Nuclear Utility Meteorological Data Users Group
(NUMUG)
&
Department of Energy Meteorological Coordinating Council
(DMCC)

Meteorological Monitoring System Surveys Past, Present, and Future

Presented at NUMUG Meeting
Chicago, Illinois
June 2011

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PREFACE

The Nuclear Utility Meteorological Data Users Group (NUMUG) was founded to provide a forum to address problems and exchange ideas among those collecting and utilizing meteorological data at nuclear power plants and facilities. One of NUMUG's first activities was to compile a data base of meteorological monitoring programs to help focus NUMUG efforts. The original survey was conducted during 1992.

The second edition of the NUMUG survey was developed by streamlining the original survey and adding some new items, so the second edition should be viewed as a supplement to the original survey and not as a stand-alone document. In addition to the information included in the original survey, additional questions were asked about work practices and Department of Energy (DOE) facilities were added. The second edition survey was conducted during 1997-1998.

The third edition of the survey was a joint effort of NUMUG and Department of Energy (DOE) Meteorological Coordinating Council (DMCC). Like the second edition survey, this edition is a supplement to the earlier surveys and not a stand-alone document. While some addition questions were asked, the survey was intended to update previous information and to add more DOE facilities. The third edition survey was conducted during 2009-2010.

This report summarizes all of the surveys.

A project of this scope cannot be done alone. The work done by Stan Marsh and the team that conducted the original NUMUG survey was invaluable in producing the second edition of the survey and also provided a template for the third edition of the survey. Many individuals provided the input for all of these surveys. Others assisted with consolidating information and reviewing the results.

Thanks to everyone concerned.

INTRODUCTION

To comply with regulatory and other guidance, nuclear utilities and facility operators develop and operate meteorological monitoring programs using a wide variety of equipment available from numerous vendors. These programs generate the meteorological data bases required for effluent release reports as well as to provide real time data for emergency response activities and normal plant operations. Because of this freedom of choice, meteorological monitoring programs nationwide vary both in content and application, which can lead to uncertainty in how to comply with requirements, as well as inconsistencies in the resulting data bases.

At the inaugural Nuclear Utility Meteorological Data Users Group (NUMUG) meeting in 1991, it was agreed that an inventory of meteorological monitoring programs nationwide would be compiled. The purpose of this effort was twofold:

1) Provide detailed information on compliance with applicable requirements as they pertain to meteorological monitoring at nuclear power plants and facilities.

2) Develop a data base from which an updated industry standard for meteorological monitoring can evolve.

The first survey was conducted during 1992.

By 1997, a number of factors indicated that it was appropriate to update the original survey.

- Facilities included in the original survey had made numerous changes. It was necessary to update existing information to accurately reflect the current state-of-the-industry.

- The original survey did not address a number of other important aspects (maintenance and calibration, data processing and archiving, and general administrative issues) concerning meteorological activities. This type of information would be helpful in developing a meteorological data collection and processing program.

- The original survey did not include several Department of Energy (DOE) sites because they are non-utility facilities. However, these sites conduct meteorological monitoring for many of the same applications as commercial nuclear plants. An expanded data base was expected to provide a useful exchange of information about meteorological monitoring programs to both the utility industry and DOE.

Consequently, the NUMUG steering committee conducted a second survey during 1997-1998. The second edition of the survey requested most of the information included in the original survey with additional questions about work practices and included DOE facilities.

By 2009, the NUMUG steering committee and the DOE Meteorological Coordinating Council (DMCC) determined a new updated survey was necessary for several reasons:

- Facilities had made further changes. It was necessary to accurately reflect the current state-of-the-industry.

- DMCC wanted to expand the scope to provide a more representative picture of DOE meteorological monitoring activities.

- There had been numerous changes in regulatory and other guidance, and more changes are expected. The survey needed to provide up-to-date information to accurately reflect the current state-of-the-industry.

The third edition of the survey was a joint effort of NUMUG and DMCC. Like the second edition survey, this edition is a supplement to the earlier surveys and not a stand-alone document. While some addition questions were asked, the survey was intended to update previous information and to add more DOE facilities. The third edition survey was conducted during 2009-2010.

SURVEY DESCRIPTION

The Meteorological Monitoring System Survey was designed to give a complete picture of the meteorological monitoring systems operating at nuclear power plants and facilities. The surveys covered the following areas:

	1992	1997	2009
• Site Characteristics	X	X	X
• Meteorological Tower Information	X	X	X
• Variables Monitored	X	X	X
• Meteorological Instrumentation	X	X	X
• Recording and Auxiliary Equipment	X	X	X
• Off-Site Data Sources	X	X	X
• Maintenance and Calibration		X	X
• Data Processing and Archiving		X	X
• Administration		X	X

Facilities Included

A total of 85 nuclear plants and DOE facilities in the United States were identified as candidates for the surveys. Of these 61 responded to one or more editions of the survey. This represents about 71 percent of the applicable U. S. Facilities.

Power Plants:

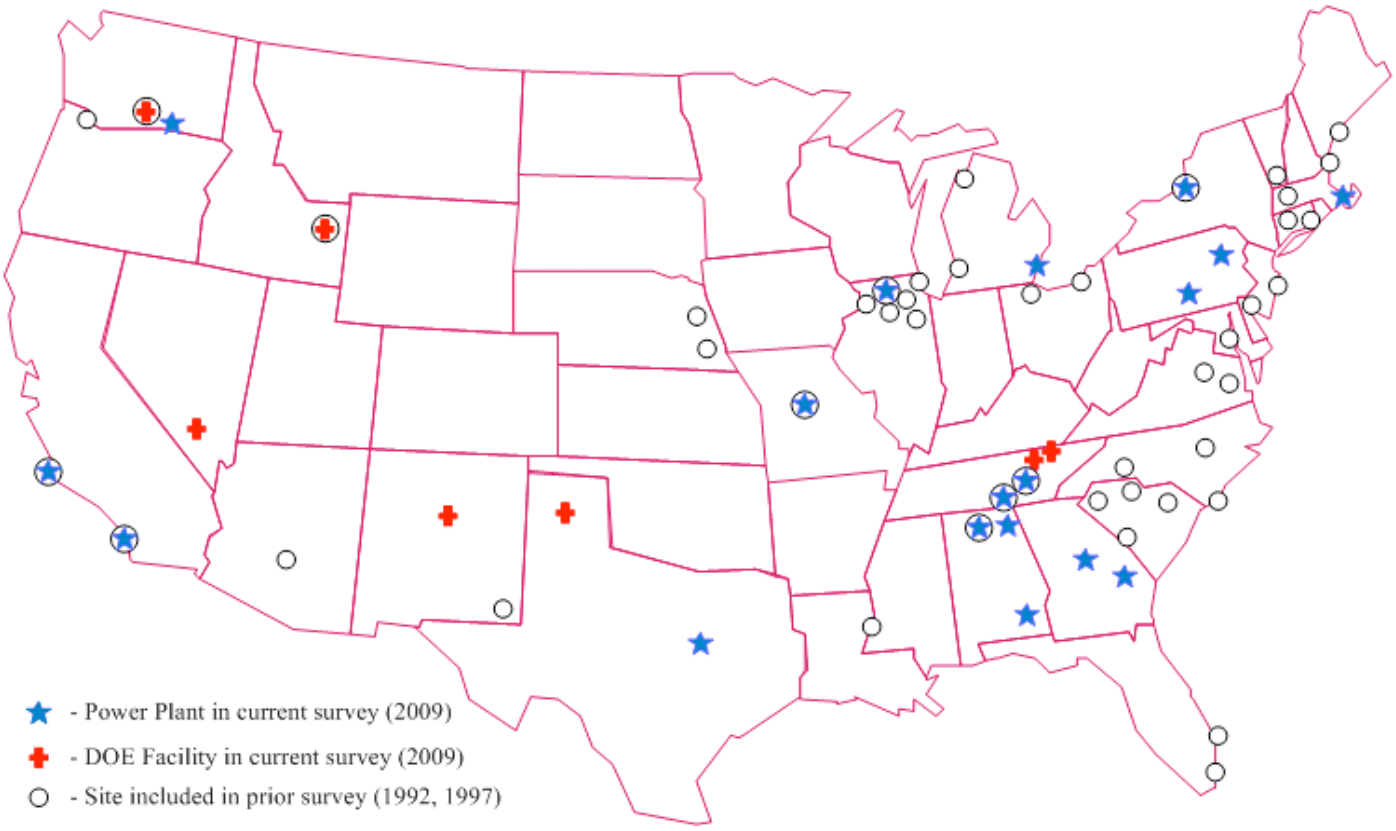
		Survey Participation		
	Location	1992	1997	2009
Bellefonte (proposed)	Hollywood, AL			X
Big Rock Point (retired)	Charlevoix, MI	X	X	
Braidwood	Braceville, IL		X	
Browns Ferry	**Athens, AL**	**X**	**X**	**X**
Brunswick	Southport, NC	X		
Byron	Byron, IL		X	X
Callaway	Fulton, MO	X		X
Calvert Cliffs	Lusby, MD		X	
Catawba	Rock Hill, SC	X	X	
Columbia Generating Station	Richland, WA			X
Comanche Peak	Glen Rose, TX			X
Cooper	Brownville, NE	X		
Davis-Besse	Toledo, OH	X		
Diablo Canyon	Avila Beach, CA	X		X
Dresden	Morris, IL		X	
Farley	Dothan, AL			X
Fermi	Newport, MI	X		X

	Location	Survey Participation 1992	1997	2009
Fort Calhoun	Blair, NE	X		
Grand Gulf	Port Gibson, MS		X	
Haddam Neck (retired)	Haddam Neck, CT	X	X	
Hatch	Baxley, GA			X
La Salle	Marseilles, IL		X	
McGuire	Huntersville, NC	X	X	
Millstone	Waterford, CT	X		
Nine Mile Point	**Oswego, NY**	**X**	**X**	**X**
North Anna	Louisa, VA	X		
Oconee	Seneca, SC	X	X	
Oyster Creek	Toms River, NJ	X	X	
Palisades	Covert, MI	X	X	
Palo Verde	Buckeye, AZ	X		
Perry	Perry, OH	X		
Pilgrim	Plymouth, MA			X
Quad Cities	Cordova, IL		X	
Robinson	Florence, SC	X		
Saint Lucie	Stuart, FL	X		
Salem/Hope Creek	Salem, NJ	X	X	
San Onofre	**San Clemente, CA**	**X**	**X**	**X**
Seabrook	Seabrook, NH	X		
Sequoyah	**Soddy-Daisy, TN**	**X**	**X**	**X**
Shearon Harris	Raleigh, NC	X		
Surry	Jamestown, VA	X		
Susquehanna	Berwick, PA			X
Three Mile Island	Middletown, PA			X
Trojan (retired)	Rainer, OR	X		
Turkey Point	Homestead, FL	X		
Vermont Yankee	Vernon, VT		X	
Vogtle	Burke County, GA			X
Watts Bar	**Spring City, TN**	**X**	**X**	**X**
Yankee Rowe (retired)	Rowe, MA	X	X	
Zion (retired)	Zion, IL		X	

Department of Energy (DOE) Facilities:

	Location	Survey Participation 1992	1997	2009
Hanford Site	Richland, WA		X	X
Idaho INEEL	Idaho Falls, ID		X	X
Los Alamos National Laboratory	Los Alamos, NM			X
Nevada Test Site	Las Vegas, NV			X
Oak Ridge National Laboratory	Oak Ridge TN			X
Pantex	Amarillo, TX			X
Savannah River Site	Aiken, SC	X	X	
Waste Isolation Pilot Plant	Carlsbad, NM		X	
Y-12 National Security Complex	Oak Ridge TN			X

Location Map:



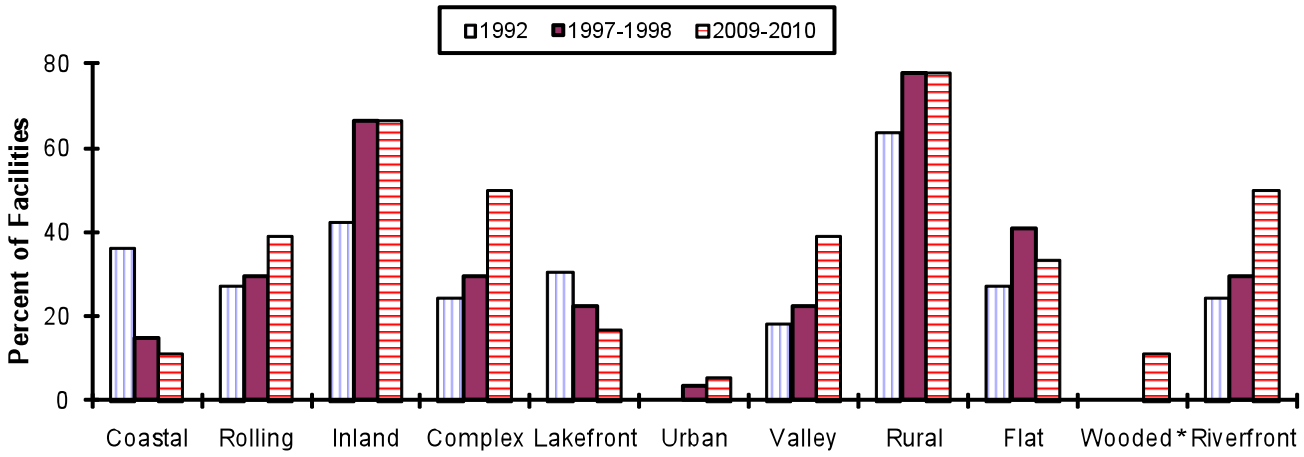
SURVEY RESULTS

A set of companion spreadsheet files (**Survey_1992.xlsx**, **Survey_1997.xlsx**, and **Survey_2009.xlsx**) contain and summarize the survey input data. They are available as companions to this report.

Site Characteristics

The site characteristics of a nuclear power facility dictate the complexity of its associated meteorological monitoring program. For example, a rural, flat, inland site will have fairly simple dispersion conditions and may need only a simple monitoring program. On the other hand, a complex, riverfront, valley site area will have to consider more difficult flow patterns and will require a more sophisticated monitoring program.

The following depicts the results as a percentage of the facilities reporting (Note: Facilities generally fall into more than one category).



* The “Wooded” category was a choice in only the 2009-2010 survey.

The Inland and Rural categories are the most common.

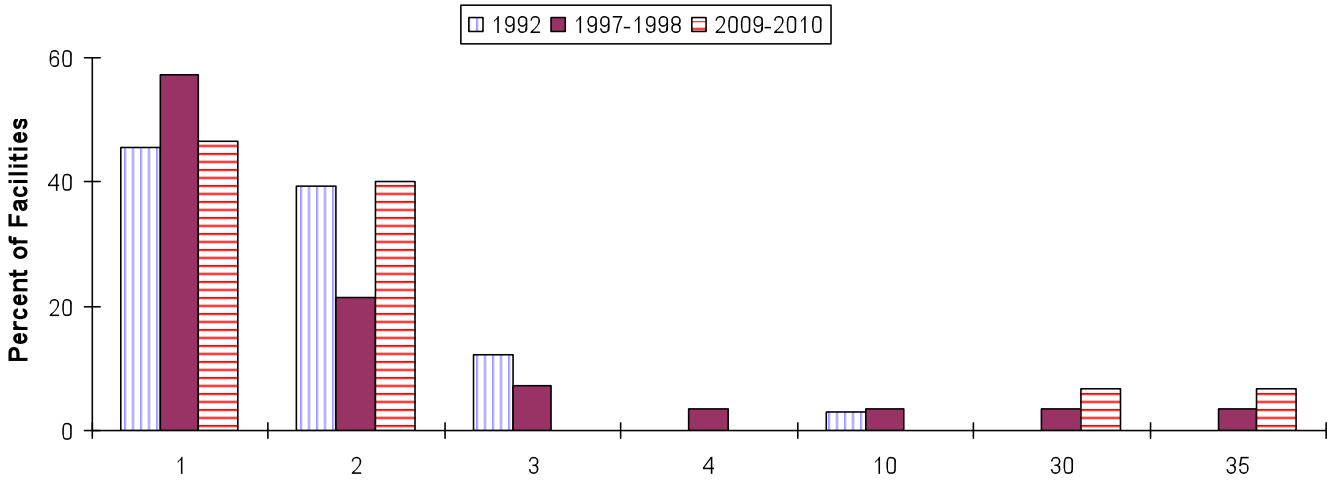
Meteorological Tower Information

Each facility was asked for information about its meteorological monitoring program. For this purpose, the **primary tower** is the predominant source of information about the site. **Other towers** include all other towers for the site, regardless of function (backup, supplemental, etc.).

Number of Meteorological Towers

The number and type of towers illustrates clear difference between power plants and DOE facilities. Power plant monitoring programs are centered around one particular facility and therefore need only one primary tower and up to three supplemental towers. DOE facilities generally cover very large areas with multiple sources that must be considered. In addition, research activities at some DOE sites require detailed knowledge about meteorological conditions. Consequently, DOE facilities generally have multiple meteorological towers.

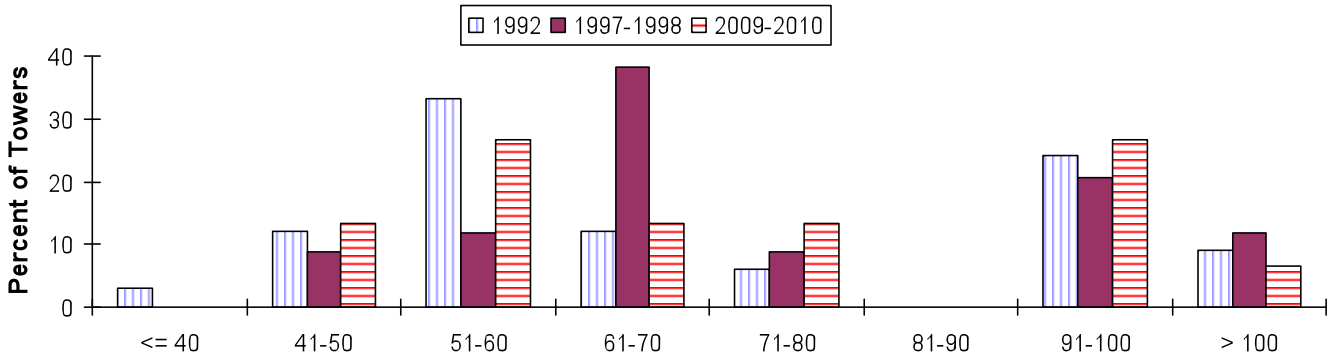
The number of meteorological towers included in the meteorological monitoring programs is shown below. As can be seen, most facilities (all power plants) have only one tower while the DOE facilities can have ten or more towers.



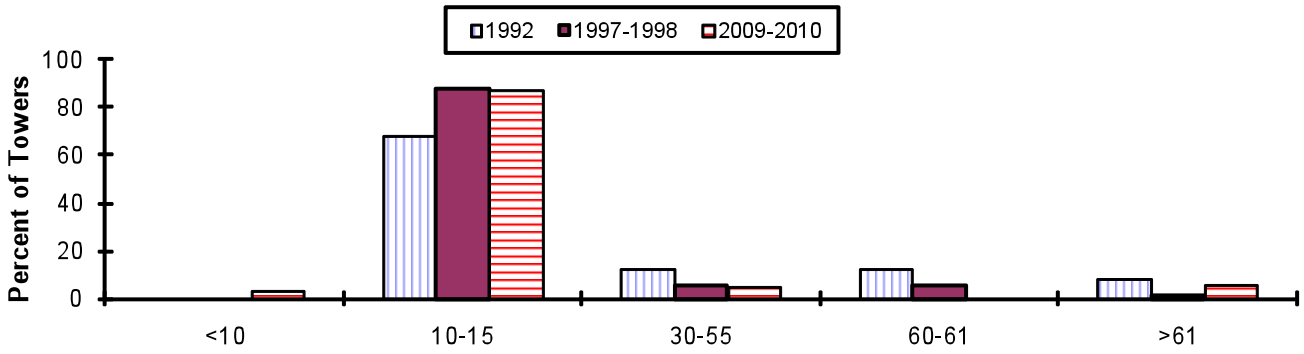
Meteorological Tower Heights

The survey includes the specific elevations at which data are collected.

Primary Towers--The primary meteorological tower height is dictated by the height of potential emission points and the need to know the dispersion characteristics of the lower portion of the atmosphere containing any effluent. As can be seen on the following graph, the most common tower height is in the 61-70 meter range, with a significant portion in the 91-100 meter range.

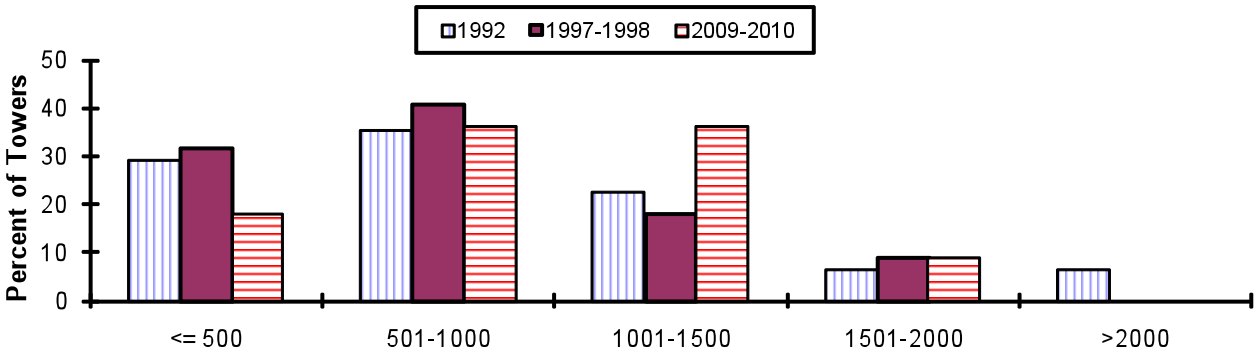


Other Towers--The heights of other meteorological towers are dictated by the specific functions those towers fulfill. While some of these towers are 30 or more meters tall, most towers are 10-15 meters tall.

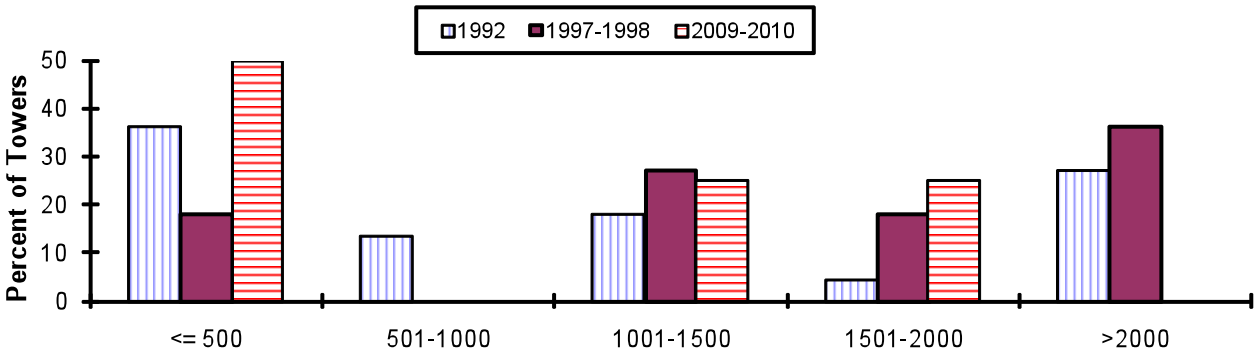


Meteorological Tower Location
(Power Plants Only)

Primary Tower--The distance of the primary tower from the emission source is important. A tower that is too close may be influenced by the source, while a tower that is too far away may not be representative of conditions at the source. This distance criterion applies only to the power plant sites because multiple sources exist at DOE facilities. The most common distance is in the 501-1000 meter range.

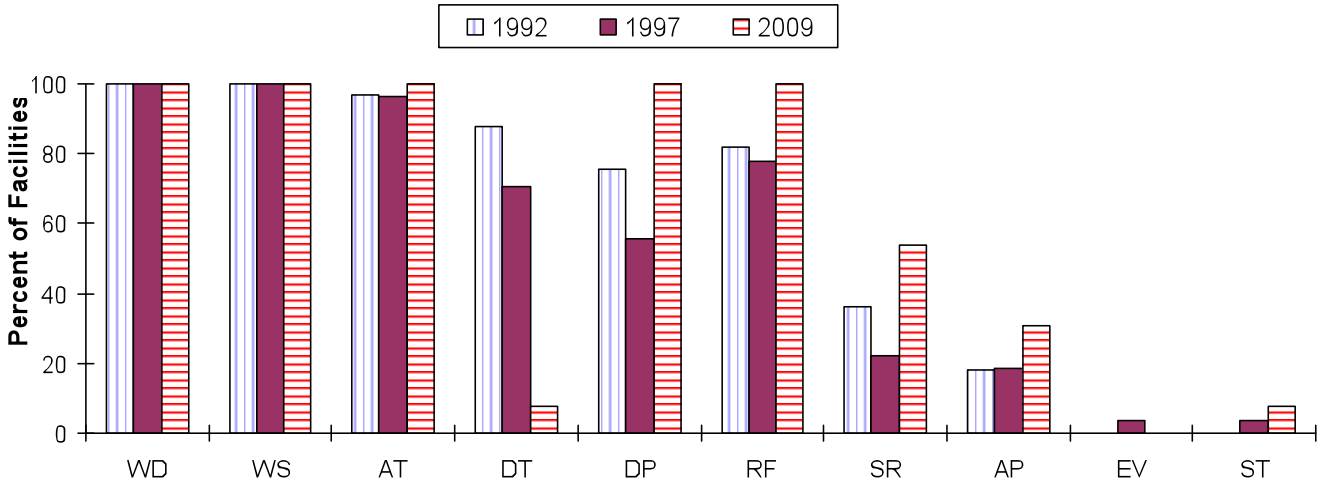


Other Towers--Most other meteorological towers are more than 1000 meters from the nearest unit. Again, the distance information does not apply to DOE facilities.



Variables Monitored

All facilities measure wind direction and wind speed. Most of the facilities also collect air temperature, delta-T (temperature difference), dewpoint and rainfall/precipitation. A few facilities collect solar radiation, atmospheric pressure, evaporation, and soil temperature.



WD – Wind Direction
WS – Wind Speed
AT - Air Temperature
DT - Delta-T
DP - Dewpoint
RF - Rainfall (Precipitation)
SR - Solar Radiation
AP - Atmospheric Pressure
EV - Evaporation
ST - Soil Temperature

Due to the diversity of release points, plant designs, and dispersion characteristics of interest; there is wide variability in the elevations at which data are collected. While 10-meters is a common level in nearly all cases, other sampling is performed at many different elevations (over 100 meters at some locations).

Meteorological Instrumentation

Meteorological sensors are available from a large number of vendors. Many of these vendors do not appear during the entire period, but this can be very misleading. Due to mergers, acquisitions, and other business actions, companies have often obtained existing product lines and continue to provide technical support.

Wind Direction/Speed

Vendor	1992	1997	2009
Belfort	X	X	
Climatronics	**X**	**X**	**X**
Climet		X	
Met One		X	X
Meteorology Research Inc.	X	X	
Qualimetrics		X	
R M Young	**X**	**X**	**X**
Teledyne Geotech	X	X	
Vaisala			X

Temperature/Delta-T

Vendor	1992	1997	2009
Campbell		X	
Climatronics	**X**	**X**	**X**
Climet		X	
EG&G	X		
Met One		X	X
Meteorology Research Inc.	X	X	
Qualimetrics		X	
R M Young	X		
RdF Corporation		X	
Rosemount	**X**	**X**	**X**
Teledyne Geotech	X	X	
Thermocouple			X
Vaisala			X
Weed	**X**	**X**	**X**

Dewpoint/Humidity

Vendor	1992	1997	2009
Campbell		X	
Climatronics	**X**	**X**	**X**
EG&G	**X**	**X**	**X**
Foxboro	X	X	
General Eastern	X	X	
Honeywell	X		
Met One		X	X
Meteorology Research Inc.	X	X	
Protimeter		X	
Rototronics			X
Technical Services		X	
Teledyne Geotech	X	X	
Vaisala			X

Precipitation

Vendor	1992	1997	2009
Belfort	X	X	
Climatronics	**X**	**X**	**X**
Climet		X	
Friez		X	X
Met One		X	X
Meteorology Research Inc.	X	X	
Qualimetrics		X	
Sutron			X
Teledyne Geotech	**X**	**X**	**X**
Texas Electronics	X		
Weather Measure	X		
Weathertronics	X		
Belfort	X	X	
Climatronics	**X**	**X**	**X**

Solar Radiation

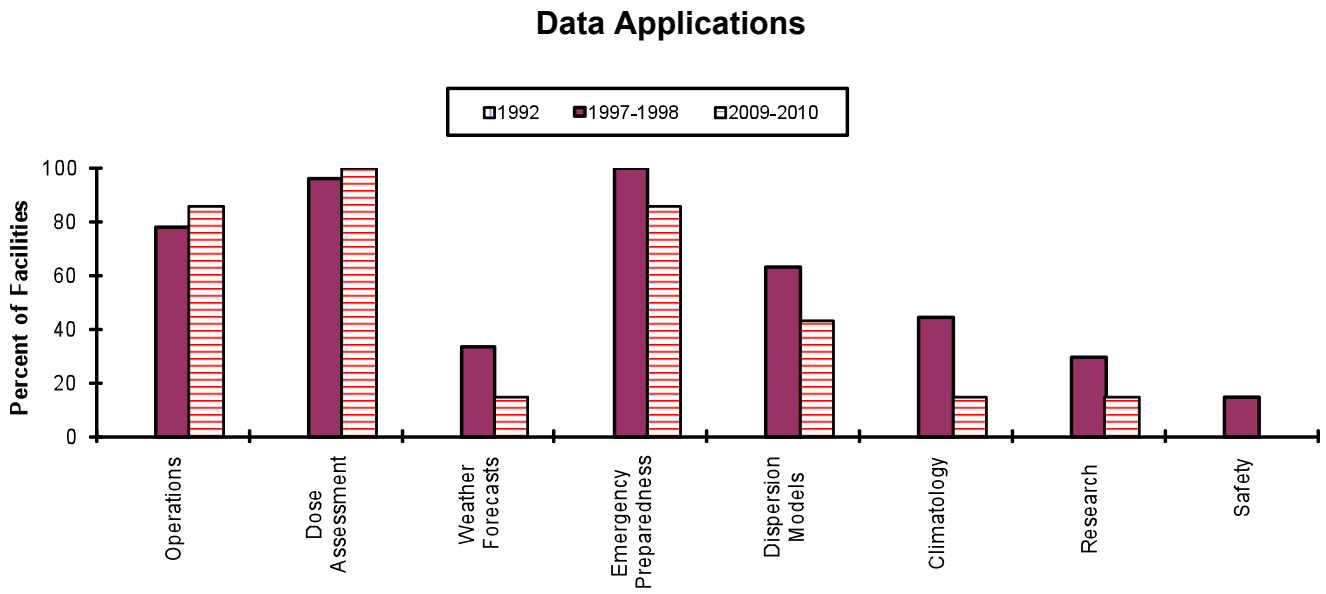
Vendor	1992	1997	2009
Eppley	**X**	**X**	**X**
LICOR			X
Teledyne Geotech	X		

Atmospheric Pressure

Vendor	1992	1997	2009
Climatronics	X		X
Climet	X	X	
ESC			X
Met One		X	
Setra		X	X
Teledyne Geotech	X		
Vaisala			X
Yellow Springs	X		

Data Applications

The following graph shows the types of applications that use the meteorological data.



Other Topics

The surveys also included questions about several other topics. The specific information is included in the companion spreadsheet files and summarized below.

- Recording and Auxiliary Equipment

  One of the biggest changes between 1992 and 2009 was in recorders and auxiliary equipment. This is primarily due to the major improvements in computer and communications technology between the periods.

  In 1992, analog (i.e., strip chart) recorders were predominately used to collect the detailed traces that described the short-term data characteristics. By 2009, advances in computer technology permit large amounts of individual instantaneous samples to be collected, stored, and processed (both to summarize the overall sampling period, but to also permit examination of short-term features).

  Data communications in 1992 were mostly analog telephone connections, either by direct line or through modems. In 2009, much of the data was transmitted over internet-based computer networks.

- Off-Site Data Sources

  Off-Site data sources are specifically used for supplemental or backup data and not just for general weather information. By far the most common is data from surface weather stations (NWS, FAA, etc.). However, other sources of data are also used.

- Maintenance and Calibration

  Maintenance and calibration of a meteorological monitoring system is critical to obtaining good data suitable for the applications at the particular site and that can be compared with data from other locations.

  Maintenance and calibration services are obtained from several different sources. Maintenance support is most common from plant staffs, but both off-site staffs and contractors provide significant levels of support. For calibration services, in-house staff is more common than vendor and contractor support combined.

- Data Processing and Archiving

  Once the meteorological data are collected, a data processing and archiving process confirms the adequacy of the data and archives the data for future access.

  Data reviews generally consist of software screening with meteorologist/technician reviews. For most facilities that use screening software to perform data validation, the software was custom-developed, but there are a few cases where commercially available software is used.

  While a copy of the raw data as collected should be retained, most facilities perform some adjustments to create the final data set. Data adjustments are generally made based on calibration results, to recover missing data from data recorders, and discard questionable data. A couple of facilities also insert off-site data to replace missing data.

FUTURE OF THE SURVEY

The Meteorological Monitoring System Survey was one of the original projects of the newly organized NUMUG in 1992. At the time, nuclear utilities and facility operators had developed and operated meteorological monitoring programs using a wide variety of equipment from numerous vendors. This diversity resulted from uncertainty in how to comply with regulatory requirements and produced potential inconsistency in the resulting data bases. NUMUG recognized that it was necessary to establish a meteorological monitoring system data base that could be used to develop updated industry standards.

The first survey established the "state of the industry" for meteorological monitoring. The second survey updated the first survey and asked some additional questions. Information from both of these surveys was subsequently considered in the development of an industry standard, ANS-3.11, "Determining Meteorological Information at Nuclear Facilities," and eventually NRC Regulatory Guide 1.23 (revision 1), "Meteorological Monitoring Programs for Nuclear Power Plants".

By 2009, a new updated survey was necessary because facilities had made further changes, DMCC wanted to provide a more representative picture of DOE meteorological monitoring activities, and there have been numerous changes in regulatory and other guidance. The third survey did identify changes reflecting advances in technology, but more importantly it showed that the "industry" was applying the standards that had been developed.

Is there another survey in the future?

> Conducting a full-scale survey is a major task for both the survey sponsor and the responding participants. Because of this, the response rate was never as high as desired (39% in the first survey and 32% in the second). To try to improve the response rate, the third survey was conducted as a series of mini-surveys (to stretch out the effort over a longer period), rather than the intense short-term effort required for a single comprehensive spot survey. Unfortunately the resulting 31% response rate was not an improvement.
>
> In addition, methods for obtaining information have improved. In 1992 and 1995, "snail" mail, telephone, and occasionally E-mail were the only practical ways to collect information. The surveys were large general-purpose efforts that tried to anticipate most likely questions. Users had to examine (and interpret) the survey documents to obtain answers about meteorological monitoring.
>
> Now E-mail, list servers, and web access enable users to get specific answers, often within hours. In this environment, even recent survey information becomes outdated quickly. It is no longer practical to expend the time and effort for a large general purpose survey.