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Derivative Classifier

COMPARISON OF SAVANNAH RIVER SITE'S METEOROLOGICAL DATABASES(U)

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Executive Summary.

A five-year meteorological database from the 61-meter, H-Area tower for the period 1987-91 was compared to an earlier database for the period 1982-86. The amount of invalid data for the newer 87-91 database was one third that for the earlier database. The data recovery percentage for the last four years of the 87-91 database was well above 90%. As described in the background sections, considerable effort was necessary to fill in for missing data periods for the newer database for the H-Area tower. Therefore, additional databases that have been prepared for the remaining SRS meteorological towers have had missing and erroneous data flagged, but not replaced. The F-Area tower's database was used for cross-comparison purposes because of its proximity to H Area.

Statistical tests were used to compare the frequency of occurrence and the mean wind speeds for the 82-86 and 87-91 databases. These tests are extremely sensitive because of the large number (~35,000-45,000) of hourly observations in the data sets. The tests show statistically significant differences in the frequency of occurrence of winds for the H-Area tower for all seven Pasquill stability classes, two of sixteen wind directions sectors (N and S), and four of six wind speed categories. The mean wind speeds between the two time periods compared more favorably, with only G stability category showing a statistically significant difference.

The differences in frequency of occurrence for stability classes may be caused by climatic changes, such as a 0.6°C temperature increase between 1982 and 1991, the period during which data was collected. The differences in the north wind sector were probably due to a coding fault and the instrument maker's design for the wind direction instruments. The differences found for the south wind sector

and all wind speed classes are probably either due to natural climatic variation, statistical variability, or differences in the data screening methods used for the two time periods. The fact that the mean wind speeds are significantly different for the G stability class may be due to the use of different data screening methods for the two time periods.

A basis was provided for future comparisons by examining wind speed power spectra and by stratifying the data by season and time of day. The wind speed power spectra showed expected yearly, 3-5 day, 24 and 12 hour peaks. Peaks occurring at periods of 8 hours and 32-26 days have not as yet been explained. The stratification by season showed a trimodal spring pattern with dominant winds from the S and SSE. During summer, winds from the N become very infrequent and the S to W wind sectors are dominant. A dramatic shift occurs in the autumn to winds from the NE and ENE. In the winter there is a very narrow peak of winds from the NE and a broad quadrant of winds from the S-WNW with a local maxima of winds from the W. Winds from the N and NNW are about equally frequent for all seasons except summer.

The evening and midnight patterns during the spring and summer are very similar, all showing minima out of the N quadrant and maxima out of the S quadrant. Spring and summer mornings and middays resemble one another with maxima out of the WSW and NE or ENE. Pre-dawn and morning periods in the autumn are similar with local maxima from the NE. Spring and summer afternoon patterns are similar with maxima in the S to W quadrant. During spring and summer the pre-dawn periods have winds which are fairly uniformly distributed with minima from the WNW to N sectors.

The primary purpose of this report is to compare the H-Tower databases for 82-86 and 87-91. Statistical methods enable the use of probability statements to be made concerning the hypothesis of no differences between the distributions of the two time periods, assuming each database is a random sample from its respective distribution. This assumption is required for the statistical tests to be valid. A number of statistical comparisons can be made between the two data sets, even though the 82-86 database exists only as distributions of frequency and mean speed.

Background

In early 1992 the Environmental Technology Section of the Savannah River Technology Center (SRTC) completed a quality-assured five-year meteorological database for the 61-meter, H-Area tower for the period 1987-91 (Parker, et al., 1992). The database was created for the New Production Reactor's (NPR) safety and environmental studies. Several onsite and offsite groups have requested similar data sets since the NPR database was created. The Parker, et al. (1992) report, provides descriptions of the data collection, processing, and validation used in producing the database. The Savannah River Site's (SRS) 87-91 H-Area database is unique since there are no missing data in the five year period. The data set includes a total of 43,824 hours of data for the five-year time period (including one leap year). Each data entry contains wind speed, wind direction, and lateral turbulence intensity. The data entries for the years 1989-91 contain temperatures and dew points as well.

One procedure used to quality assure the 87-91 H-Tower database involved plotting a time series of fifteen-minute records by tower for one-week periods. These one-week plots, showing all eight of SRS's meteorological towers simultaneously, allowed comparative checks to be made of the H-Area tower both spatially and temporally. Malfunctioning sensors and missing data could be readily distinguished from valid data and time periods noted. Invalid data were also identified by inspection of log books and records which identified calibration periods, maintenance activities, and other downtimes. In addition, during the initial, real-time computer acquisition of the data, software algorithms are used to check data ranges and to test the consistency of data entries. Additional data consistency checks were also used in the software which prepared the 87-91 database.

Time periods were flagged when the H-Area data did not pass the visual or computer quality assurance tests, or had missing data blocks. If the length of the flagged time interval was 1-4 hours (1.1% of the total), the data was filled by linear interpolation. If the time period was from 5-13 hours (0.4% of the total), data was either filled from a nearby tower's records, or by interpolating and accounting for the diurnal cycle. If the length of the flagged time interval was from 13 hours to several days (6.8% of the total), the data was

filled from nearby towers, backup data collected at the site (called SUM-X data), Plant Vogtle's meteorological tower, or from National Weather Service observations. The result of these efforts was a high quality database with no missing observations. A total of only 8.3% of the data had to be substituted in these ways for the H-Area tower 87-91 database. The amount of invalid data was one third that for an earlier five year database (Laurinat, 1987).

Laurinat (1987) produced a quality assured five-year database covering the period 1982-86 for each of the SRS Area towers. The 82-86 databases differ from the 87-91 H-Tower database in that the quality assurance tests were applied only during computer processing using statistical screening algorithms. Visual data inspection techniques were not used. Time periods with missing data were not filled, consequently, the 1982-86 data records contain missing periods whenever the data failed the computer screening algorithms or the tower was out of service for maintenance, damaged by lightning, etc.

The 82-86 computer screening algorithms rejected data for failure to pass a statistical test known as the Dixon ratio test (Dixon, 1957), and for large differences between lateral and longitudinal turbulence intensities. The Dixon ratio test is used to detect outliers based on statistical similarities of the towers' distribution (or spatial "agreement") of wind speed, direction, or turbulence intensity during a given hour's time). Data was rejected from both 82-86 and 87-91 data sets whenever voltages exceeded acceptable ranges or when more than 90% of the possible data within a fifteen-minute period was missing. The amount of data rejected due to application of these tests in the 82-86 database amounted to about 21% for each of the Area towers. Missing or unreadable tape archive files accounted for an additional 2% of data being incomplete. The quality assurance procedures used to produce the data set resulted in about 23% missing data for each tower. However, at the time this database was generated, there was no requirement for percentage of data recoverability. The 87-91 database, by contrast, was required to meet the DOE's current guidance of 90% annual data recovery for meteorological data. New procedures and meteorological instruments were installed in 1987 to improve the quality and to capture a larger percentage of meteorological data.

The new procedures and instruments resulted in a significant gain in the percentage of valid data captured in annual data sets. This can be substantiated by comparing the data recovery rate percentages for the 1987 wind data with those

from later years in the table below (extracted from Parker, et al., 1992). The large increase between 1987 and succeeding years in Table 1 shows the successful nature of the quality improvement programs.

Table 1. Data recovery percentages for each year of the period 1987-91 for the H-Area meteorological tower.

Wind Data (Yr.)	1987	1988	1989	1990	1991	5-Yr. Ave.
H-Area (%)	78.15	96.21	92.84	96.58	94.55	91.71

The 82-86 databases were converted to frequency distributions shortly after their creation for use in dosimetry models. The frequency distributions consist of frequencies of occurrences within each of six speed ranges (0-2, 2-4, 4-6, 6-8, 8-12, and 12-50 m/sec), seven Pasquill-Gifford stability categories (A-G), and sixteen wind direction sectors (1-N — 16-NNW). The data sets also contain mean wind speeds (and mean wind speeds by inverse averaging) for the same speed ranges, Pasquill-Gifford categories, and direction sectors. (Pasquill-Gifford stability categories were determined from the measured lateral turbulence intensity according to the U. S. Nuclear Regulatory Commission Guide 1.23.) The 87-91 H-Tower database exists both as a frequency distribution (as for the 82-86 database) and as a permanent on-line data set, containing the original hourly observations.

Additional databases were created later in 1992 for the remaining Area towers A, C, D, F, K, L, and P for the 87-91 time period except that missing data was not filled. The applications of these databases did not require that the missing time periods be filled, and in some instances this is not desired. In addition, considerable effort is needed to provide data for a tower when the data records are incomplete. The 87-91 data sets for the remaining towers contain hourly-averaged data and frequency distributions. These databases exist primarily for special studies or research where having a completely filled database for the entire five years is unimportant. One of these 87-91 data sets for the F-Area tower was used extensively in this report for cross comparison purposes in some of the statistical studies described later. The earlier 82-86 database for the F-Area tower by Laurinat was also used for cross comparison purposes.

Statistical Comparisons Between the 82-86 and 87-91 Databases

The statistical comparisons are described in this section but more mathematical details are included in Appendix A. The (null) hypothesis being tested is: *There is no difference between the distributions for the two time periods.* In order to test this hypothesis, the frequency of occurrence and mean wind speed distributions by sector, wind speed category, and stability for both periods were compared. A primary question to be answered — are the proportional differences *that exist* between the number of observations in each data set within the range of expected random statistical variations? And similarly — are the mean wind speed differences within the range of expected random statistical variations?

A test was applied to the differences between the observed and expected number of observations for the sixteen sectors, seven stability categories, and six wind speed categories. The squared difference between the number observed and the number expected for both data sets can be used to determine if the differences are statistically significant. If this squared difference is divided by the expected number of observations, the result is the adjusted residual squared, or the cell contribution to the chi square. The sum of these contributions is assumed to form a chi-square distribution with degrees of freedom equal to one less than the number of classes being compared.

The probability of getting a larger chi square than the one observed (assuming there is no difference

between the two time periods) and the value of the chi square statistic are shown in Table 2 for F-Area tower (used for comparison) and H-Area tower data by stability category, wind speed, and sector. The results in Table 2 show there are significant differences between time periods for both F and H Area towers, since the probability

of getting a larger chi square is less than 0.001 for stability, sector, and wind speed. If one took a large number of samples from a distribution with the same proportions in each category and randomly assigned them to the two time periods in the same proportions as observed, fewer than one sample in 1000 would produce a larger chi square.

Table 2. Differences between the frequency of occurrence of the 82-86 and 87-91 databases determined from the chi square test.

Tower	Stability		Sector		Wind Speed	
	χ^2	Prob> χ^2	χ^2	Prob> χ^2	χ^2	Prob> χ^2
F	219.148	<0.001*	93.277	<0.001*	459.032	<0.001*
H	852.280	<0.001*	98.455	<0.001*	463.789	<0.001*

*Statistically significant differences

The chi square statistic indicates there are differences between the data sets by stability, sector, and wind speed; but it is not able to indicate whether the differences are due to large differences in only one or two categories, or whether all categories have differences. It is important to understand that the chi-square statistic and hence whether there are statistically significant differences depends not only on the percentage differences but on the total number of observations being compared. As the total number of observations increases, smaller percentage differences will be statistically significant.

To determine *which categories* had significant differences between the old and new data sets, the contribution for each category was determined by dividing the adjusted residual by its standard deviation. This random variable is approximately normally distributed with mean 0 and variance 1. If the null hypothesis is true, then all category comparisons should be within acceptable limits with probability 0.95. The Bonferroni method (Miller, 1981) was used to determine the individual probabilities for acceptance in order that the simultaneous probability was 0.95. Appendix A describes this methodology. If the standardized adjusted residual is less than the comparison value given in Table 3 for stability, sector, and wind direction categories, then we accept the (null) hypothesis of no differences between time periods. Table 3 shows which categories have the biggest contributions to the over-all chi square. Figs. 1-6 show which categories have the biggest differences. Only stability categories B and G were not significantly different for the F-Area tower, however all stability categories showed a

statistically significant difference for the H-Area tower. For the 16 wind direction sectors, five of the sixteen were significantly different for F-Area tower and two (winds from N and S) for H-Area tower. Four out of six wind speed categories were different for both towers.

Figure 1 shows the percentage of observations in each of the sixteen wind direction sectors for the two time periods for the H-Area tower. One's visual perception may be that the differences are small enough to indicate that the two data sets come from the same distribution, even though the chi-square statistic indicates two statistically significant differences. Visual impression is not reliable in this case because of the large number of observations in each of the data sets (H-Area: 35,252 for 82-86 and 43,824 for 87-91; F-Area: 33,331 for 82-86 and 41,818 for 87-91). If there had been only 200 observations over the two time periods, the percentage differences and distributions observed in Fig. 1 would not result in a statistically significant chi-square, and visual impression would be vindicated. (The ordinates in Figures 1-12 are connected by a straight line rather than plotting separate points to enable the eye to gain an overall impression of the difference between the curves.)

Similar small but statistically significant differences in the percentage of observations for five of the sixteen wind direction sectors for F-Area tower are shown in the plot in Figure 2. Figures 3 and 4 show the percentage differences by stability categories for H-Area tower and F-Area tower, respectively. Figures 5 and 6 show the percentage differences by wind speed categories for H-Area and F-Area towers, respectively. Again the probabilities of accepting

Table 3. Differences between the frequency of occurrence of the 82-86 and 87-91 databases determined from the chi square test for individual contributions by stability category, sector, and speed category.

Stability Category	Results of the Adjusted Residuals F Area	Divided by the Standard Deviation H Area
A	5.536*	19.039*
B	1.879	10.043*
C	5.102*	6.960*
D	3.573*	17.377*
E	10.529*	10.811*
F	8.789*	10.407*
G	0.190	3.657*

Values greater than 2.69 indicate significant differences and are marked by an asterisk.

Sector	F Area	H Area
1 (N)	2.726	4.531*
2 (NNE)	3.670*	0.855
3 (NE)	2.996*	2.416
4 (ENE)	3.016*	0.476
5 (E)	4.921*	2.277
6 (ESE)	0.227	0.864
7 (SE)	0.578	0.682
8 (SSE)	3.635*	1.936
9 (S)	2.151	6.970*
10 (SSW)	1.509	0.107
11 (SW)	1.114	1.696
12 (WSW)	1.320	1.979
13 (W)	1.625	1.176
14 (WNW)	2.873	1.612
15 (NW)	0.712	2.302
16 (NNW)	1.275	1.725

Values greater than 2.955 indicate significant differences and are marked by an asterisk.

Wind Speed (m/sec)	F Area	H Area
0-2	19.298*	1.903
2-4	3.430*	16.076*
4-6	11.687*	8.284*
6-8	5.195*	15.160*
8-12	1.829	7.521*
12-50	2.204	2.004

Values greater than 2.638 indicate significant differences and are marked by an asterisk.

Table 4. Differences between the 82-86 and 87-91 databases for mean wind speed determined from the t-test for individual contributions by stability category, sector, and speed category.

Stability Category	F Area		H Area	
	t-Ratio	Prob > t	t-Ratio	Prob > t
A	0.6007	0.5490	-0.6016	0.5485
B	0.3497	0.7271	0.6394	0.5236
C	1.4246	0.1566	0.4276	0.6695
D	0.4850	0.6283	-1.510	0.1331
E	-0.202	0.8403	-0.136	0.8921
F	0.4205	0.6749	-1.277	0.2041
G	0.7254	0.4705	-3.219	0.0020*

Ratios with probabilities less than 0.00714 indicate significant differences.

Sector	F Area		H Area	
	t-Ratio	Prob > t	t-Ratio	Prob > t
1 (N)	0.3280	0.7443	-0.309	0.7584
2 (NNE)	-0.283	0.7784	0.4186	0.6771
3 (NE)	-0.819	0.4158	0.5460	0.5872
4 (ENE)	0.2034	0.8395	-0.164	0.8703
5 (E)	0.3219	0.7487	-0.025	0.9801
6 (ESE)	0.4134	0.6809	-0.594	0.5549
7 (SE)	0.3788	0.7063	-0.672	0.5044
8 (SSE)	0.3825	0.7035	-0.364	0.7172
9 (S)	1.2257	0.2269	-0.327	0.7451
10 (SSW)	0.1121	0.9111	-0.792	0.4313
11 (SW)	0.0458	0.9636	-0.245	0.8071
12 (WSW)	0.4941	0.6230	-0.809	0.4217
13 (W)	1.1427	0.2576	-0.903	0.3700
14 (WNW)	0.9194	0.3614	-0.474	0.6376
15 (NW)	0.2200	0.8267	-0.314	0.7551
16 (NNW)	0.3324	0.7409	-0.565	0.5745

Ratios with probabilities less than 0.003125 indicate significant differences.

the individual comparisons have been determined by the Bonferroni method, so that the simultaneous probability of accepting no difference across the seven stability categories, sixteen sectors, and six wind speed categories is 0.95 for each category (stability, sector, and wind speed). To determine whether the mean speed distributions are statistically different between the 82-86 and 87-91 data sets, the mean speeds were averaged within each stability, sector, and wind speed category for the two data sets, and compared using the two sample t-test. This test assumes the differences divided by the standard deviation of the difference is from a student's t-distribution. Tests for equality of variance were applied before computing the t-ratios. The results of the t-tests are given in Table 4. The table shows that differences between mean wind speeds are insignificant except for stability category G on the H-Area tower. The probability required to declare a significant difference has been determined so that all (within category) comparisons for stability, sector, and wind speed will be insignificant with 0.95 probability when

there are no true differences. Figs. 7-8 show the average wind speeds for F and H Area towers for the sixteen wind direction sectors, Figs 9-10 are average wind speeds for stability classes A-G, and Figs. 11-12 are average wind speeds for the six wind speed classes. There appears to be a statistically significant difference in the results for stability category G of Table 4 and Figs. 9-10. Fig. 9 shows the difference was 1.24 m/sec for stability category G on the H-Area tower (the largest observed difference between time periods for any of the stability categories or wind direction sectors). However, the largest difference between the two time periods for the F-Area tower was 1.36 m/sec in sector 9 (winds from S, Fig. 8) which was not statistically significant. The reason for this apparent inconsistency is that stability category G for the H-Tower had one of the smallest estimates of variability for time period, stability, or sector for either tower. Small variability within time period, stability, or sector may cause statistically significant differences even when these differences have no practical significance.

Sources of Differences Between the 1982-86 and the 1987-91 Databases

(a) Climatic variation

Meteorological data could be expected to vary between two contiguous five year periods due to worldwide climatic variations which are caused by increased concentrations of optically active constituents in the atmosphere. The time scale of these variations is generally quite long, but variations can occur on shorter time scales. Measured changes in the mean temperature for the Southeast region of the U.S. show a mean temperature increase of about 0.6° C from 1982 to 1991 (Michaels, et al. 1991). A temperature change of this amount might be large enough to cause changes in the wind frequency distribution and/or mean values.

It is worth noting that the statistically significant differences in stability categories in Table 3 might be a result of the mean temperature increase. Fig. 3 shows a shift between 82-86 and 87-91 from the more stable categories E-G to more unstable categories A-C, which could be attributed to the temperature increase. This shift in stability categories is also found in F-Area tower data shown in Fig. 4. Exhibit 4 was used to sum the absolute values of the percentage differences over stability categories A-C and E-G for the H-Area tower during 87-91. The sum of

the absolute values was 13.2%, a considerable amount. The amount of this shift from Exhibit 1 for the F-Area tower, summed similarly over the stability categories, is equal to 7.92%.

A number of books and papers have been written on the connection between climatic variations and sunspots, solar flares, and other solar activity. Some of the relationships have been shown to be statistically significant, but often the effect is obscured by other equally important changes in atmospheric constituents. Sunspots occur over a period of 10-12 years and the 82-86 and 87-91 databases are about half the required period, so sunspot effects on the database, although slight, might also appear in the data.

Climatic variations can also be caused by significant atmospheric forcing functions such as volcanic activity, El Niño, deforestation, etc.; these phenomenon are well documented. Random statistical fluctuations can also occur in any turbulent fluid such as the atmosphere. Several causes for statistical differences between the two databases exist if we acknowledge these mechanisms for climatic variations.

(b) Instrument and coding faults

D. M. Hamby (1992) used the 82-86 and 87-91 H-Area data sets in dosimetry codes to determine the relative two-hour and annual average χ/Q (concentrations divided by source strength) from both data sets. One of Hamby's plots showed a noticeable dip for one wind direction sector in an otherwise smooth curve. Examining the curve closely showed the 87-91 data set had a relative minimum in χ/Q for north winds.

An extensive investigation led to two possible causes for the north wind minimum concentrations which have been identified since Hamby's report: (1) the algebraic sign in an "IF" statement of an archiving module of VAX-8550 software was found to have a positive value where a negative value was required; (2) there is a bivariate potentiometer gap of about 3-5° width which occurs at (north) with bivanes used on the

Area towers prior to the end of 1987; there is also a bivariate resolver gap of about one degree width which occurs at 359.5°-0.5° (north) with improved wind direction instrumentation installed on the Area towers at the end of 1987.

The algebraic sign fault excluded wind directions within the range 0 to +5° for an interval of time after a software maintenance modification was implemented. The code fault was carefully traced using computer archive tapes and was found to have originated on February 24, 1989. The fault was corrected on July 29, 1992. Data for 34 of 60 months of the 87-91 database were affected. The percentage of missing data caused by this factor can be estimated by assuming the wind directions are uniformly distributed. A five degree exclusion zone would have caused the deletion of 1.11% of the azimuths in the north sector in the

1987-91 database for the H-Area tower. It should be noted that the effect of the excluded wind directions would actually be spread somewhat to adjoining sectors because of turbulent fluctuations during a fifteen minute period.

The north wind direction was one of two sectors which showed statistically significant differences in frequency of occurrence and is flagged in Table 3. The dip in Hamby's χ/Q curve is caused by the wind speeds being biased to lower values and/or the percentage frequency of occurrence being lower for the 87-91 data. Both effects are present and can be verified in the tables and figures. One can determine from Table 4 and the software used that the negative t-ratio means the mean speeds for 4-6 m/sec category are biased toward lower values in the 87-91 H-Area database. Fig. 1 shows the percentage frequency of occurrence for North winds is lower for the new database for H-Area.

The bivanes used prior to the end of 1987 had two-potentiometer systems designed to correct the problem of bivanes with a single potentiometer. The two-potentiometer system always has a wiper in contact with potentiometer windings and thus generates a valid signal even when one of the potentiometer wipers is in the gap. In spite of the existence of the two potentiometer system, it was apparently not used, because of complexity of the software that would have been needed. Rather, the system was operated with a single potentiometer. This caused a gap of 3-5° in the wind directions about north prior to the end of 1987. Improved wind instruments were installed on the Area towers at the end of 1987. (Resolvers replaced potentiometers as the mechanical-electronic

component translating mechanical displacement into electrical signals.) Replacement of the older bivanes was also highly desirable since it led to more accurate and reliable wind directions over the compass range 359.5°-0.5.

The effect of the potentiometer gap operating over a 60 month period for the 1982-86 database can be estimated by assuming the wind directions are uniformly distributed. A 3-5° gap would have caused 0.83-1.39% of the azimuth data around north to be missing. For the 12 months in 1987 included in the new database (1987-91), a total of 0.17-0.28% of the data would have been affected.

The effect of the resolver gap can be estimated similarly. If the resolver gap is one degree wide and the wind directions are distributed uniformly, then about 0.22% of the total azimuths would have been affected in a 48 month period. Wind tunnel experiments have shown the effect on the voltage signal caused by the resolver gap is a spurious voltage, i.e., the wind is indicated as coming from an incorrect sector. This means that a secondary effect of the resolver gap is excessively large standard deviations of azimuth angle. This would produce a slightly larger than expected frequency of A-D stability categories when winds blow from the north sector. The percentage of data affected is estimated to be the same as the percentage of azimuths affected (0.22%).

The potentiometer and resolver gap effects are not independent of the software "sign" omission, because of overlapping azimuth ranges. Consequently, subjective estimations of the exact amount of data affected in the 1987-91 database have a high uncertainty.

(c) Sources used for filling missing data

Data were filled in for the H-Area tower 87-91 database as described earlier. Linear interpolation, data from backup computers at the towers, and data from nearby Area towers were the preferred choices for fill-in data. Data from the Augusta National Weather Service (NWS) tower and Plant Vogtle were also used when absolutely necessary. The NWS service tower was needed for only 0.54% of 1988's wind data or 0.11% of the total five years. The Plant Vogtle tower instruments are mounted at 60 meters, about the same height as the 61-meter Area tower instruments. Only

0.92% of the wind data for the 87-91 H-Area tower were substituted from the Plant Vogtle tower.

The wind instruments used by Plant Vogtle were less sensitive than those used on SRS's Area towers. The Pasquill-Gifford stability categories determined from these instruments utilized fifteen-minute averages of turbulence intensity during the one-hour period rather than true one-hour averages which include the effect of wind meandering (as is done at the SRS).

Providing a Basis for Future Comparisons

(a) Spectra for the 86-91 Database

Spectral analysis is used to determine periodicities in statistical data. Boundary layer wind spectra for short periods (0.1 seconds to a few hours) often show broad maxima corresponding to thermal convection and mechanical turbulence and a broad minimum corresponding to a mesoscale spectral gap. These spectral properties are usually presented in "equal-area" plots in which the abscissa is the logarithm of frequency and the ordinate is frequency multiplied by spectral density. Equal-area plots are used because the total energy is the same between frequencies bounding equal areas. Unfortunately, equal-area presentations obscure periodicities and were not used in the plots of spectra for the five-year database.

The 87-91 five year database presents an opportunity to determine spectral density for periods between two hours (the Nyquist frequency) and five years (the range of the data). It was decided to present the wind speed spectra in linear plots (spectral density vs. period) using the 87-91 database to determine where periodicities occur.

Spectral densities were determined from the hourly-averaged wind speeds at H-Area. The spectral density estimates are shown in Figs. 13a-d where the power (m^2/sec^2) per unit frequency (cycles/hr) are plotted against the period (hrs/cycle). The longest period possible to represent on the plot corresponds to the length of record (five years). The major peak in Fig. 13a corresponds to (8760 hrs) one year — the annual cycle. The annual peak is separated from several smaller spectral maxima near the origin by a relative minimum, or spectral gap at 1300 to 1400 hrs (about 2 months). The smaller spectral maxima all occur at periods less than 1000 hrs (one month or less) and are shown in more detail in Figs. 13b-d. The peaks at 760, 590, and 300 hrs correspond to 31.6, 24.5, and 12.5 days, respectively. These long periodicities may be related to shifts in the Rossby wave patterns in the upper atmosphere. The peaks at 140, 100, and 70 hrs probably correspond to the period of extratropical cyclones (about 3-6 days).

The peaks at 24 and 12 hours are caused by atmospheric tides which follow the sun as the earth turns. The peak at 8 hrs may correspond to the period of convective activity in the boundary

layer. There is no way of ascribing absolute causality using spectral methods, however the most reasonable physical mechanism is being proposed for the peaks.

Statistical significance of spectra are measured by determining 95% confidence limits. These spectra were smoothed by applying a 21 point triangular smoothing to the raw spectral density estimates from the SAS® Proc Spectra procedure. The 21 point triangular smoothing results in a confidence limit multiplier in the range 0.59 to 2.4 for spectral peaks. There are 21 degrees of freedom corresponding to the confidence interval (Jenkins and Watts, 1968). Another rule of thumb for determining if a spectral peak is significant is if it contains at least three computed points which deviate from the noise and has a maximum two or three times greater than the surrounding noise level (Stuart, et al., 1971). All peaks described earlier fit these criteria.

In order to increase confidence that the spectral peaks discussed above are real, a similar spectral analysis was performed on one of the fifteen minute data records from H-Area tower which were used to construct the one-hour averages. This fifteen minute data set contained substitution data from other towers on plant but lacked the one-hour interpolations and substitutions from Plant Vogtle and the National Weather Service that were discussed earlier. (The fact that this data set was not a continuous five year record was adjusted by removing time periods corresponding to missing data and concatenating the remaining time periods.) This process resulted in a data set that was 955 hours (40 days) short of the full five years. The fact that the data set contains missing periods and the resulting time series are joined together in a discontinuous manner means that the period corresponding to a given peak will be shorter than expected. However, if the peaks are real, they should be observed in the same relative position as the original spectrum.

The spectral analysis of the fifteen minute data set is shown in Figs. 14a-d. These data substantiate the peaks at 8, 12, and 24 hours, but do not show peaks at 6, 4.8 and 300 hours. Table 5 summarizes the peaks found in both data sets.

Table 5. Periods of the major spectral density peaks measured in days and hours for the H-Area tower hourly and fifteen-minute data sets (1987-91).

	365	32	26	12.5	5.8	4.2	3	1	0.5	0.33	0.25	0.2	days
Hourly	8760	760	590	300	140	100	70	24	12	8	6	4.8	hours
15-min	8760	760	590	.	140	100	70	24	12	8	.	.	hours

The third row of Table 5 shows the peaks that are not present in the fifteen-minute data set as missing values (.). The fact that three of the peaks are not present in the fifteen-minute data sets is evidence that the peaks may not be real,

but are simply due to the inherent uncertainty of power spectrum estimation techniques. Another possibility is that the peaks which disappear are caused by the substitution techniques for flagged and missing data.

(b) Stratification by Season and Time of Day

An interesting basis for establishing future comparisons of five-year databases can be obtained by stratifying the data by season and time of day. Figures 15a-b show the H-Area tower 82-86 & 87-91 hourly averaged wind data as percentage of occurrence for the sixteen wind sectors presented in bar charts. Similar information was produced for the Laurinat's 82-86 database except wind "roses" were used. The bar charts were used here instead of wind roses since they provide an easier method for the eye to

compare quantitatively the amounts in various stability categories. Fig. 15a could be described as a trimodal distribution with maxima at the NE, WSW, and S sectors. The 82-86 database in Fig. 15b is bimodal and lacks the S sector maximum. The plots for the F-Area tower (Figs. 15c-d) both show the trimodal distribution but the 82-86 South sector maximum is relatively small. The H-Area tower sectors with the greatest difference between 82-86 and 87-91 are the S and N sectors.

When the H-Area tower data is stratified by season and time-of-day some interesting patterns begin to emerge. The following definitions were applied.

Spring:	March, April, and May
Summer:	June, July, and August
Autumn:	September, October, and November
Winter:	December, January, and February
Morning:	Between sunrise and true solar noon minus 1/6 of the daylight hours
Midday:	Time period between end of morning and beginning of afternoon
Afternoon:	Between true solar noon and sunset plus 1/6 of the daylight hours
Evening:	Between sunset and true solar midnight minus 1/6 of the nighttime hours
Midnight:	Time period between end of evening and beginning of pre-dawn
Pre-dawn:	Between true solar midnight and sunrise plus 1/6 of the nighttime hours

The spring pattern for the H-Area tower 1987-91 database in Fig. 16a shows the trimodal distribution but the peak for winds from S and SSE is very sharp and dominant. Fig. 16b shows the northerly winds during summer becoming very infrequent and the S to W wind sectors dominate. Fig. 16c shows a dramatic shift in the autumn to winds from the NE and ENE. In the winter Fig. 16d shows there is a very narrow peak of winds from the NE and a broad quadrant of winds from the S-WNW with a local maxima of winds from the west. Winds from the north and north-northwest are about equally frequent for all seasons except summer.

patterns are very similar and all show (Figs. 17a-d) minima out of the north quadrant and maxima out of the south quadrant. Spring and summer mornings and middays resemble one another with maxima out of the WSW and NE or ENE (Figs. 18a-d). Autumn pre-dawn and mornings are similar with local maxima from the NE (Figs. 19a-b). Spring and summer afternoons have maxima in the S to W quadrant (Figs 20a-b). Spring and summer pre-dawns are fairly uniformly distributed with minima from the WNW to N sectors (Figs. 21a-b). The remaining plots have varying degrees of similarity and are included for completeness (autumn—Figs 22a-d, and winter—23a-f).

Spring and summer evening and midnight

Conclusions

New procedures and meteorological instruments resulted in a significant gain in the percentage of valid data captured in annual data sets forming a basis for the 1987-91 database. The data recovery percentage for the last four years of the 87-91 database was well above 90%. The missing and bad data decreased by a factor of three from the 1982-86 database. This fact and the considerable work expended in filling in missing periods for the new database permitted detailed analyses that could not have been performed on the earlier database.

The chi-square statistic was used to compare the frequency of occurrence for two time periods for F-Area and H-Area towers. The chi-square statistic showed there were significant differences by stability, wind direction sector, and wind speed class. The chi-square statistic does not have the ability to show where the differences exist, so the standardized adjusted residual together with the Bonferroni method was used. These methods showed that only two of sixteen wind direction sectors (north and south) had statistical differences between the 82-86 and 87-91 data sets for the H-Area tower. Reasons were found to explain the north sector difference but the south sector remains unexplained. The differences in the north wind sector were probably due to a combination of a coding fault and the instrument maker's design for the wind direction instruments. The F-Area tower showed five sectors with differences but these may reflect a combination of natural meteorological variability and differences in the methods used to create the databases.

Tests on the difference between the two data sets using the standardized adjusted residual together with the Bonferroni method showed that a majority of stability categories and wind speed classes were different for both F-Area and H-Area towers. The reasons for the differences in stability categories may be related to an increase of 0.6° C in temperature over the ten year period. Climatic variations resulting from volcanic activity, El Niño, and deforestation could cause differences both in stability categories and speed classes between the data sets.

The majority of mean wind speed differences for both H-Area and F-Area towers when examined by sector, and stability category showed no

differences between the new and old data sets. Only the G stability category for H-Area tower indicated a significant difference out of the seven stability categories and sixteen direction sectors. This difference was only 1.24 m/sec for the G stability class. This gives a measure of confidence that dosimetry calculations will not change significantly when using the 87-91 data set.

The fact that the two data sets have different mean wind speed distributions for the G stability class may be due to the fact that the 82-86 database was created using an outlier screening test. This could have eliminated valid data during frontal passages, thunderstorms, periods of light winds, etc., when there were valid reasons to expect a given Area tower to show a different wind direction than the others. If these cases of screening out valid data was not uniformly distributed, then a bias could have been created in the mean wind speeds (or frequency of occurrence). It would seem reasonable to assume that application of the Dixon ratio test during a period of light winds (nighttime, stable conditions) probably resulted in more cases being rejected for the 82-86 database.

The statistical tests used to detect differences between the two data sets is quite sensitive because of the large number of observations available. A summary of the ability of statistical tests to determine differences is as follows:

- Large sample sizes provide the ability to detect small differences between categories.
- Small variability in mean wind speeds provides the ability to detect small differences between categories.
- Small sample sizes only provide the ability to detect large differences between categories.
- Large variability in mean wind speeds only provides the ability to detect large differences between categories.

Power spectra show expected peaks at periods of one year due to the earth's rotation about the sun, 3-6 days due to extratropical cyclones, 24 and 12 hours due to solar tides. The probable cause is not apparent for peaks occurring at periods of 32-26 days and 8 hours.

Bar charts were used to compare the distribution of stability categories within wind direction sectors. The frequency distribution by wind direction sector could be described as a trimodal distribution with maxima at the NE, WSW, and S sectors.

When the H-Area tower data is stratified by season and time-of-day some interesting patterns emerge. The spring pattern shows a trimodal distribution with dominant winds from the S and SSE. Northerly winds become very infrequent during summer and the south through west winds dominate. In the autumn a dramatic shift occurs to winds from the NE and ENE. In the winter there is a very narrow peak of winds from the NE and a broad quadrant of winds from the S to WNW with a local maxima from the west. Winds from the N and NNW are about equally frequent for all seasons except summer.

Spring and summer evening and midnight patterns are very similar and all show minima out of the north quadrant and maxima out of the south quadrant. Spring and summer mornings and middays resemble one another with maxima out of the WSW and NE or ENE. Autumn pre-dawn and mornings are similar with local maxima from the NE. Spring and summer afternoons are similar with maxima in the S to W quadrant. During spring and summer pre-dawn winds are fairly uniformly distributed with minima from the WNW to N sectors.

The new 87-91 H-Tower data set provides a good basis for future comparisons since the additional time and effort spent on quality assurance provides more confidence that new information determined by inference and by statistical methods is valid.

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Appendix A

Statistical Calculations

Statistical tests were performed to test the following hypothesis, termed the null hypothesis:

H_0 : There are no differences between the distributions in the old and new data sets.

Differences were determined in the number of observations for each of seven stability categories, 16 wind direction sectors, and six wind speed categories by comparing the number observed with the number expected using the chi-square distribution.

Definition of terms:

Let n_{ij} = number of actual observations for data set i ($i=1$ for the 87-91 data set and $i=2$ for the 82-86 data set) and class j , ($j=1$ to 7 for stability categories, $j=1$ to 6 for wind speed categories, and $j=1$ to 16 for wind direction sectors.)

$N_{i+} = \sum n_{ij}$ = total number observations for data set i summed over all classes ($j=1$ to 7 for stability categories, $j=1$ to 6 for wind speed categories, and $j=1$ to 16 for wind direction sectors.)

$N_{+j} = \sum n_{ij}$ = total number of observations in category j summed over both data sets.

$N = N_1 + N_2 = \sum N_{+j}$ = total number of observations in both data sets.

Under the null hypothesis, the same proportion in each category should come from each data set. Thus, if p_j is the proportion observed in category- j over both data sets, then the same proportion of each data set should also be in category- j or

$$p_j = N_{+j}/N.$$

The expected number of observations in each class is given by

$$F_{ij} = p_j * N_{i+} = N_{i+} * N_{+j}/N.$$

The squared difference between the observed and expected number divided by the expected number of observations is termed the adjusted residual squared. The adjusted residual squared is summed over all categories for both data sets.

$$r_{ij}^2 = (n_{ij} - F_{ij})^2 / F_{ij}, \text{ and}$$

$$\chi^2 = \sum \sum r_{ij}^2.$$

The χ^2 ratio is distributed as a chi square random variable with $(I-1)(J-1)$ degrees of freedom where $I = 2$ and $J = \text{no. of categories, 6, 7 or 16}$. Since there are only two data sets, the number of degrees of freedom is equal to the number of categories minus one.

SAS® (Proc Freq) software was used to analyze the data. The results of the SAS® procedure are

presented in Exhibit 1 for stability category and F-Tower data, Exhibit 2 for wind speed category and F-Tower data, Exhibit 3 for wind direction sectors for F-Tower data, Exhibit 4 for stability category and H-Tower data, Exhibit 5 for wind speed category and H-Tower data, Exhibit 6 for wind direction sectors and H-Tower data. In addition to the χ^2 defined above, two additional chi-square variables are computed by SAS®. These are the likelihood ratio χ^2 and the Mantel-

Haenszel Chi-Square. Probabilities of accepting the null hypothesis based on these two additional tests were approximately the same as for the chi-square test discussed. These additional tests will not be described. SAS® (Proc Freq) also computes three tests for association between the classes and the time periods. These are the Phi Coefficient, Contingency Coefficient, and Cramer's V. Since no probabilities of acceptance nor rejection are computed, these were not used and are not described.

A frequency table is also included with the two time periods (NEW for 87-91 data set and OLD for 82-86 data set) as the two rows, and stability, sector, or wind speed category as the column. The numbers in each cell are labeled under period. The first value is the number observed, the second is the number expected under the null hypothesis, the third is the cell chi-square contribution or the adjusted residual squared (r_{ij}^2), the fourth is the percent of the total of both data sets in the cell and the last number is the percent of each data set in the cell. The marginal totals for the rows include the total per row or data set and the percent of the total in each data set. The marginal totals for columns gives the total per column or category and the percent of the total in each category which is the expected proportion under the null hypothesis.

SAS® Proc Freq does not compute the adjusted residual divided by its standard deviation. The residual squared is computed and labeled as the cell chi-square value. The standard deviation (S_{ij}) of the adjusted residual is given by

$$S_{ij} = [(1 - N_{+j}/N)(1 - N_{i+}/N)]^{1/2}.$$

The random variable, $e_{ij} = r_{ij}/S_{ij}$, is distributed approximately as a normal variate with mean zero and variance one. Since only two time periods are being compared, $e_{1j} = -e_{2j}$ for all j categories. Thus, residuals need to be computed for only one data set and a two-tailed comparison based on the normal distribution is made.

Since each individual comparison is distributed as a normal (0,1) variate, the probability of getting a larger absolute value can be determined by $\text{Prob}\{|e_{ij}| \leq z(1-\alpha/2)\} = (1-\alpha)$ if the null hypothesis is true where $z(1-\alpha/2)$ is the $100(1-\alpha/2)$ percentile for the normal distribution.

Thus, if the calculated $|e_{ij}| \leq z(1-\alpha/2)$, accept the null hypothesis of no difference between time

periods for the j th category. The simultaneous probability of accepting all J comparisons when the null hypothesis is true was set to be 0.95 (95% confidence of accepting the null hypothesis when it is true.) In order to have the simultaneous probability equal to 0.95, the individual comparison probabilities of acceptance were determined using the following Bonferroni method.

$$\alpha/2 = (1-0.95)/(2J).$$

For the seven stability categories, $\alpha/2 = 0.0036$ and $z(1-\alpha/2) = 2.69$. For the six wind speed categories, $\alpha/2 = 0.0042$ and $z(1-\alpha/2) = 2.638$. For the sixteen sectors, $\alpha/2 = 0.00156$ and $z(1-\alpha/2) = 2.955$.

Additional statistical tests were performed for the null hypothesis that there is no difference in the mean wind speeds between the two data sets. To test this null hypothesis, an analysis of variance (ANOVA) was done which modeled the mean wind speed as a function of time period, stability category, and wind direction sector. The mean wind speed was determined from the original data by grouping all the observations into 672 categories (seven stability by six wind speed by 16 sectors) and calculating the average wind speed. These 672 mean wind speeds were the set of observations analyzed by the analysis of variance. The wind speed class was not included in the model since there is a correlation between mean wind speed and wind speed category. The model also included the two-factor interactions which are the interaction between time periods and category and between stability and sector categories. The results are given in Exhibit 7 for F Tower and Exhibit 8 for H Tower. Only stability was a significant factor in the analysis of variance.

An analysis of variance was also done with stability as a blocking factor (this compares only the differences between time periods within each stability category and not the averages between stability category). When this was done, there was no significant difference between time periods. If there are significant differences between time periods, the F-test on the period within stability factor will be inflated and the probability of getting a larger F-value will be small. This was not the case when both period within stability category and period within sector category were compared. The F-test is similar to the chi-square in that it only indicates significant differences across all subcategories but not which subcategory(ies) are different. The results for

differences between data sets within stability category for F-Tower data is shown in Exhibit 9 and for sector in Exhibit 10. The results for stability category for H-Tower data is shown in Exhibit 11 and for sectors in Exhibit 12 for H-Tower.

The 672 mean wind speeds for each time period were averaged for each of the seven stability categories, sixteen sectors, and six wind speed categories within each time period and compared using a two sample t-test. There is one difference between the two sample t-test done separately for each category and the ANOVA. In the ANOVA the variance estimates within time periods and categories are pooled, while in the t-test, a preliminary F-test is done to determine if the true variances between time periods within each category can be considered equal, and depending on the results of the F-test, SAS® computes

either an equal or unequal variance t-test. SAS® ANOVA procedure does not test for equality of variances. For these reasons, the two sample t-tests were used.

SAS® procedure TTEST was used to compute the t-test or t-ratio between the two time periods for each of the 7 stability categories, and 16 wind direction categories. The mean wind speeds were averaged within each time period. TTEST calculates the average, variance, standard deviation, F-ratio, probability of getting a larger F-ratio, t-ratio, and probability of getting a larger t-ratio assuming both equal and unequal variances. The ratio of the largest variance to smallest variance is compared with the corresponding percentiles of the F-distribution so that two-tailed percentiles are used (folded F statistic).

Let x_{ijk} = the kth mean wind speed for time period i in category j, then

$$\bar{x}_{ij} = \sum x_{ijk} / n_{ij} \text{ and}$$

$$s_{ij}^2 = \sum (x_{ijk} - \bar{x}_{ij})^2 / (n_{ij} - 1).$$

Then for each category -j, form the following ratio

$$F = \text{largest of } s_{1j}^2 \text{ and } s_{2j}^2 / \text{smallest of } s_{1j}^2 \text{ and } s_{2j}^2.$$

The probability computed by SAS® is the probability of getting a larger ratio under the assumption

$$\sigma_{1j}^2 = \sigma_{2j}^2.$$

The two sample t-test is given by

$$t = (\bar{x}_{1j} - \bar{x}_{2j}) / s_{dj}$$

If the variances are assumed to be equal, then the standard deviation of the difference in average wind speeds is given by

$$s_{dj} = s_{pj} (1/n_{1j} + 1/n_{2j})^{1/2} \text{ with } (n_{1j} + n_{2j} - 2) \text{ degrees of freedom.}$$

$$s_{pj}^2 = [(n_{1j} - 1) s_{1j}^2 + (n_{2j} - 1) s_{2j}^2] / (n_{1j} + n_{2j} - 2).$$

If the variances are assumed to be unequal, then the standard deviation of the difference is given by

$$s_{dj} = [(s_{1j}^2 / n_{1j}) + (s_{2j}^2 / n_{2j})]^{1/2}.$$

The degrees of freedom are given by (Satterwaite's approximation)

$$df_j = \{[(s_{1j}^2 / n_{1j}) + (s_{2j}^2 / n_{2j})] / [(s_{1j}^4 / (n_{1j} - 1)) + (s_{2j}^4 / (n_{2j} - 1))]\}.$$

Again the probability of simultaneous acceptance of all J comparisons when the null hypothesis is true was set at 0.95 and the probability of accepting each individual comparison was determined using the Bonferroni method. Each individual t -ratio is distributed as a student's t -distribution with df_j degrees of freedom. Thus, if $t(1-\alpha/2)(df_j)$ is the $100(1-\alpha/2)$ percentile of the student's t -distribution with df_j degrees of freedom, then $\text{Prob.}\{|t| \leq t(1-\alpha/2)(df_j)\} = (1 - \alpha)$, where df_j is the degrees of freedom for the j th category. The Bonferroni method requires solving the following for α

$$\alpha/2 = (1-0.95)/(2*J).$$

However, SAS has already computed the probability that $|t| > t(1-\alpha/2)(df_j)$ or $\text{Prob.}\{|t| > t(1-\alpha/2)(df_j)\} = \alpha$. So the Bonferroni adjustment for α for the SAS two-sample t -tests is given by

$$\alpha = (1-0.95)/J.$$

For the 7 stability categories $\alpha = 0.00714$. For the sixteen wind directions, $\alpha = 0.003125$ and $\alpha = 0.00833$ for the six wind speed categories.

Results from the SAS® TTEST procedure are shown in Exhibits 13, 14, and 15 for stability, sector, and wind speed, respectively for the F-Tower data and in Exhibits 16, 17, and 18 respectively, for the H-Tower data.

References for Appendix A:

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A| Appendix B

Ap Appendix B contains a number of plots for F and H-Area towers for both the 82-86 & 87-91 data sets which
are are too numerous to comment on individually within the text, nevertheless, occasions will arise when these
plo plots are needed for various purposes. Their breakdown is as follows:

- (1) (1) plots showing how the stability categories are distributed over the speed classes (Figs. 24a-d)
- (2) (2) plots showing how the speed classes are distributed over the stability categories (Figs. 25a-d)
- (3) (3) plots showing how the speed classes are distributed over the direction sectors (Figs. 26a-d)
- (4) (4) plots showing how the direction sectors are distributed over the stability categories (Figs. 27a-d)

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Exhibits

Exhibit 1. Tables from SAS® Proc Frequency for F-Area Tower. Comparison of New versus Old databases by the seven stability classes. "New" refers to 1987-91 data. "Old" is 1982-86 data.

Exhibit 2. As in Exhibit 1 except for comparisons by the six wind speed classes.

Exhibit 3. As in Exhibit 1 except for comparisons by the sixteen sectors.

Exhibit 4. As in Exhibit 1 except for H-Area tower.

Exhibit 5. As in Exhibit 1 except for H-Area tower and comparisons by the six wind speed classes.

Exhibit 6. As in Exhibit 1 except for H-Area tower and comparisons by the sixteen sectors.

Exhibit 7. Tables from SAS® Proc GLM (General Linear Models) for the average speed from the F-Area tower. "STAB" refers to the seven stability classes, "SEC" refers to the sixteen sectors, and "PERIOD" refers to the two datasets.

Exhibit 8. As in Exhibit 7 except for the H-Area tower.

Exhibit 9. As in Exhibit 7 except that the two datasets "PERIOD" are modeled as nested within the seven stability "STAB" classes.

Exhibit 10. As in Exhibit 9 except for the two datasets are modeled as nested within the sixteen sectors "SEC".

Exhibit 11. As in Exhibit 9 except for the H-Area tower.

Exhibit 12. As in Exhibit 10 except for the H-Area tower.

Exhibit 13. Tables from SAS® Proc TTEST for comparing the average wind speed from the F-Area tower between the two datasets, "NEW" versus "OLD" within each of the seven stability classes.

Exhibit 14. As in Exhibit 13 except for comparisons within each of the sixteen sectors.

Exhibit 15. As in Exhibit 13 except for comparisons within each of the six wind speed classes.

Exhibit 16. As in Exhibit 13 except for H-Area tower.

Exhibit 17. As in Exhibit 14 except for H-Area tower.

Exhibit 18. As in Exhibit 15 except for H-Area tower.

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Figures

Figure 1. Percentage of H-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each wind direction sector (1-16).

Figure 2. Percentage of F-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each wind direction sector (1-16).

Figure 3. Percentage of H-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each stability class (A-G).

Figure 4. Percentage of F-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each stability class (A-G).

Figure 5. Percentage of H-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each wind speed class (0-2 — ≥ 12).

Figure 6. Percentage of F-Area tower observations from the 82-86 (solid) and 87-91 (dashed) databases for each wind speed class (0-2 — ≥ 12).

Figure 7. Mean wind speeds for the H-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each wind direction sector (1-16).

Figure 8. Mean wind speeds for the F-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each wind direction sector (1-16).

Figure 9. Mean wind speeds for the H-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each stability class (A-F & G).

Figure 10. Mean wind speeds for the F-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each stability class (A-F & G).

Figure 11. Mean wind speeds for the H-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each wind speed class (1-6).

Figure 12. Mean wind speeds for the F-Area tower from the 82-86 (solid) and 87-91 (dashed) databases for each wind speed class (1-6).

Figure 13a. Spectral density estimates of one-hour mean wind speeds for the 87-91 H-Area tower database. Spectral density estimates have units of power (m^2/sec^2) per unit frequency (cycles/hr) and are plotted against the period (hrs/cycle).

Figure 13b. Same as Fig. 13a except for a limited range of the period.

Figure 13c. Same as Fig. 13b except for a limited range of the period.

Figure 13d. Same as Fig. 13c except for a limited range of the period.

Figure 14a. Spectral density estimates of fifteen-minute mean wind speeds for the 87-91 H-Area tower database. Spectral density estimates have units of power (m^2/sec^2) per unit frequency (cycles/hr) and are plotted against the period (hrs/cycle).

Figure 14b. Same as Fig. 14a except for a limited range of the period.

Figure 14c. Same as Fig. 14b except for a limited range of the period.

Figure 14d. Same as Fig. 14c except for a limited range of the period.

Figure 15a. Percentage of H-Area tower observations from the 87-91 databases for each wind direction sector (1-16) broken down by stability class.

Figure 15b. As for 15a except for 82-86.

Figure 15c. As for 15a except for the F-Area tower.

Figure 15d. As for 15c except for 82-86.

Figure 16a. Frequency of occurrence of H-Area tower observations from the 87-91 databases for each wind direction sector (1-16) broken down by stability class for the spring season (March, April, May).

Figure 16b. As for 16a except for summer (June, July, August).

Figure 16c. As for 16a except for autumn (September, October, November).

Figure 16d. As for 16a except for winter (December, January, February).

Figure 17a. As for 16a except for evening (between sunset and true solar midnight minus 1/6 of the nighttime hours).

Figure 17b. As for 17a except for midnight (time period between end of evening and beginning of pre-dawn).

Figure 17c. As for 17a except for summer and evening.

Figure 17d. As for 17b except for summer and midnight.

Figure 18a. As for 17a except for spring and morning (between sunrise and true solar noon minus 1/6 of the daylight hours).

Figure 18b. As for 17a except for spring and midday (time period between end of morning and beginning of afternoon).

Figure 18c. As for 17a except for summer and morning.

Figure 18d. As for 17a except for summer and midday.

Figure 19a. As for 17a except for autumn and pre-dawn (between sunrise and true solar midnight plus 1/6 of the nighttime hours).

Figure 19b. As for 17a except for autumn and morning.

Figure 20a. As for 17a except for spring and afternoon (between sunset and true solar noon plus 1/6 of the daylight hours).

Figure 20b. As for 17a except for summer and afternoon.

Figure 21a. As for 17a except for spring and pre-dawn.

Figure 21b. As for 17a except for summer and pre-dawn.

Figure 22a. As for 17a except for autumn and midnight.

Figure 22b. As for 17a except for autumn and evening.

Figure 22c. As for 17a except for autumn and afternoon.

Figure 22d. As for 17a except for autumn and midday.

Figure 23a. As for 17a except for winter and morning.

Figure 23b. As for 17a except for winter and midday.

Figure 23c. As for 17a except for winter and afternoon.

Figure 23d. As for 17a except for winter and evening.

Figure 23e. As for 17a except for winter and midnight.

Figure 23f. As for 17a except for winter and pre-dawn.

Figure 24a. Percentage of H-Area tower observations from the 87-91 database for each speed class (0-2 — ≥ 12) broken down by stability class (A — F-G).

Figure 24b. Same as Fig. 24a except for 82-86.

Figure 24c. Same as Fig. 24a except for the F-Area tower.

Figure 24d. Same as Fig. 24c except for 82-86.

Figure 25a. Percentage of H-Area tower observations from the 87-91 database for each stability class (A — F-G) broken down by speed class (0-2 — ≥ 12).

Figure 25b. Same as 25a except for 82-86.

Figure 25c. Same as 25a except for the F-Area tower.

Figure 25d. Same as 25c except for 82-86.

Figure 26a. Percentage of H-Area tower observations from the 87-91 database for each direction sector (S — SSE) broken down by speed class (0-2 — ≥ 12).

Comparison of Savannah River Site's Five-Year Meteorological Databases

- Fi Figure 26b. Same as Fig. 26a except for 82-86.
- Fi Figure 26c. Same as Fig. 26a except for the
F- Area tower.
- Fi Figure 26d. Same as Fig. 26c except for 82-86.
- Fi Figure 27a. Percentage of H-Area tower
ol observations from the 87-91 database for each
st stability category (A-G) broken down by sector
(S — SSE).
- Fi Figure 27b. Same as 27a except for 82-86.
- Fi Figure 27c. Same as 27a except for the F-Area
to tower.
- Fi Figure 27d. Same as 27c except for 82-86.

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DATA FROM F AREA TOWER

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TABLE OF PERIOD BY STAB

PERIOD	STAB							
Frequency								
Expected								
Cell Chi-Square								
Percent								
Row Pct								
	1	2	3	4	5	6	7	Total
NEW	8092	4083	7092	12095	8661	1638	157	41818
	7798.3	4007.7	6835.1	11876	9256.3	1886.4	158.59	
	11.058	1.4155	9.6561	4.0541	38.284	32.716	0.016	
	10.77	5.43	9.44	16.09	11.53	2.18	0.21	55.65
	19.35	9.76	16.96	28.92	20.71	3.92	0.38	
OLD	5922	3119	5191	9246	7973	1752	128	33331
	6215.7	3194.3	5447.9	9465.4	7377.7	1503.6	126.41	
	13.874	1.7759	12.115	5.0864	48.032	41.046	0.0201	
	7.88	4.15	6.91	12.30	10.61	2.33	0.17	44.35
	17.77	9.36	15.57	27.74	23.92	5.26	0.38	
Total	14014	7202	12283	21341	16634	3390	285	75149
	18.65	9.58	16.34	28.40	22.13	4.51	0.38	100.00

STATISTICS FOR TABLE OF PERIOD BY STAB

Statistic	DF	Value	Prob
Chi-Square	6	219.148	0.000
Likelihood Ratio Chi-Square	6	218.387	0.000
Mantel-Haenszel Chi-Square	1	132.750	0.000
Phi Coefficient		0.054	
Contingency Coefficient		0.054	
Cramer's V		0.054	

Sample Size = 75149

EXHIBIT EXHIBIT 1

DATA FROM _F_ AREA TOWER

TABLE OF PERIOD BY SP_CL

PERIOD	SP_CL						
Frequency							
Expected							
Cell Chi-Square							
Percent							
Row Pct							
	1	2	3	4	5	6	Total
NEW	3261	16978	17234	3562	759	24	41818
	4037.2	16749	16456	3764.5	792.97	17.807	
	149.22	3.1276	36.741	10.893	1.455	2.1539	
	4.34	22.59	22.93	4.74	1.01	0.03	
	7.80	40.60	41.21	8.52	1.82	0.06	55.65
OLD	3994	13121	12339	3203	666	8	33331
	3217.8	13350	13117	3000.5	632.03	14.193	
	187.22	3.9239	46.096	13.667	1.8254	2.7023	
	5.31	17.46	16.42	4.26	0.89	0.01	
	11.98	39.37	37.02	9.61	2.00	0.02	44.35
Total	7255	30099	29573	6765	1425	32	75149
	9.65	40.05	39.35	9.00	1.90	0.04	100.00

STATISTICS FOR TABLE OF PERIOD BY SP_CL

Statistic	. DF	Value	Prob
Chi-Square	5	459.032	0.000
Likelihood Ratio Chi-Square	5	456.744	0.000
Mantel-Haenszel Chi-Square	1	83.583	0.000
Phi Coefficient		0.078	
Contingency Coefficient		0.078	
Cramer's V		0.078	

Sample Size = 75149

TABLE OF PERIOD BY SEC

PERIOD	SEC									
Frequency										
Expected										
Cell Chi-Square										
Percent										
Row Pct										
	1	2	3	4	5	6	7	8	Total	
NEW	1025	2362	4302	3608	2111	1725	1951	2950	41818	
	1084	2249.2	4179.6	3725	2262.6	1731.2	1967.7	2825.7		
	3.2112	5.6526	3.5827	3.6746	10.157	0.022	0.1412	5.4639		
	1.36	3.14	5.72	4.80	2.81	2.30	2.60	3.93	55.65	
	2.45	5.65	10.29	8.63	5.05	4.13	4.67	7.05		
OLD	923	1680	3209	3086	1955	1386	1585	2128	33331	
	864	1792.8	3331.4	2969	1803.4	1379.8	1568.3	2252.3		
	4.0288	7.092	4.495	4.6103	12.744	0.0276	0.1772	6.8552		
	1.23	2.24	4.27	4.11	2.60	1.84	2.11	2.83	44.35	
	2.77	5.04	9.63	9.26	5.87	4.16	4.76	6.38		
Total	1948	4042	7511	6694	4066	3111	3536	5078	75149	
(Continued)	2.59	5.38	9.99	8.91	5.41	4.14	4.71	6.76	100.00	

TABLE OF PERIOD BY SEC

PERIOD	SEC									
Frequency										
Expected										
Cell Chi-Square										
Percent										
Row Pct										
	9	10	11	12	13	14	15	16	Total	
NEW	2995	2607	3329	3697	4065	2658	1402	1031	41818	
	2920.3	2657.1	3288.2	3748.4	3999.9	2755.1	1419.5	1004.4		
	1.9086	0.9459	0.507	0.7039	1.0598	3.4202	0.217	0.7032		
	3.99	3.47	4.43	4.92	5.41	3.54	1.87	1.37	55.65	
	7.16	6.23	7.96	8.84	9.72	6.36	3.35	2.47		
OLD	2253	2168	2580	3039	3123	2293	1149	774	33331	
	2327.7	2117.9	2620.8	2987.6	3188.1	2195.9	1131.5	800.58		
	2.3945	1.1868	0.6361	0.8832	1.3297	4.2911	0.2722	0.8822		
	3.00	2.88	3.43	4.04	4.16	3.05	1.53	1.03	44.35	
	6.76	6.50	7.74	5.12	9.37	6.88	3.45	2.32		
Total	5248	4775	5909	6736	7188	4951	2551	1805	75149	
	6.98	6.35	7.86	8.96	9.56	6.59	3.39	2.40	100.00	

DATA FROM _F_ AREA TOWER

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STATISTICS FOR TABLE OF PERIOD BY SEC

Statistic	DF	Value	Prob
Chi-Square	15	93.277	0.000
Likelihood Ratio Chi-Square	15	93.246	0.000
Mantel-Haenszel Chi-Square	1	0.119	0.731
Phi Coefficient		0.035	
Contingency Coefficient		0.035	
Cramer's V		0.035	

Sample Size = 75149

EXHIBIT 3 CONTINUED

DATA FROM _H_ AREA TOWER

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TABLE OF PERIOD BY STAB

PERIOD	STAB							
Frequency								
Expected								
Cell Chi-Square								
Percent								
Row Pct								
	1	2	3	4	5	6	7	Total
NEW	10387	5391	8682	9952	7664	1601	147	43824
	9298.9	4946.8	8300.8	11005	8254.8	1897	120.26	
	127.31	39.887	17.504	100.81	42.287	46.193	5.9449	
	13.14	6.82	10.98	12.59	9.69	2.02	0.19	55.42
	23.70	12.30	19.81	22.71	17.49	3.65	0.34	
OLD	6392	3535	6296	9906	7231	1822	70	35252
	7480.1	3979.2	6677.2	8832.7	6640.2	1526	96.738	
	158.27	49.587	21.76	125.33	52.57	57.428	7.3903	
	8.08	4.47	7.96	12.53	9.14	2.30	0.09	44.58
	18.13	10.03	17.86	28.10	20.51	5.17	0.20	
Total	16779	8926	14978	19858	14895	3423	217	79076
	21.22	11.29	18.94	25.11	18.84	4.33	0.27	100.00

STATISTICS FOR TABLE OF PERIOD BY STAB

Statistic	. DF	Value	Prob
Chi-Square	6	852.280	0.000
Likelihood Ratio Chi-Square	6	854.704	0.000
Mantel-Haenszel Chi-Square	1	693.103	0.000
Phi Coefficient		0.104	
Contingency Coefficient		0.103	
Cramer's V		0.104	

Sample Size = 79076

DATA FROM _H_ AREA TOWER

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TABLE OF PERIOD BY SP_CL

PERIOD	SP_CL						
Frequency							
Expected							
Cell Chi-Square							
Percent							
Row Pct							
	1	2	3	4	5	6	Total
NEW	4145	20687	16350	2231	409	2	43824
	4067.8	19570	16914	2744.4	523.17	4.9878	
	1.4638	63.761	18.784	96.044	24.913	1.7898	
	5.24	26.16	20.68	2.82	0.52	0.00	55.42
	9.46	47.20	37.31	5.09	0.93	0.00	
OLD	3195	14625	14169	2721	535	7	35252
	3272.2	15742	13605	2207.6	420.83	4.0122	
	1.8197	79.266	23.352	119.4	30.971	2.225	
	4.04	18.49	17.92	3.44	0.68	0.01	44.58
	9.06	41.49	40.19	7.72	1.52	0.02	
Total	7340	35312	30519	4952	944	9	79076
	9.28	44.66	38.59	6.26	1.19	0.01	100.00

STATISTICS FOR TABLE OF PERIOD BY SP_CL

Statistic	.DF	Value	Prob
Chi-Square	5	463.789	0.000
Likelihood Ratio Chi-Square	5	462.456	0.000
Mantel-Haenssel Chi-Square	1	331.240	0.000
Phi Coefficient		0.077	
Contingency Coefficient		0.076	
Cramer's V		0.077	

Sample Size = 79076

TABLE OF PERIOD BY SEC

PERIOD	SEC								
Frequency Expected Cell Chi-Square Percent Row Pot	1	2	3	4	5	6	7	8	Total
NEW	1392 1507.4 8.8385 1.76 3.18	2598 2626.4 0.3062 3.29 5.93	3983 4081.1 2.3598 5.04 9.09	3312 3329.6 0.0935 4.19 7.86	2318 2390.3 2.185 2.93 5.29	2068 2093.8 0.3172 2.62 4.72	2221 2200.2 0.1971 2.81 5.07	2787 2721.7 1.5676 3.52 6.36	43824
OLD	1328 1212.6 10.988 1.68 3.77	2141 2112.6 0.3807 2.71 6.07	3381 3282.9 2.9336 4.28 9.59	2896 2678.4 0.1162 3.41 7.65	1995 1922.7 2.7163 2.52 5.66	1710 1684.2 0.3943 2.16 4.85	1749 1769.8 0.245 2.21 4.96	2124 2189.3 1.9488 2.69 6.03	35252
Total	2720 3.44	4739 5.99	7364 9.31	6008 7.60	4313 5.45	3778 4.78	3970 5.02	4911 6.21	79076 100.00
(Continued)									

TABLE OF PERIOD BY SEC

PERIOD	SEC								
Frequency Expected Cell Chi-Square Percent Row Pot									
	9	10	11	12	13	14	15	16	Total
NEW	3543 3286.4 20.033 4.48 8.08	3031 3034.8 0.0048 3.83 6.92	3445 3381.7 1.1836 4.36 7.86	3779 3702.1 1.8989 4.78 8.62	3453 3497.6 0.5678 4.37 7.88	2904 2960.5 1.0799 3.67 6.63	1618 1679.8 2.2724 2.05 3.69	1372 1330.6 1.2858 1.74 3.13	43824
OLD	2387 2643.6 24.905 3.02 6.77	2445 2441.2 0.0059 3.09 6.94	2657 2720.3 1.4714 3.36 7.54	2901 2977.9 1.9877 3.67 8.23	2858 2813.4 0.7058 3.61 8.11	2438 2381.5 1.3424 3.08 6.92	1413 1351.2 2.825 1.79 4.01	1029 1070.4 1.5985 1.30 2.92	35252
Total	5930 7.50	5476 6.92	6102 7.72	6680 8.45	6311 7.98	5342 6.76	3031 3.83	2401 3.04	79076 100.00

DATA FROM _H_ AREA TOWER

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STATISTICS FOR TABLE OF PERIOD BY SEC

Statistic	DF	Value	Prob
Chi-Square	15	98.455	0.000
Likelihood Ratio Chi-Square	15	98.688	0.000
Mantel-Haenszel Chi-Square	1	9.626	0.002
Phi Coefficient		0.035	
Contingency Coefficient		0.035	
Cramer's V		0.035	

Sample Size = 79076

DATA FROM _F_ AREA TOWER
General Linear Models Procedure

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Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	333.88616057	7.76479443	1.03	0.4252
Error	911	6887.03997932	7.55986825		
Corrected Total	954	7220.92613990			
R-Square		C.V.	Root MSE		SPD Mean
0.046239		57.47315	2.74952146		4.78401047

Source	DF	Type I SS	Mean Square	F Value	Pr > F
STAB	6	171.48428805	28.58071467	3.78	0.0010
SEC	15	90.88061348	6.05870757	0.80	0.6769
PERIOD	1	16.68796265	16.68796265	2.21	0.1377
PERIOD*STAB	6	15.38194069	2.56365678	0.34	0.9163
PERIOD*SEC	15	39.45135571	2.63009038	0.35	0.9899

Source	DF	Type III SS	Mean Square	F Value	Pr > F
STAB	6	167.51642773	27.91940462	3.69	0.0012
SEC	15	87.38339841	5.82569323	0.77	0.7114
PERIOD	1	12.90697926	12.90697926	1.71	0.1917
PERIOD*STAB	6	14.36088025	2.39348004	0.32	0.9285
PERIOD*SEC	15	39.45135571	2.63009038	0.35	0.9899

EXHIBIT 7

DATA FROM _H_ AREA TOWER
General Linear Models Procedure

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Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	43	299.07753490	6.95529151	1.12	0.2764
Error	876	5433.30389814	6.20240171		
Corrected Total	919	5732.38143304			
	R-Square	C.V.	Root MSE		SPD Mean
	0.052173	54.29493	2.49046215		4.58691304

Source	DF	Type I SS	Mean Square	F Value	Pr > F
STAB	6	146.91112536	24.48518756	3.95	0.0007
SEC	15	74.57959206	4.97197280	0.80	0.6767
PERIOD	1	13.62829005	13.62829005	2.20	0.1386
PERIOD*STAB	6	44.24850064	7.37475011	1.19	0.3098
PERIOD*SEC	15	19.71002679	1.31400179	0.21	0.9994
Source	DF	Type III SS	Mean Square	F Value	Pr > F
STAB	6	135.03129086	22.50521914	3.63	0.0015
SEC	15	78.24452416	5.21630161	0.84	0.6318
PERIOD	1	22.69432665	22.69432665	3.66	0.0561
PERIOD*STAB	6	45.35665184	7.55944197	1.22	0.2941
PERIOD*SEC	15	19.71002679	1.31400179	0.21	0.9994

EXHIBIT 8

DATA FROM _F_ AREA TOWER
General Linear Models Procedure

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Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	205.10226760	15.77709751	2.12	0.0114
Error	941	7015.82387229	7.45571081		
Corrected Total	954	7220.92613990			
R-Square		C.V.	Root MSE	SPD Mean	
0.028404		57.07585	2.73051475	4.78401047	

Source	DF	Type I SS	Mean Square	F Value	Pr > F
STAB	6	171.48428805	28.58071467	3.83	0.0009
PERIOD(STAB)	7	33.61797955	4.80256851	0.64	0.7195
Source	DF	Type III SS	Mean Square	F Value	Pr > F
STAB	6	169.82993654	28.30498942	3.80	0.0010
PERIOD(STAB)	7	33.61797955	4.80256851	0.64	0.7195

DATA FROM _F_ AREA TOWER
General Linear Models Procedure

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Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	150.46721473	4.85378112	0.63	0.9412
Error	923	7070.45892516	7.66030219		
Corrected Total	954	7220.92613990			
R-Square		C.V.	Root MSE	SPD Mean	
0.020838		57.85366	2.76772509	4.78401047	

Source	DF	Type I SS	Mean Square	F Value	Pr > F
SEC	15	90.54077868	6.03605191	0.79	0.6921
PERIOD (SEC)	16	59.92643605	3.74540225	0.49	0.9532
Source	DF	Type III SS	Mean Square	F Value	Pr > F
SEC	15	87.73658498	5.84910567	0.76	0.7191
PERIOD (SEC)	16	59.92643605	3.74540225	0.49	0.9532

EXHIBIT 10

DATA FROM _H_ AREA TOWER
General Linear Models Procedure

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Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	201.50207409	15.50015955	2.54	0.0019
Error	906	5530.87935895	6.10472335		
Corrected Total	919	5732.38143304			

R-Square	C.V.	Root MSE	SPD Mean
0.035152	53.86572	2.47077384	4.58691304

Source	DF	Type I SS	Mean Square	F Value	Pr > F
STAB	6	146.91112536	24.48518756	4.01	0.0006
PERIOD (STAB)	7	54.59094873	7.79870696	1.28	0.2582

Source	DF	Type III SS	Mean Square	F Value	Pr > F
STAB	6	140.65467402	23.44244567	3.84	0.0009
PERIOD (STAB)	7	54.59094873	7.79870696	1.28	0.2582

XHIBIT XHIBIT 11

DATA FROM _H_ AREA TOWER
General Linear Models Procedure

13:23 Friday, January 22, 1993 25

Dependent Variable: SPD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	113.59439137	3.66433521	0.58	0.9688
Error	888	5618.78704167	6.32746288		
Corrected Total	919	5732.38143304			

R-Square	C.V.	Root MSE	SPD Mean
0.019816	54.83960	2.51544487	4.58691304

Source	DF	Type I SS	Mean Square	F Value	Pr > F
SEC	15	79.67239183	5.31149279	0.84	0.6336
PERIOD(SEC)	16	33.92199955	2.12012497	0.34	0.9935

Source	DF	Type III SS	Mean Square	F Value	Pr > F
SEC	15	80.45744038	5.36382936	0.85	0.6241
PERIOD(SEC)	16	33.92199955	2.12012497	0.34	0.9935

EXHIBIT 12

DATA FROM _F_ AREA TOWER

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TTEST PROCEDURE

***** CLASS=A *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	78	4.93435897	2.94595456	0.33356367	1.47000000	17.32000000	Unequal	0.5995	145.5	0.5498
OLD	72	4.63791667	3.09744144	0.36503697	1.33000000	20.33000000	Equal	0.6007	148.0	0.5490

For H0: Variances are equal, F' = 1.11 DF = (71,77) Prob>F' = 0.6651

***** CLASS=B *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	74	4.75756757	2.59333012	0.30146850	1.52000000	12.92000000	Unequal	0.3497	145.0	0.7271
OLD	73	4.61027397	2.51282874	0.29410436	1.16000000	9.87000000	Equal	0.3497	145.0	0.7271

For H0: Variances are equal, F' = 1.07 DF = (73,72) Prob>F' = 0.7895

***** CLASS=C *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	83	5.66325301	4.31602293	0.47374506	1.53000000	33.60000000	Unequal	1.4246	135.5	0.1566
OLD	78	4.87012821	2.58282866	0.29244776	1.28000000	9.49000000	Equal	1.4037	159.0	0.1624

For H0: Variances are equal, F' = 2.79 DF = (82,77) Prob>F' = 0.0000

***** CLASS=D *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	84	5.44845238	3.01741711	0.32922720	1.55000000	12.93000000	Unequal	0.4852	164.0	0.6282
OLD	82	5.22536585	2.90648368	0.32096743	1.17000000	12.83000000	Equal	0.4850	164.0	0.6283

For H0: Variances are equal, F' = 1.08 DF = (83,81) Prob>F' = 0.7360

DATA FROM _F_ AREA TOWER

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TTEST PROCEDURE

***** CLASS=E *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	68	4.31647059	1.98609702	0.24084964	1.36000000	8.56000000	Unequal	-0.2020	129.0	0.8403
OLD	68	4.39323529	2.42497111	0.29407094	0.63000000	12.96000000	Equal	-0.2020	134.0	0.8403

For H0: Variances are equal, F' = 1.49 DF = (67,67) Prob>F' = 0.1046

***** CLASS=F *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	58	4.44637931	1.69941445	0.22314405	0.76000000	8.08000000	Unequal	0.4225	118.9	0.6734
OLD	63	4.30761905	1.91240072	0.24093984	0.45000000	8.68000000	Equal	0.4205	119.0	0.6749

For H0: Variances are equal, F' = 1.27 DF = (62,57) Prob>F' = 0.3681

***** CLASS=G *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	40	4.23050000	1.50488257	0.23794283	0.42000000	6.68000000	Unequal	-0.7164	65.5	0.4763
OLD	34	3.95558824	1.75556982	0.30107774	0.45000000	6.58000000	Equal	0.7254	72.0	0.4705

For H0: Variances are equal, F' = 1.36 DF = (33,39) Prob>F' = 0.3543

DATA FROM _F_ AREA TOWER

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TTEST PROCEDURE

***** SEC=1 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	27	4.55629630	2.16464982	0.41658705	1.58000000	9.41000000	Unequal	0.3280	51.9	0.7443
OLD	27	4.35925926	2.24934166	0.43288600	0.63000000	8.97000000	Equal	0.3280	52.0	0.7443

For H0: Variances are equal, F' = 1.08 DF = (26,26) Prob>F' = 0.8463

***** SEC=2 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	29	4.79172414	2.70722983	0.50271996	0.42000000	12.11000000	Unequal	-0.2820	52.8	0.7791
OLD	27	5.00444444	2.92250727	0.56243679	1.01000000	12.83000000	Equal	-0.2828	54.0	0.7784

For H0: Variances are equal, F' = 1.17 DF = (26,28) Prob>F' = 0.6902

***** SEC=3 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	32	4.65468750	2.34478279	0.41450295	1.52000000	8.65000000	Unequal	-0.8154	55.1	0.4183
OLD	31	5.23096774	3.18694562	0.57239233	0.45000000	12.96000000	Equal	-0.8194	61.0	0.4158

For H0: Variances are equal, F' = 1.85 DF = (30,31) Prob>F' = 0.0944

***** SEC=4 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	31	4.96967742	2.34508349	0.42118943	1.36000000	9.07000000	Unequal	0.2042	61.8	0.8389
OLD	33	4.84181818	2.66224348	0.46343710	0.45000000	9.40000000	Equal	0.2034	62.0	0.8395

For H0: Variances are equal, F' = 1.29 DF = (32,30) Prob>F' = 0.4874

TTEST PROCEDURE

***** SEC=5 *****

table:table: SPD

IOD	IOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
		31	4.84645161	2.52669421	0.45380768	1.55000000	12.11000000	Unequal	0.3229	58.0	0.7479
		29	4.64551724	2.29262885	0.42573049	1.33000000	9.32000000	Equal	0.3219	58.0	0.7487

H0: V H0: Variances are equal, F' = 1.21 DF = (30,28) Prob>F' = 0.6076

***** SEC=6 *****

table:table: SPD

IOD	IOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
		31	4.75548387	2.52362020	0.45325557	1.51000000	12.20000000	Unequal	0.4147	58.0	0.6799
		29	4.49758621	2.29274890	0.42575278	1.40000000	10.41000000	Equal	0.4134	58.0	0.6809

H0: V H0: Variances are equal, F' = 1.21 DF = (30,28) Prob>F' = 0.6124

***** SEC=7 *****

table:table: SPD

IOD	IOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
		27	4.45592593	2.11700125	0.40741708	1.47000000	8.96000000	Unequal	0.3792	53.0	0.7061
		28	4.23392857	2.22508317	0.42050119	0.45000000	8.79000000	Equal	0.3788	53.0	0.7063

H0: V H0: Variances are equal, F' = 1.10 DF = (27,26) Prob>F' = 0.8016

***** SEC=8 *****

table:table: SPD

IOD	IOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
		29	4.53827586	2.26209932	0.42006130	1.31000000	9.37000000	Unequal	0.3823	54.8	0.7037
		28	4.30535714	2.33505569	0.44128405	1.29000000	9.49000000	Equal	0.3825	55.0	0.7035

H0: V H0: Variances are equal, F' = 1.07 DF = (27,28) Prob>F' = 0.8672

TTEST PROCEDURE

***** SEC=9 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	33	5.99090909	5.86313715	1.02064117	1.48000000	33.60000000	Unequal	1.2257	43.5	0.2269
OLD	30	4.62733333	2.42488810	0.44272197	1.30000000	9.17000000	Equal	1.1844	61.0	0.2409

For H0: Variances are equal, F' = 5.85 DF = (32,29) Prob>F' = 0.0000

***** SEC=10 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	32	4.62656250	2.46214123	0.43524919	0.59000000	10.06000000	Unequal	0.1121	58.4	0.9111
OLD	29	4.55586207	2.45656194	0.45617210	1.38000000	9.41000000	Equal	0.1121	59.0	0.9111

For H0: Variances are equal, F' = 1.00 DF = (31,28) Prob>F' = 0.9953

***** SEC=11 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	28	4.62392857	2.33145057	0.44060274	1.54000000	9.30000000	Unequal	0.0460	57.8	0.9634
OLD	32	4.59500000	2.53343576	0.44785240	0.45000000	9.76000000	Equal	0.0458	58.0	0.9636

For H0: Variances are equal, F' = 1.18 DF = (31,27) Prob>F' = 0.6651

***** SEC=12 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	33	5.64242424	3.23703185	0.56349492	1.55000000	13.37000000	Unequal	0.4919	59.5	0.6246
OLD	31	5.21193548	3.72801683	0.66957159	1.37000000	20.33000000	Equal	0.4941	62.0	0.6230

For H0: Variances are equal, F' = 1.33 DF = (30,32) Prob>F' = 0.4334

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TTEST PROCEDURE

***** SP_CL=1 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	92	1.61456522	0.22771880	0.02374133	0.42000000	1.97000000	Unequal	5.2032	187.3	0.0001
OLD	99	1.42696970	0.26997526	0.02713353	0.45000000	1.91000000	Equal	5.1710	189.0	0.0000

For H0: Variances are equal, F' = 1.41 DF = (98,91) Prob>F' = 0.1012

***** SP_CL=2 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	111	3.18666667	0.26303589	0.02496626	2.60000000	3.99000000	Unequal	3.3563	203.1	0.0009
OLD	106	3.08132075	0.19585260	0.01902289	2.68000000	3.99000000	Equal	3.3341	215.0	0.0010

For H0: Variances are equal, F' = 1.80 DF = (110,105) Prob>F' = 0.0025

***** SP_CL=3 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	111	4.82144144	0.15758315	0.01495713	4.31000000	5.38000000	Unequal	-2.5671	208.5	0.0110
OLD	110	4.88290909	0.19610588	0.01869796	4.53000000	5.85000000	Equal	-2.5696	219.0	0.0108

For H0: Variances are equal, F' = 1.55 DF = (109,110) Prob>F' = 0.0229

***** SP_CL=4 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	103	6.56058252	0.25842974	0.02546384	6.10000000	7.26000000	Unequal	-1.4157	200.0	0.1584
OLD	99	6.61131313	0.25086644	0.02521303	6.02000000	7.20000000	Equal	-1.4149	200.0	0.1587

For H0: Variances are equal, F' = 1.06 DF = (102,98) Prob>F' = 0.7681

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TTEST PROCEDURE

***** SP_CL=5 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	56	8.82589286	0.46186097	0.06171877	8.04000000	10.06000000	Unequal	-1.2814	104.8	0.2029
OLD	52	8.94173077	0.47632054	0.06605377	8.12000000	10.41000000	Equal	-1.2829	106.0	0.2023

For H0: Variances are equal, F' = 1.06 DF = (51,55) Prob>F' = 0.8206

***** SP_CL=6 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	12	14.82166667	6.07729131	1.75436289	12.11000000	33.60000000	Unequal	0.0338	8.8	0.9738
OLD	4	14.73500000	3.73054809	1.86527254	12.82000000	20.33000000	Equal	0.0265	14.0	0.9792

For H0: Variances are equal, F' = 2.65 DF = (11,3) Prob>F' = 0.4568

EXHIBIT 15 CONTINUED

TTEST PROCEDURE

***** CLASS=A *****

Variable: SPD

ERIOD	ERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	74	4.63243243	2.98656000	0.30068149	1.45000000	10.88000000	Unequal	-0.6016	132.3	0.5485
LD	LD	74	4.94297297	3.40970371	0.41961953	1.41000000	22.01000000	Equal	-0.6016	146.0	0.5484

or H0: Variances are equal, F' = 1.95 DF = (73,73) Prob>F' = 0.0049

***** CLASS=B *****

Variable: SPD

ERIOD	ERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	75	4.69080000	2.41298669	0.27862770	1.48000000	9.60000000	Unequal	0.6402	142.8	0.5231
LD	LD	70	4.43871429	2.32811606	0.27826309	1.20000000	9.04000000	Equal	0.6394	143.0	0.5236

or H0: Variances are equal, F' = 1.07 DF = (74,69) Prob>F' = 0.7652

***** CLASS=C *****

Variable: SPD

ERIOD	ERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	80	5.11962500	2.80481297	0.31358762	1.45000000	14.03000000	Unequal	0.4279	155.9	0.6693
LD	LD	78	4.93371795	2.65587372	0.30071848	1.28000000	12.20000000	Equal	0.4276	156.0	0.6695

or H0: Variances are equal, F' = 1.12 DF = (79,77) Prob>F' = 0.6319

***** CLASS=D *****

Variable: SPD

ERIOD	ERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	74	4.65189189	2.36909478	0.27540167	1.31000000	9.51000000	Unequal	-1.5100	151.5	0.1331
LD	LD	82	5.30146341	2.99247951	0.33046408	1.22000000	13.24000000	Equal	-1.4922	154.0	0.1377

or H0: Variances are equal, F' = 1.60 DF = (81,73) Prob>F' = 0.0435

TTEST PROCEDURE

***** CLASS-E *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	64	4.06046875	1.83436718	0.22929590	1.44000000	8.39000000	Unequal	-0.1361	127.6	0.8920
OLD	66	4.10621212	1.99652218	0.24575489	0.97000000	8.24000000	Equal	-0.1359	128.0	0.8921

For H0: Variances are equal, F' = 1.18 DF = (65,63) Prob>F' = 0.5010

***** CLASS-F *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	56	3.76500000	1.68589550	0.22528726	1.03000000	6.60000000	Unequal	-1.2794	111.7	0.2034
OLD	58	4.18741379	1.83828158	0.24137820	0.45000000	6.58000000	Equal	-1.2774	112.0	0.2041

For H0: Variances are equal, F' = 1.19 DF = (57,55) Prob>F' = 0.5207

***** CLASS-G *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	40	3.69550000	1.63355040	0.25828700	0.77000000	6.17000000	Unequal	-3.2655	63.3	0.0018
OLD	29	4.93413793	1.49588368	0.27777863	0.45000000	6.98000000	Equal	-3.2195	67.0	0.0020

For H0: Variances are equal, F' = 1.19 DF = (39,28) Prob>F' = 0.6334

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TTEST PROCEDURE

***** SEC=1 *****

Variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	25	4.18280000	2.00338988	0.40067798	1.53000000	8.54000000	Unequal	-0.3107	49.9	0.7573
LD	LD	27	4.36629630	2.25489408	0.43395457	1.22000000	9.34000000	Equal	-0.3092	50.0	0.7584

or H0: Variances are equal, F' = 1.27 DF = (26,24) Prob>F' = 0.5633

***** SEC=2 *****

Variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	30	4.72833333	2.28161027	0.41656314	1.50000000	8.74000000	Unequal	0.4183	54.2	0.6774
LD	LD	27	4.47296296	2.31931657	0.44635268	1.40000000	10.10000000	Equal	0.4186	55.0	0.6771

or H0: Variances are equal, F' = 1.03 DF = (26,29) Prob>F' = 0.9267

***** SEC=3 *****

Variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	30	4.58266667	2.37367885	0.43337248	1.43000000	9.30000000	Unequal	0.5480	57.9	0.5872
LD	LD	30	4.25333333	2.29789609	0.41953651	0.43000000	8.71000000	Equal	0.5480	58.0	0.5872

or H0: Variances are equal, F' = 1.07 DF = (29,29) Prob>F' = 0.8625

***** SEC=4 *****

Variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	27	4.30962963	2.09724430	0.40361489	1.31000000	8.61000000	Unequal	-0.1642	51.0	0.8702
LD	LD	26	4.40230769	2.01192308	0.39457058	1.22000000	8.11000000	Equal	-0.1641	51.0	0.8703

or H0: Variances are equal, F' = 1.09 DF = (26,25) Prob>F' = 0.8376

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DATA FROM _H_ AREA TOWER

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TTEST PROCEDURE

***** SEC=9 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	30	4.41933333	2.27101668	0.41462902	1.38000000	9.08000000	Unequal	-0.3264	56.6	0.7454
OLD	29	4.61758621	2.39089292	0.44397767	1.44000000	9.51000000	Equal	-0.3266	57.0	0.7451

For H0: Variances are equal, F' = 1.11 DF = (28,29) Prob>F' = 0.7838

***** SEC=10 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	32	4.56343750	2.44941548	0.43299957	0.77000000	9.60000000	Unequal	-0.7895	57.6	0.4330
OLD	31	5.11290323	3.03350534	0.54483364	0.45000000	13.24000000	Equal	-0.7922	61.0	0.4313

For H0: Variances are equal, F' = 1.53 DF = (30,31) Prob>F' = 0.2419

***** SEC=11 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	31	4.58677419	2.41854831	0.43438410	1.25000000	9.32000000	Unequal	-0.2460	56.8	0.8066
OLD	28	4.73821429	2.30899538	0.43635911	1.17000000	9.16000000	Equal	-0.2454	57.0	0.8071

For H0: Variances are equal, F' = 1.10 DF = (30,27) Prob>F' = 0.8118

***** SEC=12 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	32	4.88437500	2.93870384	0.51949435	1.47000000	14.03000000	Unequal	-0.8007	52.6	0.4269
OLD	30	5.60900000	4.05868192	0.74101055	1.35000000	22.01000000	Equal	-0.8090	60.0	0.4217

For H0: Variances are equal, F' = 1.91 DF = (29,31) Prob>F' = 0.0804

EXHIBIT 17 CONTINUED

TTEST PROCEDURE

***** SEC=13 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	30	4.59133333	2.68270930	0.48979347	0.80000000	10.88000000	Unequal	-0.9122	56.9	0.3655
OLD	32	5.33000000	3.64764882	0.64481930	0.50000000	18.29000000	Equal	-0.9034	60.0	0.3700

For H0: Variances are equal, F' = 1.85 DF = (31,29) Prob>F' = 0.1998

***** SEC=14 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	30	4.84433333	2.76686014	0.50515724	1.03000000	12.23000000	Unequal	-0.4735	57.2	0.6376
OLD	30	5.20400000	3.10678079	0.56721797	1.05000000	12.31000000	Equal	-0.4735	58.0	0.6376

For H0: Variances are equal, F' = 1.26 DF = (29,29) Prob>F' = 0.5366

***** SEC=15 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	28	4.39928571	2.22052368	0.41963953	1.49000000	8.69000000	Unequal	-0.3116	48.6	0.7567
OLD	25	4.60160000	2.47743429	0.49548686	1.15000000	9.79000000	Equal	-0.3136	51.0	0.7551

For H0: Variances are equal, F' = 1.24 DF = (24,27) Prob>F' = 0.5789

***** SEC=16 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	27	4.27814815	2.38930636	0.45982222	1.45000000	9.68000000	Unequal	-0.5656	53.9	0.5740
OLD	29	4.64586207	2.47479367	0.45955765	1.29000000	9.34000000	Equal	-0.5649	54.0	0.5745

For H0: Variances are equal, F' = 1.07 DF = (28,26) Prob>F' = 0.8603

EXHIBIT 17 CONTINUED

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TTEST PROCEDURE

***** SEC=5 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	26	4.27192308	2.13705408	0.41911079	1.44000000	8.90000000	Unequal	-0.0250	51.0	0.9801
OLD	28	4.28607143	2.01012500	0.37987792	1.19000000	8.39000000	Equal	-0.0251	52.0	0.9801

For H0: Variances are equal, F' = 1.13 DF = (25,27) Prob>F' = 0.7534

***** SEC=6 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	29	4.15862069	2.18592858	0.40591675	0.98000000	10.19000000	Unequal	-0.5945	55.0	0.5546
OLD	28	4.49500000	2.08563606	0.39414817	1.46000000	8.83000000	Equal	-0.5940	55.0	0.5549

For H0: Variances are equal, F' = 1.10 DF = (28,27) Prob>F' = 0.8091

***** SEC=7 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	26	4.00230769	1.79969399	0.35294903	1.46000000	6.87000000	Unequal	-0.6772	51.2	0.5013
OLD	28	4.37107143	2.19416793	0.41465876	1.38000000	8.95000000	Equal	-0.6722	52.0	0.5044

For H0: Variances are equal, F' = 1.49 DF = (27,25) Prob>F' = 0.3225

***** SEC=8 *****

Variable: SPD

PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NEW	30	4.40333333	2.31462268	0.42259035	0.96000000	9.51000000	Unequal	-0.3637	56.6	0.7174
OLD	29	4.62862069	2.43875220	0.45286492	0.45000000	8.95000000	Equal	-0.3640	57.0	0.7172

For H0: Variances are equal, F' = 1.11 DF = (28,29) Prob>F' = 0.7805

EXHIBIT 17 CONTINUED

TTEST PROCEDURE

***** SP_CL=1 *****

/ariab/variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
IEW	IEW	104	1.56471154	0.19790140	0.01940583	0.77000000	1.89000000	Unequal	4.3407	160.6	0.0001
ILD	ILD	92	1.41173913	0.28215656	0.02941686	0.45000000	2.00000000	Equal	4.4327	194.0	0.0000

or H0: Variances are equal, F' = 2.03 DF = (91,103) Prob>F' = 0.0005

***** SP_CL=2 *****

/ariab/variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	107	3.15308411	0.21896158	0.02116781	2.59000000	3.91000000	Unequal	-1.1987	205.7	0.2320
LD	LD	104	3.19115385	0.24145718	0.02367682	2.63000000	4.00000000	Equal	-1.2004	209.0	0.2314

or H0: Variances are equal, F' = 1.22 DF = (103,106) Prob>F' = 0.3184

***** SP_CL=3 *****

/ariab/variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	112	4.76312500	0.16630609	0.01571445	4.10000000	5.54000000	Unequal	-4.0188	214.1	0.0001
LD	LD	108	4.85814815	0.18359926	0.01766685	4.48000000	5.43000000	Equal	-4.0261	218.0	0.0001

or H0: Variances are equal, F' = 1.22 DF = (107,111) Prob>F' = 0.3024

***** SP_CL=4 *****

/ariab/variable: SPD

PERIOD	PERIOD	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
EW	EW	91	6.51659341	0.24521745	0.02570577	6.06000000	7.02000000	Unequal	-2.3881	184.3	0.0179
LD	LD	102	6.59813725	0.22699383	0.02247574	6.10000000	7.08000000	Equal	-2.3987	191.0	0.0174

or H0: Variances are equal, F' = 1.17 DF = (90,101) Prob>F' = 0.4496

DATA FROM _H_ AREA TOWER

13:23 Friday, January 22, 1993 14

TTEST PROCEDURE

***** SP_CL=5 *****

Var: SPDs: SPD

PE	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NI	47	8.81063830	0.63087036	0.09202190	8.01000000	10.88000000	Unequal	-0.6430	87.0	0.5219
OI	44	8.88750000	0.50603854	0.07628818	8.08000000	10.34000000	Equal	-0.6384	89.0	0.5249

F=1.55 Variances are equal, F' = 1.55 DF = (46,43) Prob>F' = 0.1473

***** SP_CL=6 *****

Var: SPDs: SPD

PE	N	Mean	Std Dev	Std Error	Minimum	Maximum	Variances	T	DF	Prob> T
NI	2	13.13000000	1.27279221	0.90000000	12.23000000	14.03000000	Unequal	-0.8720	6.2	0.4158
OI	7	14.64428571	3.92909598	1.48505869	12.11000000	22.01000000	Equal	-0.5147	7.0	0.6226

F=9.53 Variances are equal, F' = 9.53 DF = (6,1) Prob>F' = 0.4860

DATA FROM H-AREA TOWER

DATA FROM F-AREA TOWER

FIGURE 2

DATA FROM H-AREA TOWER

FIGURE 3

DATA FROM F-AREA TOWER

DATA FROM H-AREA TOWER

DATA FROM F-AREA TOWER

DATA FROM H-AREA TOWER

GURE GURE 7

DATA FROM F-AREA TOWER

FIGURE 8

DATA FROM H-AREA TOWER

FIGURE 9

DATA FROM F-AREA TOWER

DATA FROM H-AREA TOWER

DATA FROM F-AREA TOWER

1987-91 WIND SPEED SPECTRA

FIGURE 13a

1987-91 WIND SPEED SPECTRA

FIGU FIGURE 13b

1987-91 WIND SPEED SPECTRA

FIGURE 13c

1987-91 WIND SPEED SPECTRA

FIGURE 13d

191987-91 FIFTEEN MIN. WIND SPEED SPECTRA

E 14aE 14a

1987-91 FIFTEEN MIN. WIND SPEED SPECTRA

FIGURE 14b

1987-91 FIFTEEN MIN. WIND SPEED SPECTRA

FIGURE 14c

1987-91 FIFTEEN MIN. WIND SPEED SPECTRA

H-AREA 87-91 DATA -- ALL STABILITIES

FIGURE 15a

H-AREA 82-86 DATA -- ALL STABILITIES

FIGURE 15b

F-AREA 87-91 DATA -- ALL STABILITIES

F—AREA 82—86 DATA — ALL STABILITIES

FIGURE 15d

H-AREA 87-91 DATA -- ALL STABILITIES

SEASON=' SPRING'

FIGURE 16a

ALL DATA -- ALL STABILITIES SEASON=' SUMMER '

IGURE IGURE 16b

H-AREA 87-91 DATA -- ALL STABILITIES

SEASON=AUTUMN

FIGURE 16c

ALL DATA -- ALL STABILITIES

SEASON=WINTER

FIGURE 16d

-AF-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES SEASON=' SPRING' PERIOD=' EVENING'

IGURE IGURE 17a

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=' SPRING' PERIOD=' MIDNIGHT'

FIGURE 17b

H-H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES SEASON=' SUMMER' PERIOD=' MIDNIGHT'

FIGURE 17d

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=' SPRING' PERIOD=' MORNING'

FIGURE 18a

H H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES SEASON=' SPRING' PERIOD=' WIDDAY'

FIGURE 18b

H-H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=' SUMMER' PERIOD=' MORNING'

E'18c E'18c

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=' SUMMER' PERIOD=' MIDDAY'

FIGURE 18d

AF-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=AUTUMN PERIOD=EARLY_AW

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=AUTUMN PERIOD=' MORNING'

FIGURE 19b

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=' SPRING' PERIOD=AFTERNOON

FIGURE 20a

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=' SUMMER' PERIOD=AFTERNOON

FIGURE 20b

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=' SPRING' PERIOD=EARLY_AM

FIGURE 21a

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=' SUMMER' PERIOD=EARLY_AM

FIGURE 21b

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=AUTUMN PERIOD='MIDNIGHT'

FIGURE 22a

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=AUTUMN PERIOD=' EVENING'

FIGURE 22b

1-1-AREA 87-91 DAYTIME DATA -- ALL STABILITIES SEASON=AUTUMN PERIOD=AFTERNOON

URE 2/URE 22c

STAB A B C D E F-G

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=AUTUMN PERIOD=' MIDDAY'

FIG FIGURE 22d

1-1-AREA 87-91 DAYTIME DATA -- ALL STABILITIES SEASON=WINTER PERIOD=' MORNING'

1 23a 1 23a

STAB A B C D E F-G

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=WINTER PERIOD=' MIDDAY'

FIGU FIGURE 23b

H-AREA 87-91 DAYTIME DATA -- ALL STABILITIES

SEASON=WINTER PERIOD=AFTERNOON

FIGURE 23c

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=WINTER PERIOD=' EVENING'

FIGURE 23d

H-AREA 87-91 NIGHTTIME DATA -- ALL STABILITIES

SEASON=WINTER PERIOD=' MIDNIGHT'

FIGURE 23e

STAB A B C D E F-G

F-AREA 87-91 DATA -- ALL STABILITIES

FIGURE 24c

STAB

A

B

C

D

E

F-G

F—AREA 82—86 DATA — ALL STABILITIES

FIG FIGURE 24d

STAB

H-AREA 87-91 DATA -- ALL STABILITIES

FIGURE 25a
SP_CL

H-AREA 82-86 DATA -- ALL STABILITIES

FIGURE 25b

SP_CL

1

2

3

4

5

6

F F-AREA 87-91 DATA -- ALL STABILITIES

FIGURE 25c

P_C/P_CL

1

2

3

4

5

6

F-AREA 82-86 DATA -- ALL STABILITIES

GURE GURE 25d

SP_SP_CL

1

2

3

4

5

6

H-AREA 87-91 DATA -- ALL STABILITIES

H-AREA 82-86 DATA -- ALL STABILITIES

FIGURE 26b

SP_CL

0-2		2-4		4-6
6-8		8-12		>=12

F-AREA 87-91 DATA -- ALL STABILITIES

FIGURE 26c

SP_CL

0-2

2-4

4-6

6-8

8-12

>=12

F-AREA 82-86 DATA -- ALL STABILITIES

FIGURE 26d

SP_CL

0-2

2-4

4-6

6-8

8-12

>=12

H-AREA 87-91 DATA -- ALL STABILITIES

H-AREA 82-86 DATA -- ALL STABILITIES

F-AREA 87-91 DATA -- ALL STABILITIES

F-AREA 82-86 DATA -- ALL STABILITIES

END

**DATE
FILMED**

31 7 1944