	3926179
[954]	Rooftop - W side Robinson between Kerr & McGee (Bank of Oklahoma – 78m agl)	35.47032	97.51672	634578	3926213
[955]	Rooftop - Kerr btwn Robinson & Broadway (Kerr McGee Center – 115m agl)	35.47023	97.51523	634713	3926205
[956]	Rooftop - Kerr btwn Robinson & Broadway (Kerr McGee Center – 26m agl)	35.46991	97.51461	634770	3926170
[963]	Rooftop – NW corner of McGee & Harvey (ONG Building roof – 20m agl)	35.47113	97.51807	634454	3926301
[964]	Rooftop - McGee btwn Harvey & Robinson (Old Post Office Roof – 37m agl)	35.47115	97.51705	634546	3926304
[965]	Rooftop - Broadway & McGee (SW Bell Bldg Roof – 72m agl)	35.47097	97.51542	634695	3926287

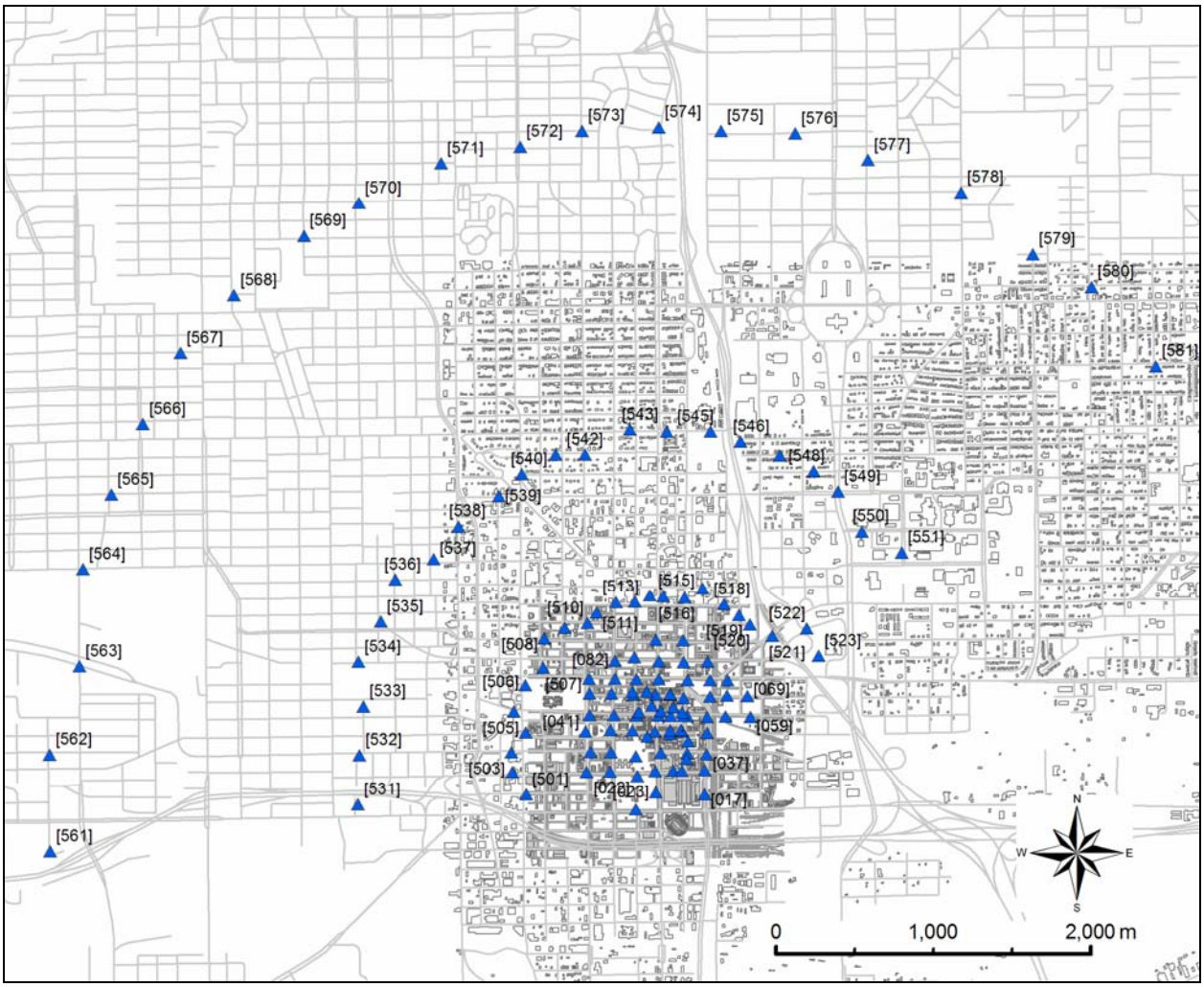

Figure A.5. Overview of ARLFRD PIGS and S-PIGS Tracer Sampler Instruments

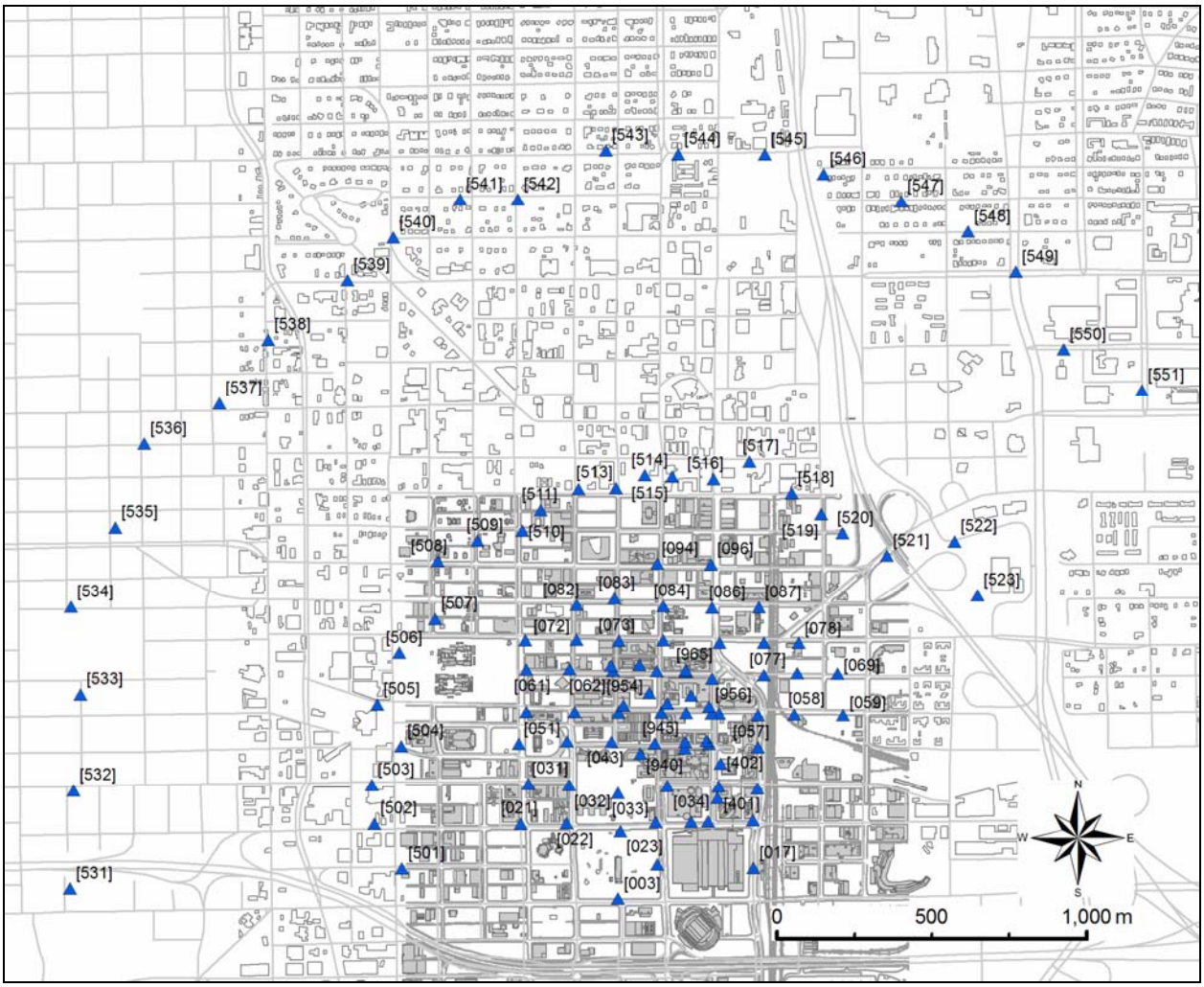

Figure A.6. ARLFRD PIGS and S-PIGS Tracer Sampler Instruments, Zoomed into the 2-km Arc

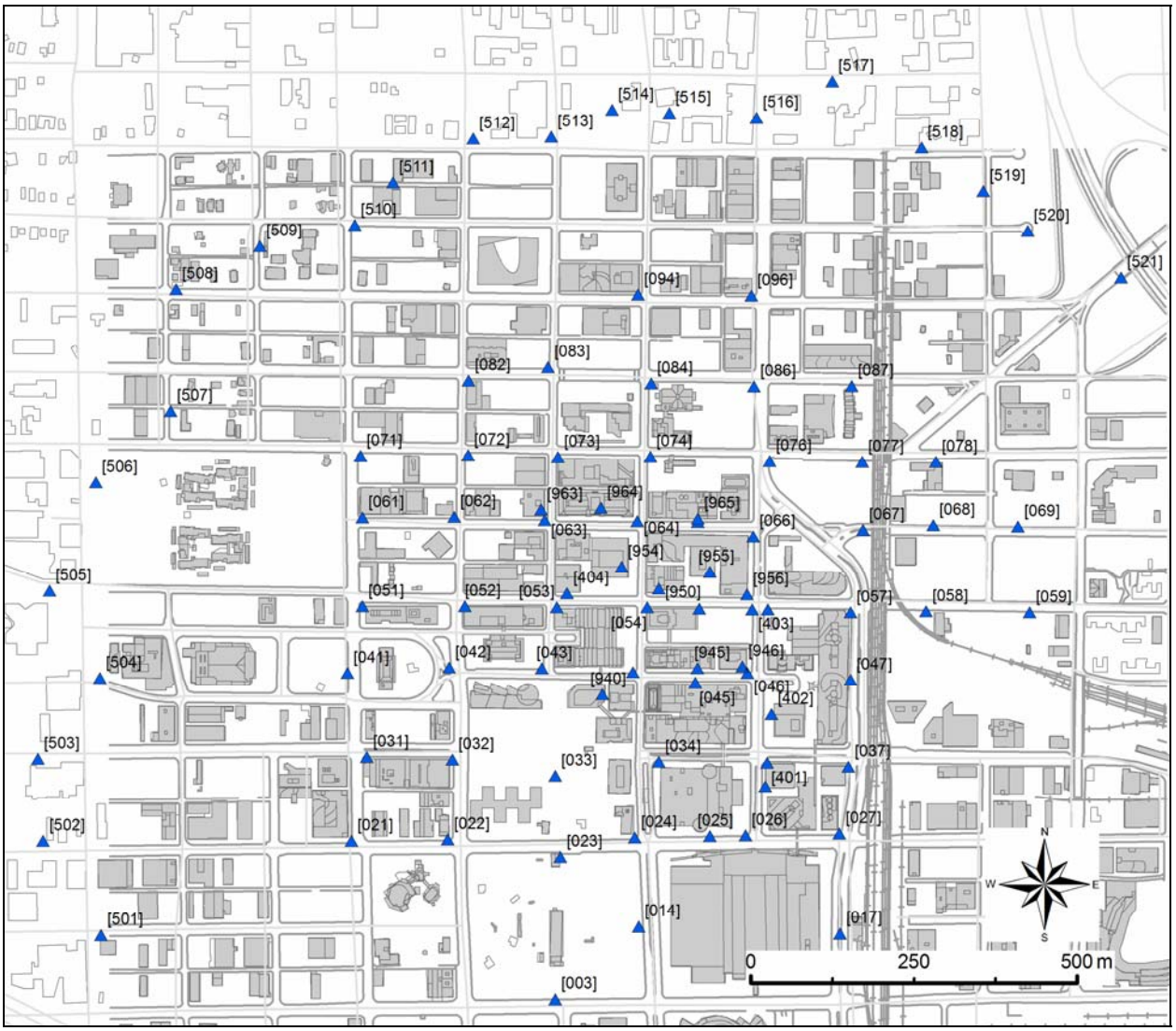

Figure A.7. ARLFRD PIGS and S-PIGS Tracer Sampler Instruments, Zoomed into the 1-km Arc

Table A.4. ARLFRD Trace Gas Analyzer Instrument Locations. Instruments marked a, b, and c represents changes in position during the IOP. See Clawson et al (2005) for additional details.

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP1 - [0]	NW Corner of Kerr & Broadway, parking meter 2085	35.46986	97.51470	634762	3926164
IOP1 - [1]	S. side McGee btwn Robinson & Broadway, parking meter 0459	35.47080	97.51559	634679	3926268
IOP1 - [2]	S. side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP1 - [3]	S. side Park btwn Robinson & Broadway (in front of Hallmark store)	35.46871	97.51560	634682	3926036
IOP1 - [4]	Park Ave E of Broadway meter 0012 (in front of Skirvin Hotel)	35.46856	97.51409	634819	3926021
IOP1 - [5]	Mobile on 4th Street				
IOP1 - [6]	S. side Main btwn Robinson & Broadway, parking meter 2092	35.46760	97.51550	634693	3925913
IOP1 - [7]	Top of Main Street Parking Garage [27m agl]	35.46790	97.51550	634692	3925946
IOP1 - [8]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP1 - [9]	NW corner of Park & Robinson meter 2113	35.46882	97.51661	634590	3926046
IOP2 - [0]	NW Corner of Kerr & Broadway meter 2085	35.46986	97.51470	634762	3926164
IOP2 – [1a]	S. side McGee btwn Robinson & Broadway, parking meter 0459	35.47080	97.51559	634679	3926268
IOP2 - [1b]	On 3rd St. btwn Walnut & Oklahoma	35.47069	97.50990	635196	3926263
IOP2 - [2a]	S. side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP2 - [2b]	3rd & Gaylord parking meter 0034 (just W of RR overpass)	35.47087	97.51260	634951	3926279
IOP2 - [3]	S. side Park btwn Robinson & Broadway (in front of Hallmark store)	35.46871	97.51560	634682	3926036
IOP2 - [4a]	SW corner 4th Street & Harvey, meter 1063	35.47193	97.51810	634450	3926389
IOP2 - [4b]	4th & Gaylord (just E of RR overpass)	35.47168	97.51190	635013	3926370
IOP2 - [5]	Mobile on 4th Street				
IOP2 - [6a]	SW corner Kerr & Harvey, meter 1119	35.46980	97.51810	634453	3926153
IOP2 - [6b]	SW corner 2nd & Oklahoma	35.46963	97.51080	635116	3926144
IOP2 - [7a]	SE corner Kerr & Hudson, meter 1112	35.46982	97.51930	634344	3926154
IOP2 - [7b]	2nd & Gaylord (just E of RR overpass)	35.46966	97.51170	635034	3926146
IOP2 - [8]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP2 - [9a]	NW corner of Park and Robinson meter 2113	35.46882	97.51661	634590	3926046
IOP2 - [9b]	NW corner of 4th & Walnut	35.47194	97.50920	635257	3926403
IOP 3 & 4	Stationary vans, same as IOP 1				
IOP3 – [5]	Mobile on 4^{th}, 8^{th}, 10^{th}, and 16^{th} Streets				
IOP4 – [5]	Mobile on 4^{th} and 8^{th} Streets				
IOP5 - [0a]	NW Corner of Kerr & Broadway meter 2085	35.46986	97.51470	634762	3926164
IOP5 - [0b]	SE Corner of Harvey & Kerr	35.46980	97.51810	634453	3926153
IOP5 - [1a]	N side Kerr btwn Robinson & Broadway (in front of Kerr Tower)	35.46987	97.51540	634698	3926165

Table A.4. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP5 - [1b]	McGee btwn Broadway & Robinson, parking meter 0459	35.47080	97.51559	634679	3926268
IOP5 - [2a]	S side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP5 - [2b]	4th St just E of Hudson, parking meter 1055	35.47194	97.51920	634350	3926389
IOP5 - [3a]	S side Park btwn Robinson & Broadway (in front of Hallmark store)	35.46871	97.51560	634682	3926036
IOP5 - [3b]	SW corner Main & Hudson	35.46776	97.51981	634302	3925925
IOP5 - [4]	Park E of Broadway meter 0012 (in front of Skirvin Hotel)	35.46856	97.51409	634819	3926021
IOP5 - [5]	Mobile on 4th & 8th Streets & CBD				
IOP5 - [6]	S side Main btwn Robinson & Broadway, parking meter 2092	35.46760	97.51550	634693	3925913
IOP5 - [7]	Top of Main Street Parking Garage [27m agl]	35.46790	97.51550	634692	3925946
IOP5 - [8a]	NW corner of McGee & Broadway	35.47098	97.51447	634781	3926289
IOP5 - [8b]	SE corner of Hudson & McGee, meter 1090	35.47091	97.51930	634343	3926275
IOP5 - [9]	NW corner of Park & Robinson, meter 2113	35.46882	97.51661	634590	3926046
IOP 6	Same as IOP 1				
IOP7 - [0a]	NW Corner of Kerr & Broadway meter 2085	35.46986	97.51470	634762	3926164
IOP7 - [0c]	SW corner of 2nd & Walnut (in front of Finley Bldg)	35.46963	97.50920	635261	3926147
IOP7 - [1a]	S side McGee btwn Broadway & Robinson, parking meter 0459	35.47080	97.51559	634679	3926268
IOP7 - [1b]	3rd St btwn Walnut & Oklahoma	35.47069	97.50990	635196	3926263
IOP7 - [2a]	S side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP7 - [2b]	Corner of 3rd & Gaylord, parking meter 0034 (just W of RR overpass)	35.47087	97.51260	634951	3926279
IOP7 - [3a]	S side Park btwn Robinson & Broadway (in front of Hallmark store)	35.46871	97.51560	634682	3926036
IOP7 - [3c]	SW corner of 4th & Walnut (in front of Bricktown Auto Bath & Shine)	35.47171	97.50910	635267	3926377
IOP7 - [4]	Park E of Broadway meter 0012 (in front of Skirvin Hotel)	35.46856	97.51409	634819	3926021
IOP7 - [5]	Mobile on 4th Street				
IOP7 - [6a]	S side Main btwn Robinson & Broadway, parking meter 2092	35.46760	97.51550	634693	3925913
IOP7 - [6c]	SW corner of Gaylord & Main, meter 2050	35.46754	97.51310	634911	3925909
IOP7 - [7a]	Top of Main Street Parking Garage	35.46790	97.51550	634692	3925946
IOP7 - [7c]	100 ft S of Stiles on 4th St	35.47145	97.50590	635558	3926353
IOP7 - [8a]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP7 - [8c]	SW corner of 3rd & Central	35.47066	97.50760	635405	3926263

Table A.4. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP7 - [9a]	NW corner of Park & Robinson, meter 2113	35.46882	97.51661	634590	3926046
IOP7 - [9b]	2nd & Gaylord (just E of RR overpass)	35.46966	97.51170	635034	3926146
IOP8 - [0a]	NW Corner of Kerr & Broadway meter 2085	35.46986	97.51470	634762	3926164
IOP8 - [0b]	SW corner of 4th & Harvey, meter 1063	35.47190	97.51810	634450	3926386
IOP8 - [1]	S side McGee btwn Broadway & Robinson, parking meter 0459	35.47080	97.51559	634679	3926268
IOP8 - [2]	S side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP8 - [3]	S side Park btwn Robinson & Broadway (in front of Hallmark store)	35.46871	97.51560	634682	3926036
IOP8 - [4a]	SW corner of 4th & Harvey, meter 1063	35.47190	97.51810	634450	3926386
IOP8 - [4b]	NW Corner of Kerr & Broadway meter 2085	35.46986	97.51470	634762	3926164
IOP8 - [5]	Mobile on 8th Street				
IOP8 - [6]	SW corner of Kerr & Harvey, meter 1119	35.46980	97.51810	634453	3926153
IOP8 - [7]	SE corner of Kerr & Hudson, meter 1112	35.46980	97.51930	634344	3926152
IOP8 - [8]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP8 - [9]	NW corner of Park & Robinson, meter 2113	35.46882	97.51661	634590	3926046
IOP9 - [0a]	N side Park btwn Harvey & Robinson, parking meter 2121 (under elev walkway)	35.46884	97.51720	634537	3926048
IOP9 - [0b]	S side 4th St just W of tracks	35.47168	97.51260	634949	3926369
IOP9 - [1]	S side McGee btwn Broadway & Robinson, parking meter 0459	35.47080	97.51559	634679	3926268
IOP9 - [2]	S side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP9 - [3]	S side Kerr btwn Harvey & Robinson	35.46978	97.51730	634526	3926152
IOP9 - [4]	S side Kerr btwn Broadway & Gaylord	35.46965	97.51370	634853	3926143
IOP9 - [5]	Mobile on 8th Street				
IOP9 - [6]	NW corner of Kerr & Robinson, parking meter 2131 (in front of Bank of OK)	35.46989	97.51660	634589	3926165
IOP9 - [7]	NW corner of Kerr & Broadway, meter 2085	35.46986	97.51470	634762	3926164
IOP9 - [8]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP9 - [9]	N side Kerr btwn Robinson & Broadway	35.46987	97.51540	634698	3926165
IOP10 - [0a]	N side Park btwn Harvey & Robinson, parking meter 2121 (under elev walkway)	35.46884	97.51720	634537	3926048
IOP10 - [0b]	SW corner of 5th & Broadway	35.47279	97.51450	634775	3926490
IOP10 - [1]	S side McGee btwn Broadway & Robinson, parking meter 0459	35.47080	97.51559	634679	3926268
IOP10 - [2a]	S side McGee btwn Harvey & Robinson (in front of Old Post Office)	35.47085	97.51720	634533	3926271
IOP10 - [2c]	Corner of 4th & Oklahoma	35.47165	97.51070	635122	3926369
IOP10 - [3a]	S side Kerr btwn Harvey & Robinson	35.46978	97.51730	634526	3926152
IOP10 - [3b]	S side 5th St btwn Broadway & RR tracks	35.47281	97.51280	634929	3926494

Table A.4. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP10 - [4]	S side Kerr btwn Broadway & Gaylord	35.46965	97.51370	634853	3926143
IOP10 - [5]	Mobile on 8th Street				
IOP10 - [6a]	NW corner of Kerr & Robinson, parking meter 2131 (in front of Bank of OK)	35.46989	97.51660	634589	3926165
IOP10 - [6c]	N side Kerr btwn Robinson & Broadway	35.46987	97.51540	634698	3926165
IOP10 - [7]	NW corner of Kerr & Broadway, meter 2085	35.46986	97.51470	634762	3926164
IOP10 - [8]	SW corner of McGee & Broadway, parking meter 0464	35.47078	97.51460	634769	3926267
IOP10 - [9a]	N side of Kerr btwn Robinson & Broadway	35.46987	97.51540	634698	3926165
IOP10 - [9c]	Out of commission				

Figure A.8. ARLFRD Trace Gas Analyzer Instrument Locations During (a) IOPs 1, 3, 4, & 6, (b) IOP 2, (c) IOP 5, (d) IOP 7, (e) IOP 8, (f) IOP 9, and (g) IOP 10. Refer to Table A.4 for instruments that were relocated during an IOP.

Figure A.8. (Contd)

Table A.5. ARLFRD SF_6 Release Locations

Release Name	Location Description	Latitude	Longitude	Easting	Northing
Westin (East)	Broadway across from Westin Hotel	35.46727	97.51444	634790	3925877
Westin	Broadway in front of the Westin Hotel	35.46736	97.51462	634773	3925887
Botanical	Robinson & Sheridan E of Botanical Gardens	35.46626	97.51652	634603	3925763
Park	S side of Park btwn Robinson & Broadway	35.46871	97.51556	634686	3926036
Fourth	N side of 4th btwn Hudson & Walker	35.47208	97.52000	634277	3926404

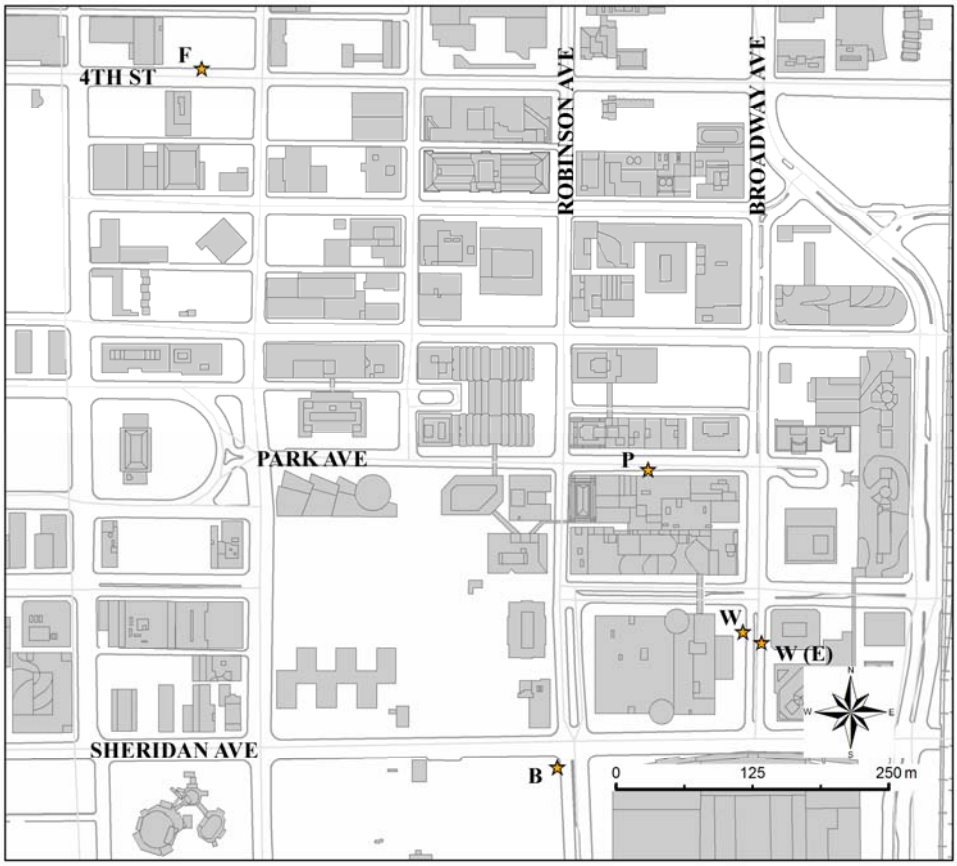

Figure A.9. ARLFRD SF_6 Release Locations: W(E) = Westin (East), W = Westin, B = Botanical, P = Park, and F = Fourth

Table A.6. ARLFRD Sodar Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Sodar	OK School of Science and Mathematics	35.48147	97.50510	635613	3927465

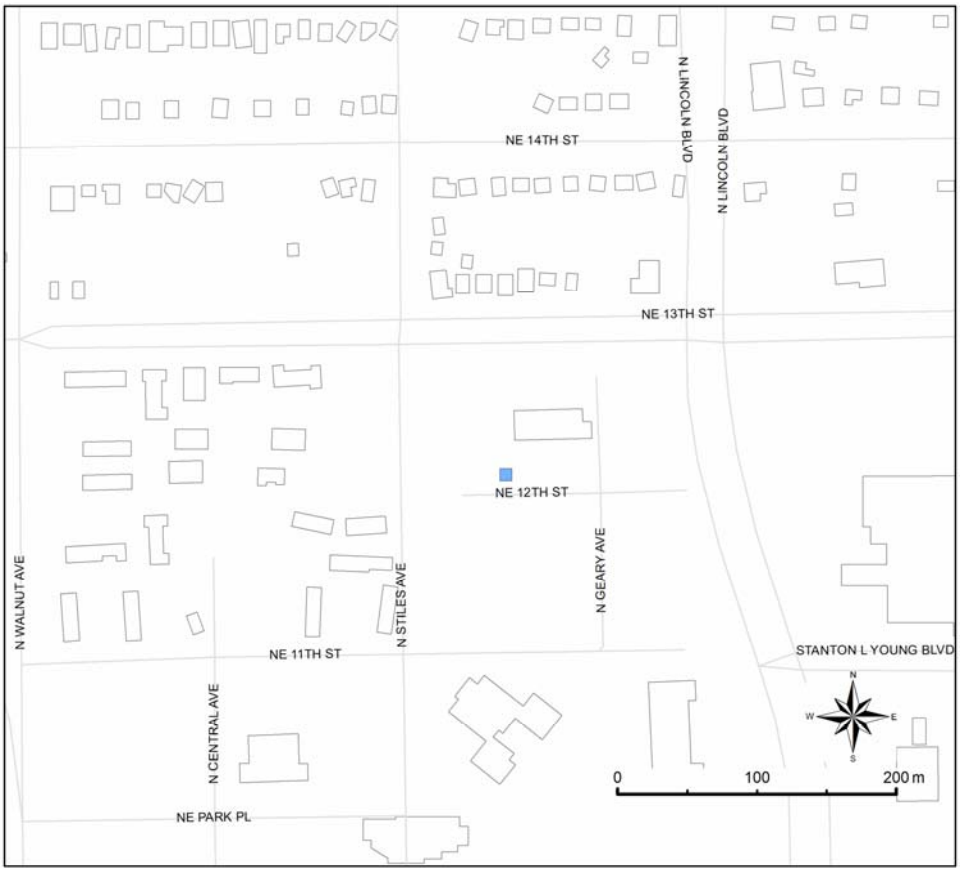

Figure A.10. ARLFRD Sodar Location

A.4 Arizona State University

Arizona State University deployed two towers and a lidar during this field study. One tower was in the heavily-instrumented Park Avenue street canyon, while the other (known as the energy tower) was northwest of the central business district. The ASU lidar was located about 3 km southeast of the central business district. The coordinates for the three ASU measurement sites are presented in Table A.7, while the locations are shown in Figures A.11 and A.12.

Table A.7. ASU Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
sonics (3) / surface temp	Park Ave ~28.5m W of Broadway	35.46879	97.51488	634747	3926046
Sonic / energy	S of 11th btwn Walker & Hudson	35.47940	97.52003	634262	3927215
lidar	SW of 25th & Akin	35.43883	97.49222	636854	3922754

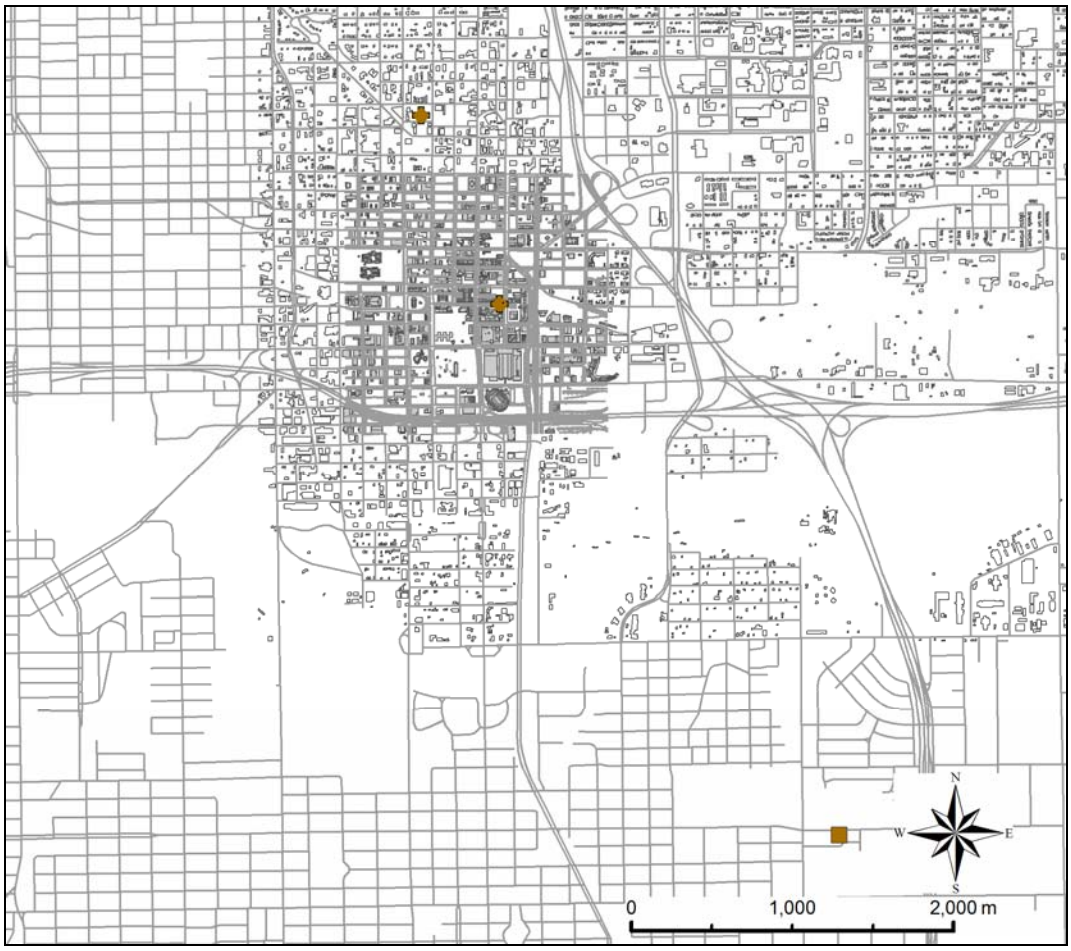

Figure A.11. Overview of ASU Instrument Locations

Figure A.12. ASU Instrument Locations: (a) Energy Tower, (b) Energy Tower with Neighboring Instrumentation Shown, (c) Park Tower, and (d) Lidar

A.5 NOAA Air Resources Laboratory—Atmospheric Turbulence and Diffusion Division

The NOAA Air Resources Laboratory Atmospheric Turbulence and Diffusion Division measured winds, energy fluxes, and pressure fluctuations continuously at several sites around Oklahoma City. The coordinates of each of the instrument sites are presented in Table A.8 and are shown on maps in Figures A.13 and A.14.

Table A.8. ATDD Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
sonics (4)	Tower 1 - 11th St E of Walker	35.47982	97.52003	634261	3927262
sonics (4)	Tower 2 - OK School of Science & Math. N of 11th E of Stiles	35.48093	97.50503	635620	3927406
energy flux	Site A - Fred Jones Parking - Main & Fred Jones	35.46848	97.52762	633592	3925994
energy flux	Site B - OK School of Science & Math - 10th & Lincoln	35.48094	97.50515	635610	3927406
energy flux	Site C - Galleria Parking - Sheridan & Hudson	35.46772	97.51849	634421	3925922
microbarograph	Site 1 - S of 13th E of Stiles	35.48213	97.50552	635574	3927538
microbarograph	Site 2 - N of 10th E of Walnut	35.47833	97.50860	635301	3927113
microbarograph	Site 3 - W of Lincoln btwn 10th & Park	35.47885	97.50316	635793	3927177

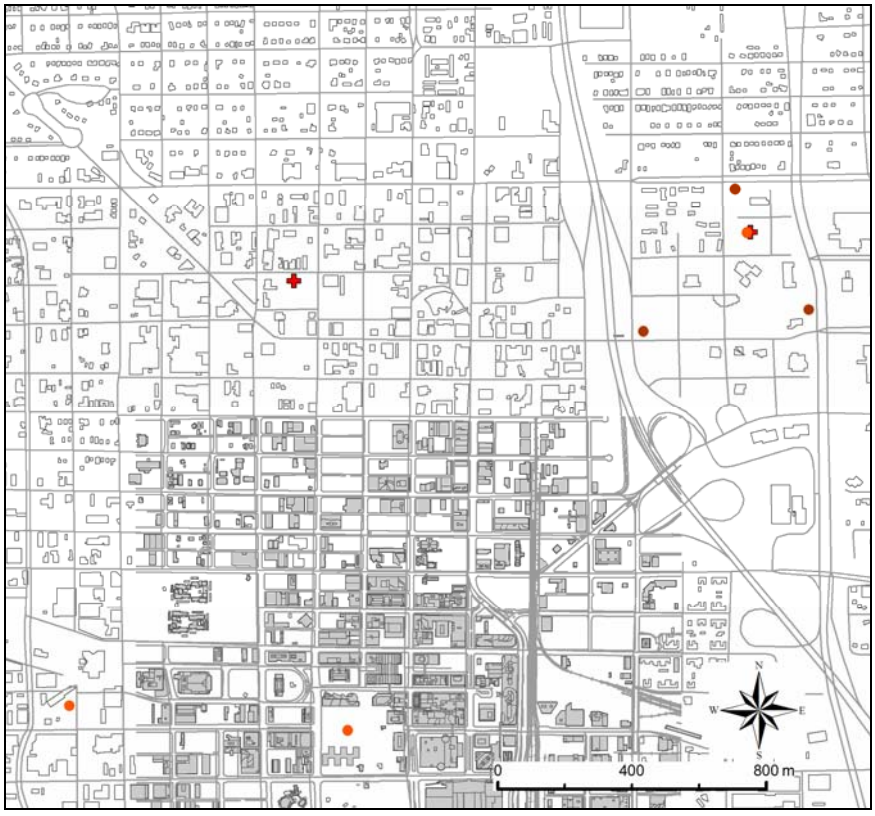

Figure A.13. Overview of ATDD Instrument Locations. Red plus-shaped markers represent the sonic anemometer towers, brown circular markers represent the micro-barograph pressure sites, and orange circular markers represent energy flux sites.

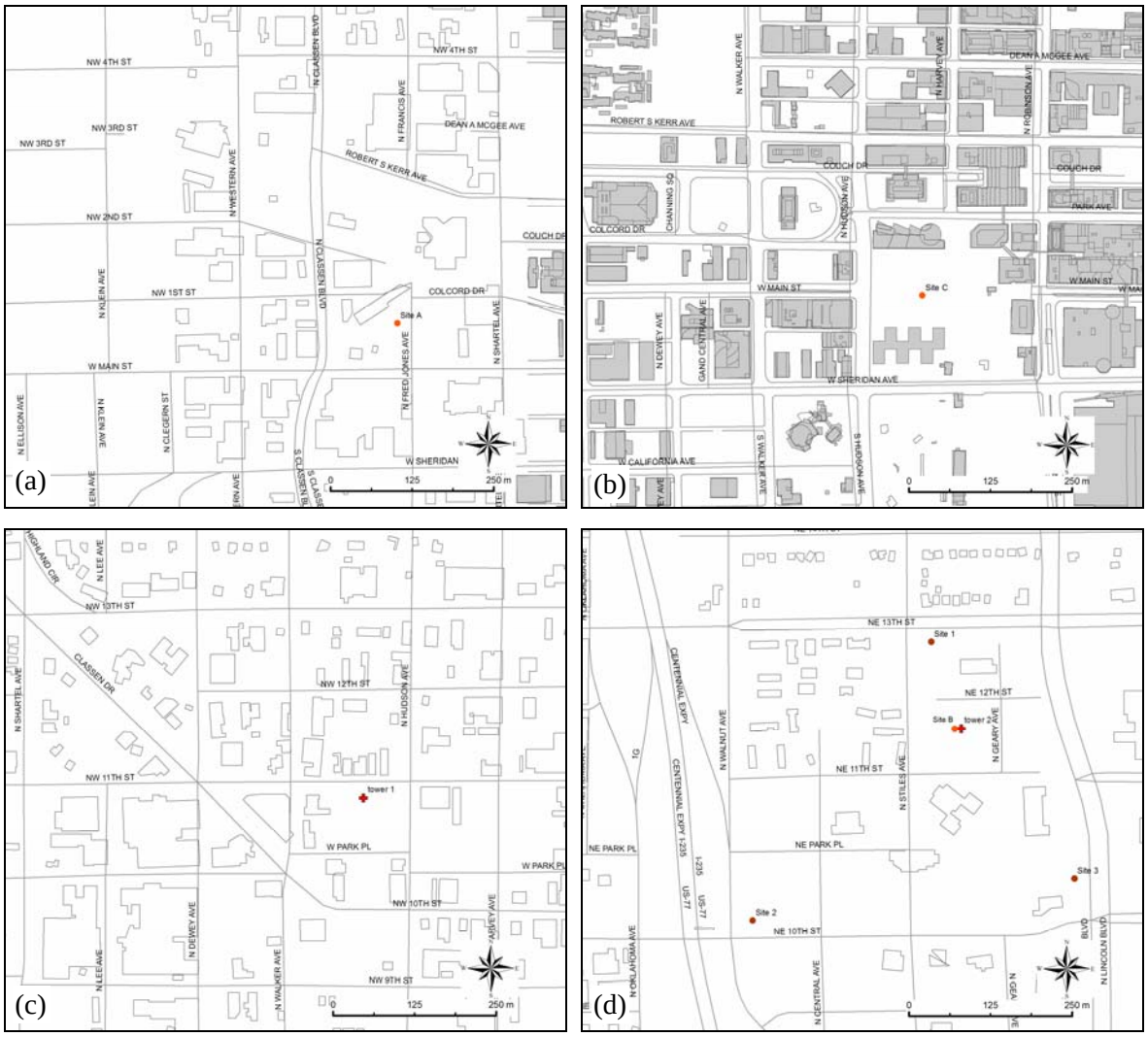

Figure A.14. ATDD Instrument Locations at (a) Energy Flux Site A, (b) Energy Flux Site C, (c) Sonic Tower 1, and (d) Energy Flux Site B and Micro-barograph Pressure Sites 1 Through 3

A.6 Dugway Proving Ground

During Joint Urban 2003, Dugway Proving Ground deployed 15 Portable Weather Information Display System (PWIDS) with propeller and vane anemometers and 20 Super PWIDS with 3D sonic anemometers. Most of these instruments were mounted on light or traffic poles at intersections in the central business district. Some of the Super PWIDS were co-located with the PWIDS for quality assurance. The PWIDS and Super PWIDS coordinates are presented in Table A.9, while their locations are shown in Figures A.15 through A.19.

DPG also had 2 profile sites; a sodar and radar were located north of the central business district, and a tethersonde was within the Park Avenue street canyon. The coordinates of the three profile instruments are presented in Table A.10 and locations are shown in Figures A.20 and A.21.

Table A.9. DPG PWIDS and SuperPWIDS Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
PWIDS 01	NW corner of Hudson/Kerr	35.46998	97.51967	634311	3926171
PWIDS 02	SW corner of Robinson/Kerr	35.46973	97.51646	634602	3926148
PWIDS 03	NE corner of Broadway/Kerr	35.46990	97.51431	634797	3926169
PWIDS 04	SW corner of Robinson/Park	35.46868	97.51648	634602	3926031
PWIDS 05	SE corner of Broadway/Park	35.46865	97.51427	634803	3926031
PWIDS 06	SE corner of Hudson/Main	35.46767	97.51933	634345	3925915
PWIDS 07	NE corner of Robinson/Main	35.46780	97.51638	634613	3925934
PWIDS 08	NE corner of Broadway/Main	35.46780	97.51437	634795	3925937
PWIDS 09	Center island on S side of Gaylord/Main	35.46733	97.51279	634939	3925886
PWIDS 10	SW corner of Hudson/Sheridan	35.46633	97.51964	634319	3925766
PWIDS 11	SW corner of Robinson/Sheridan	35.46632	97.51649	634605	3925769
PWIDS 12	NW corner of Broadway/Sheridan	35.46656	97.51468	634769	3925798
PWIDS 13	SE corner of Gaylord/Sheridan	35.46636	97.51278	634942	3925779
PWIDS 14	S edge of Cox Convention Center roof	35.46468	97.51456	634783	3925590
PWIDS 15	320 SW 5th St; Post Office roof [30m AGL]	35.45971	97.51896	634392	3925033
SuperPWIDS 01	SW corner of Robinson/4th	35.47181	97.51639	634605	3926378
SuperPWIDS 02	SE corner of Broadway/4th	35.47179	97.51414	634809	3926379
SuperPWIDS 03	SW corner of Robinson/McGee	35.47078	97.51643	634603	3926264
SuperPWIDS 04	SW corner of Broadway/McGee	35.47072	97.51448	634780	3926260
SuperPWIDS 05	SW corner of Robinson/Kerr	35.46973	97.51646	634602	3926148
SuperPWIDS 06	NE corner of Broadway/Kerr	35.46990	97.51431	634797	3926169
SuperPWIDS 07	NW corner of Robinson/Park	35.46884	97.51656	634595	3926049
SuperPWIDS 08	NE corner of Robinson/Park	35.46885	97.51636	634613	3926050
SuperPWIDS 09	SW corner of Robinson/Park	35.46868	97.51648	634602	3926031
SuperPWIDS 10	SE corner of Robinson/Park	35.46872	97.51635	634614	3926036
SuperPWIDS 11	NW corner of Broadway/Park	35.46881	97.51462	634771	3926048
SuperPWIDS 12	NE corner of Broadway/Park	35.46886	97.51435	634795	3926054
SuperPWIDS 13	SW corner of Broadway/Park	35.46864	97.51455	634777	3926029
SuperPWIDS 14	SE corner of Broadway/Park	35.46865	97.51427	634803	3926031
SuperPWIDS 15	Robinson; 75 ft. N of Robinson/Main	35.46796	97.51639	634612	3925952
SuperPWIDS 16	NE corner of Broadway/Main	35.46780	97.51437	634795	3925937
SuperPWIDS 17	SW corner of Robinson/Sheridan	35.46632	97.51649	634605	3925769
SuperPWIDS 18	NW corner of Broadway/Sheridan	35.46656	97.51468	634769	3925798
SuperPWIDS 19	NE corner of Broadway/Sheridan	35.46657	97.51439	634795	3925800
SuperPWIDS 20	NW corner of Robinson/Reno	35.46435	97.51648	634609	3925551

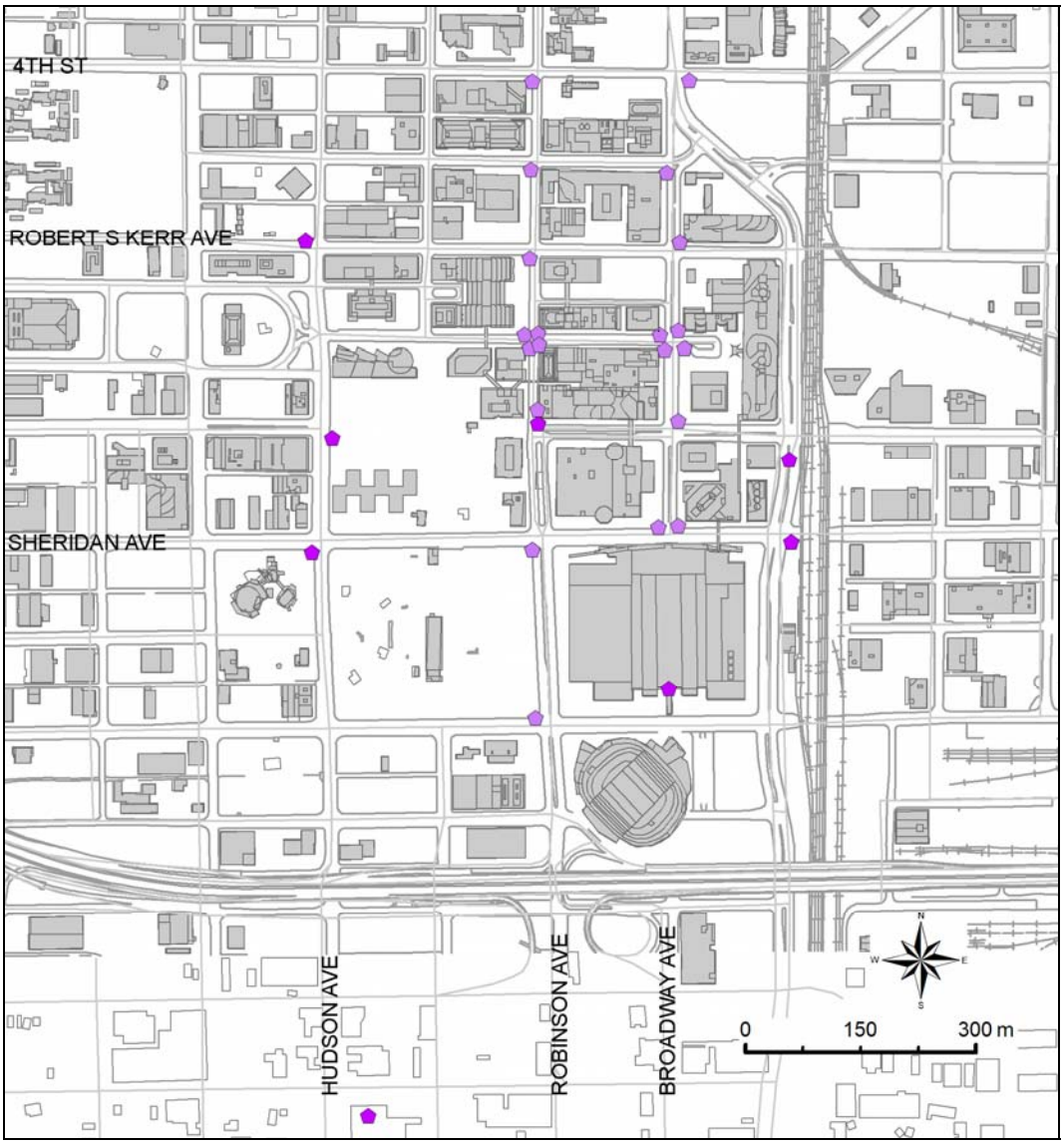

Figure A.15. Overview of DPG PWIDS and Super PWIDS Locations

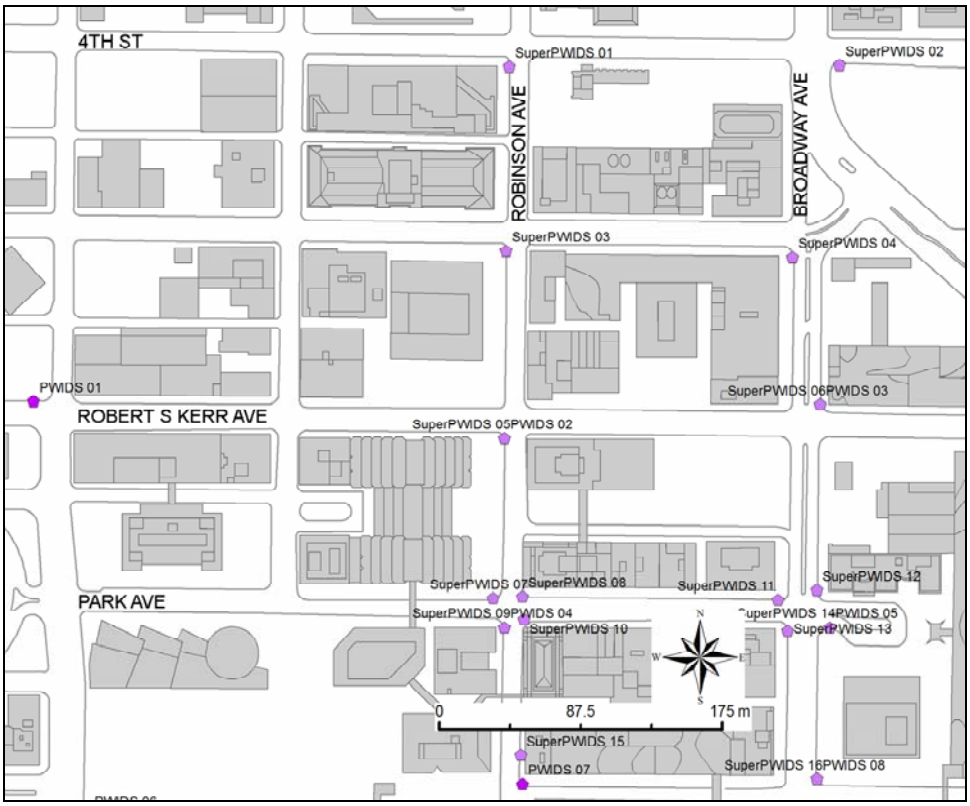

Figure A.16. DPG PWIDS and SuperPWIDS in the Northern Portion of the CBD

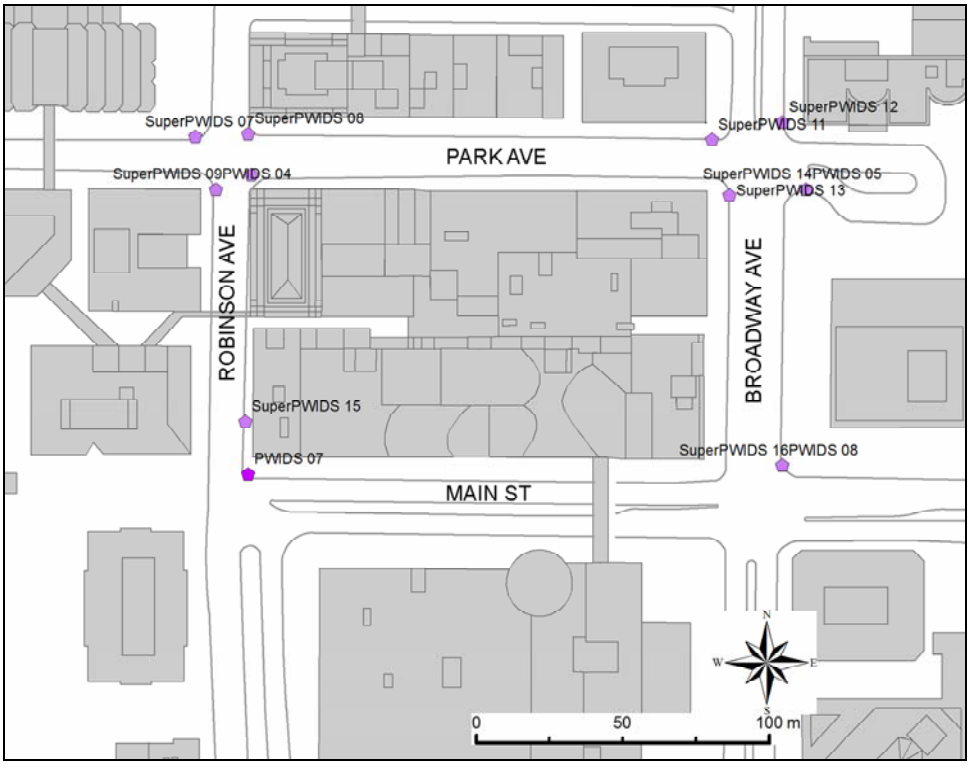

Figure A.17. DPG PWIDS and SuperPWIDS in the Central Portion of the CBD

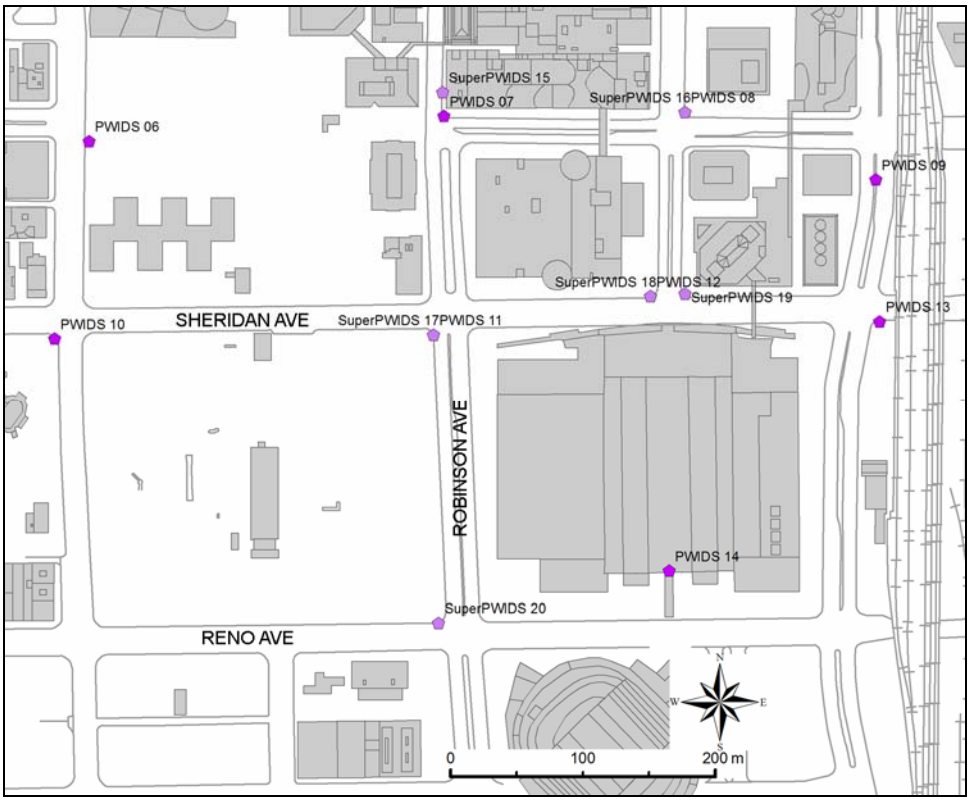

Figure A.18. DPG PWIDS and SuperPWIDS in the Southern Portion of the CBD

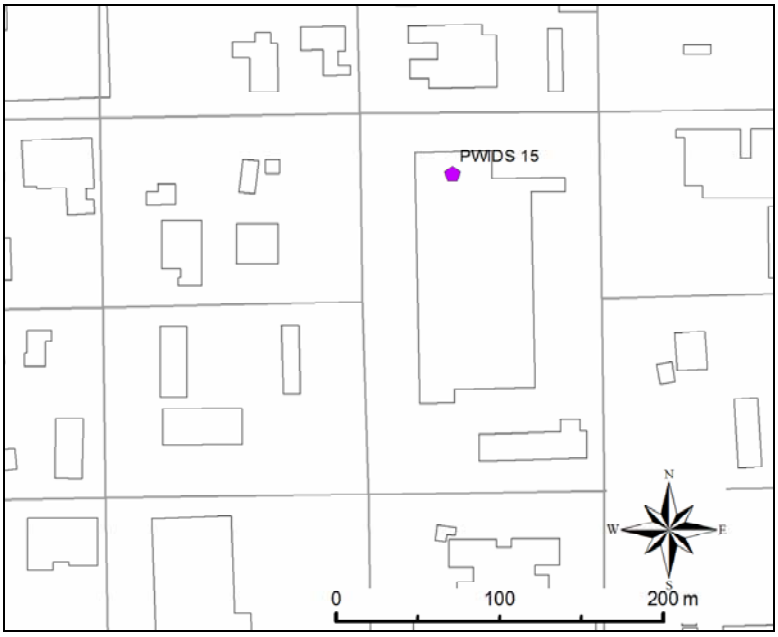

Figure A.19. DPG PWIDS on the Post Office Roof, South of the CBD

Table A.10. DPG Profile Instrument Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Sodar	S of 13th btwn Harvey & Robinson	35.48203	97.51668	634562	3927512
FM-CW Radar	S of 13th btwn Harvey & Robinson	35.48217	97.51668	634562	3927527
Tethersonde	101 Park Ave	35.46884	97.51505	634732	3926051

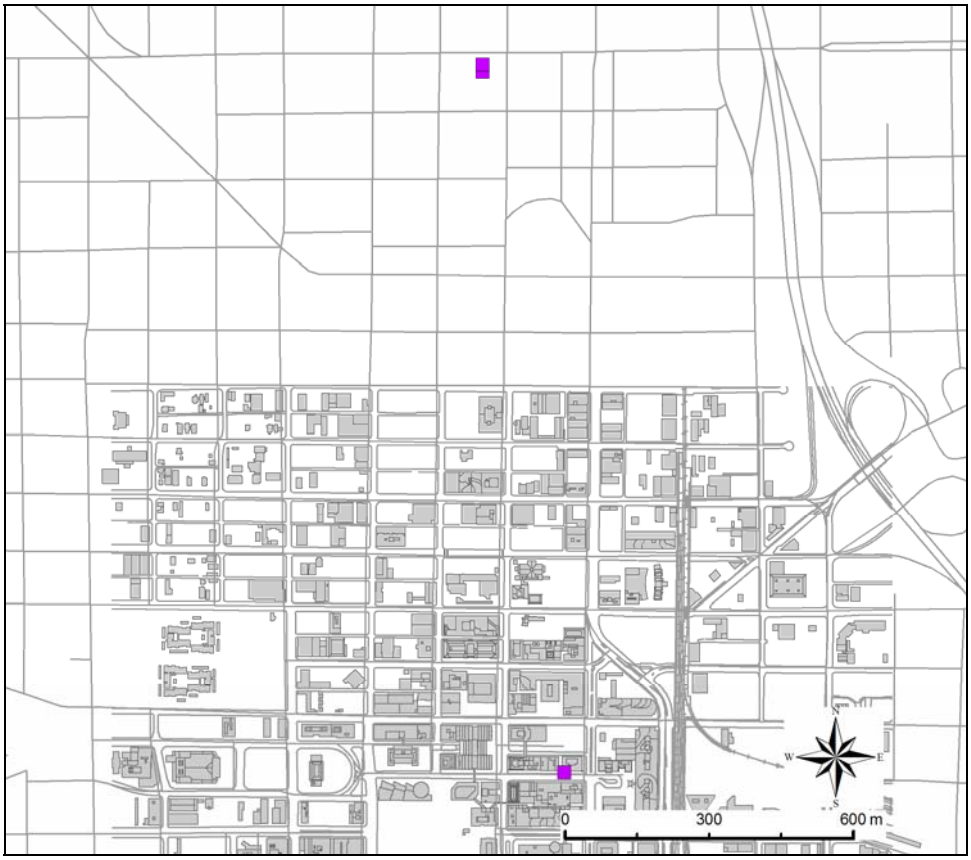

Figure A.20. Overview of DPG Profile Instrument Locations

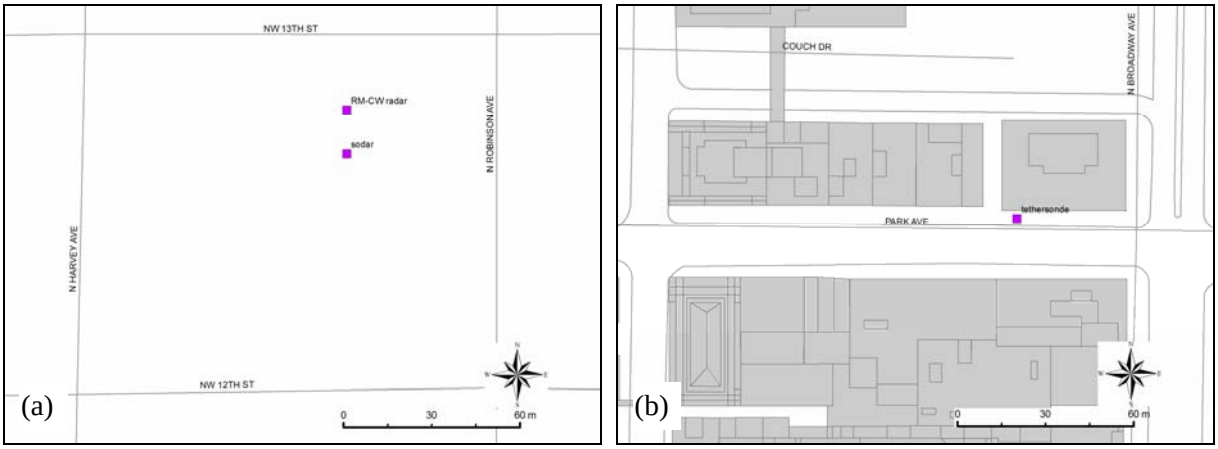

Figure A.21. DPG (a) Radar and Sodar, and (b) Tethersonde Locations

A.7 Defense Science and Technology Laboratory

The Defense Science and Technology Laboratory had two towers and a portable sonic anemometer on a tripod in the Park Avenue street canyon. Due to some technical difficulties, the instrumentation was only functional during IOPs 5 through 10. The coordinates of these instruments are presented in Table A.11 and the locations are shown in Figure A.22.

Table A.11. DSTL Sonic Anemometer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
tower 1 – sonic 6	E end of Park on S side across from ASU tower [3.5m agl]	35.468730	97.514892	634746.2	3926038.9
tower 1 – sonic 2	E end of Park on S side across from ASU tower [5m agl]	35.468730	97.514892	634746.2	3926038.9
tower 1 – sonic 1	E end of Park on S side across from ASU tower [6.5m agl]	35.468730	97.514892	634746.2	3926038.9
tower 2 – sonic 5*	W end of Park on N side across from UU tower [3m agl]	35.468819	97.515940	634651.0	3926047.3
tower 2 – sonic 4	W end of Park on N side across from UU tower [5m agl]	35.468819	97.515940	634651.0	3926047.3
tower 2 – sonic 3	W end of Park on N side across from UU tower [10m agl]	35.468819	97.515940	634651.0	3926047.3
Tri-pod – sonic 7	W end of Park on S side across from LANL sonics [2m agl]	35.468685	97.516232	634624.7	3926032.1

* Sonic number 5 was replaced with sonic number 8 for IOPs 7 through 10

Figure A.22. DSTL Sonic Anemometer Locations in Park Ave

A.8 ITT Industries

ITT Industries deployed five instantaneous tracer instruments called trace gas analyzers (TGAs) and 11 3D sonic anemometers during each IOP. The TGA coordinates for each IOP are presented in Table A.12 while all the TGA positions are shown in Figure A.23. The sonic anemometers were deployed in one of three configurations based on the release position for the IOP. Table A.13 presents the sonic anemometer coordinates for each of the three configurations and Figure A.24 shows all of these positions on a single map.

Table A.12. ITT Tracer Analyzer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP1 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP1 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP1 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP1 – TGA4	Courthouse grounds – Park & Harvey	35.46899	97.51809	634456	3926063
IOP1 – TGA5	Near Sooner Statue – Robinson & Couch	35.46929	97.51624	634623	3926099
IOP2 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP2 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP2 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP2 – TGA4	Courthouse grounds – Park & Harvey	35.46899	97.51809	634456	3926063
IOP2 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP3 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP3 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP3 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP3 – TGA4	Not Deployed				
IOP3 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP4 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP4 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP4 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP4 – TGA4	Courthouse grounds – Park & Harvey	35.46894	97.51824	634442	3926058
IOP4 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP5 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP5 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP5 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP5 – TGA4	Courthouse grounds – Park & Harvey	35.46894	97.51824	634442	3926058
IOP5 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP6 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP6 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP6 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP6 – TGA4	Courthouse grounds – Park & Harvey	35.46894	97.51824	634442	3926058
IOP6 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP7 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP7 – TGA2	Robinson & McGee	35.47075	97.51648	634599	3926261
IOP7 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP7 – TGA4	Courthouse grounds – Park & Harvey	35.46898	97.51811	634454	3926062
IOP7 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148

Table A.12 (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP8 – TGA1	Harvey & McGee	35.47075	97.51800	634461	3926259
IOP8 – TGA2	Not Deployed				
IOP8 – TGA3	Park btwn Robinson & Harvey	35.46888	97.51718	634538	3926052
IOP8 – TGA4	Courthouse grounds – Park & Harvey	35.46898	97.51811	634454	3926062
IOP8 – TGA5	Kerr & Robinson	35.46973	97.51623	634623	3926148
IOP9 - TGA1	4th & Broadway	35.47173	97.51449	634778	3926372
IOP9 – TGA2	Not Deployed				
IOP9 - TGA3	3td & Gaylord	35.47088	97.51318	634898	3926280
IOP9 - TGA4	4th & Robinson	35.47201	97.51650	634595	3926400
IOP9 - TGA5	4th & Broadway	35.47202	97.51772	634484	3926400
IOP10 - TGA1	4th & Broadway	35.47173	97.51449	634778	3926372
IOP10 – TGA2	Not Deployed				
IOP10 - TGA3	3td & Gaylord	35.47088	97.51318	634898	3926280
IOP10 - TGA4	4th & Robinson	35.47201	97.51650	634595	3926400
IOP10 - TGA5	4th & RR tracks (during 2100)	35.47163	97.51267	634943	3926363
IOP10 - TGA5	4th & RR tracks (after 2100)	35.47157	97.51283	634929	3926357

Figure A.23. Overview of All ITT TGA Locations

Table A.13. ITT Sonic Anemometer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
sonic01 (botanical)	On Robinson (blvd) N of Sheridan	35.46662	97.51634	634618	3925803
sonic02 (botanical)	N side of Sheridan W of Robinson	35.46672	97.51688	634569	3925813
sonic03 (botanical)	rooftop - SW corner parking garage	35.46672	97.51612	634638	3925814
sonic04 (botanical)	W side Robinson N of Sheridan (halfway to Main)	35.46704	97.51674	634581	3925849
sonic05 (botanical)	Sheridan & Robinson. SW of Robinson Plaza	35.46705	97.51724	634536	3925849
sonic06 (botanical)	W side Robinson N of Sheridan (halfway to Main)	35.46708	97.51656	634598	3925854
sonic07 (botanical)	E side of Robinson N of Sheridan (halfway to Main)	35.46703	97.51619	634631	3925849
sonic08 (botanical)	W side Robinson at the end of Main	35.46773	97.51661	634592	3925926
sonic09 (botanical)	On Robinson (blvd) S of Main	35.46757	97.51637	634614	3925908
sonic10 (botanical)	SE corner Main & Robinson	35.46750	97.51621	634629	3925901
sonic11 (botanical)	rooftop - NW corner pkg garage	35.46748	97.51610	634639	3925899
sonic01 (westin)	Santa Fe Plaza N of Bank One Tower	35.46848	97.51390	634837	3926012
sonic02 (westin)	S side Main W of Broadway	35.46759	97.51493	634745	3925912
sonic03 (westin)	On Broadway (blvd) N of Main	35.46788	97.51449	634784	3925945
sonic04 (westin)	N side Main E of Broadway	35.46780	97.51385	634842	3925937
sonic05 (westin)	On Main (blvd) W of Broadway	35.46768	97.51498	634740	3925922
sonic06 (westin)	E side of Broadway S of Park W of Bank One	35.46824	97.51425	634805	3925985
sonic07 (westin)	On Broadway (blvd) S of Park W of Bank One	35.46824	97.51446	634786	3925985
sonic08 (westin)	On Main (blvd) E of Broadway S of Bank One	35.46764	97.51380	634847	3925920
sonic09 (westin)	S side Main W of Broadway	35.46757	97.51470	634766	3925911
sonic10 (westin)	N side Main W of Broadway	35.46777	97.51482	634754	3925932
sonic11 (westin)	N side Main E of Broadway	35.46785	97.51358	634867	3925943
sonic01 (park)	W side Broadway near Alley (NE corner of Sonic Bldg)	35.46912	97.51457	634775	3926083
sonic02 (park)	E side Broadway N of Park	35.46896	97.51433	634797	3926065
sonic03 (park)	N side Park E of Broadway	35.46881	97.51414	634814	3926049
sonic04 (park)	W side Broadway S of Park	35.46845	97.51457	634776	3926008
sonic05 (park)	E side Broadway S of Park	35.46843	97.51425	634805	3926006
sonic06 (park)	E of Broadway S of Park N of Bank One Bldg	35.46842	97.51406	634822	3926006
sonic07 (park)	E of Broadway S of Park N of Bank One Bldg	35.46842	97.51376	634849	3926006
sonic08 (park)	W of Broadway N of Park N of Sonic Bldg (alley)	35.46923	97.51477	634756	3926094
sonic09 (park)	W side Broadway N of Alley N of Park	35.46922	97.51461	634771	3926094
sonic10 (park)	E of Broadway N of Park	35.46920	97.51401	634825	3926092
sonic11 (park)	E of Broadway N of Park	35.46921	97.51426	634803	3926093

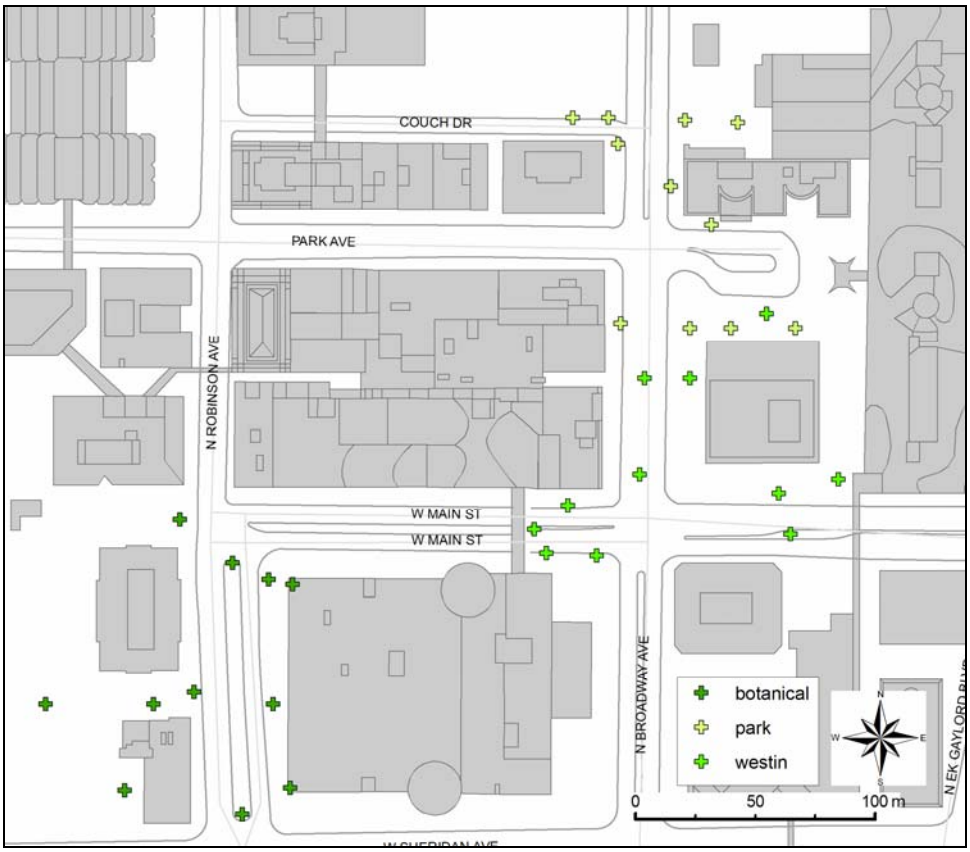

Figure A.24. ITT Sonic Locations for All IOPs. The dark green markers represent the deployment configuration for the Botanical release, the light green represents the deployment for the Park Avenue release, and the bright green represents deployment for the Westin release.

A.9 Indiana University

The Indiana University deployed a number of sonic anemometers and energy instrumentation at several sites about 6 km south of downtown Oklahoma City. Table A.14 presents the coordinates for each site, while Figure A.25 shows the locations on a map. Additional details about the instruments and data can be found at the following website: http://www.indiana.edu/~muhd/okcWeb/index.htm.

Table A.14. IU Sonic and Energy Tower Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
sonics (2), energy	BH - Brick House	35.40473	97.51338	634990	3918943
energy	BHB – Brich House Building	35.40433	97.51418	634918	3928897
sonic (1) , energy	GR – Grass	35.41287	97.51137	635159	3919848
sonic (1) , energy	GR-TM - Grass at Tyler Media	35.41522	97.51063	635222	3920109
sonics (2) , energy	TMA - Tyler Media (A)	35.41505	97.51008	635272	3920091
sonics (2) , energy	TMB - Tyler Media (B)	35.41505	97.51008	635272	3920091
sonic (1) , energy	WH - Wood House	35.41047	97.51005	635283	3919583
energy	WHB – Wood House Building	35.41305	97.51134	635162	3929868

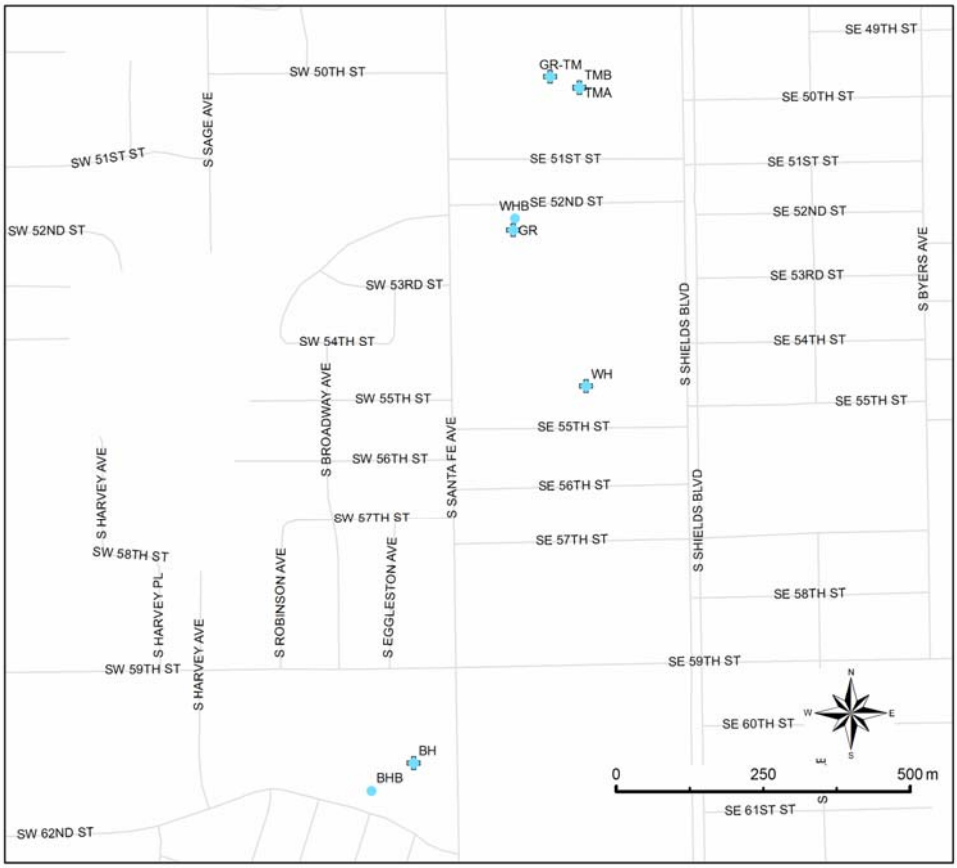

Figure A.25. IU Energy and Sonic Tower Locations

A.10 Los Alamos National Laboratory

Los Alamos National Laboratory deployed a number of 3D and 2D sonic anemometers in the Park Avenue street canyon in Oklahoma City. The 2D sonics were deployed during each IOP, while the 3D sonics collected data continuously through the month. The coordinates and locations of these instruments are presented in Table A.15 and Figure A.26.

Table A.15. LANL Sonic Anemometer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
3D sonic (yellow)	100 Park N Rooftop Overhang [45.3m agl]	35.468662	97.514757	634758.6	3926031.5
3D sonic (red)	100 Park Rooftop Flagpole [47.7m agl]	35.468633	97.514673	634766.2	3926028.4
3D sonic (white)	Park Avenue & Robinson Avenue on tripod [2.2m agl]	35.468850	97.516217	634625.8	3926050.4
3D sonic (black)	Sonic Building NW Rooftop Overhang [47.5m agl]	35.469129	97.515117	634725.1	3926082.9
3D sonic (green)	Sonic Building SW Rooftop Overhang [47.5m agl]	35.468852	97.515090	634728.0	3926052.2
3D sonic 6 (blue)	Sonic Building SE Rooftop Overhang [47.5m agl]	35.468846	97.514651	634767.9	3926052.1
2D sonic (white)	S side Park W of Broadway [2.1m agl]	35.468660	97.514720	634761.9	3926031.4
2D sonic (black)	S side Park W of Broadway [2.05m agl]	35.468660	97.514778	634756.7	3926031.3
2D sonic (yellow)	N side Park W of Broadway [2.1m agl]	35.468854	97.514719	634761.7	3926052.9
2D sonic (red)	N side Park W of Broadway [2.1m agl]	35.468855	97.514777	634756.4	3926052.9
2D sonic (green)	N side Park E of Robinson [2.1m agl]	35.468890	97.516216	634625.8	3926054.8

Figure A.26. LANL Sonic Anemometer Locations in Park Ave

A.11 Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory deployed a number of tracer samplers, tracer analyzers and several 3D sonic anemometers. Forty-four tracer sampling instruments, called BlueBoxes (BB), were deployed at 22 unique outdoor locations during each of the IOPs 1 through 3 and 8 through 10. The BlueBoxes were used in the indoor study during IOPs 4 through 7. The outdoor coordinates for the BlueBoxes are presented in Table A.16, and the locations are shown in Figure A.27. LLNL deployed ten Miran instantaneous tracer analyzers. The deployment of the Mirans for each IOP is presented in Table A.16 and Figure A.28.

The eight 3D sonic anemometers deployed by LLNL were mounted on a crane that was located about 1 km north of the downtown release locations. Data from this site was collected continuously through the month-long study. Table A.18 presents the coordinates of the anemometers, while Figure A.29 shows the location on a map.

Table A.16. LLNL Tracer Sampler Locations for Each IOP. Samplers were not deployed outside for IOPs 4-7. The numbering system presented here is arbitrary, as the LLNL datafiles had no BlueBox identifiers.

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP01 BB-1	Bank One btwn Park & Main - [1m AGL]	35.46806	97.51426	634805	3925965
IOP01 BB-2	Century Center Parking - [1m AGL]	35.46755	97.51529	634712	3925908
IOP01 BB-3	Century Center Parking Top - [18m AGL]	35.46755	97.51529	634712	3925907
IOP01 BB-4	Convention Center 2nd Level - [6m AGL]	35.46631	97.51514	634728	3925770
IOP01 BB-5	Corporate Towers Roof - [54m AGL]	35.46788	97.51661	634592	3925942
IOP01 BB-6	Corporate Towers - [1m AGL]	35.46788	97.51659	634594	3925942
IOP01 BB-7	Convention Center - [1m AGL]	35.46634	97.51514	634728	3925773
IOP01 BB-8	Broadway and Main NE - [1m AGL]	35.46789	97.51427	634804	3925947
IOP01 BB-9	Broadway and Main SE - [1m AGL]	35.46759	97.51438	634795	3925913
IOP01 BB-10	Broadway and Main SW - [1m AGL]	35.46756	97.51462	634773	3925909
IOP01 BB-11	Park & Broadway SW - [1m AGL]	35.46860	97.51463	634770	3926025
IOP01 BB-12	Robinson and Main SE - [1m AGL]	35.46753	97.51613	634636	3925904
IOP01 BB-13	Sheridan & Broadway NW - [1m AGL]	35.46656	97.51470	634767	3925799
IOP01 BB-14	Main St. W of Broadway - [1m AGL]	35.46768	97.51500	634738	3925922
IOP01 BB-15	Main Street Parking - [1m AGL]	35.46783	97.51509	634730	3925939
IOP01 BB-16	Main Street Parking Top - [26m AGL]	35.46784	97.51509	634730	3925940
IOP01 BB-17	NW corner of Renaissance - [1m AGL]	35.46715	97.51437	634796	3925864
IOP01 BB-18	OKLand Bldg. - [1m AGL]	35.46785	97.51620	634629	3925939
IOP01 BB-19	OKLand Bldg. Roof - [18m AGL]	35.46785	97.51620	634629	3925940
IOP01 BB-20	Park & Broadway Roof SW - [48m AGL]	35.46860	97.51464	634769	3926025
IOP01 BB-21	Westin Lobby - [1m AGL]	35.46712	97.51473	634764	3925860
IOP01 BB-22	Westin Roof - [14m AGL]	35.46712	97.51474	634763	3925860
IOP02	Same as IOP01				

Table A.16 (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP03 BB-1	Cox Convention Ctr Entrance - [1 m AGL]	35.46634	97.51514	634728	3925773
IOP03 BB-2	Cox Convention Center Roof - [6 m AGL]	35.46633	97.51514	634728	3925772
IOP03 BB-3	Sheridan & Broadway NW - [1 m AGL]	35.46656	97.51470	634767	3925799
IOP03 BB-4	Westin Lobby ground - [1 m AGL]	35.46712	97.51473	634764	3925860
IOP03 BB-5	NW corner Cox Convention Ctr - [1m AGL]	35.46635	97.51606	634644	3925773
IOP03 BB-6	Corporate Towers ground - [1 m AGL]	35.46788	97.51659	634594	3925942
IOP03 BB-7	Corporate Towers roof - [54 m AGL]	35.46788	97.51661	634592	3925942
IOP03 BB-8	Colcord Building ground - [1 m AGL]	35.46659	97.51659	634596	3925799
IOP03 BB-9	Colcord Building roof - [40 m AGL]	35.46660	97.51659	634596	3925800
IOP03 BB-10	Broadway & Main SW - [1 m AGL]	35.46754	97.51460	634775	3925907
IOP03 BB-11	Century Center West ground - [1 m AGL]	35.46720	97.51612	634637	3925868
IOP03 BB-12	Century Center West top - [18 m AGL]	35.46720	97.51611	634638	3925868
IOP03 BB-13	Century Center South ground - [1 m AGL]	35.46670	97.51589	634659	3925812
IOP03 BB-14	Century Center South top - [18 m AGL]	35.46671	97.51589	634659	3925813
IOP03 BB-15	Main Street Parking ground - [1 m AGL]	35.46783	97.51509	634730	3925939
IOP03 BB-16	Main Street Parking top - [26 m AGL]	35.46784	97.51509	634730	3925940
IOP03 BB-17	Robinson Plaza NE - [1 m AGL]	35.46767	97.51657	634596	3925919
IOP03 BB-18	Robinson Plaza NW - [1 m AGL]	35.46762	97.51703	634554	3925913
IOP03 BB-19	Robinson Plaza SW - [1 m AGL]	35.46707	97.51711	634548	3925852
IOP03 BB-20	Robinson Plaza SE - [1 m AGL]	35.46712	97.51662	634592	3925858
IOP03 BB-21	Okland Building Ground - [1 m AGL]	35.46785	97.51620	634629	3925939
IOP03 BB-22	Okland Building Roof - [18 m AGL]	35.46785	97.51620	634629	3925940
IOP08 BB-1	101 Park Avenue S ground - [1 m AGL]	35.46886	97.51506	634731	3926053
IOP08 BB-2	101 Park Avenue 3-S - [34 m AGL]	35.46886	97.51506	634731	3926053
IOP08 BB-3	101 Park Avenue 4-S - [12 m AGL]	35.46886	97.51506	634731	3926053
IOP08 BB-4	101 Park Avenue Roof-S - [47 m AGL]	35.46886	97.51506	634731	3926053
IOP08 BB-5	Bank One Building roof - [148 m AGL]	35.46805	97.51416	634814	3925965
IOP08 BB-6	Bank One Building ground - [1 m AGL]	35.46806	97.51419	634811	3925965
IOP08 BB-7	Broadway&Main NE - [1 m AGL]	35.46777	97.51427	634804	3925933
IOP08 BB-8	Broadway&Main NW - [1 m AGL]	35.46780	97.51467	634768	3925936
IOP08 BB-9	Broadway&Main SE - [1 m AGL]	35.46755	97.51435	634797	3925909
IOP08 BB-10	Broadway&Main SW - [1 m AGL]	35.46756	97.51462	634773	3925909
IOP08 BB-11	Main St median W of Broadway - [1m AGL]	35.46768	97.51500	634738	3925922
IOP08 BB-12	NW corner Renaissance - [1 m AGL]	35.46715	97.51437	634796	3925864
IOP08 BB-13	Corporate Towers ground - [1 m AGL]	35.46788	97.51659	634594	3925942
IOP08 BB-14	Corporate Towers roof - [54 m AGL]	35.46788	97.51661	634592	3925942
IOP08 BB-15	Okland Building ground - [1 m AGL]	35.46785	97.51620	634629	3925939
IOP08 BB-16	Okland Building roof - [18 m AGL]	35.46785	97.51620	634629	3925940
IOP08 BB-17	Century Ctr Parking N ground - [1 m AGL]	35.46755	97.51529	634712	3925908
IOP08 BB-18	Century Center Parking N top - [18 m AGL]	35.46755	97.51529	634712	3925907
IOP08 BB-19	Main Street Parking ground - [1 m AGL]	35.46783	97.51509	634730	3925939
IOP08 BB-20	Main Street Parking top - [26 m AGL]	35.46784	97.51509	634730	3925940
IOP08 BB-21	Westin Hotel ground - [1 m AGL]	35.46712	97.51473	634764	3925860
IOP08 BB-22	Westin Hotel roof - [14 m AGL]	35.46712	97.51474	634763	3925860

Table A.16 (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP09 BB-1	101 Park South Ground - [1 m AGL]	35.46886	97.51497	634739	3926053
IOP09 BB-2	101 Park 3-South Profile - [34 m AGL]	35.46886	97.51497	634739	3926053
IOP09 BB-3	101 Park 4-South Profile - [11 m AGL]	35.46886	97.51497	634739	3926053
IOP09 BB-4	101 Park South Roof - [47 m AGL]	35.46886	97.51497	634739	3926053
IOP09 BB-5	101 Park West Ground - [1 m AGL]	35.46903	97.51511	634726	3926072
IOP09 BB-6	101 Park 5-West Profile - [34 m AGL]	35.46903	97.51511	634726	3926072
IOP09 BB-7	101 Park 6-West Profile - [11 m AGL]	35.46903	97.51511	634726	3926072
IOP09 BB-8	101 Park West Roof - [47 m AGL]	35.46903	97.51511	634726	3926072
IOP09 BB-9	101 Park North Ground - [1 m AGL]	35.46915	97.51502	634734	3926085
IOP09 BB-10	101 Park 7-North Profile - [11 m AGL]	35.46915	97.51502	634734	3926085
IOP09 BB-11	101 Park 8-North Profile - [34 m AGL]	35.46915	97.51502	634734	3926085
IOP09 BB-12	101 Park North Roof - [47 m AGL]	35.46915	97.51502	634734	3926085
IOP09 BB-13	101 Park East Ground - [1 m AGL]	35.46903	97.51462	634770	3926072
IOP09 BB-14	101 Park 1-East Profile - [35 m AGL]	35.46903	97.51462	634770	3926072
IOP09 BB-15	101 Park 2-East Profile - [12 m AGL]	35.46903	97.51462	634770	3926072
IOP09 BB-16	101 Park East Roof - [47 m AGL]	35.46903	97.51462	634770	3926072
IOP09 BB-17	Robinson & Park NE - [1 m AGL]	35.46889	97.51609	634637	3926055
IOP09 BB-18	Robinson & Couch SE - [1 m AGL]	35.46916	97.51614	634632	3926085
IOP09 BB-19	Leadership Square - [1 m AGL]	35.46933	97.51661	634589	3926103
IOP09 BB-20	Robinson & Kerr SE - [1 m AGL]	35.46973	97.51621	634625	3926148
IOP09 BB-21	100 Park North Ground - [1 m AGL]	35.46870	97.51496	634740	3926035
IOP09 BB-22	100 Park Roof - [48 m AGL]	35.46860	97.51467	634767	3926025
IOP10 BB-1	101 Park South Ground - [1 m AGL]	35.46886	97.51497	634739	3926053
IOP10 BB-2	101 Park 3-South Profile - [34 m AGL]	35.46886	97.51497	634739	3926053
IOP10 BB-3	101 Park 4-South Profile - [11 m AGL]	35.46886	97.51497	634739	3926053
IOP10 BB-4	101 Park South Roof - [47 m AGL]	35.46886	97.51497	634739	3926053
IOP10 BB-5	101 Park West Ground - [1 m AGL]	35.46903	97.51511	634726	3926072
IOP10 BB-6	101 Park 5-West Profile - [34 m AGL]	35.46903	97.51511	634726	3926072
IOP10 BB-7	101 Park 6-West Profile - [11 m AGL]	35.46903	97.51511	634726	3926072
IOP10 BB-8	101 Park West Roof - [47 m AGL]	35.46903	97.51511	634726	3926072
IOP10 BB-9	101 Park North Ground - [1 m AGL]	35.46915	97.51502	634734	3926085
IOP10 BB-10	101 Park 7-North Profile - [11 m AGL]	35.46915	97.51502	634734	3926085
IOP10 BB-11	101 Park 8-North Profile - [34 m AGL]	35.46915	97.51502	634734	3926085
IOP10 BB-12	101 Park North Roof - [47 m AGL]	35.46915	97.51502	634734	3926085
IOP10 BB-13	101 Park East Ground - [1 m AGL]	35.46903	97.51462	634770	3926072
IOP10 BB-14	101 Park 1-East Profile - [35 m AGL]	35.46903	97.51462	634770	3926072
IOP10 BB-15	101 Park 2-East Profile - [12 m AGL]	35.46903	97.51462	634770	3926072
IOP10 BB-16	101 Park East Roof - [47 m AGL]	35.46903	97.51462	634770	3926072
IOP10 BB-17	Robinson&Park NE - [1 m AGL]	35.46889	97.51609	634637	3926055
IOP10 BB-18	Robinson&Couch SE - [1 m AGL]	35.46916	97.51614	634632	3926085
IOP10 BB-19	Leadership Square - [1 m AGL]	35.46933	97.51661	634589	3926103
IOP10 BB-20	101 Park Bldg Vent in Alley - [1 m AGL]	35.46906	97.51511	634726	3926075
IOP10 BB-21	100 Park Ground North - [1 m AGL]	35.46870	97.51496	634740	3926035
IOP10 BB-22	100 Park Roof - [48 m AGL]	35.46860	97.51467	634767	3926025

Figure A.27. LLNL BlueBox Locations During (a) IOP 1 and 2, (b) IOP 3, (c) IOP 8, (d) IOP 9, and (e) IOP 10

Table A.17. LLNL Tracer Analyzer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP01 - A	East of Broadway North of Main	35.46783	97.51401	634828	3925940
IOP01 - B	East of Broadway South of Main	35.46757	97.51410	634820	3925911
IOP01 - C	NE corner Main and Broadway	35.46783	97.51437	634795	3925940
IOP01 - D	Broadway btwn Main and Park	35.46820	97.51464	634770	3925980
IOP01 - E	NW corner Main and Broadway	35.46776	97.51463	634772	3925932
IOP01 - F	N side of Main W of Broadway	35.46782	97.51498	634740	3925938
IOP01 - G	S side of Main W of Broadway	35.46755	97.51498	634740	3925908
IOP01 - H	SW corner Main and Broadway	35.46756	97.51461	634774	3925910
IOP01 - I	Broadway btwn Main and Sheridan	35.46713	97.51466	634770	3925862
IOP01 - J	Broadway btwn Main and Sheridan	35.46707	97.51433	634800	3925855
IOP02 - A	East of Broadway North of Main	35.46783	97.51401	634828	3925940
IOP02 - B	East of Broadway South of Main	35.46757	97.51410	634820	3925911
IOP02 - C	NE corner Main and Broadway	35.46783	97.51437	634795	3925940
IOP02 - D	Broadway btwn Main and Park	35.46820	97.51464	634770	3925980
IOP02 - E	NW corner Main and Broadway	35.46776	97.51463	634772	3925932
IOP02 - F	N side of Main W of Broadway	35.46782	97.51498	634740	3925938
IOP02 - G	S side of Main W of Broadway	35.46755	97.51498	634740	3925908
IOP02 - H	SW corner Main and Broadway	35.46756	97.51461	634774	3925910
IOP02 - I	Broadway btwn Main and Sheridan	35.46713	97.51466	634770	3925862
IOP02 - J	Broadway btwn Main and Sheridan	35.46707	97.51433	634800	3925855
IOP03 - A	Sheridan SW corner of Colcord	35.46658	97.51677	634579	3925798
IOP03 - B	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP03 - C	SE corner Sheridan and Robinson	35.46636	97.51602	634648	3925774
IOP03 - D	Sheridan entrance to Visitor's Center	35.46667	97.51560	634685	3925809
IOP03 - E	Main and Robinson on median	35.46751	97.51637	634614	3925902
IOP03 - F	Robinson btwn Sheridan and Main	35.46710	97.51660	634594	3925856
IOP03 - G	On Main E of Robinson	35.46753	97.51597	634650	3925904
IOP03 - H	Robinson at Sheridan on median	35.46664	97.51634	634618	3925805
IOP03 - I	West of Colcord building	35.46672	97.51688	634569	3925813
IOP03 - J	NW corner Sheridan and Robinson	35.46658	97.51652	634602	3925798
IOP04 - A	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP04 - B	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP04 - C	SE corner Sheridan and Robinson	35.46636	97.51602	634648	3925774
IOP04 - D	Sheridan entrance to Visitor's Center	35.46667	97.51560	634685	3925809
IOP04 - E	NW corner Sheridan and Robinson	35.46658	97.51652	634602	3925798
IOP04 - F	On Main E of Robinson	35.46753	97.51597	634650	3925904
IOP04 - G	Robinson at Sheridan on median	35.46664	97.51634	634618	3925805
IOP04 - H	Main and Robinson on median	35.46751	97.51637	634614	3925902
IOP04 - I	Sheridan SW corner of Colcord	35.46658	97.51677	634579	3925798
IOP04 - J	Robinson btwn Sheridan and Main	35.46710	97.51660	634594	3925856
IOP05 - A	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP05 - B	Robinson at Sheridan on median	35.46664	97.51634	634618	3925805
IOP05 - C	Sheridan SW corner of Colcord	35.46658	97.51677	634579	3925798
IOP05 - D	NW corner Sheridan and Robinson	35.46658	97.51652	634602	3925798
IOP05 - E	Sheridan entrance to Visitor's Center	35.46667	97.51560	634685	3925809
IOP05 - F	On Main E of Robinson	35.46753	97.51597	634650	3925904

Table A.17. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP05 - G	SE corner Sheridan and Robinson	35.46636	97.51602	634648	3925774
IOP05 - H	Main and Robinson on median	35.46751	97.51637	634614	3925902
IOP05 - I	West of Colcord building	35.46672	97.51688	634569	3925813
IOP05 - J	Robinson btwn Sheridan and Main	35.46710	97.51660	634594	3925856
IOP06 - A	West of Colcord building	35.46672	97.51688	634569	3925813
IOP06 - B	Robinson at Sheridan on median	35.46664	97.51634	634618	3925805
IOP06 - C	Sheridan entrance to Visitor's Center	35.46667	97.51560	634685	3925809
IOP06 - D	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP06 - E	SE corner Sheridan and Robinson	35.46636	97.51602	634648	3925774
IOP06 - F	On Main E of Robinson	35.46753	97.51597	634650	3925904
IOP06 - G	Sheridan SW corner of Colcord	35.46658	97.51677	634579	3925798
IOP06 - H	NW corner Sheridan and Robinson	35.46658	97.51652	634602	3925798
IOP06 - I	Robinson btwn Sheridan and Main	35.46710	97.51660	634594	3925856
IOP06 - J	Main and Robinson on median	35.46751	97.51637	634614	3925902
IOP07 - A	West of Colcord building	35.46672	97.51688	634569	3925813
IOP07 - B	SE corner Sheridan and Robinson	35.46636	97.51602	634648	3925774
IOP07 - C	Sheridan entrance to Visitor's Center	35.46667	97.51560	634685	3925809
IOP07 - D	Robinson at Sheridan on median	35.46664	97.51634	634618	3925805
IOP07 - E	NE corner Sheridan and Robinson	35.46666	97.51619	634632	3925808
IOP07 - F	Sheridan SW corner of Colcord	35.46658	97.51677	634579	3925798
IOP07 - G	Robinson btwn Sheridan and Main	35.46710	97.51660	634594	3925856
IOP07 - H	NW corner Sheridan and Robinson	35.46658	97.51652	634602	3925798
IOP07 - I	On Main E of Robinson	35.46753	97.51597	634650	3925904
IOP07 - J	Main and Robinson on median	35.46751	97.51637	634614	3925902
IOP08 - A	East of Broadway North of Main	35.46783	97.51401	634828	3925940
IOP08 - B	East of Broadway South of Main	35.46757	97.51410	634820	3925911
IOP08 - C	NE corner Main and Broadway	35.46783	97.51437	634795	3925940
IOP08 - D	Broadway btwn Main and Park	35.46820	97.51464	634770	3925980
IOP08 - E	NW corner Main and Broadway	35.46776	97.51463	634772	3925932
IOP08 - F	N side of Main W of Broadway	35.46782	97.51498	634740	3925938
IOP08 - G	S side of Main W of Broadway	35.46755	97.51498	634740	3925908
IOP08 - H	SW corner Main and Broadway	35.46756	97.51461	634774	3925910
IOP08 - I	Broadway btwn Main and Sheridan	35.46713	97.51466	634770	3925862
IOP08 - J	Broadway btwn Main and Sheridan	35.46707	97.51433	634800	3925855
IOP09 - A	SW corner Park and Broadway	35.46868	97.51461	634772	3926034
IOP09 - B	Couch Street just E of Robinson	35.46924	97.51545	634695	3926095
IOP09 - C	Broadway E of Couch Street	35.46927	97.51432	634797	3926100
IOP09 - D	Couch Street in Kerr Park	35.46924	97.51514	634723	3926095
IOP09 - E	Park Avenue S of City Place	35.46884	97.51566	634676	3926050
IOP09 - F	Park Avenue median E of Broadway	35.46871	97.51419	634810	3926038
IOP09 - G	Robinson just S of Park	35.46857	97.51638	634611	3926019
IOP09 - H	Park Avenue just E of Robinson	35.46870	97.51561	634681	3926035
IOP09 - I	NW corner Park and Broadway	35.46882	97.62617	634768	3926048
IOP09 - J	NW corner Couch and Broadway	35.46916	97.51481	634753	3926087

Table A.17. (contd)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
IOP10 - A	Couch Street just E of Robinson	35.46924	97.51545	634695	3926095
IOP10 - B	Park Avenue S of City Place	35.46884	97.51566	634676	3926050
IOP10 - C	Park Avenue just E of Robinson	35.46870	97.51561	634681	3926035
IOP10 - D	Broadway E of Couch Street	35.46927	97.51432	634797	3926100
IOP10 - E	NW corner Park and Broadway	35.46882	97.51465	634768	3926049
IOP10 - F	NW corner Couch and Broadway	35.46916	97.51481	634753	3926087
IOP10 – G	Not used				
IOP10 – H	SW corner Park and Broadway	35.46868	97.51461	634772	3926034
IOP10 - I	Not used				
IOP10 - J	Couch Street in Kerr Park	35.46924	97.51514	634723	3926095

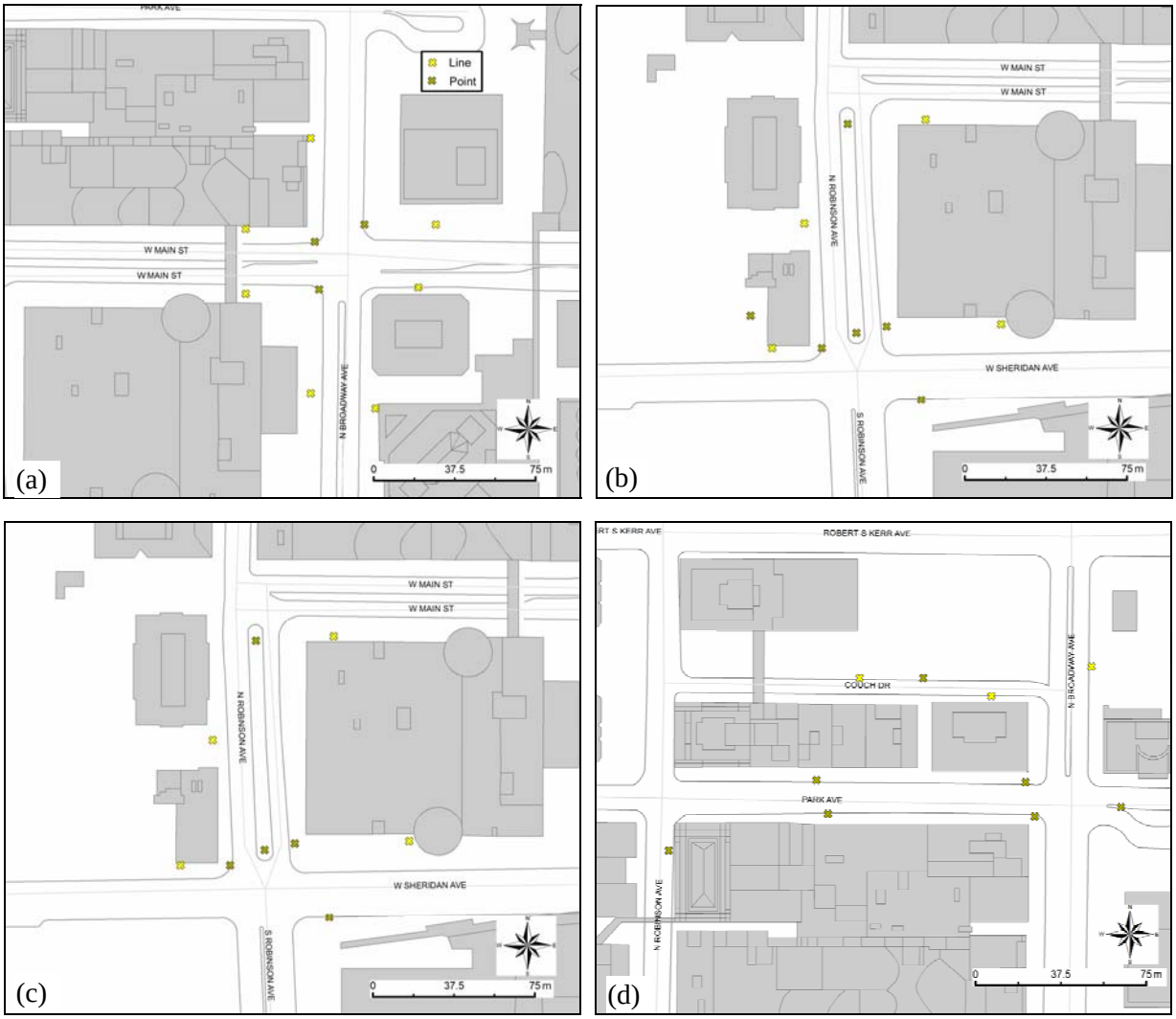

Figure A.28. LLNL Miran Locations During (a) IOP 1, 2, and 8, (b) IOP 3, 5, 6, and 7, (c) IOP 4, (d) IOP 9, and (e) IOP 10

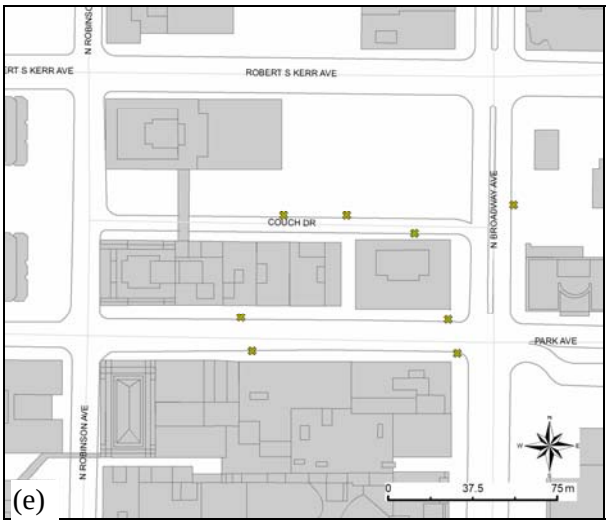

Figure A.28. (Contd)

Table A.18. LLNL Sonic Anemometer Location

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Sonic A - 7.8m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic B - 14.6m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic C - 21.5m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic D - 28.3m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic E - 42.5m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic F - 55.8m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic G - 69.7m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810
Sonic H - 83.2m agl	SW corner of 8th & Harvey	35.475718	97.51784	634467	3926810

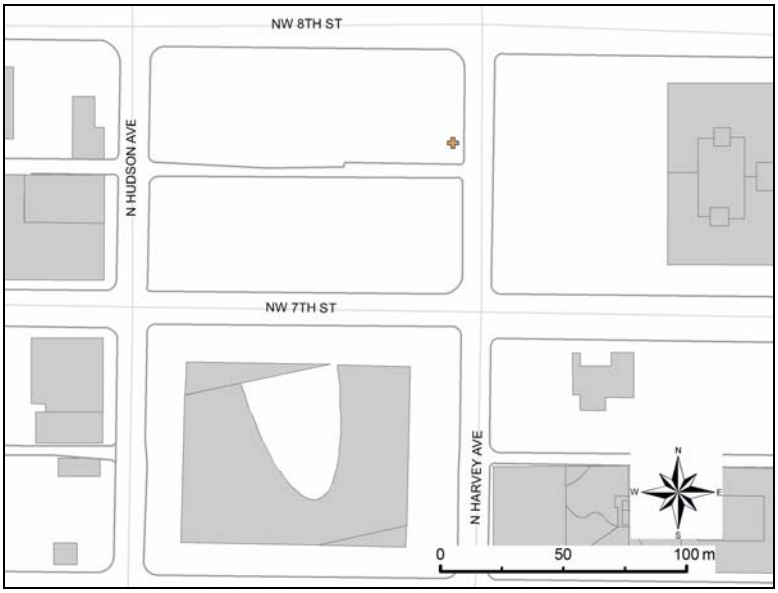

Figure A.29. LLNL Sonic Anemometer Location

A.12 Oklahoma Climatological Survey

The Oklahoma Climatological Survey was responsible for collecting data from the permanent meteorological stations of the Oklahoma Mesonet, National Weather Service (NWS) automated surface observing system (ASOS) sites, profiler/RASS, and weather radar sites. Coordinates for the meteorological measurement sites are presented in Table A.19, while the locations are shown in Figures A.30 and A.31.

Table A.19. OCS Meteorological Measurement Locations (Note: KINX Tulsa is in UTM Zone 15)

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Mesonet - ELRE	5miles WNW of El Reno	35.54848	98.03655	587327	3934297
Mesonet - GUTH	4 miles WSW of Guthrie	35.84892	97.47979	637279	3968258
Mesonet - KING	2 miles NE of Kingfisher	35.88052	97.91123	598278	3971244
Mesonet - MINC	2 miles SSW of Minco	35.27224	97.95557	594991	3903734
Meosnet - NRMN	2.1 miles NW of Norman	35.23612	97.46489	639683	3900308
Meosnet - SPEN	2 miles ENE of Spencer	35.54207	97.34142	650350	3934424
NWS - KOUN	Max Westhiemer Field	35.24694	97.47250	638972	3901498
NWS - KPWA	Wiley Post Airport	35.53590	97.64749	622612	3933316
NWS - KOKC	Will Rogers Airport	35.38861	97.60028	627124	3917039
NWS - KTLX	Twin Lakes Radar (OKC)	35.33310	97.27780	656522	3911344
Radar - KVNX	Vance AFB Radar	36.74080	98.12780	577868	4066474
Radar - KFDR	Frederick Radar	34.36220	98.97640	502170	3802317
Radar - KINX	Tulsa	36.17500	101.56470	269338	4006407
Profiler/RASS	Norman, OK	35.23505	97.46442	639728	3900190

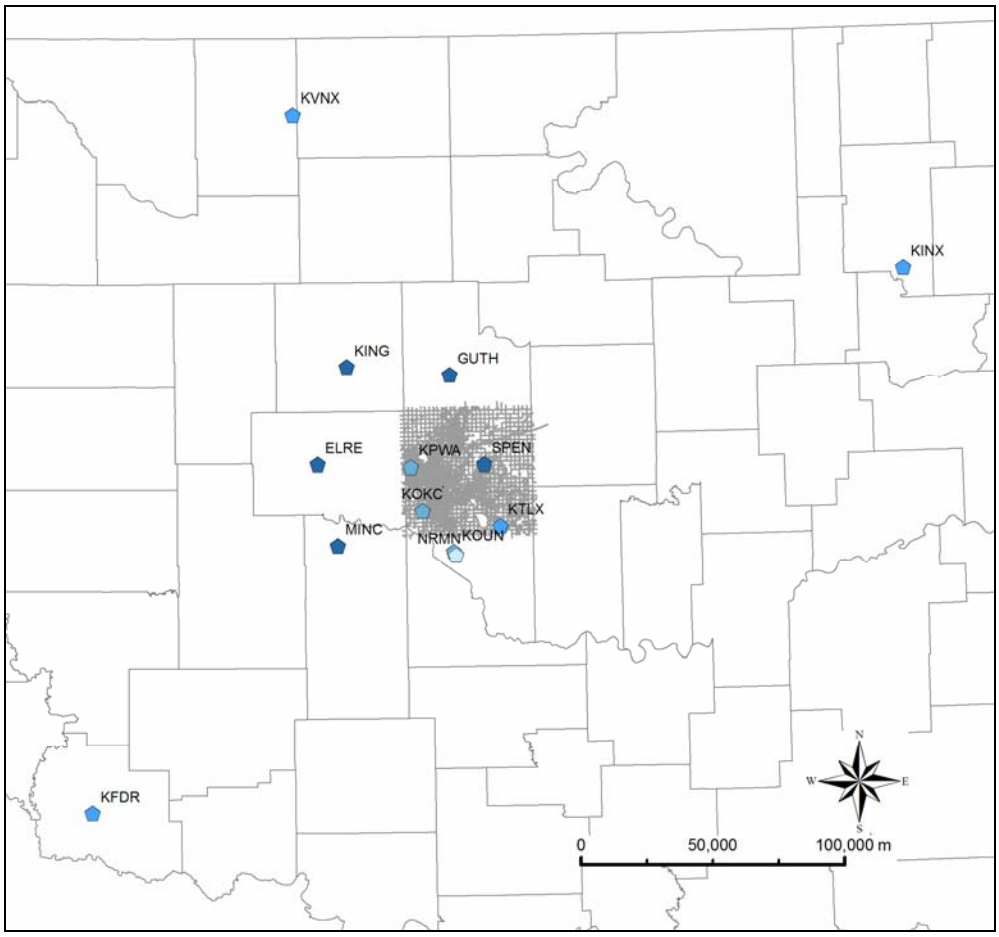

Figure A.30. Overview of OCS Meteorological Measurement Locations. Light grey outlines represent county borders. Oklahoma City is in the center of this image.

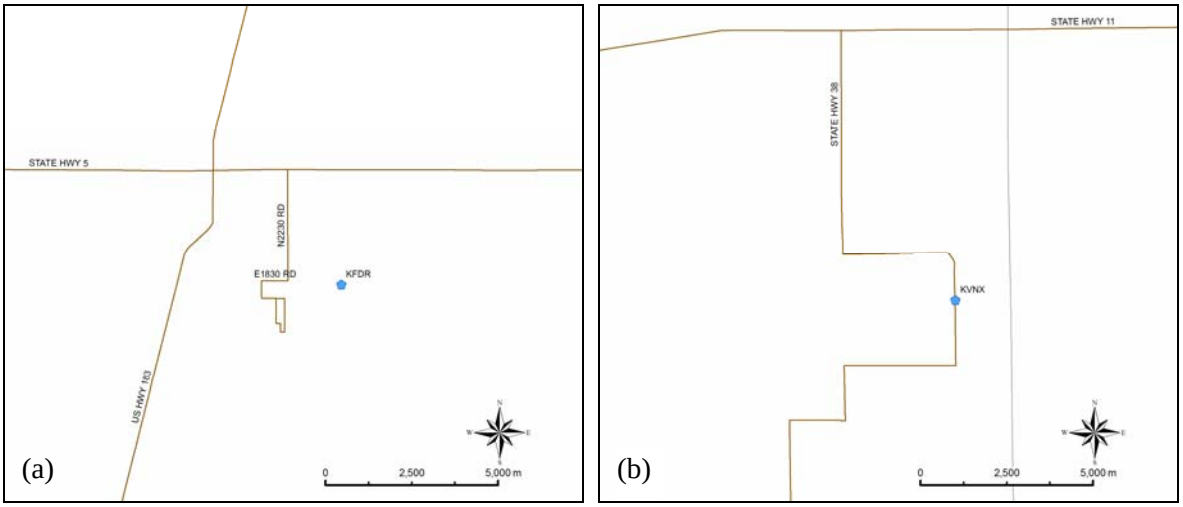

Figure A.31. OCS Meteorological Measurement Locations (a) KFDR, (b) KVNS, (c) KING, (d) ELRE, (e) MINC, (f) GUTH, (g) KPWA, (h) KOKC, (i) NRMN and KOUN, (j) SPEN, (k) KTLX, and (l) KINX

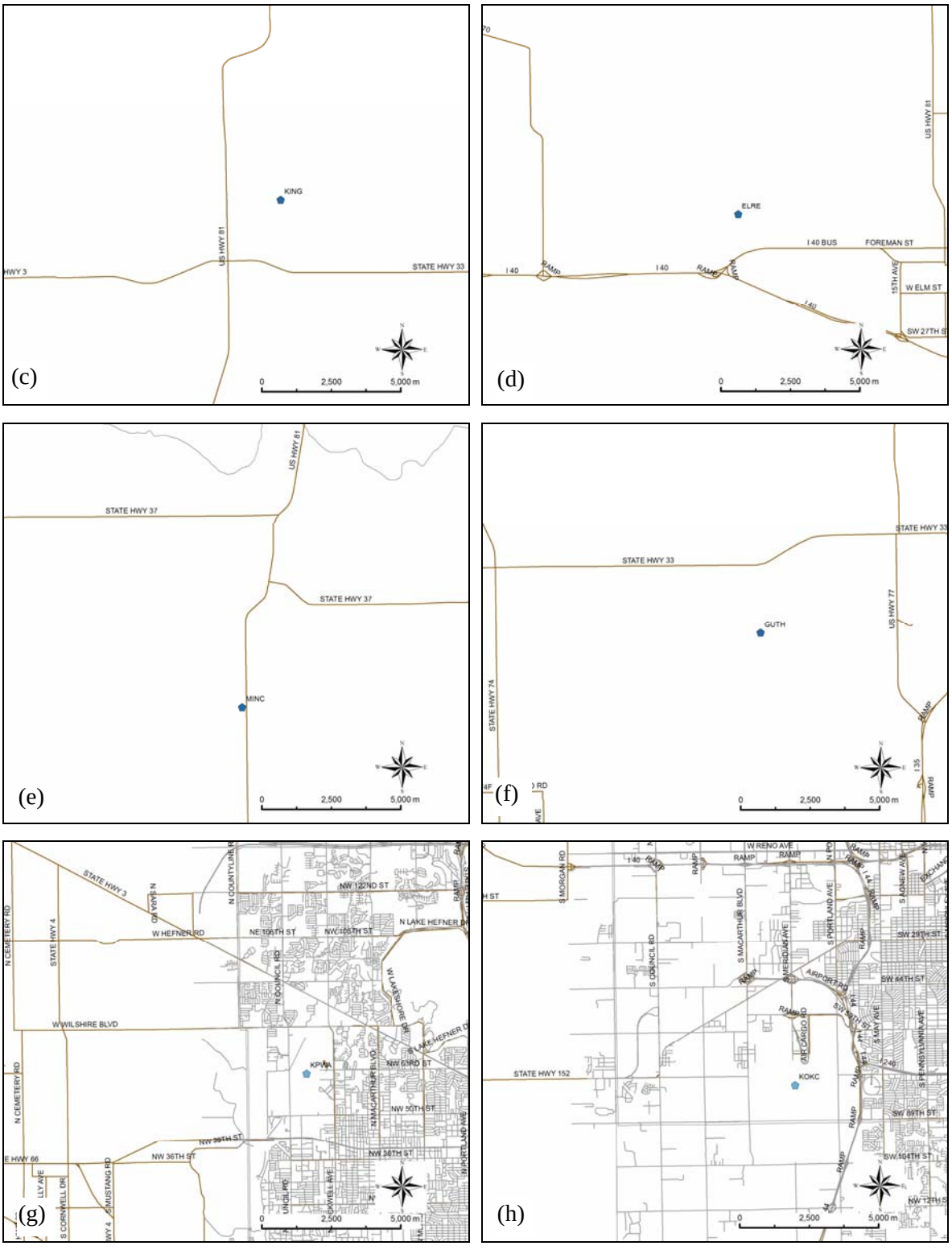

Figure A.31. (Contd)

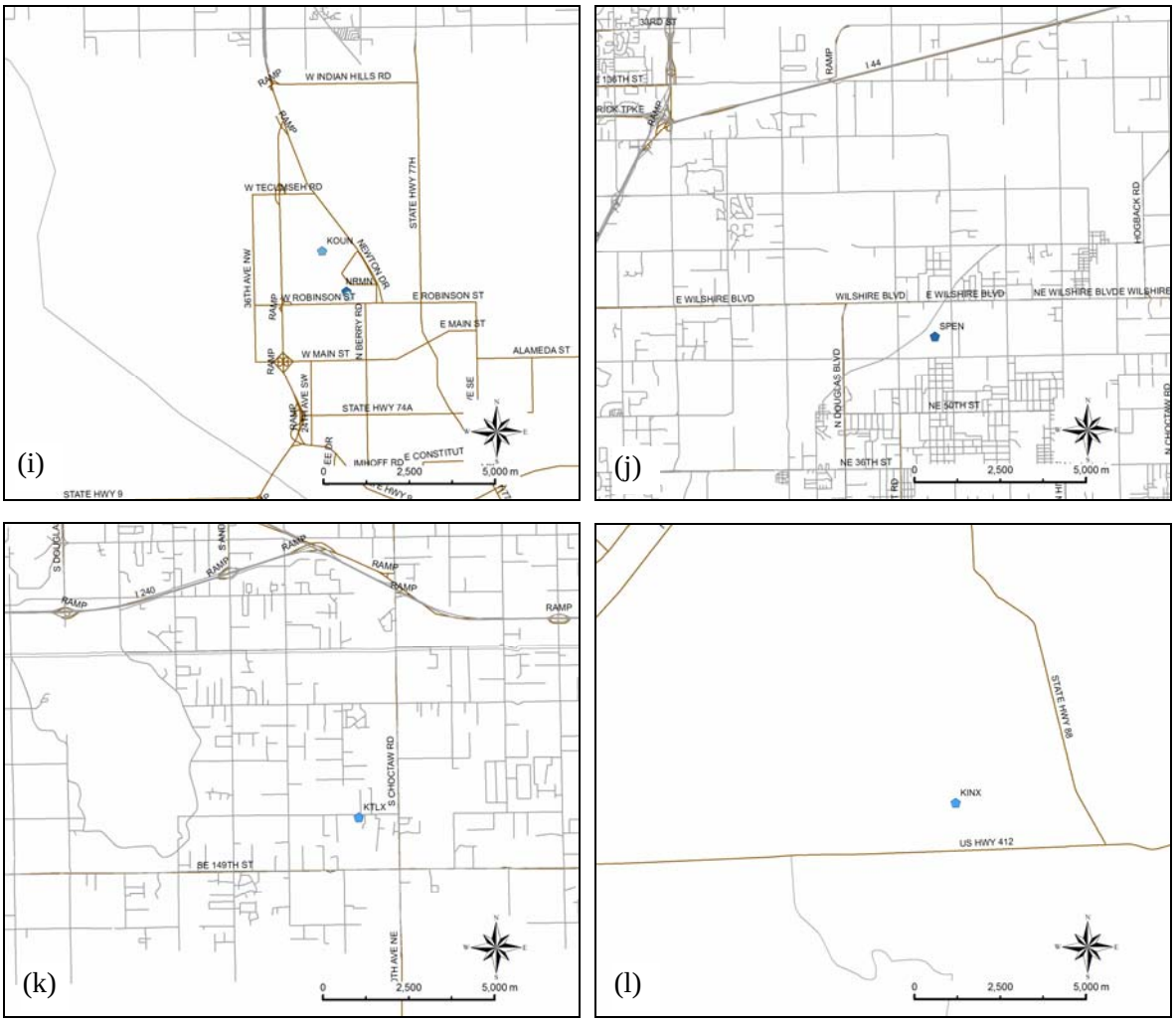

Figure A.31. (Contd)

A.13 University of Oklahoma

The University of Oklahoma instrumented two towers in the center of the Park Avenue street canyon with 5 3D sonic anemometers on each tower. These anemometers collected data continuously throughout the month-long field study. The coordinates of these towers are presented in Table A.20, while the locations are shown in Figure A.32. OU also took a number of photographs documenting the urban landscape of Oklahoma City. These photos can be found on the following website: http://weather.ou.edu/~pkklein/OKCphotos/OKCbuildmain.htm

Table A.20. OU Tower Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Tower 1 (5 sonics)	North side of Park Ave	35.468815	97.515616	634680.4	3926047.3
Tower 2 (5 sonics)	South side of Park Ave	35.468736	97.515563	634685.3	3926038.7

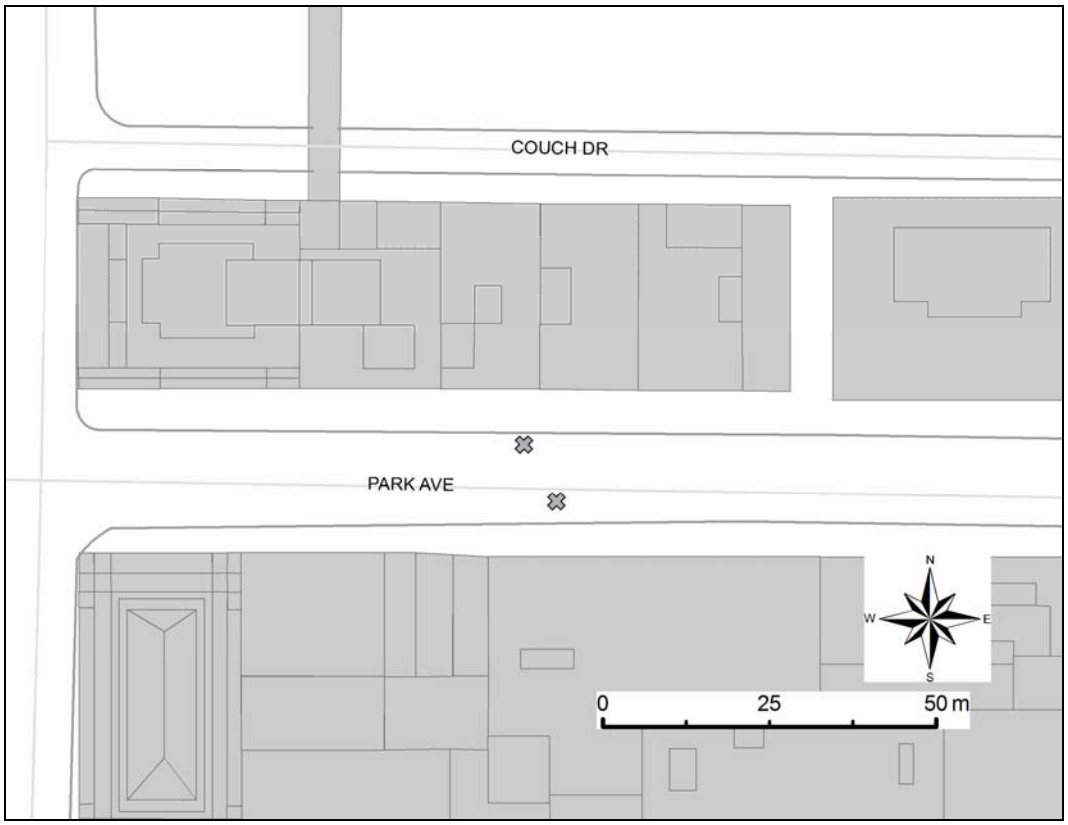

Figure A.32. OU Sonic Tower Locations

A.14 Pacific Northwest National Laboratory

The Pacific Northwest National Laboratory deployed five meteorological stations, several profile instruments, and 33 HOBO temperature sensors throughout Oklahoma City. The coordinates of the instruments are presented in Table A.21, and locations are shown in Figures A.33 through A.35.

Table A.21. PNNL Meteorological Station, Profile, and HOBO Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
Met station 01	N 10th & Dewey - St Anthony's Hospital [45m agl]	35.47786	97.52346	633954	3927040
Met station 02	Park btwn Harvey & Robinson - OK Tower [153m agl]	35.46848	97.51705	634551	3926008
Met station 03	Colcord & Lee - Civic Ctr Music Hall [37m agl]	35.46889	97.52380	633938	3926045
Met station 04	N 10th btwn Harvey & Robinson - Ed Minor's Bldg [15m agl]	35.47835	97.51688	634550	3927103
Met station 05	Robinson btwn N 6th & 7th - OK DEQ [49m agl]	35.47426	97.51650	634591	3926650
sodar, rawindsonde, & profiler/RASS	1400 S Shartel Ave – along fence N of the OKC traffic maintenance	35.45295	97.52534	633824	3924274
HOBO T01	Main & Ellison	35.46785	97.53377	633035	3925916
HOBO T02	Main & Clegern	35.46781	97.53125	633263	3925915
HOBO T03	Main & Classen	35.46788	97.52898	633469	3925925
HOBO T04	Main & Shartel	35.46791	97.52592	633747	3925933
HOBO T05	Main & Dewey	35.46796	97.52271	634038	3925943
HOBO T06	Main & Walker	35.46793	97.52147	634151	3925941
HOBO T07	Main & Hudson	35.46789	97.51968	634313	3925939
HOBO T08	Main & Harvey	35.46771	97.51792	634473	3925922
HOBO T09	Main & Robinson	35.46775	97.51654	634598	3925928
HOBO T10	Main & Broadway	35.46780	97.51436	634796	3925937
HOBO T11	Main & Gaylord	35.46775	97.51295	634924	3925933
HOBO T12	Main & Oklahoma	35.46769	97.51073	635126	3925929
HOBO T13	Main & Mickey Mantle	35.46760	97.50863	635316	3925922
HOBO T14	Main & Joe Carter	35.46688	97.50609	635548	3925846
HOBO T15	Sheridan & Byers	35.46634	97.50380	635757	3925789
HOBO T16	Tracks & Lindsay	35.46810	97.50067	636038	3925989
HOBO T17	Tracks & Kelley	35.46815	97.49593	636468	3926001
HOBO T18	Robinson & S 11th	35.45388	97.51608	634663	3924390
HOBO T19	Robinson & S 9th	35.45581	97.51612	634656	3924604
HOBO T20	Robinson & S 6th	35.45915	97.51637	634628	3924974
HOBO T21	Robinson & S 4th	35.46117	97.51636	634626	3925198
HOBO T22	Robinson & S 2nd	35.46303	97.51637	634622	3925405
HOBO T23	Robinson & Reno	35.46415	97.51659	634600	3925529
HOBO T24	Robinson btwn Reno and Sheridan	35.46544	97.51648	634608	3925672
HOBO T25	Robinson & Sheridan	35.46635	97.51658	634597	3925773
HOBO T26	Robinson & Park	35.46868	97.51649	634601	3926031
HOBO T27	Robinson & Kerr	35.46973	97.51647	634601	3926148
HOBO T28	Robinson & McGee	35.47078	97.51644	634602	3926264
HOBO T29	Robinson & N 4th	35.47181	97.51640	634604	3926378
HOBO T30	Robinson & N 6th	35.47392	97.51636	634604	3926612
HOBO T31	Robinson & N 8th	35.47582	97.51604	634630	3926824
HOBO T32	Robinson & N 10th	35.47813	97.51617	634615	3927080
HOBO T33	Robinson & N 11th	35.48010	97.51593	634633	3927299

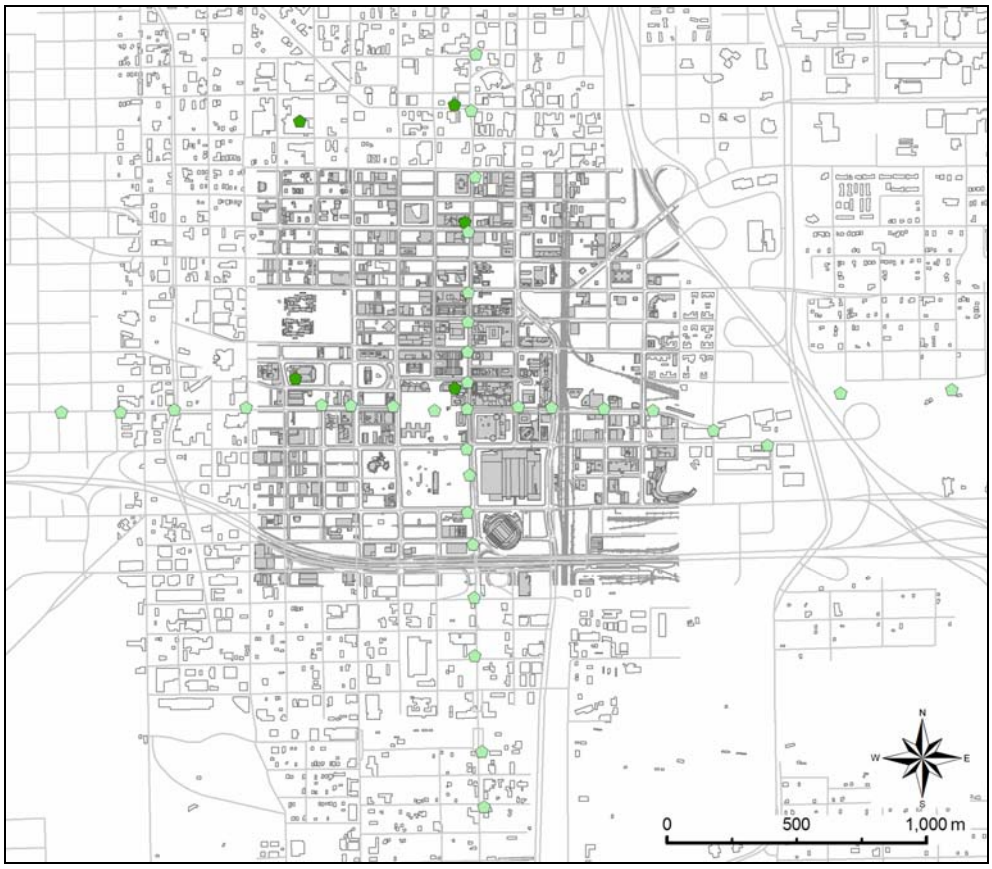

Figure A.33. Overview of PNNL Meteorological Station and HOBO Locations. Dark green pentagons represent meteorological stations, while light green pentagons are HOBOs.

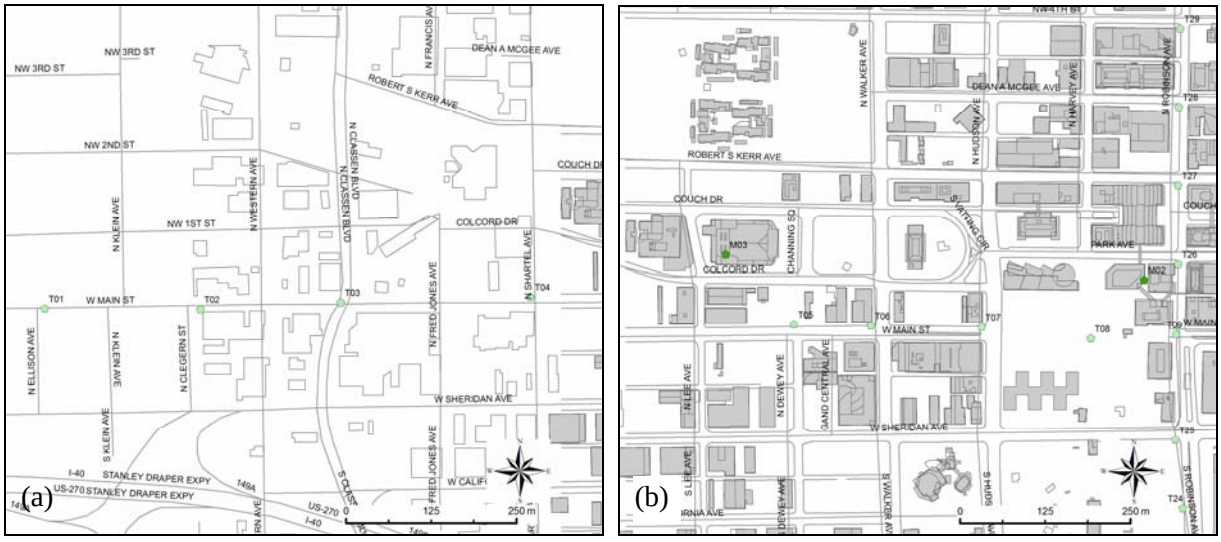

Figure A.34. PNNL HOBO and Meteorological Station Locations. Light green pentagons represent HOBOS while dark green pentagons are meteorological stations. (a) through (d) show instruments from west to east, while (e) through (h) show instruments from south to north.

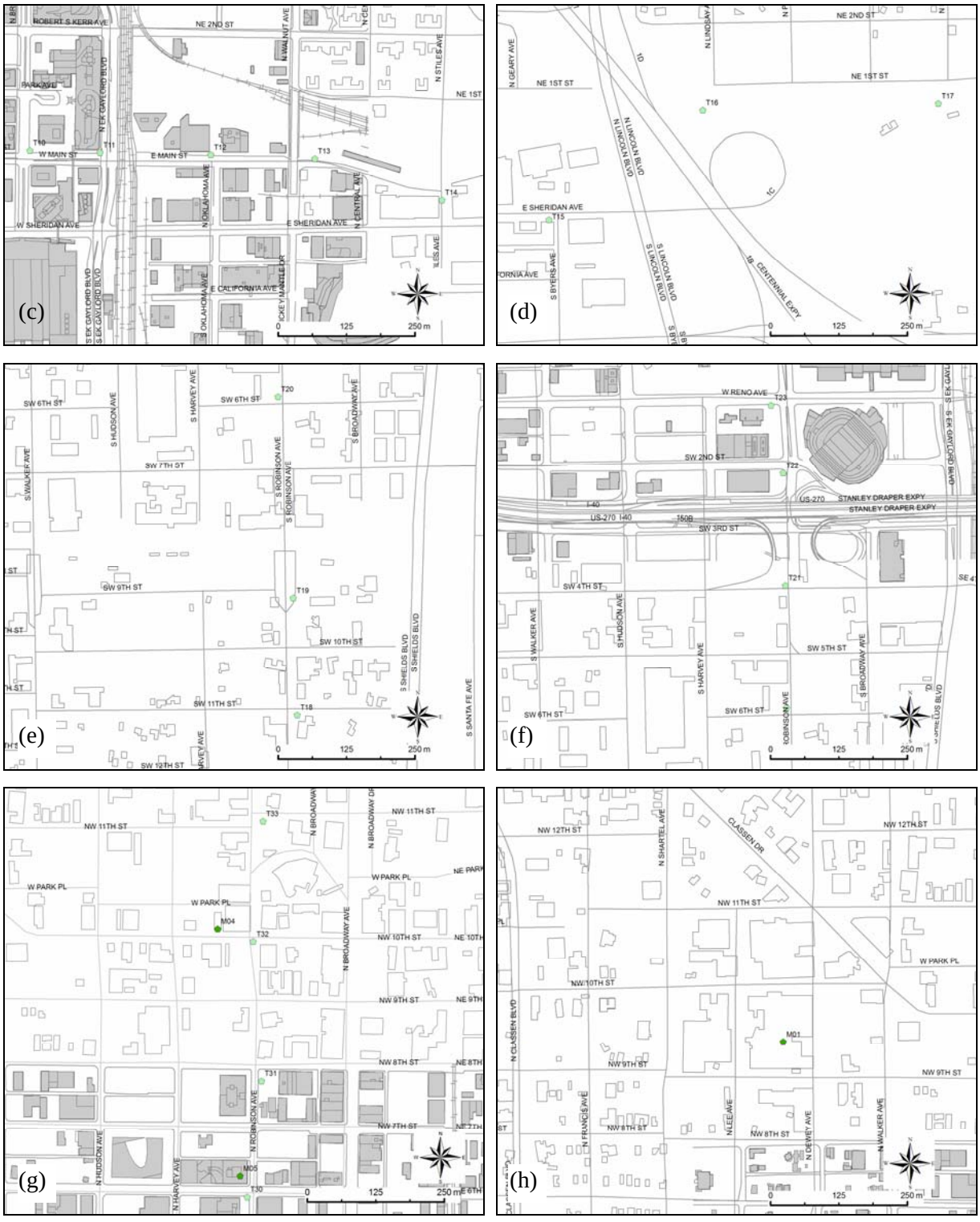

Figure A.34. (Contd)

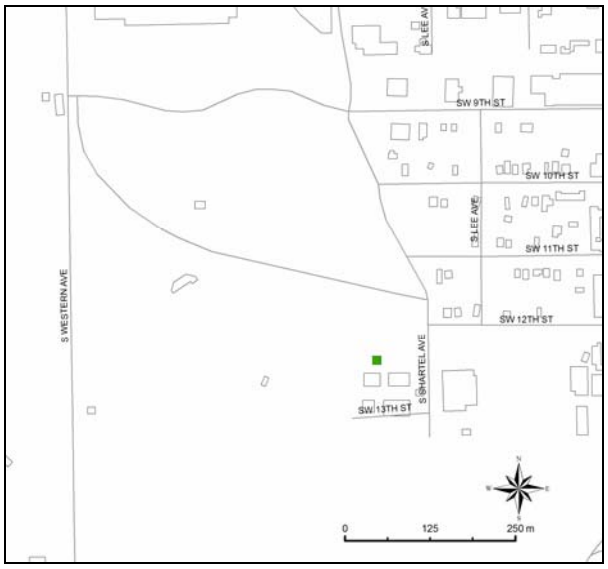

Figure A.35. PNNL Profile Site at Shartel Avenue

A.15 University of Houston

The University of Houston deployed a sodar about 1.5 km northwest of downtown Oklahoma City. Data was collected continuously from this site for the duration of the field study. Table A.22 presents the coordinates of this instrument, while Figure A.36 shows the instrument location on a map.

Table A.22. UH Sodar Location

Instrument	Location Description	Latitude	Longitude	Easting	Northing
sodar	E edge of pkg lot btwn 10th & 11th and Walker & Hudson	35.47941	97.52039	634230	3927216

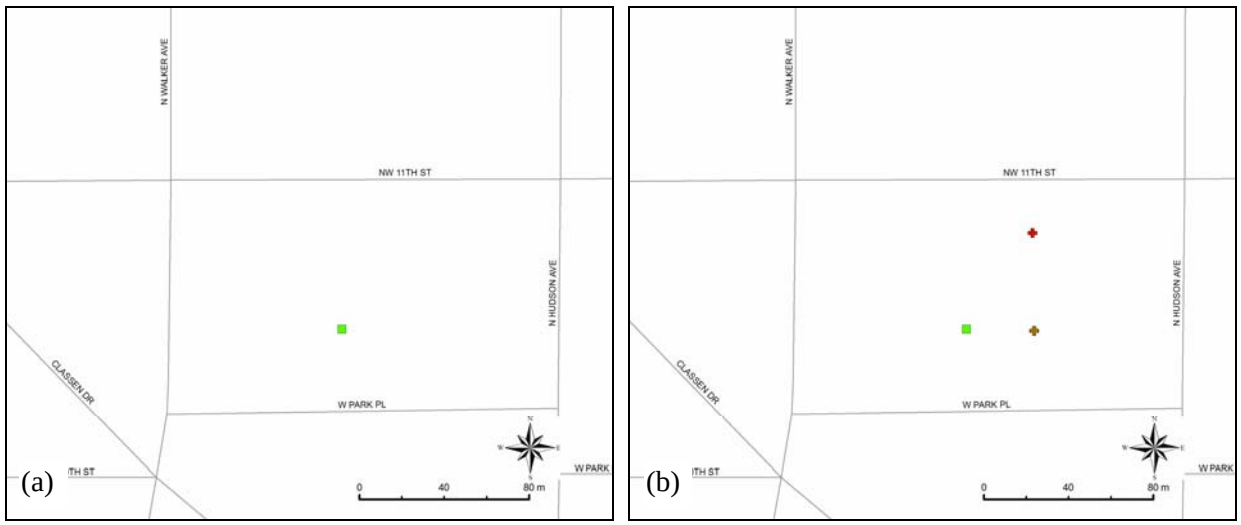

Figure A.36. UH Sodar Location (a) with only the UH Instrument, and (b) with Neighboring ATDD and ASU Instruments

A.16 University of Utah

The University of Utah deployed three 3D sonic anemometer towers and one tethersonde in Park Avenue and a minisodar on a parking garage to the northeast of Park Avenue. The sonic anemometers and minisodar operated continuously throughout the study period, while the tethersonde was deployed only during the IOPs. The coordinates of these instruments are presented in Table A.23 and the locations are shown in Figure A.37.

Table A.23. UU Sonic Anemometer and Profile Measurement Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
3D Sonic 2	Chamber of commerce rooftop [19m agl]	35.469031	97.515506	634690.0	3926071.4
3D Sonic 4	Chamber of commerce rooftop [20.5m agl]	35.469031	97.515506	634690.0	3926071.4
3D Sonic 9	Chamber of commerce rooftop [22m agl]	35.469031	97.515506	634690.0	3926071.4
3D sonic 1	City business center rooftop [6m agl]	35.469095	97.515215	634716.3	3926078.9
3D sonic 6	City business center rooftop [8m agl]	35.469095	97.515215	634716.3	3926078.9
3D sonic 7	City business center rooftop [10m agl]	35.469095	97.515215	634716.3	3926078.9
3D sonic 3	100 Park Ave tower [3.19m agl]	35.468738	97.515942	634650.9	3926038.3
3D sonic 5	100 Park Ave tower [4.19m agl]	35.468738	97.515942	634650.9	3926038.3
3D sonic 8	100 Park Ave tower [5.04m agl]	35.468738	97.515942	634650.9	3926038.3
3D sonic 10	100 Park Ave tower [7.24m agl]	35.468738	97.515942	634650.9	3926038.3
3D sonic 11	100 Park Ave tower [9.84m agl]	35.468738	97.515942	634650.9	3926038.3
minisodar	Broadway-Kerr parking garage. North of Bank One Bldg [17m agl]	35.46994	97.51416	634811	3926174
tethersonde	S side of Park W of Broadway South of Sonic Bldg	35.46866	97.51479	634756	3926031

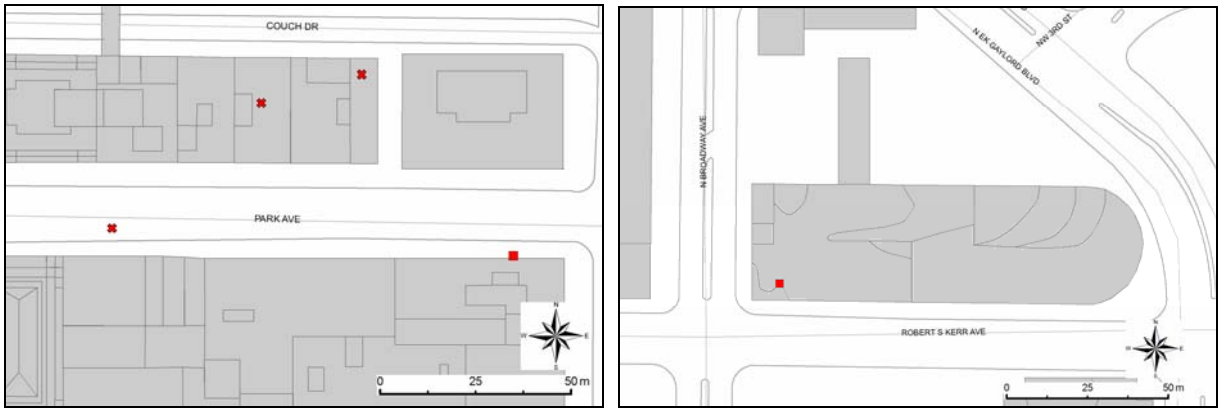

Figure A.37. UU Sonic Anemometer (red X's) and Profile (red boxes) Measurement Locations (a) in Park Ave and (b) on the Broadway-Kerr Parking Garage

A.17 Volpe/University of Central Florida

Volpe/University of Central Florida deployed tracer sampler instruments called MiniVols in two different configurations. Configuration 1 was used when the release location was at the Westin Hotel or in Park Avenue (IOPs 1,2,8,9, & 10). Configuration 2 was used when the release occurred at the Botanical Gardens on Robinson (IOPs 3 though 7). Two 2D sonic anemometers were also deployed at fixed locations during each IOP. Table A.24 presents the coordinates of the Volpe instruments, while Figures A.38 through A.40 shows the locations on maps.

Table A.24. Volpe Tracer Sampler and Sonic Anemometer Locations

Instrument	Location Description	Latitude	Longitude	Easting	Northing
MiniVol 1-1	NE corner of Robinson & Park abt 1m SW of City Place Bldg	35.46888	97.51637	634612	3926054
MiniVol 1-3	N side of Park btwn Robinson & Broadway	35.46883	97.51576	634667	3926049
MiniVol 1-5	N side of Park btwn Robinson & Broadway	35.46882	97.51516	634722	3926049
MiniVol 1-7	NW corner of Broadway & Park abt 2m E of Sonic Bldg	35.46886	97.51463	634770	3926054
MiniVol 1-9	SE corner of Robinson & Park abt 1m NW of 1st Natl Bldg	35.46868	97.51637	634612	3926031
MiniVol 1-11	S side of Park btwn Robinson & Broadway	35.46870	97.51577	634667	3926034
MiniVol 1-13	S side of Park btwn Robinson & Broadway	35.46871	97.51516	634722	3926036
MiniVol 1-15	SW corner of Broadway & Park abt 3m NE of 1st Natl Bldg	35.46866	97.51463	634770	3926031
MiniVol 2-1	NE corner of Robinson & Park abt 1m SW of City Place Bldg	35.46888	97.51637	634612	3926054
MiniVol 2-3	~18m east of Robinson on N side of Main	35.46780	97.51618	634631	3925934
MiniVol 2-5	E side of Robinson btwn Main & Sheridan	35.46699	97.51624	634627	3925844
MiniVol 2-7	~30m east of Robinson on N side of Sheridan	35.46663	97.51594	634655	3925805
MiniVol 2-9	SE corner of Robinson & Park abt 1m NW of 1st Nat'l Bldg	35.46868	97.51637	634612	3926031
MiniVol 2-11	SW corner of Robinson & Main	35.46756	97.51651	634601	3925907
MiniVol 2-13	W side of Robinson btwn Main & Sheridan	35.46699	97.51650	634603	3925844
MiniVol 2-15	NW corner of Robinson & Sheridan	35.46665	97.51651	634603	3925806
2D sonic	N side of Park ~7 m from bldg corner at Robinson	35.46887	97.51629	634619	3926053
2D sonic	S side of Park ~7 m from bldg corner at Robinson	35.46869	97.51630	634619	3926032

Figure A.38. Volpe MiniVol Configuration 1

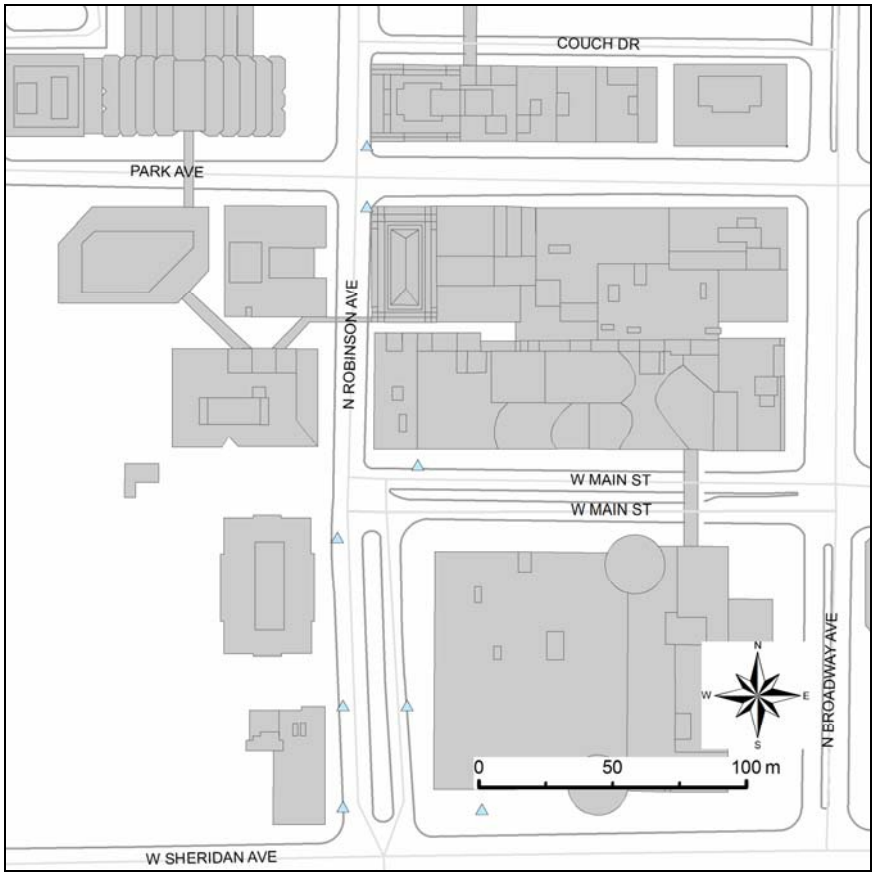

Figure A.39. Volpe MiniVol Configuration 2

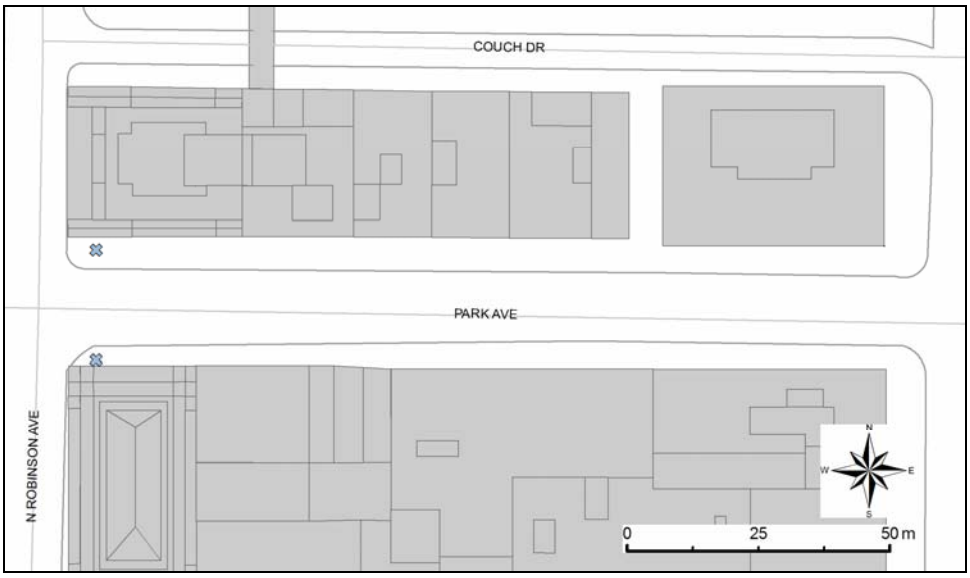

Figure A.40. Volpe Sonic Anemometer Locations

A.18 Washington State University

Washington State University deployed a tracer profiler system mounted on a crane (with the LLNL sonic anemometers) about 1 km north of downtown Oklahoma City. The coordinates of the tracer inlets are presented in Table A.25, and the location is shown in Figure A.41.

Table A.25. WSU Tracer Profiler Location

Instrument	Location Description	Latitude	Longitude	Easting	Northing
SF6 sampler 10.7m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 17.5m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 24.4m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 34.7m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 48.4m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 62.1m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810
SF6 sampler 75.8m agl	SW corner of 8th & Harvey	35.47572	97.51785	634466	3926810

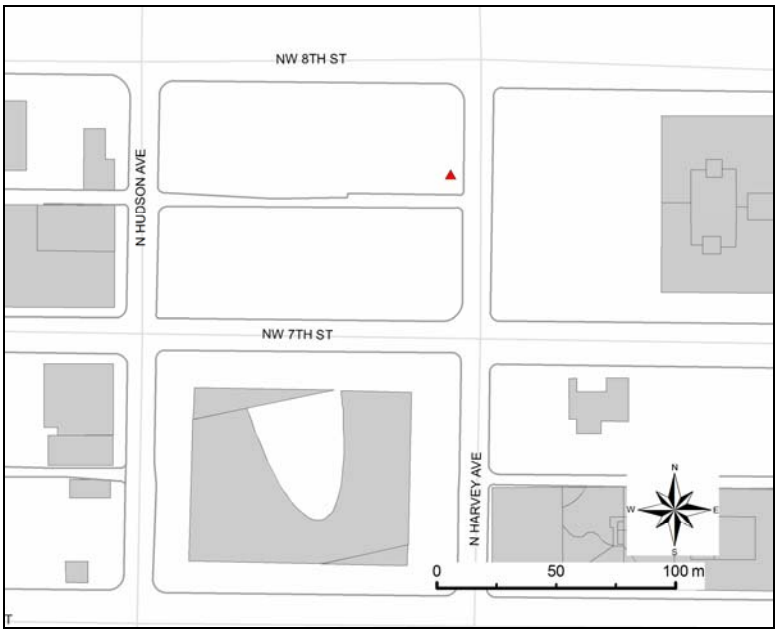

Figure A.41. WSU Tracer Profiler Location

Appendix B

The following table, Table B.1, presents a summary of the principal investigators from each of the participating institutions. Additionally, Table B.2 presents all of the study participants from the various institutions. The Joint Urban 2003 lead scientist was Jerry Allwine (PNNL) who oversaw study design, logistical arrangements and field operations with the help of Joe Shinn (LLNL), Marty Leach (LLNL), Ray Hosker (ATDD), Leo Stockham (NGIT) and Jim Bowers (DPG).

Table B.1. Summary of Principal Investigators from the Participating Institutions of the Joint Urban 2003 Study

Participating Institution	**Principal Investigator**	**Email**
Argonne National Laboratory	Rich Coulter	rlcoulter@anl.gov
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Arizona State University	Ron Calhoun Marko Princevac	ronald.calhoun@asu.edu marko@eng.ucr.edu
NOAA Air Resources Laboratory - Atmospheric Turbulence and Diffusion Division	Ray Hosker	ray.hosker@noaa.gov
Dugway Proving Ground	Jim Bowers Donny Storwold	jbowers@dpg.army.mil storwold@dpg.army.mil
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ITT Industries	Don Burrows	don.burrows@itt.com
Indiana University	Sue Grimmond	Sue.Grimmond@kcl.ac.uk (currently with King's College London)
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Lawrence Berkeley National Laboratory	Rich Sextro	rgsextro@lbl.gov
Lawrence Livermore National Laboratory	Marty Leach Joe Shinn	leach6@llnl.gov shinn1@llnl.gov
Oklahoma Climatological Survey	Jeff Basara	jbasara@ou.edu
University of Oklahoma	Petra Klein	pkklein@ou.edu
Pacific Northwest National Laboratory	Jerry Allwine	jerry.allwine@pnl.gov
Edgewood Chemical Biological Center	Francis D'Amico	fran.damico@us.army.mil
University of Central Florida	Roger Wayson	wayson@ucf.edu
University of Houston	Shiyuan Zhong	szhong@uh.edu
University of Utah	Eric Pardyjak	pardyjak@eng.utah.edu
DOT - Volpe	Gregg Fleming	gregg.g.fleming@volpe.dot.gov
Washington State University	Brian Lamb	blamb@wsu.edu

Table B.2. Summary of Participants in the Joint Urban 2003 Study

Participating Institution	Participant	
Argonne National Laboratory (ANL)	Rich Coulter	Tim Martin
	Erin Hockanson	Mikhail Pekour
Army Research Laboratory (ARL)	Dennis Garvey	Walter Bach
	Ronald Cionco	Young Yee
	Chat Williamson	Dave Quintis
	David Ligon	Ed Creegan
	Ed Vidal	Gail Vaucher
	Giap Huyhn	James Cogan
	Jimmy Yarbrough	John Noble
	Raymond Pickering	Manny Bustillos
	Mario Torres	Alan Mariner
	Yansen Want	Shaun Jackson
	Sam Chang	Scott Elliott
NOAA Air Resources Laboratory- Field Research Division (ARLFRD)	Kirk Clawson	Roger Carter
	Debbie Lacroix	Tom Watson
	Randy Johnson	Janna Goldman
	Bradley Reese	Neil Hukari
	Bob McMillen	Camille Erwin
	David George	Dianne Hoover
	Mark Hoover	Chris Biltoft
Arizona State University (ASU)	Ron Calhoun	Marko Princevac
	Joe Fernando	Dragah Zajic
	John Holeman	Rob Heap
NOAA Air Resources Laboratory - Atmospheric Turbulence and Diffusion Division (ATDD)	Ray Hosker	Laureen Gunter
	Carmen Nappo	Mark Heuer
	Randy Meyer	Randy White
	Will Stachowiak	
Centers for Disease Control and Prevention (CDC)	Duanne Hammond	Ken Mead
	Mike Gressel	Rebecca Valladares
	Scott Earnest	
Colorado State University (CSU)	Rob Newsom	
Dugway Proving Ground (DPG)	Jim Bowers	Donny Storwold
	Erik Vernon	Scott Halvorson
	Frank Gallagher	Frederick Davis
	Paul Broderick	Roland Barbero
	Bill Grayson	

Table B.2 (contd)

Participating Institution	Participant	
Defense Science and Technology Laboratory (DSTL)	Nicola Felton	Ian Griffiths
	David Brook	Douglas Strickland
Defense Threat Reduction Agency (DTRA)	John Pace	Linda Ritchie
	Rick Fry	
ITT Industries (ITT)	Don Burrows	Steve Diehl
	John Betz	John LeSage
	Vernon Smith	Alan Gaddy
	Bill Schrami	Bob Keith
	Chuck Tobin	Eric Hendricks
	Gary Paderewski	Greg Boyle
	Leldon Troyer	Les Mann
Indiana University (IU)	Sue Grimmond	Hong Bing Su
	Brian Offerle	Steve Scott
	Ben Crawford	
Los Alamos National Laboratory (LANL)	Michael Brown	Brad Hansen
	David Boswell	Gerald Streit
	Matt Nelson	Tim Hilton
	Tim McPherson	
Lawrence Berkeley National Laboratory (LBNL)	Rich Sextro	Tracy Thatcher
	Woody Delp	Doug Black
	Emily Wood	Mark Sippola
	Toshifumi Hotchi	
Lawrence Livermore National Laboratory (LLNL)	Marty Leach	Joe Shinn
	Frank Gouveia	Bill Ralph
	Garrett Keating	Tom Humphreys
	Julie Lundquist	Branko Kosovic
	Don Ermak	Marshall Stuart
	Ronald Leif	Ronald Pletcher
Northrop Grumman Information Technology (NGIT)	Leo Stockham	Tom Mazzola
Oklahoma Climatological Survey (OCS)	Jeff Basara	Peter Hall
	Cerry Leffler	Aaron Kennedy
	Andy Moore	Ben Baranowski
	Brad Illston	Brianna Patterson
	Chad Ringley	Christy Carlson
	Danny Cheresnick	Don Giuliano
	Grant Stewart	Justin Monroe
	Ken Crawford	Kevin Kloesel
	Kodi Nemunaitis	Kristen Poole
	Kyle Walker	Loucinda Smith
	Lynn Perkinton	Matt Shawhan
	Matt Haugland	Megan Ferris
	Michael James	Michael Morris
	Ryan Barnes	Sarah Davis
	Renee McPherson	

Table B.2 (contd)

Participating Institution	Participant	
University of Oklahoma (OU)	Petra Klein	Daniel Walker
	May Yuan	Mang Lung Cheuk
	John Snow	Geoff Maas
	James Clark	T.H. Lee Wiliams
	Melissa Moon	
University of Oklahoma Health Sciences Center (HSC)	M. Muntimagadu	Sridhar Agraharam
University of Oklahoma REU (REU)	Allen Logan	Andrew Hamm
	Becca Mazur	Christy Nestlerode
	Corey Potvin	Dustin Rapp
	Jenny Esker	Marc Dahmer
	Maura Hahnenberger	Melissa Walker
	Mike Charles	Nick Metz
	Tina Kalb	Victoria Sankovich
	Aaron Barclay	
Pacific Northwest National Laboratory (PNNL)	Jerry Allwine	Will Shaw
	Larry Berg	Stephan DeWekker
	Geoffrey Harvey	Duard Crandal
	Brad Fritz	
Edgewood Chemical Biological Center (ECBC)	Francis D'Amico	
Redstone Arsenal Airfield (RAA)	Aaron Allen	Bill Cruger
	Blake Pattillo	Chris Teague
	Chuck Ricketts	Danny Rinehart
	Jeffrey Smith	John Burkhead
	Les Haas	Ned Norton
	Russ Matteo	Samuel Maki
	Tim Collins	Tim Ricks
Texas Tech University (TTU)	Caleb Midgley	Gabriel Rothman
	John Schroeder	Thomas Gill
University of Central Florida (CFU)	Roger Wayson	
University of Hamburg (UH)	Bernd Leitl	Frauke Pascheke
University of Houston (UH)	Shiyuan Zhong	Craig Clements
	Alex Cuclis	Bonnie Cheng
	Daewon Byun	Hee-Jin In
	Soontae Kim	Seung-Burn Kim
	Violeta Coarfa	
University of Utah (UU)	Eric Pardyjak	Joe Klewicki
	Prathap Ramamurthy	Suhas Pol
	Brett Verhoeff	James Allison
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