A DISCUSSION OF HORIZONTAL WIND VECTOR DETERMINATIONS IN SOUTH LOUISIANA: A METEOROLOGICAL MONITORING STUDY

FINAL REPORT

BY

GEORGE H. CRAMER, II
HIGHWAY ENVIRONMENTAL ANALYST

PAUL M. GRIFFIN, JR.
SOILS TESTING ENGINEER

and

CHARLES D. WALTERS, JR.
ENVIRONMENTAL ANALYST

RESEARCH PROJECT NO. 73-3G(B)
LOUISIANA HPR-1(12)

Conducted by

LOUISIANA DEPARTMENT OF HIGHWAYS
Materials Section
In Cooperation with
U.S. Department of Transportation
FEDERAL HIGHWAY ADMINISTRATION

March 1975

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

The impact of air pollution caused by traffic has become a major environmental consideration in developing new and improved highway facilities. The acquisition of meaningful meteorological data which are applicable to individual highway projects is essential to effective air quality analyses. These data are used as inputs to air pollution dispersion models and for other departmental needs.

This research was undertaken primarily to develop a standard technique for determining meteorological monitoring sites in south central and southwestern Louisiana from which wind vectors that are representative of any highway project undertaken in the region of south Louisiana from the Texas border to 90^{o} 30'W longitude may be obtained.

The primary conclusions of this study are:

1. For projects on open and homogeneous terrain, wind vectors obtained from any national weather service sensor in south central and southwestern Louisiana not relatively close (within 10 to 20 miles) to a large water body may be used.

2. Other highway project sites require localized mapping of wind streamlines determined from data taken over a minimum period of one year.

IMPLEMENTATION

The purpose of this project was to develop a standard technique for immediate department use in the selection of wind monitoring sites in order to provide proper input data for predictive air pollution dispersion models; thus, the recommendations contained in this report have been fully implemented by the Department during the course of the study.

INTRODUCTION

The primary objective and scope of this study was to develop a standard technique for selecting meteorological monitoring sites for the determination of wind vectors by demonstrating the degree of consistency or, more appropriately, the correlation among wind speed and direction observations taken at various sites in the south central and southwestern Louisiana regions from the Texas border to 90^{o} 30' W longitude. The secondary aim was to ascertain the necessity of establishing in these regions centralized weather stations in predetermined subregions within which the meteorological data are homogeneous. These centralized stations, if found to be necessary, would provide the data applicable to the entire region of which they are respectively representative.

The need for this information is critical in the prediction of the environmental effects of highway projects in the south central and southwestern Louisiana regions. This need is exemplified in air pollution dispersion predictive models where meteorological data are essential inputs and these data can not be obtained precisely at a highway project site. In such cases, the data from an appropriate central station would provide the best input to such a model.

This information may also be used for other purposes (e.g., wind-wave set-up for structural design purposes on bridge spans, wind related erosion effects, etc.) and need not necessarily be limited to air pollution effects.

THE ROLE OF WIND VECTORS IN POLLUTION DISPERSION

The fundamental model for prediction of dispersion of pollutants is based on a normally distributed particulate dispersion pattern. This is called a Gaussian plume model (1) and is basically of the form:

$$\bar{\chi} = \frac{Q}{\pi \bar{U} \sigma_y \sigma_z} \exp -\tfrac{1}{2} \left\{ \frac{y^2}{\sigma_{y}^2} + \frac{h^2}{\sigma_{z}^2} \right\}$$

where:

- $\bar{\chi}$ ≡ receptor mean concentration of pollutant
- Q ≡ emission rate of pollutant
- σ_y ≡ horizontal standard deviation of dispersion
- σ_z ≡ vertical standard deviation of dispersion
- y ≡ horizontal distance of receptor from source of emission
- h ≡ vertical height of emission source of receptor
- $\bar{U}$ ≡ mean horizontal wind speed

This model predicts the concentration along the centerline from a point source. The parameters σ_y and σ_z are dependent on atmospheric stability within the vertical height of interest and on the horizontal distance downwind from the source.

Naturally, variations of this model are required for the predictions of dispersion from highway line sources. For one thing, Q is computed from such things as traffic density, type of vehicles in traffic, etc. More important to this study, however, is that the point source becomes a line source, and dispersion downwind becomes a function of not only wind speed but also wind direction. As the wind direction changes from more nearly perpendicular to more nearly parallel to a highway, the pollution concentration horizontal gradient from the highway becomes significantly greater. This is taken into account in the several variations of the Gaussian plume model, including the ones currently in use by the Federal Highway Administration. Examples of these models are delineated by Beaton, et. al. (2).

Thus, for any particular highway project, the importance of understanding the wind vector behavior patterns can not be overemphasized in the determination of predictive data for an environmental impact statement. Some local influences on these patterns should also be understood, therefore the important ones are discussed later in this report.

SITE SELECTION

For the purposes of this initial study three weather stations operated by the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), were selected in an attempt to cover substantially the portion of southern Louisiana from the Texas border to approximately longitude 90° 30' W. The stations are located at Lake Charles, Lafayette and Baton Rouge. It was felt that the primary influence of atmospheric behavior in this region would be the inland weather modification effects in addition to the Gulf of Mexico weather modification effects. Between longitude 90° 30' W and the Mississippi border, the abrupt change in the coastline coupled with the effects of Lake Pontchartrain may contribute a marked deviation from any consistency observed in the selected study region. The region is illustrated in Figure 1. In addition, at the three principal cities, mechanical wind speed and direction recording instruments were maintained by the Louisiana Department of Highways in order to determine the degree of correlation between these instruments' data and that of the NOAA stations. The NOAA sensors were approximately 10 feet above the surface and the mechanical sensors were approximately 30 feet above the surface. Hand-held anemometer data were taken at various times at random locations within the study region in order to supplement the NOAA and mechanical sensor data.

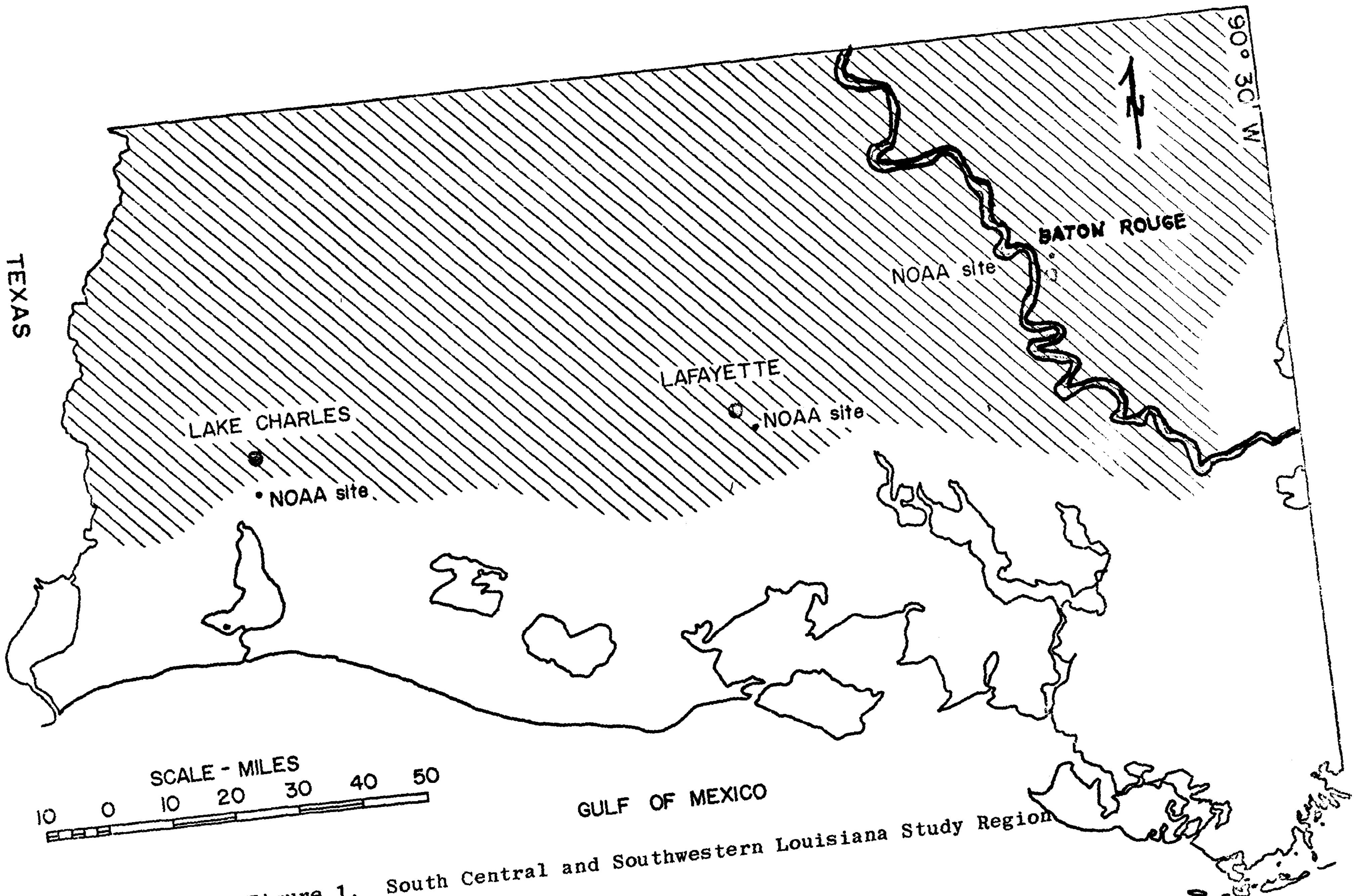

Figure 1. South Central and Southwestern Louisiana Study Region

EQUIPMENT DESCRIPTION

Three types of equipment were used for this project: mechanical weather stations, supporting towers, and hand-held anemometers. As previously mentioned, three tower-weather station combinations were used at fixed locations, and two hand-held instruments were utilized for the monitoring sites in between.

The mechanical weather stations used were the Meteorology Research, Inc., Model 1074. The Model 1074 instrument is a combined cup and vane sensor, in addition to a temperature sensor. All recording is done by scribes on pressure sensitive paper (see Figure 2) which eliminates the need for ink. The anemometer cups are positioned directly above the azimuth vane (see Figure 3) so that all data are recorded from a single point in space. The bi-metal temperature sensor is mounted to the north and covered with a sun shield.

The chart paper is driven by a clock work mechanism (see Figure 4) which is periodically wound by an electric motor powered by two D-cell batteries. Batteries may last up to four months; however, for the purpose of this study they were changed every other month to insure complete data collection.

The Model 1074 instrument is mounted by means of a heavy duty hub, which will accept a 1¼ inch O.D. pipe. Since the hub is recessed into the bottom of the sensor, the locking screws are only accessible through the inside of the instrument and are therefore protected when the instrument is locked.

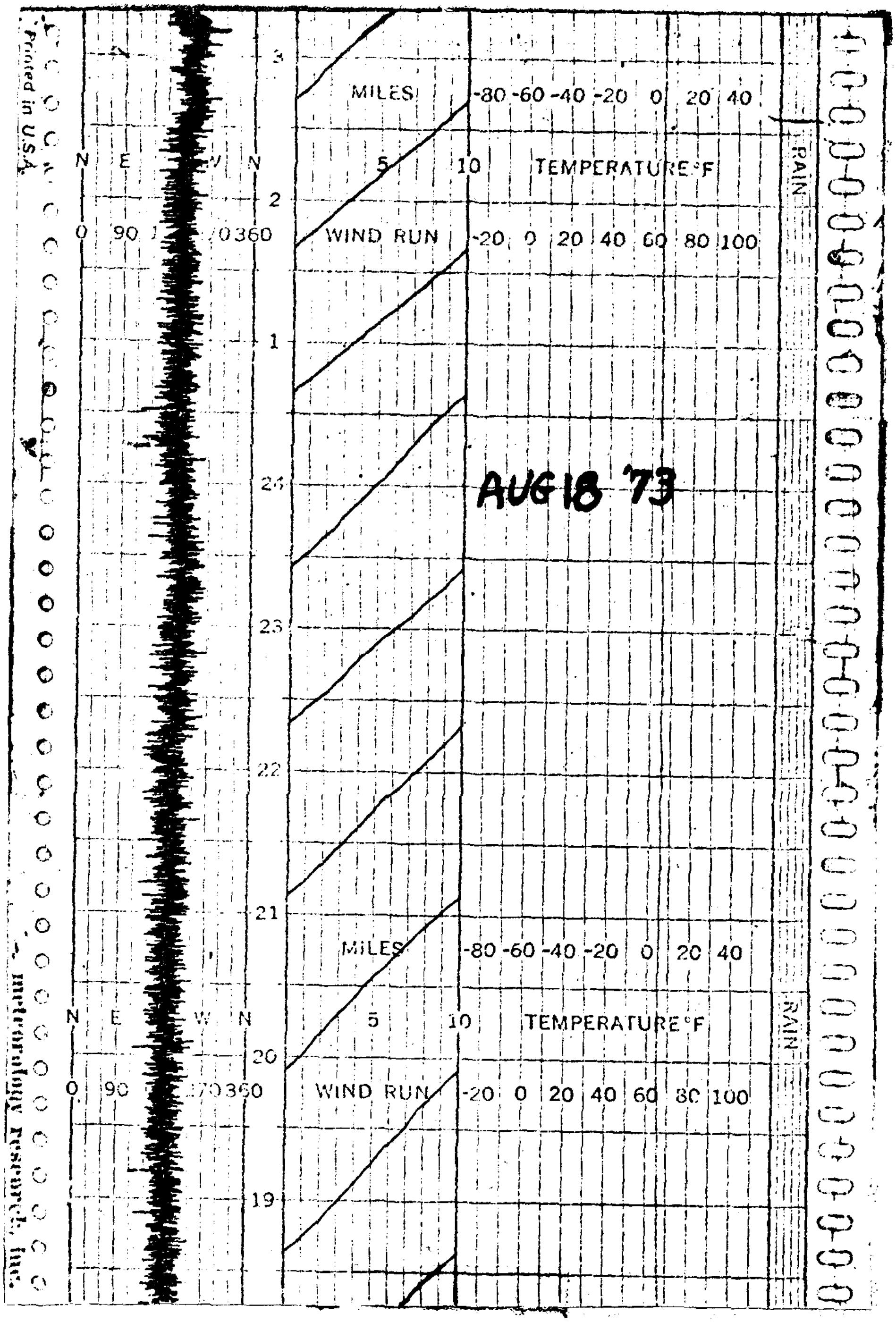

Figure 2. Mechanical Weather Station Chart Paper

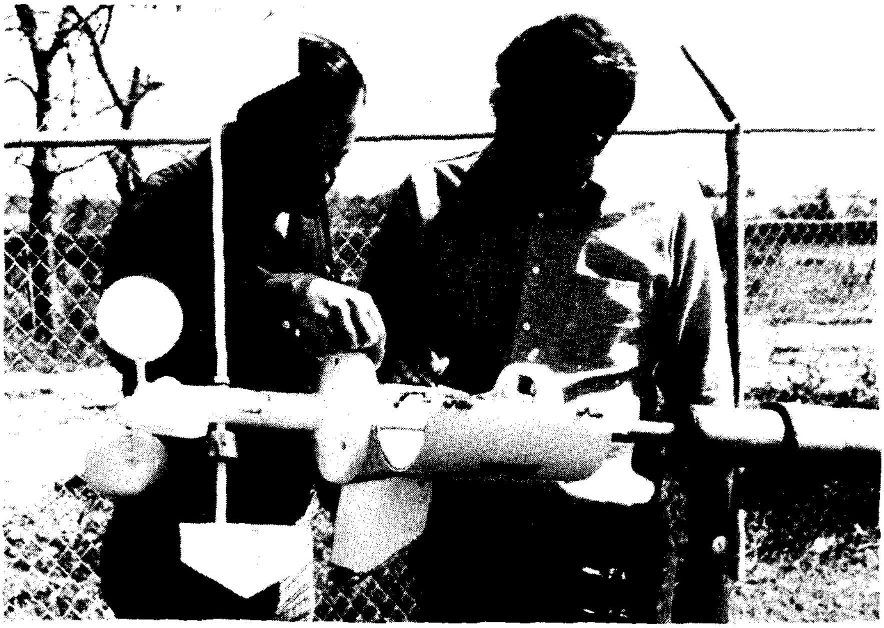

Figure 3. Mechanical Weather Station Being Serviced

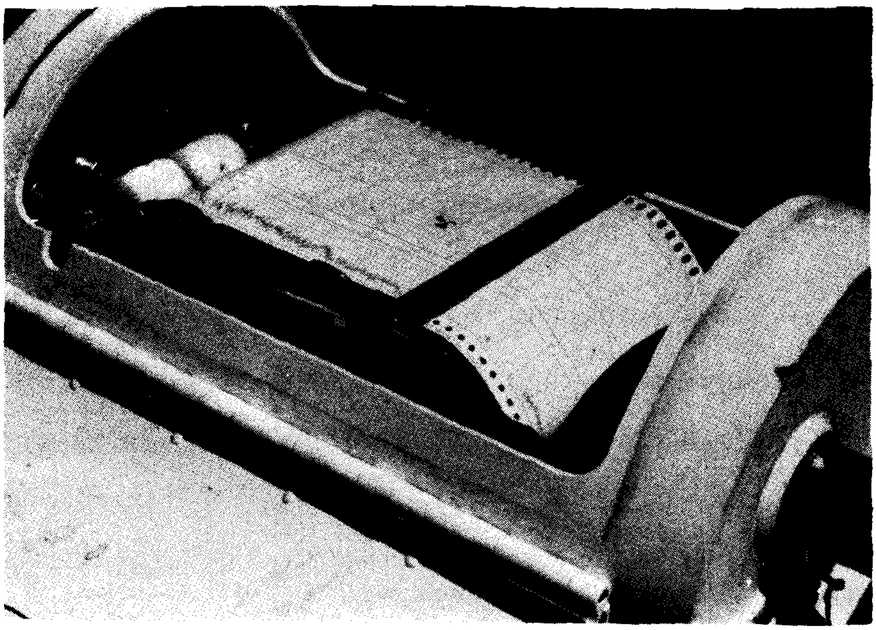

Figure 4. Internal View of Mechanical Weather Station

The support towers are made by Tristro Tower Company of California. The towers are made of tubular aluminum and extend from 20 to a maximum of 35 feet by means of a hand crank assembly. The accompanying base for the tower provides non-guyed support in most soil types; however, this may not be sufficient in the organic soils of the coastal marshes of Louisiana. The tower may be raised and lowered (see Figure 5) for servicing of the weather instrument by means of another crank assembly.

The Hand-Held Wind Measuring Set (see Figures 6, 7, and 8) is made by the Belfort Co. of Baltimore, Maryland. It will measure wind speeds up to 60 knots, with a threshold of 1 knot. The speed is measured by a three-scoop rotor, turbine type, enclosed in a protective cage. The rotor drives a small direct current generator which produces a current flow in proportion to wind speed. The meter read-out comes in either of two scales, 0 - 15 knots or 0 - 60 knots.

Wind direction is determined by a balanced, twin-tailed vane and pointer assembly which rotates about a fixed 360 degree directional dial. A trigger assembly on the pistol grip handle, when depressed, allows the vane to rotate freely; however, when it is released it locks the vane in a given position. A two-pole sight is provided for aligning the instrument.

The three mechanical weather station-tower assemblies (see Figure 9) were in use throughout the duration of field

Figure 5. Tower Being Lowered to Servicing Position

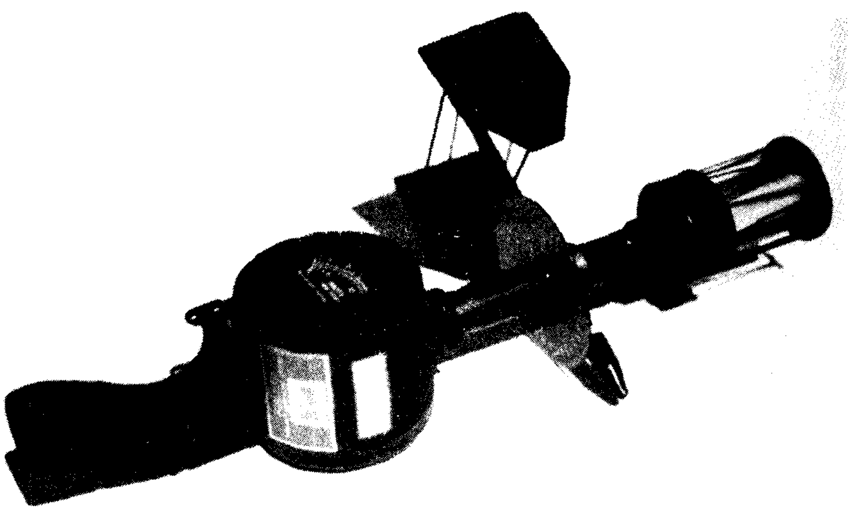

Figure 6. Hand-Held Anemometer

Figure 7. Hand-Held Anemometer Disassembled in Case

Figure 8. Hand-Held Anemometer in Use

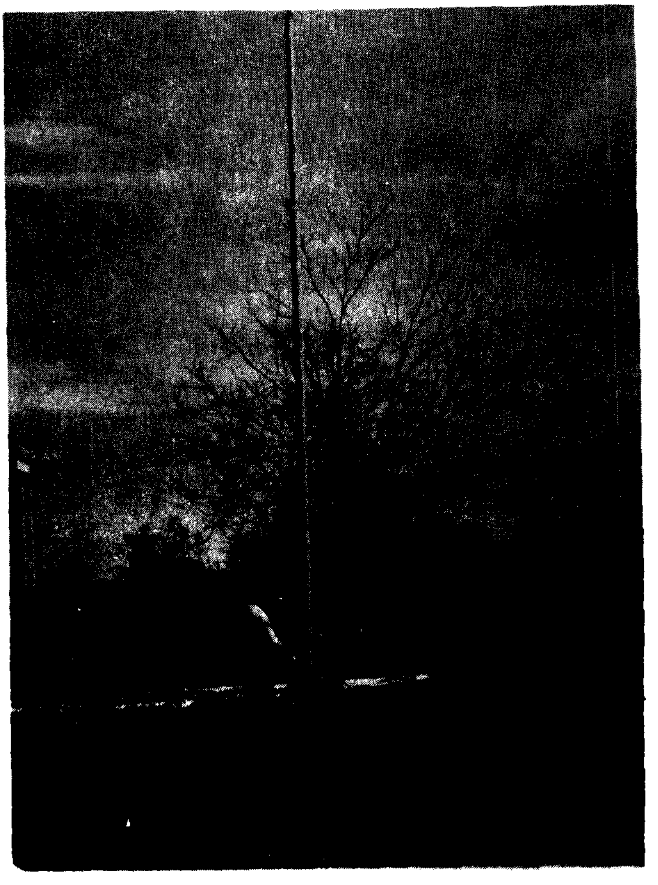

Figure 9. Tower in Fully Raised and Extended Position

sampling, while the hand-held anemometers were used periodically for random sampling.

FIELD OPERATIONS

Prior to the installation of the monitors and towers near the three chosen airports, the Federal Aviation Administration was contacted to insure compliance with federal regulations governing obstacles near runways. As a result, two of the towers were painted orange and white to maximize visual observation. The tower at Lafayette was located on the property of the Department's district office and was not near enough to a runway to require striping. However, it was in close proximity to the NOAA sensor at the Lafayette Airport.

The towers and sensors were installed immediately upon receipt in September of 1973. In addition to being checked periodically, they were serviced once a month. The chart paper was changed and examined to insure that the clock mechanism was operating properly. Batteries were changed every two months to prevent a power failure in the chart drive.

Periodically, usually twice a week, a technician with a hand-held anemometer would measure the wind speed and direction at ten pre-selected sites between Baton Rouge and Lake Charles. (See Figure 10 .) The anemometer was held at arm's length, at a distance of 5 to 5½ feet above the ground, and sighted at a preselected object. All directional readings were referenced to that object which had a predetermined orientation from true north. Corrections were then made for these readings when the data was reduced.

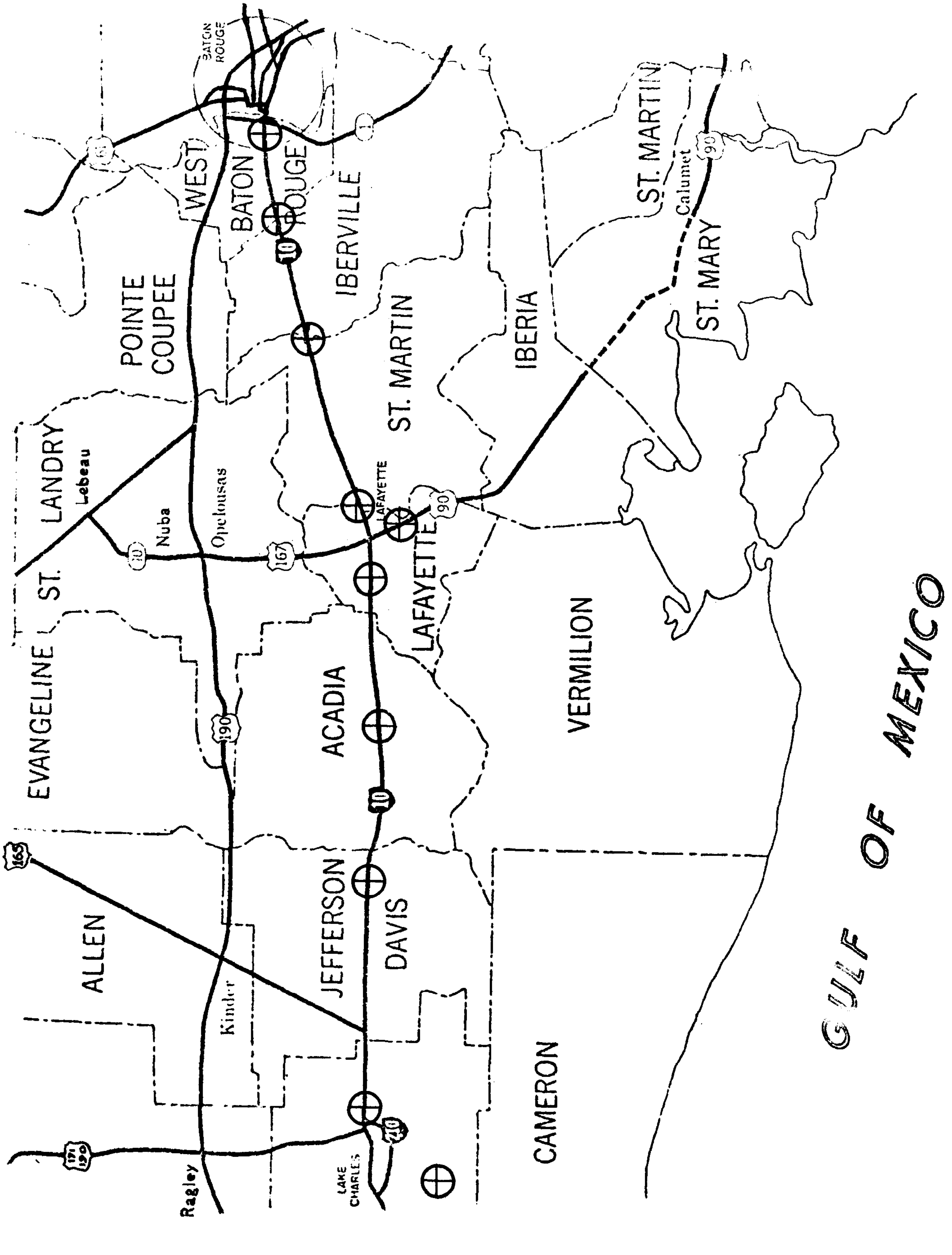

Figure 10. Map Showing Hand-Held Anemometer Sites

On several occasions two technicians were utilized to double the amount of data taken in one day. At such times, one would operate between Lake Charles and Lafayette, and the other between Lafayette and Baton Rouge, each making two round trips per day.

DATA REDUCTION

The field data used in this study were processed in two different manners, depending upon their source. Mechanical weather station data were received as rolls of chart paper, while the hand-held anemometer data were received on field worksheets referenced to a particular object at each site.

The mechanical weather station data were first reduced to a column format on worksheets prepared for such a purpose. (See Figure 11.) To accomplish this the wind direction and temperature were read directly from the chart. Wind speed was interpreted by means of an overlay, prepared by the manufacturer, which indicates wind speed via the angle of the lines in the "Wind Run" column of the chart. The wind speed is proportional to the angle of these lines.

The worksheets were then transposed to an IBM coding sheet. The data were so coded that it was compatible with magnetic tape data purchased from NOAA for each major location. In this manner, both sets of data could be evaluated by the computer program, WNDROS (3), originally developed by the California Division of Highways.

The hand-held anemometer data was transcribed from the field worksheets to laboratory worksheets (see Figure 12) in which the correction to true north for all directional data was made. Both sets of data, the mechanical and the hand-held were then tabulated in a compatible format and were evaluated for agreement.

DATE 11-7-73 PROJ. NO. 73-3G(B)

STATION LOCATION Ryan Airport, Baton Rouge

TIME	WIND* DIRECT	CLOUD** COVER	m.p.h. WIND SPEED	Degrees F. TEMP	REMARKS
0000	0		3.0	48	ALL SAMPLES TAKEN AT
0100	0		5.0	49	APPROXIMATELY 10 METERS
0200	0		5.0	49	ABOVE SURFACE
0300	20		5.0	49	
0400	25		5.0	50	
0500	0		3.0	53	
0600	0		2.0	55	
0700	0		4.5	58	
0800	0		7.0	62	
0900	0		5.0	66	
1000	0		4.5	69	
1100	20		6.0	70	
1200	20		6.5	71	
1300	0		5.0	70	
1400	0		5.0	70	
1500	345		3.0	68	
1600	320		2.5	65	
1700	320		5.0	63	
1800	340		4.5	62	
1900	340		3.5	61	
2000	5		8.0	61	
2100	0		7.5	61	
2200	0		4.5	60	
2300	0		5.0	60	

* Degrees from True North ** Available from NOAA Sheets

Figure 11. Example of Meteorological Worksheet

DATE See Remarks **PROJ. NO.** 73-36(B)

STATION LOCATION Site 1 7/10 Miles from I-10 sign at Mississippi River Bridge

TIME	WIND* DIRECT	CLOUD COVER	KNOTS WIND SPEED	TEMP	REMARKS
1020	332	Clear	4	N/A	12-15-73
0740	075	P.C.	12		12-17-73
0830	250	Clear	4		12-19-73
0930	295	Cloudy	8		12-27-73
1315	335	Clear	5		1-7-74
0840	305	Cloudy	3		1-7-74
1525	290	Cloudy	5		1-11-74
1300	140	Foggy	4		1-11-74
1535	090	P.C.	7		1-15-74
1100	065	Foggy	7		1-15-74
1430	300	P.C.	7		1-16-74
1145	072	Cloudy	8		1-16-74
1450	095	P.C.	5		1-17-74
0850	080	Cloudy	3		1-17-74
0927	260	Foggy	4		1-18-74
1548	295	Cloudy	3		1-22-74
0845	095	Foggy	5		1-22-74
1530	260	Cloudy	8		1-23-74
0855	270	Cloudy	3		1-23-74
1545	230	P.C.	7		1-29-74
0930	215	Clear	2		1-29-74
1535	235	Clear	2		1-30-74
0917	082	Haze	1		1-30-74
1548	252	Clear	6		2-4-74

*Degrees from True North

Figure 12. Example of Hand-Held Worksheet

DATA ANALYSIS

Resultant wind speed and direction data are published by NOAA (see Figure 13) for the stations at Baton Rouge and Lake Charles on a monthly basis (4). For Lafayette, hourly data are recorded and available from NOAA. The hourly wind speed and direction data were reduced to daily resultant data in order to be compatible with the Lake Charles and Baton Rouge data.

Random days during the period August, 1973, through June, 1974, were selected; and the assumption was made that wind speeds and directions are normally distributed temporally. Thus, a statistical test of difference among the three principal stations was made from a completely randomized design (5) with 61 samples at each location. The wind speeds exhibited a highly significant difference over the time period, whereas the wind directions indicated no significant difference. (See Appendix A). This, in effect, states that approximately 95 percent of the time, no large difference in wind directions should exist among the three principal cities. There is, however, no certainty about the difference in wind speeds at these three locations from this test alone.

It is now established, based on these three locations, that during the sampling period of one year, any one location may be chosen; and the wind direction at any given time should be valid for the entire study region, except for possible localized effects to be described later. In order to detect what the approximate wind speed gradient will be between the locations, further statistical tests of difference

LOCAL CLIMATOLOGICAL DATA

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
ENVIRONMENTAL DATA SERVICE

[illegible]
NATIONAL WEATHER SERVICE OFC
RYAN AIRPORT
JULY 1974

LATITUDE 30° 32′ N LONGITUDE 91° 09′ W ELEVATION (GROUND) 64 FT. STANDARD TIME USED: CENTRAL WBAN #13970

DATE	TEMPERATURE °F: MAXIMUM	MINIMUM	AVERAGE	DEPARTURE FROM NORMAL	AVERAGE DEW POINT	DEGREE DAYS BASE 65°: HEATING	COOLING	WEATHER TYPES ON DATES OF OCCURRENCE (1 FOG, 2 HEAVY FOG X, 3 THUNDERSTORM, 4 ICE PELLETS, 5 HAIL, 6 GLAZE, 7 DUSTSTORM, 8 SMOKE, HAZE, 9 BLOWING SNOW)	SNOW, ICE PELLETS OR ICE ON GROUND AT 06AM IN.	PRECIPITATION: WATER EQUIVALENT IN.	SNOW, ICE PELLETS IN.	AVG. STATION PRESSURE IN. ELEV. 78 FEET M.S.L.	WIND: RESULTANT DIRECTION	RESULTANT SPEED M.P.H.	AVERAGE SPEED M.P.H.	FASTEST MILE: SPEED M.P.H.	DIRECTION	SUNSHINE: HOURS AND TENTHS	PERCENT OF POSSIBLE	SKY COVER TENTHS: SUNRISE TO SUNSET	MIDNIGHT TO MIDNIGHT	DATE
1	2	3	4	5	6	7A	7B	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	91	69	80	-2	68	0	16	1 8	0	0	0	29.96	18	3.7	7.8	15	25			4	3	1
2	93	70	82	0	69	0	17	1 8	0	0	0	30.01	16	7.4	8.3	17	17			4	3	2
3	94	70	82	0	69	0	17	1 8	0	.01	0	30.05	13	3.5	5.9	18	18			6	4	3
4	93	68	81	-1	69	0	16	1 8	0	0	0	30.00	29	4.7	5.6	12	20			7	5	4
5	92	71	82	0	71	0	17	3 8	0	.04	0	29.95	28	1.8	7.3	16	29			8	8	5
6	80	70	75*	-7	70	0	10	1 3 8	0	1.98	0	29.96	21	3.2	5.9	17	36			9	8	6
7	88	67	78	-4	69	0	13	1 3 8	0	1.07	0	30.03	32	1.3	4.6	22	03			8	8	7
8	88	67*	78	-4	70	0	13	3 8	0	.02	0	30.04	17	3.1	4.8	16	25			7	5	8
9	92	69	81	-1	71	0	16		0	0	0	29.98	31	2.2	5.8	9	24			3	2	9
10	92	74	83	1	72	0	18	3 8	0	0	0	29.97	27	7.0	7.3	10	24			3	2	10
11	92	73	83	1	70	0	18		0	0	0	29.97	26	4.4	5.8	12	29			6	4	11
12	94	74	84	2	72	0	19	1 3	0	T	0	30.01	34	5.9	7.8	22	07			4	3	12
13	94*	74	84	2	72	0	19	1 3 8	0	.62	0	30.02	35	3.0	7.3	31	35			7	8	13
14	92	73	83	1	73	0	18	1 3 8	0	.42	0	29.98	04	1.5	5.3	20	27			8	9	14
15	90	72	81	-1	71	0	16	8	0	0	0	29.91	10	3.4	5.9	9	27			9	8	15
16	91	71	81	-1	70	0	16	1 8	0	0	0	29.91	10	4.7	5.6	12	05			4	4	16
17	91	70	81	-1	71	0	16	1 3 8	0	.10	0	30.00	10	3.8	6.3	15	18			6	4	17
18	91	69	80	-2	70	0	15	8	0	0	0	30.10	20	.6	6.0	10	25			4	4	18
19	92	71	82	0	71	0	17	1 8	0	0	0	30.09	11	3.3	5.8	10	18			3	2	19
20	93	73	83	1	73	0	18	1 8	0	0	0	30.01	20	2.7	4.2	12	32			2	2	20
21	88	74	81	-1	75	0	16	8	0	.46	0	29.90	21	4.6	7.9	20	25			10	8	21
22	93	73	83	1	74	0	18	1 8	0	0	0	29.96	21	2.9	3.9	8	18			4	4	22
23	93	75	84	2	73	0	19	1 8	0	0	0	29.98	28	.8	7.5	14	16			7	7	23
24	90	71	81	-1	72	0	16	1 8	0	.04	0	29.92	28	1.6	6.2	14	22			8	8	24
25	86	70	78	-3	72	0	14	23 8	0	T	0	29.93	19	3.4	6.9	12	20			7	5	25
26	90	77	84	2	75	0	19	1 8	0	0	0	29.89	25	8.8	10.2	14	24			9	8	26
27	90	74	82	0	74	0	17	1 3 8	0	.86	0	29.89	27	6.0	7.3	12	24			9	9	27
28	91	73	82	0	73	0	17	1 8	0	0	0	29.89	32	7.0	7.5	12	30			7	4	28
29	92	75	84*	2	75	0	19	1 8	0	0	0	29.86	31	4.4	4.8	9	34			8	5	29
30	92	71	82	0	73	0	17	1 3 8	0	.47	0	29.91	33	1.0	9.1	29	13			8	7	30
31	89	71	80	-2	70	0	15	3	0	0	0	29.96	07	3.4	6.2	12	10			9	8	31
	SUM 2820	SUM 2219				TOTAL 0	TOTAL 511			TOTAL 5.89	TOTAL 0	29.96	29	1.1	6.4	31	35	TOTAL	% FOR MONTH	SUM 199	SUM 186	
	AVG. 91.0	AVG. 71.6	AVG. 81.3	DEP. -0.7	AVG. 72	DEP. 0	DEP. -16			DEP. -0.82						DATE: 13		POSSIBLE		AVG. 6.4	AVG. 6.4	

NUMBER OF DAYS				SEASON TO DATE	
MAXIMUM TEMP. ≥ 90° F	≤ 32°	MINIMUM TEMP. ≤ 32°	≤ 0°	TOTAL 0	TOTAL 1642
25	0	0	0	DEP. 0	DEP. 132

NUMBER OF DAYS	
PRECIPITATION ≥ .01 INCH	12
SNOW, ICE PELLETS ≥ 1.0 INCH	0
THUNDERSTORMS	13
HEAVY FOG X	1
CLEAR 4 PARTLY CLOUDY 15 CLOUDY 12	

GREATEST IN 24 HOURS AND DATES: PRECIPITATION		SNOW, ICE PELLETS	GREATEST DEPTH ON GROUND OF SNOW, ICE PELLETS OR ICE AND DATE
2.03	5- 6	0	0

HOURLY PRECIPITATION (WATER EQUIVALENT IN INCHES)

DATE	A.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	P.M. HOUR ENDING AT 1	2	3	4	5	6	7	8	9	10	11	12	DATE
1																									1
2																									2
3														T		.01	T	T	T						3
4																									4
5															.04	T	T								5
6						.21	1.34	.10	.17	.09	.04	.03	.01	T	T										6
7													.23	.84	T	T									7
8																	.02								8
9																									9
10																									10
11																									11
12																		T	T	T					12
13															.58	.02	.02								13
14																.41	.01	T							14
15																									15
16																									16
17															.09	.01									17
18																									18
19																									19
20																									20
21										.25	.20														21
22																									22
23																									23
24															T	.04	T								24
25													T												25
26																									26
27	.65	.01																							27
28																									28
29																									29
30														.21	.01	.03	.01	.11	.08	.01	.01				30
31																									31

* EXTREME TEMPERATURES FOR THE MONTH. MAY BE THE LAST OF MORE THAN ONE OCCURRENCE.
\- BELOW ZERO TEMPERATURE OR NEGATIVE DEPARTURE FROM NORMAL.
‡ - TO 0° AT ALASKAN STATIONS.
\+ ALSO ON AN EARLIER DATE, OR DATES.
X HEAVY FOG RESTRICTS VISIBILITY TO 1/4 MILE OR LESS.
T IN THE HOURLY PRECIPITATION TABLE AND IN COLUMNS 9, 10, AND 11 INDICATES AN AMOUNT TOO SMALL TO MEASURE.

THE SEASON FOR DEGREE DAYS BEGINS WITH JULY FOR HEATING AND JANUARY FOR COOLING.
DATA IN COLUMNS 6, 12, 13, 14, AND 15 ARE BASED ON 8 OBSERVATIONS PER DAY AT 3-HOUR INTERVALS.
WIND DIRECTIONS ARE THOSE FROM WHICH THE WIND BLOWS. RESULTANT WIND IS THE VECTOR SUM OF WIND DIRECTIONS AND SPEEDS DIVIDED BY THE NUMBER OF OBSERVATIONS. FIGURES FOR DIRECTIONS ARE TENS OF DEGREES FROM TRUE NORTH: I.E., 09=EAST, 18=SOUTH, 27=WEST, 36=NORTH, AND 00=CALM. WHEN DIRECTIONS ARE IN TENS OF DEGREES IN COL. 17, ENTRIES IN COL. 16 ARE FASTEST OBSERVED 1-MINUTE SPEEDS. IF THE / APPEARS IN COL. 17, SPEEDS ARE GUSTS.
ANY ERRORS DETECTED WILL BE CORRECTED AND CHANGES IN SUMMARY DATA WILL BE ANNOTATED IN THE ANNUAL SUMMARY.

SUBSCRIPTION PRICE: LOCAL CLIMATOLOGICAL DATA $2.00 PER YEAR INCLUDING ANNUAL ISSUE IF PUBLISHED. FOREIGN MAILING 75¢ EXTRA. SINGLE COPY: 20¢ FOR MONTHLY ISSUE: 15¢ FOR ANNUAL SUMMARY. MAKE CHECKS PAYABLE TO DEPARTMENT OF COMMERCE, NOAA. SEND PAYMENTS AND ORDERS TO NATIONAL CLIMATIC CENTER, FEDERAL BUILDING, ASHEVILLE, NORTH CAROLINA 28801.

I CERTIFY THAT THIS IS AN OFFICIAL PUBLICATION OF THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, AND IS COMPILED FROM RECORDS ON FILE AT THE NATIONAL CLIMATIC CENTER, ASHEVILLE, NORTH CAROLINA, 28801

William H. Haggard

DIRECTOR, NATIONAL CLIMATIC CENTER

SUMMARY BY HOURS

HOUR LOCAL TIME	AVERAGES: SKY COVER TENTHS	STATION PRESSURE IN.	TEMPERATURE: AIR °F	WET BULB °F	DEW PT. °F	RELATIVE HUMIDITY %	WIND SPEED M.P.H.	RESULTANT WIND: DIRECTION	SPEED M.P.H.
00	3	29.96	75	72	71	88	5.1	19	1.1
03	3	29.95	73	72	71	92	3.7	25	.7
06	5	29.97	73	72	71	94	4.9	09	1.0
09	5	30.00	83	76	74	74	7.1	32	2.8
12	6	29.99	87	77	72	61	7.9	28	1.0
15	7	29.95	86	76	71	62	9.5	25	3.1
18	8	29.93	82	75	71	71	7.6	24	2.7
21	5	29.95	77	73	71	82	5.3	19	2.0

BATON ROUGE, LOUISIANA

USCOMM - NOAA - ASHEVILLE 300

8/16/74

Figure 13. Example of Monthly Summary of Climatological Data

(i.e. paried t-tests (5)) were conducted on all three of the possible combinations of any two locations. The paired t-tests were chosen to determine if differences exist in the wind vectors when simultaneous samples were chosen at each site.

The first paired t-test between Lafayette and Baton Rouge consisted of the same 61 random samples (applicable to these two cities) used in the completely randomized design. The same is true for the second paired t-test between Lake Charles and Lafayette. The tests again verify that there is no difference in wind directions over the sample period. Moreover, there is no significant difference in wind speeds over this period between Baton Rouge and Lafayette. However, the wind speed at Lake Charles is found to be somewhat greater than at Lafayette. The mean wind speed value at Lake Charles is approximately 1.7 miles per hour greater than at Lafayette, with the actual value being between 1.2 and 2.3 miles per hour greater 95 percent of the time. (See Appendix A.)

The difference in wind speeds between Lake Charles and Lafayette can be explained easily by the fact that a large body of water (Calcasieu Lake) is in close proximity to the Lake Charles municipal airport; thus, the NOAA sensors were subjected continuously to a localized land-sea breeze effect. This will be discussed in greater detail later, but theoretically, due to the relatively homogeneous relief in the study area, the average wind gradient between the cities themselves should not be significant. This is a very good example of the importance of considering localized topography in line segments of a highway project.

Paired t-tests were also performed on a monthly basis between Lake Charles and Baton Rouge. The results of these tests are basically the same as above and are delineated in Appendix B. The data was taken from May, 1973, to July, 1974. During the month of March, 1974, there was a highly significant difference in wind directions indicated between the two sites. Also, during the months of August, September and December, 1973, no significant difference in wind speeds was found between the two sites.

The agreement between the mechanical weather station data and the NOAA data was not what would normally be expected. The mechanical weather station data generally was from one to two miles per hour lower than the NOAA data. This is an unacceptable result due to the fact that each of the instrument pairs (i.e. NOAA and mechanical) were over the same terrain in close proximity to one another. It would be expected that the wind speeds would be higher at the mechanical station than at the NOAA station due to the vertical (logarithmic) positive wind gradient. The wind directions also demonstrate a high degree of inconsistency which cannot be explained by natural phenomena such as the Ekman spiral (6). The cause of these possibly anomolous results was not determined, and should be a topic of future investigations.

The hand-held anemometer data did not agree with either the NOAA or the mechanical wind data. However, this would be expected to be the case due to the fact that each hand-held reading sample was taken very close to the ground (5 to 5½ feet), and the topography at each sample point was extremely heterogeneous as opposed to that at the NOAA stations. The heterogeneity was primarily due to trees and surface horizontal heating-cooling rate differentials. Examples of heterogeneous topography are:

1. Large bodies of water, swampland, or other matter close to the site under consideration. The specific heat of the land is considerably different from other matter; therefore, the land heats and cools at a different rate from the other matter, creating a much greater horizontal pressure differential and, thus, much greater wind speeds. This was the case with the Lake Charles airport NOAA station which is located within 10 miles of Calcasieu Lake. If the proximity of the considered site is even closer (one to two miles), this heating differential effect may also tend to dominate the wind direction.

2. Trees, shrubbery, buildings, etc., close to the site under consideration. These objects or obstacles appreciably alter the streamlines which would ordinarily be predominant in the study region and are good cause for supplementary monitoring for a specified highway project. This was generally the case with the hand-held instrument data and its disagreement with the NOAA data. No real conclusions can be drawn from the data itself since there was only ran-

dom, sporadic monitoring. These obstacle effects are time dependent. Thus a correlation among, or continuity with, mesoscale atmospheric phenomena is impractical to attempt to establish with the available data.

3. Relief differences between measuring stations. Wind vectors of the upper atmosphere are transposed to the lower atmosphere mechanically and thermally. The mechanical, or friction, effect causes wind speeds at higher reliefs to be generally greater than those at lower reliefs. Also, the Ekman spiral effect (6) may cause significant wind direction changes from a high to a low relief.

4. Nocturnal and diurnal effects at a site. The solar thermal energy transference causes mass modification during sunrise and sunset. The vectors at one site during these times are not altered simultaneously with those at a different longitude. The difference in the vectors is dependent on the magnitude of the difference in longitude. For the width of the study region of this report, this is not thought to be a significant factor in comparison with those mentioned above.

In addition, frontal passage certainly causes mass modification, and discretion must be used during such an occurrence so that parameters at a site on one side of a front are not erroneously extrapolated to those on the other.

CONCLUSIONS AND RECOMMENDATIONS

The mesoscale wind directions and wind speeds over the region of southwestern and south central Louisiana (from the Texas border to approximately 90^{o} 30' W) are basically the same for a given height at a given time under certain conditions. These conditions are that upper atmosphere behavior is the primary controlling factor and that the wind is over the same general relief with homogeneous topography. The region is illustrated by the shaded area in Figure 1.

Localized effects need to be mapped where the topography is heterogeneous, and it is suggested that such effects be monitored for at least a one year period for each project being undertaken. Whenever hand-held instruments are used, the sole purpose should be to obtain data which are dependent on the local topography at the site under observation. In virtually all cases, these data cannot practically be extrapolated for appreciable distances either horizontally or vertically.

It is recommended that the regions in the vicinity of highway project segments be mapped by streamlines for hourly and/or quarter-year periods. These streamlines should be based on mean data taken over the one-year study period.

Because there is a pronounced change in relief and basic topography in the northern region of the state, it would be highly desirable to pursue such a study for that region in the near future. Also, the effect of the large inland lakes and the coastline change between 90° 30' W longitude and Mississippi should be studied in greater detail.

REFERENCES

1. W. D. Sellers, Physical Climatology. Chicago, Ill.: The University of Chicago Press, 1965.

2. J. L. Beaton, A. J. Ranzieri, E. C. Shirley, and J. B. Skog, Mathematical Approach to Estimating Highway Impaction on Air Quality, Federal Highway Administration Report No. FHWA-RD-72-36. Washington, D.C., April, 1972.

3. Highway/Air Quality Computer Programs, Federal Highway Administration, Environmental Development Division, July, 1973.

4. Local Climatological Data. U. S. Department of Commerce, 1973 - 1974.

5. G. W. Snedecor and W. G. Cochran, Statistical Methods, 6th Ed., Ames, Iowa: The Iowa State University Press, 1967.

6. S. L. Hess, Introduction to Theoretical Meteorology. New York, N.Y.: Holt, Rinehart and Winston, 1959.

7. A. Hald, Statistical Tables and Formulas. New York, N.Y.: J. Wiley & Sons, Inc., 1952.

APPENDIX A

STATISTICAL TESTS FOR PERIOD OF AUGUST, 1973 TO JUNE, 1974

Completely Randomized Design for Lafayette, Lake Charles, and Baton Rouge Wind Speeds in Miles Per Hour

61 samples

Treatment Sum of Squares = 126.980

Error Sum of Squares = 2343.632

Total Sum of Squares = 2470.612

F value = 4.876 with 2 and 180 degrees of freedom

F value for 2 and 180 degrees of freedom at 0.01 significance level is less than 4.750 (7)

Completely Randomized Design for Lafayette, Lake Charles, and Baton Rouge Wind Directions in Degrees from True North

61 samples

Treatment Sum of Squares = 10075.3

Error Sum of Squares = 1671000.2

Total Sum of Squares = 1681075.5

F value = 0.543 with 2 and 180 degrees of freedom

F value for 2 and 180 degrees of freedom at 0.05 significance level is greater than 3.04 (7)

(Appendix A continued)

<u>Paired t-test for Lafayette and Baton Rouge Wind Directions in Degrees from True North</u>

n = 61

Mean Difference = 0.328 degrees (Lafayette clockwise from Baton Rouge)

Sum of Squares = 39993.443

Variance of Mean Difference = 10.927

t value = 0.099 with 60 degrees of freedom

t value for 60 degrees of freedom at 0.05 significance level is 2.0 (7)

Standard Error (95%)* = ±6.61 degrees

<u>Paired t-test for Lafayette and Baton Rouge Wind Speeds in Miles Per Hour</u>

n = 61

Mean difference = 0.185 miles per hour (Lafayette less than Baton Rouge)

Sum of Squares = 147.642

Variance of Mean Difference = 0.040

t value = 0.921 with 60 degrees of freedom

t value for 60 degrees of freedom at 0.05 significance level is 2.0 (7)

Standard Error (95%)* = ±0.4 miles per hour

*Percent value is amount of total time that parameter will be included by mean difference and standard error sums

(Appendix A continued)

Paired t-test for Lafayette and Lake Charles Wind Directions in Degrees from True North

n = 61

Mean Difference = 2.131 degrees (Lafayette clockwise from Lake Charles)

Sum of Squares = 65,622.951

Variance of Mean Difference = 17.930

t value = 0.503 with 60 degrees of freedom

t value for 60 degrees of freedom at 0.05 significance level is 2.0 (7)

Standard Error (95%) = ±8.47 degrees

Paired t-test for Lafayette and Lake Charles Wind Speeds in Miles Per Hour

n = 61

Mean Difference = 1.718 miles per hour (Lafayette less than Lake Charles)

Sum of Squares = 264.230

Variance of Mean Difference = 0.072

t value = 6.394 with 60 degrees of freedom

t value for 60 degrees of freedom at 0.01 significance level is 2.66 (7)

Standard Error (95%) = ±1.72 miles per hour

APPENDIX B

STATISTICAL TESTS FOR PERIOD OF MAY, 1973 TO JULY, 1974

(All Tests are Paired-t between Lake Charles and Baton Rouge)

MAY, 1973

	WIND DIRECTION	WIND SPEED
Samples	31	31
Mean Difference	1.29°	1.99 mph
Sum of Squares	45348.39	198.54
Variance of Mean Difference	48.76	0.21
t Value	0.185	4.31
Significance level	0.05	0.01
Significant t (7)	2.042	2.750
Standard Error	$\pm$14.3° (95%)	$\pm$0.94 mph (95%)

JUNE, 1973

	WIND DIRECTION	WIND SPEED
Samples	30	30
Mean Difference	3.67°	3.29 mph
Sum of Squares	36296.67	151.46
Variance of Mean Difference	41.72	0.714
t value	0.568	7.880
Significance Level	0.05	0.01
Significant t (7)	2.045	2.756
Standard Error	$\pm$13.2° (95%)	$\pm$0.85 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	JULY, 1973	
Samples	31	31
Mean Difference	16.77°	1.01 mph
Sum of Squares	93177.42	98.35
Variance of Mean Difference	100.19	0.11
t value	1.68	3.09
Significance level	0.05	0.01
Significant t (7)	2.042	2.750
Standard Error	±20.44° (95%)	±0.77 mph (95%)

	WIND DIRECTION	WIND SPEED
	AUGUST, 1973	
Samples	31	31
Mean Difference	14.19°	0.66 mph
Sum of Squares	127954.84	131.00
Variance of Mean Difference	137.59	0.141
t value	1.21	1.75
Significance Level	0.05	0.05
Significant t (7)	2.042	2.042
Standard Error	±23.95° (95%)	±0.77 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	SEPTEMBER, 1973	
Samples	30	30
Mean Difference	3.67^{o}	0.427 mph
Sum of Squares	46696.67	288.26
Variance of Mean Difference	53.67	0.33
t value	0.5	0.74
Significance Level	0.05	0.05
Significant t (7)	2.045	2.045
Standard Error	$\pm 14.98^{o}$ (95%)	± 1.18 mph (95%)

	WIND DIRECTION	WIND SPEED
	OCTOBER, 1973	
Samples	31	31
Mean Difference	0.65^{o}	1.15 mph
Sum of Squares	15187.10	129.88
Variance of Mean Difference	16.33	0.14
t value	0.16	3.06
Significance Level	0.05	0.01
Significant t (7)	2.042	2.750
Standard Error	$\pm 8.25^{o}$ (95%)	± 0.76 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	NOVEMBER, 1973	
Samples	30	30
Mean Difference	6.67°	1.18 mph
Sum of Squares	12466.67	125.45
Variance of Mean Difference	14.33	0.14
t value	1.76	3.11
Significant Level	0.05	0.01
Significant t (7)	2.045	2.756
Standard Error	±7.74° (95%)	±0.78 mph (95%)

	WIND DIRECTION	WIND SPEED
	DECEMBER, 1973	
Samples	31	31
Mean Difference	1.29°	0.08 mph
Sum of Squares	77948.39	284.55
Variance of Mean Difference	83.82	0.31
t value	0.14	0.15
Significance Level	0.05	0.05
Significant t (7)	2.042	2.042
Standard Error	±18.70° (95%)	±1.13 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	JANUARY, 1974	
Samples	31	31
Mean Difference	10^{o}	2.49 mph
Sum of Squares	46400	149.02
Variance of Mean Difference	49.89	0.16
t value	1.42	6.22
Significance Level	0.05	0.01
Significant t (7)	2.042	2.750
Standard Error	$\pm 14.42^{o}$ (95%)	± 0.82 mph (95%)

	WIND DIRECTION	WIND SPEED
	FEBRUARY, 1974	
Samples	28	28
Mean Difference	1.79^{o}	1.56 mph
Sum of Squares	22210.72	260.55
Variance of Mean Difference	29.38	0.35
t value	0.06	2.66
Significance Level	0.05	0.05
Significant t (7)	2.052	2.052
Standard Error	$\pm 11.12^{o}$ (95%)	± 1.21 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	MARCH, 1974	
Samples	31	31
Mean Difference	12.26°	2.96 mph
Sum of Squares	17941.94	155.14
Variance of Mean Difference	19.29	0.17
t value	2.80	7.24
Significance Level	0.01	0.01
Significant t (7)	2.75	2.75
Standard Error	$\pm 8.97^{\circ}$ (95%)	± 0.83 mph (95%)

	WIND DIRECTION	WIND SPEED
	APRIL, 1974	
Samples	30	30
Mean Difference	8°	2.02 mph
Sum of Squares	14080	126.78
Variance of Mean Difference	16.18	0.15
t value	1.99	5.28
Significance Level	0.05	0.01
Significant t (7)	2.045	2.756
Standard Error	$\pm 8.23^{\circ}$ (95%)	± 0.78 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	MAY, 1974	
Samples	31	31
Mean Difference	5.16^{o}	1.69 mph
Sum of Squares	25974.19	61.80
Variance of Mean Difference	27.93	0.07
t value	0.98	25.39
Significance Level	0.05	0.01
Sifnificant t (7)	2.042	2.750
Standard Error	10.79^{o} (95%)	0.53 mph (95%)

	WIND DIRECTION	WIND SPEED
	JUNE, 1974	
Samples	30	30
Mean Difference	2.67^{o}	1.31 mph
Sum of Squares	92786.67	165.82
Variance of Mean Difference	106.65	0.19
t value	0.26	3.01
Significance Level	0.05	0.01
Significant t (7)	2.045	2.756
Standard Error	$\pm 21.12^{o}$ (95%)	$\pm$0.89 mph (95%)

(Appendix B continued)

	WIND DIRECTION	WIND SPEED
	JULY, 1974	
Samples	31	31
Mean Difference	15.16^{o}	0.95 mph
Sum of Squares	136774.2	145.00
Variance of Mean Difference	147.07	0.16
t value	1.25	2.41
Significance Level	0.05	0.05
Significant t (7)	2.042	2.042
Standard Error	$\pm 24.76^{o}$ (95%)	± 0.81 mph (95%)