United States
Environmental Protection
Agency

Region 3
6th and Walnut Street
Philadelphia, PA 19106

EPA

Fugitive Emissions at a Secondary Lead Smelter

DCN: 81-240-016-15-07

FUGITIVE EMISSIONS AT A SECONDARY LEAD SMELTER

Final Report

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December, 1981

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SECTION 1

INTRODUCTION AND SUMMARY

This report describes an EPA-funded project to provide support to the Commonwealth of Pennsylvania, Department of Environmental Resources (DER), in development of Pennsylvania's State Implementation Plan (SIP) for lead. Specifically, Radian was contracted to provide the sampling and analytical services and data analysis necessary to quantitate fugitive lead emissions from a secondary lead smelting operation in Pennsylvania.

Point source emissions for the major process stacks were known. Unknown was the contribution from open working areas, lead entrainment from the access road caused by truck traffic, and the fugitive emissions from the smelter building. This data gap needed to be filled so that a ranking in the order of importance of all contributing sources could be made. A quantitation of all emission sources is a prerequisite for planning and implementing of the most cost-effective emission controls.

The plant is large and complex. The problem of determining fugitive emissions was attacked by subdividing the plant into the following functional areas:

- Battery storage,
- Battery breaking,
- Charge make-up,
- Slag storage,
- Access road,
- Smelter building.

The area entrainments were quantitated through upwind-downwind lead concentration determinations as function of height. A 20' meteorological tower supplied wind speed and direction.

Collection devices were high-volume samplers at 4', 10', and 16'. Low-volume samplers at 10', 20', and 30' supplied the bulk of the raw data.

Measured lead concentrations were evaluated by applying a ventilation model. In areas of unobstructed air flow, a linear decreasing lead concentration gradient in vertical direction was applied, leading to the following mathematical expression for area fugitive emissions:

$$AE = 1/2\ C_{h_o} \cdot h_{max} \cdot v \cdot Vb\ [gPb/hr]$$

Obstructed flow generated by complex topography and buildings cause the air to be well mixed in certain plant areas. Emissions can be described in these cases as follows:

$$AE = \overline{C} \cdot h_{max} \cdot v \cdot Vb\ [gPb/hr]$$

C_{h_o} = Lead concentration in air at ground level $[gPb/m^3]$

$\overline{C}$ = Average lead concentration in a well mixed air volume $[gPb/m^3]$

v = Wind velocity [m/hr]

Vb = Ventilation base [m]

h_{max} = Height at which the lead concentration gradient approaches zero [m]

The lead distribution gradient in reality lies in between these two bracketing extremes.

Additional information gathered was particle size distribution and lead concentration as function of particle size. The dust coverage at the studied locations was quantitated, and silt and lead content determined. The results of five plant-operated hi-vols complement the information gathered.

The findings of the study are as follows:

1. Point Source Emissions:

Battery Breaking Stack	9 g/hr
Process Stack #1	45-1950 g/hr**
Ventilation Stack #1	540 g/hr
Process Stack #2	23 g/hr
Ventilation Stack #2	0.1-9 g/hr**
Rotary Grid Casting (SLI)*	15 g/hr
Singles Grid Casting (SLI)*	4 g/hr
Oxide Ball Mills	2 g/hr
Grid Casting (Industrial)	5 g/hr
Grid Casting (Motorcycle Batteries)	1 g/hr
Baghouse Assembly (Motorcycle Batteries)	61 g/hr

*(SLI) - Starting, lighting and ignition.
**Extremes of several previous measurements.

Several sources of the SLI, Industrial Battery, and Motorcycle Battery plants were not characterized in the past.

2. Area Source Emissions:

Battery Storage Area North	3 g/hr
Battery Storage Area South	103 g/hr
Battery Breaking Yard	260 g/hr
Charge Make-up Area (September 9, 1981)	460 g/hr
(September 10, 1981)	340 g/hr
(September 8, 1981, rainy day)	255 g/hr
Slag Storage Area (September 6, 1981)	200 g/hr
(September 7, 1981)	270 g/hr
Smelter Access Road (Workday)	41 g/hr
(Saturday)	10 g/hr

3. Fugitive Building Emissions:

Smelter Building (Only blast furnace #1 and reverb #1 operating)	114 g/h
Estimated emissions under full load	228 g/h

4. Particle Size Results (Average Values):

Particles with an aerodynamic diameter
>7.5μ:14 weight %
7.5-2.5μ:24 weight %
<2.5μ:62 weight %

5. Lead Concentration (Average Values):

In particles with an aerodynamic diamter
>7.5μ:20 weight %
7.5-2.5μ:28 weight %
<2.5μ:52 weight %

6. Surface Dust Characteristics: 10-28 g/m^2

Particles <200 mesh (silt):	15-34 weight %
Lead content in particles <200 mesh	12-27 weight %

7. A linear relationship between lead concentration in the air at the access road and axle count was found.

8. Company measured hi-vol results during the sampling period are given in Table 1.

TABLE 1. HIGH VOLUME AIR SAMPLING DATA 8/31/81 THROUGH 9/11/81

Date	Site 01		Site 02		Site 03		Site 04		Site 05	
	TP	TL	TP	TL	TP	TL	TP	TL	TP	TL
8/31/81	47.4	1.46	44.6	0.57	36.2	0.20	33.8	0.24	51.3	4.41
9/01/81	45.4	0.75	53.7	0.53	39.4	0.14	36.8	0.19	63.6	2.88
9/02/81	47.6	1.05	50.8	0.63	40.2	0.10	36.0	0.10	61.5	4.23
9/03/81	57.4	1.85	69.9	0.95	48.0	0.19	46.3	0.19	70.8	6.15
9/04/81	59.3	1.18	74.4	0.94	52.5	0.29	50.1	0.35	74.6	6.57
9/05/81	--	--	--	--	--	--	--	--	--	--
9/06/81	--	--	--	--	--	--	--	--	--	--
9/07/81	41.6	0.40	41.4	0.29	36.7	0.12	36.1	0.25	--	--
9/08/81	44.3	2.36	42.0	4.49	29.4	1.38	28.8	1.56	--	--
9/09/81	48.1	2.71	46.2	2.56	33.2	0.96	36.1	1.85	55.3	7.53
9/10/81	62.7	2.01	75.3	1.49	57.2	1.92	55.4	2.41	76.9	8.53
9/11/81	94.2	3.51	96.2	1.38	86.2	1.94	80.1	1.05	140.3	28.89

All values μg/m^3
TP = Total particulate.
TL = Total lead

SECTION 2

SMELTER DESCRIPTION

The secondary lead smelter studied is located in Pennsylvania. This plant produces hard and soft lead ingots and antimonial alloys in two blast furnace-reverbatory furnace installations. Scrap industrial and SLI batteries are the major raw materials. When the plant was constructed in 1971, it had two blast furnaces, a reverberatory furnace and ten kettles. In 1976-1978 reverb No. 2 and additional process gas handling and sanitary ventilation/gas treatment systems were added.

This plant, with a daily production of 260-320 tons is among the largest U.S. secondary smelters. In addition to smelting operations, it manufactures SLI, industrial, and motorcycle batteries at this facility. Lead emissions from battery manufacture as well as vehicular traffic contribute to the ambient lead levels measured around this plant, which is in an urban, partly residential area.

PLANT ENVIRONMENT

Figure 1 is a plot plan of the 30-acre plant site located in a basin extending in a north-south direction. The smelter is situated on the western boundary of the plant. North of the smelter is a paved area approximately 300 X 600 feet in dimension where battery containing trailers are parked. Beyond the northern boundary is undeveloped land. Directly east of the smelter is the Conrail Railroad right-of-way, running north-south through the plant. Across the tracks are the warehouse, industrial battery, and motorcycle battery buildings. The eastern property line is dominated by high wooded hills. The main offices and parking lots lie south of the smelter. Private residences and small businesses surround the southern end of the plant. Directly west of the smelter is a monastery, which sits on a hill above a grassy slope.

Vehicular traffic is fairly heavy on the paved public road south and east of the plant. This traffic could contribute to background lead levels. A major paved plant access road runs north-south through the plant immediately east of the smelter. It is bordered on the east by 30' buildings and on the west by a heavily wooded 60' ridge. Other paved areas are around the battery breaking building and the parking lots.

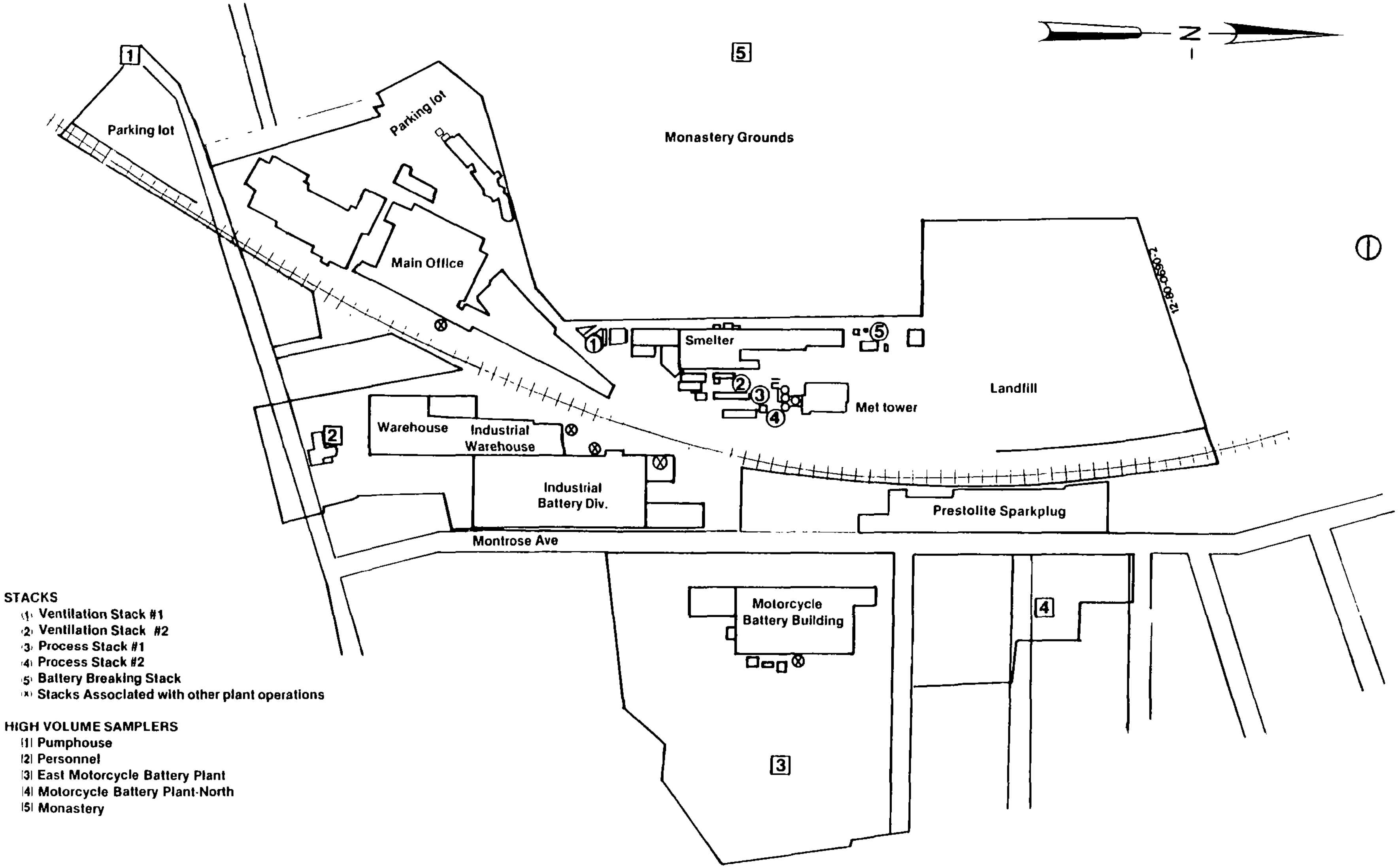

Figure 1. Plot Plan Showing Locations of Stacks and Ambient Monitoring Sites

PROCESS DESCRIPTION AND EMISSION SOURCES

This plant charges entire (crushed) plastic-cased batteries and grids and posts of rubber-cased batteries to two blast and two reverberatory furnaces, each of which has a rated capacity of 65-80 tons/day. Each of the two blast reverb furnace combinations shares a process gas and ventilation gas treatment system. Dust collected in the baghouse is fed to the reverberatory furnaces. Lead-rich slag from the reverbs is recycled to the blast furnaces.

As shown in Figure 2, a material flow through the smelter occurs generally from the north to the south. The operations occur in the following order: raw material receiving and storage, battery breaking, charge storage and preparation, smelting/refining/casting operations, and slag storage. Reverb furnace slag is transported from the south storage area back to the charge storage area for blast furnace feed located at the north end of the smelter building. The processing operations and emission sources are described in detail in Reference 1.

Figure 2 also shows the locations of major emission sources by number. The fugitive sources to be addressed in this study include battery storage (Area 1), battery breaking (Area 2), charge stockpile (Area 3), slag and lead storage (Area 4), access road (Area 5) and smelter building openings.

EXISTING DATA

There are five stacks (point sources) associated with smelter operations: two metallurgical process stacks, two process ventilation stacks and a stack for the battery breaking ventilation system. Lead emission rates have been measured for these sources. In addition, there are other emission points associated with battery manufacturing operations. Table 2 summarizes these sources and lists emissions previously measured.

The monitoring system includes a ring of five samplers around the plant (see Figure 1) and a wind speed and direction monitor on top of the office building at the smelter site. Wind speed and direction are automatically recorded. Lead and TSP are sampled five to six days a week. All samples are analyzed for lead and TSP. An "upset" log is maintained to note the time and nature of operations thought to produce higher than normal visible or particulate emissions. Daily monitoring results are correlated with wind speed and direction, other meteorological conditions, and number of furnaces in operation. Monitoring results are also compared to data obtained by a state-operated monitor at sampling site No. 01 (pumphouse). Table 3 shows quarterly averages monitored during the third and fourth quarters of 1979 and the first three quarters of 1980.

Table 4 gives lead levels measured when the plant shut down in 1979 and 1980 for extended periods. Levels measured during plant operation in the same time period are included for comparison. They range from 1.21 to 4.65 $\frac{\mu g Pb}{m^3}$.

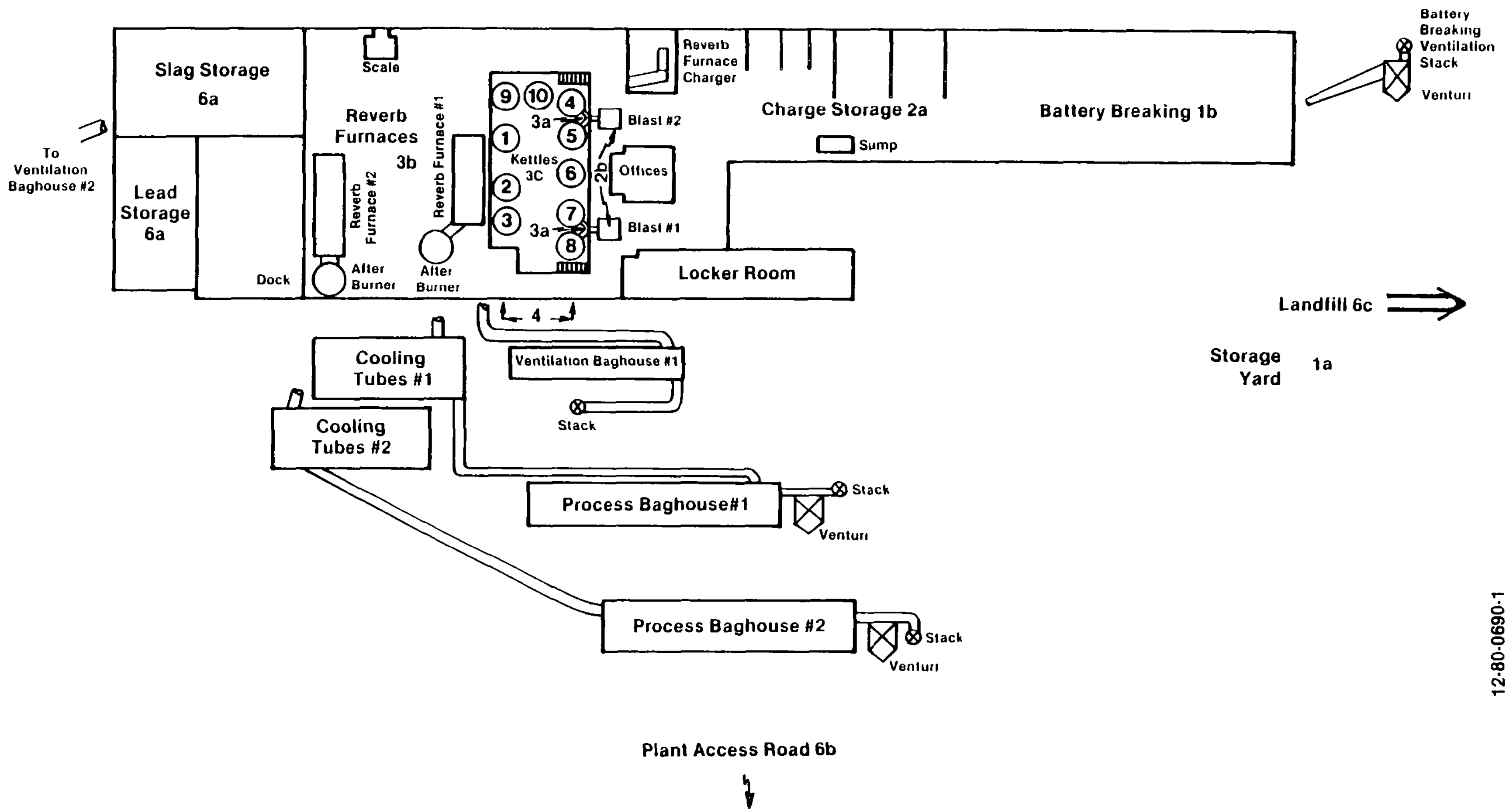

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Figure 2. Smelter Plot Plan Showing Locations of Point Emission Sources (Stacks) and Area Emission Sources

TABLE 2. SMELTER - EMISSION POINTS

Point No.	Control Device	Service	Exhaust Stack Dimensions	Exhaust Stack Height	Temp. °F	Flow Rate SCFM	Emissions lb/hr Lead
Smelter--							
1	Wet Scrubber	Battery Breaker/Crusher	36" Dia.	20'	113	7,345	.02
2	Baghouse and Scrubber	Smelter #1 Process	63" Dia.	63'	125	-	3.2
	"	" " "	" "	"	"	-	4.3
	"	" " "	" "	"	"	-	-
	"	" " "	" "	"	"	-	0.29
	"	" " "	" "	"	"	-	0.12
	"	" " "	" "	"	"	-	0.10
3	Baghouse	Smelter #1 Ventilation	52" Dia.	53'	87	-	1.2
4	Baghouse and Scrubber	Smelter #2 Process	63" Dia.	74'	115	-	0.05
	"	" " "	" "	"	"	-	0.06
	"	" " "	" "	"	"	-	0.09
	"	" " "	" "	"	"	-	-
	"	" " "	" "	"	"	-	0.57
5	Baghouse	Smelter #2 Ventilation	48" Dia.	75'	89	-	0.0002
	"	" " "	" "	"	"		0.01
	"	" " "	" "	"	"	-	0.02
	"	" " "	" "	"	"	-	-
SLI--							
6	Exhauster	Rotary Grid Casting	33" X 33"	14'→	142	19,400	.0330
7	Exhauster	Singles Grid Casting	30" X 43"	26'	91	27,200	.00858
8	Baghouse	Oxide Ball Mills	25" Dia.	30'	130	8,500	.00464
9	Baghouse	Assembly	Discharge from Cells	10'↓	Ambient	95,000D	-
10	Wet Collector	Paste Mixing	20" X 17"	14'→	Ambient	5,360	-
11	Baghouse	Oxide Bulk Storage	6" Dia.	63'→	Ambient	No Fan	-
12	Baghouse	Assembly	44" X 53"	36'	Ambient	108,000D	-
Industrial--							
13	Exhauster	Grid Casting	25" X 30"	30'→	159	9,300	.011
14	Baghouse	Linklater Oxide Mills	18" X 22"	21'→	200	8,000D	-
15	Baghouse	Oxide Bulk Storage	6" Dia.	50'→	Ambient	No Fan	-
16	Wet Collector	Paste Mixing	11" X 14"	26'	110	9,400D	-
17	Baghouse	Assembly	29" X 24"	32'	Ambient	28,000D	-
18	Baghouse	Assembly	53" X 44"	15'	Ambient	108,000D	-
Motorcycle Battery--							
19	Exhauster	Grid Casting	42" Dia.	28'	82	19,300	.0026
20	Wet Collector	Paste Mixing	30" X 24"	41'	Ambient	21,014	-
21	Baghouse	Assembly	44" X 36"	15'	Ambient	43,700	.134
22	Baghouse	Oxide Bulk Storage	6" Dia.	55'→	Ambient	No Fan	-

Stack Height = Height Above Grade
→ = Horizontal Discharge
↓ = Downward Discharge

Other Possible Emission Sources

Smelter
- Sludge dewatering area
- Slag storage area

SLI
- Central vacuum system
- Water treatment lime storage dust collector
- Acid mist scrubbers (formation area)

Industrial
- Central vacuum system

Motorcycle Batteries
- Central vacuum system
- Acid mist scrubbers (formation area)

Average ambient lead levels at the five sites during a two week period when all four furnaces were out of service range from 0.8 to 1.6 μg/m^3. For a two-month period in 1979 when the total facility was down, average ambient levels were from 0.8 to 1.3 μg/m^3.

This indicates that ambient background levels may contribute 1/3 to the values measured during full plant operation.

TABLE 3. QUARTERLY AVERAGE LEAD LEVELS AT COMPANY-OPERATED MONITORING SITES (μg/m^3)

Sampling Period Year	Quarter	01 Pumphouse	02 Personnel	03 MCBP No.*	04 MCBP East*	05 Monastery
1979	3	1.48	1.52	1.50	1.98	1.91
1979	4	3.32	6.25	8.72	1.58	2.56
1980	1	3.62	5.15	1.73	1.20	2.17
1980	2	2.73	3.05	1.79	1.21	4.65
1980	3	2.59	1.95	1.47	1.54	3.99

TABLE 4. AMBIENT AIR LEAD LEVELS DURING PLANT OPERATION AND SHUT DOWN PERIODS

Monitoring Period	Measured Lead Level (μg/m^3) at Monitoring Site					Plant Operating Status
	01	02	03	04	05	
April - June (2nd Quarter) 1980	2.73	3.05	1.79	1.21	4.65	Data for periods of plant production in second quarter 1980.
30 June through 15 July 1980 (Sample taken on 10 of 17 days)	1.64	1.06	0.82	1.53	1.18	All 4 furnaces out of service, however slag and sludge hauling continued.
1 May through 8 July 1979	1.26	1.06	0.75	0.79	1.08	Total facility shutdown due to strike.

*MCBP-Motorcycle Battery Plant.

SECTION 3

SAMPLING AND SAMPLE ANALYSIS

No previous measurements have been made of the contribution to fugitive lead emission of:

- The battery storage area (Area I)
- The battery breaking area (Area II)
- The charge storage and handling area (Area III)
- The slag storage area (Area IV)
- The north-south access road (Area V), and
- The smelter building.

The location of these fugitive emission sources is marked in Figure 3. On days with favorable meteorological conditions, samples were collected separately upwind and downwind of each area of interest and the data was evaluated. Equipment used for this task comprised:

- Regular hi-volume samplers, to measure total suspended particulates and $\mu gPb/m^3$,
- Hi-volume samplers equipped with cascade impactors, to determine particle size and lead distribution as function of particle size, and
- Low-volume samplers (lo-vols), to determine $\mu gPb/m^3$. (Their weight gain is too small for an accurate measurement of total particulates).

The hi-volume samplers were positioned in heights of 4', 10', and 16'. The low-volume samplers were placed on telescopic poles in heights of 10', 20' and 30'. The purpose of these low volume sampling devices was to find the vertical concentration gradient for lead. Wind speed and direction were monitored continuously at each fugitive emission area at a height of 20 feet. Synoptic data were provided from the company's meteorological monitoring system.

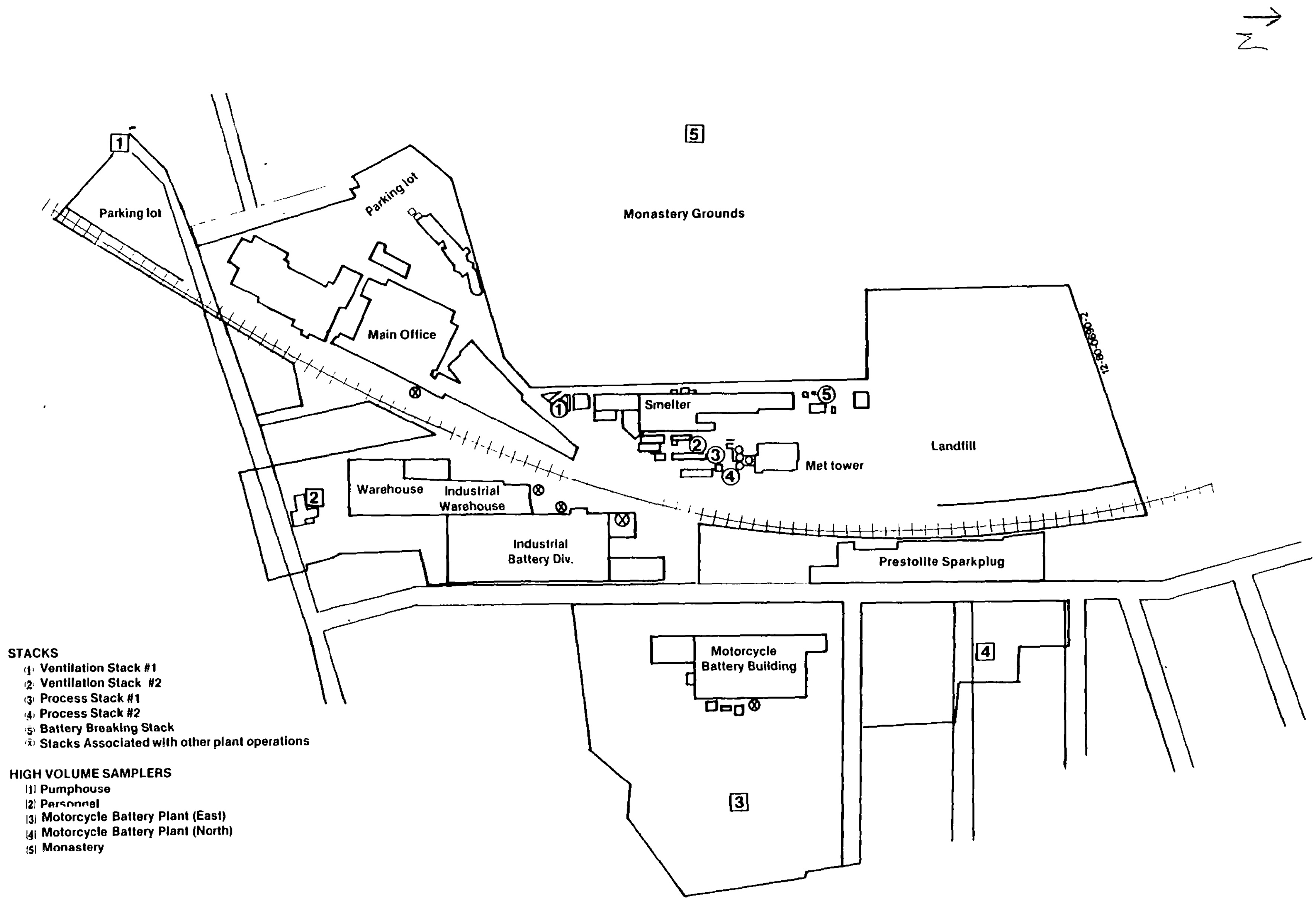


Figure 3. Plot Plan Showing Locations of Stacks and Ambient Monitoring Sites

SAMPLING APPROACH

The location of samplers in each of the individual plant areas are noted on plot plans in Section 5, Data Evaluation. A separate plot plan is included there for each sampling area and day.

Sampling Schedule

Sampling was conducted between September 2 and September 11, 1981. Table 5 shows the chronological sequence of the sampling effort. The battery storage, access road, and slag storage areas were sampled twice on separate days. The smelter building openings were sampled twice on the same day (September 11). Battery breaking and charge storage are adjacent to one another and were sampled simultaneously on three separate days.

Sampling at the areas was conducted over approximately an eight-hour period during the day shift at the plant. The second day of sampling at the access road was conducted on a Saturday. The slag storage area was sampled on a Sunday and Labor Day holiday. All other samples were taken during the working week. Surface samples on several plant sites were collected to determine surface dust loading, moisture content, percent silt, and lead concentration in the silt. Production at the plant during the period of September 1 through September 11, 1981 is presented in Table 6.

Sampling Procedures

High-Volume Sampling--

High volume air samplers were equipped with 20.3 cm x 25.4 cm (8 inches by 10 inches) glass fiber filters. The collection efficiency is 99.9% for 0.3 μDOP particles. The flow rates of all the hi-vols were calibrated before sampling. An NBS traceable standard orifice was used. The filters were equilibrated before and after sampling at constant humidity for at least 24 hours and then weighed. Sampling time, sampling flow rate and the particulate mass collected were used to calculate the total suspended particles (in micrograms per cubic meter). Suspended particulate lead in the air was determined on the same filters by chemical analysis.

High-Volume Particle Sizing--

These high-volume samplers were equipped with five-stage cascade impactors to provide particle size data in the range of 10 to 0.5 micrometers. The five-stage impactor fractionates particles according to their aerodynamic size. The aerodynamic size determines the penetration of particles in the human lung, the particle collection efficiency in pollution control equipment and the transport of particles through the air.

Low-Volume Samplers--

These sampling devices are supplied by Millipore, Incorporated. Their normal use is for aerosol monitoring. Figure 4 illustrates its components. A 37 mm filter is placed into a plastic filter cassette. An adapter is airtight connected to the filter cassette. A vacuum hose leads to a vacuum pump.

TABLE 5. SAMPLING SCHEDULE

Date	Area	Samples Taken
9/2/81	Area I: Battery Storage	2 HiVols, 1 impactor, 4 telescope poles, Met data
9/3/81	Area I: Battery Storage	3 HiVols, 2 impactors, 4 telescope poles, Met data, surface dust
9/4/81	Area V: Access Road	3 HiVols, 2 impactors, 4 telescope poles, Met data
9/5/81	Area V: Access Road	3 HiVols, 2 impactors, 4 telescope poles, Met data, surface dust
9/6/81	Area IV: Slag Storage	3 HiVols, 2 impactors, 4 telescope poles, Met data
9/7/81	Area IV: Slag Storage	3 HiVols, 2 impactors, 4 telescope poles, Met data, surface dust
9/8/81	Area II & III: Battery Breaking and Charge Storage	3 HiVols, 2 impactors Met data
9/9/81	Area II & III: Battery Breaking and Charge Storage	3 HiVols, 2 impactors, 5 telescope poles, Met data, surface dust
9/10/81	Area II & III: Battery Breaking and Charge Storage	3 HiVols, 2 impactors, 5 telescope poles, Met data
9/11/81	Smelter Building	15 low volume samples Velometer determinations at smelter building openings

TABLE 6. SMELTER OPERATION DURING THE SAMPLING PERIOD SEPTEMBER 1 THROUGH SEPTEMBER 11, 1981*

Date	Furnace Production Lbs. of Lead		Furnace Slag Lbs. of Slag		Lbs. Finished Kettles	# Batteries Broken	Feed Material in Lbs.	
	#2 Blast	#2 Reverb	#2 Blast	#2 Reverb			#2 Blast	#2 Reverb
9/1/81	133,610	171,000	42,700	49,000	400,666	4,614/9,441	155,330	286,500
9/2/81	117,280	171,000	46,200	39,200	560,788	4,680/13,503	147,750	276,700
9/3/81	88,720	99,000	24,750	57,800	235,571	5,589/17,067	85,500	195,300
9/4/81	102,260	87,000	67,650	16,600	498,801	5,415/17,187	169,350	137,433
9/5/81	146,700	174,000	75,900	38,200	452,584	0/0	205,460	281,867
9/6/81	178,710	216,000	55,650	64,400	562,039	0/0	207,000	364,399
9/7/81	203,530	216,000	43,350	65,600	272,861	0/0	247,500	365,500
9/8/81	152,410	192,000	61,050	51,800	555,000	0/9,602	197,970	318,600
9/9/81	163,320	186,000	78,750	56,000	190,108	0/9,434	163,840	102,900
9/10/81	148,120	147,000	42,900	46,900	421,259	0/9,529	121,500	251,100
9/11/81	151,775	144,000	62,700	51,000	579,653	0/6,431	183,020	251,000

*Blast furnace #1 and reverbatory furnace #1 were not in service during 1 September 1981 through 11 September 1981.

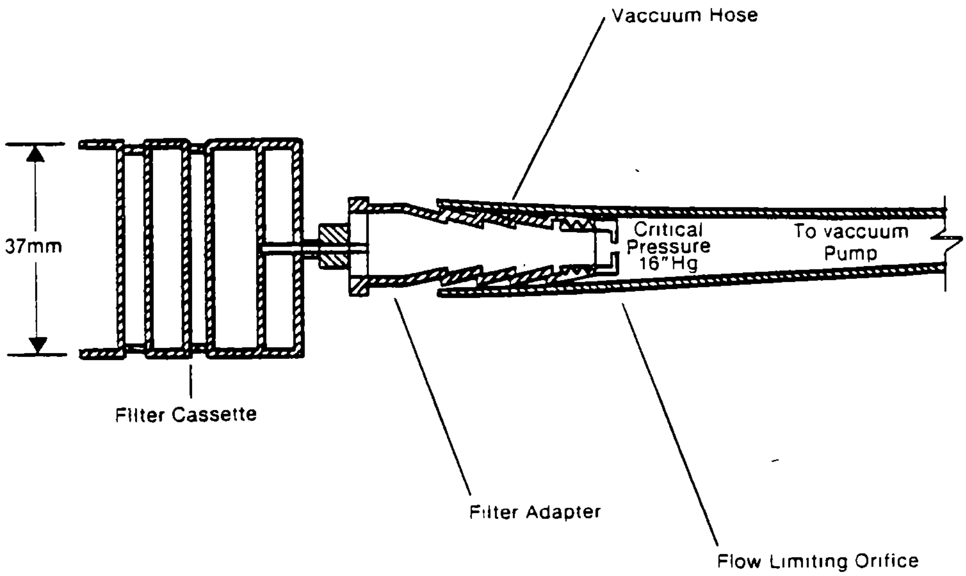


Figure 4. Sketch of Low Flow Sampling Device Consisting of 37mm Filter, Filter Cassette, Adapter and Flow Controlling Orifice

The flow through the device is regulated by the opening of the flow limiting orifice. The flow through the filter is constant for an applied vacuum $<16''$ mercury. Flow rates of 4.9 L/min and 10 L/min were used.

The cellulose membrane filter had a pore size of 0.8μ. After clogging of the pores, a collection efficiency of 99% for particles of 0.3μ diameter is reported.

These sampling devices have the following advantages over normal hi-vols:

- Their light weight allows easy elevation to measure the vertical concentration gradient,
- Several filters can be serviced by one vacuum pump,
- Flow is easily controlled by observing the vacuum gage,
- The filters may be assembled and disassembled easily and quickly,
- Filters are transported within the plastic cassette. Exit and entrance are closed by plastic caps when the filters are not in use,
- The filter devices can be assembled in a clean lab and need not be touched until analysis.

The main disadvantage is the small amount of air volume sampled. It is $2.3 m^3$ during an 8-hr sampling period if a 4.9 L/min orifice is used and $4.6 m^3$ if a 10 L/min orifice is attached. Sampling is below isokinetic.

ANALYTICAL PROCEDURES

The EPA method used to digest the lead was equivalent to Method EQL-0380-043. Lead in the filters is solubilized in a mixture of nitric acid and hydrochloric acid with the aid of heat and ultrasonication. After an appropriate dilution, the lead concentration was determined by Atomic Absorption Spectrophotometry (AAS) using an air-acetylene flame. In cases of low loading the more sensitive graphite furnace technique was applied.

QUALITY ASSURANCE

Sampling quality was assured by sampling each location twice.

Analytical quality assurance concentrated on repeatability and accuracy assessment. Instrument response was calibrated using commercially available reference solutions. Sample analysis proceeded only upon verification that: 1) the standards were internally consistent, and 2) analyte concentrations measured in standard reference materials were accurate.

Ten percent of the digestions and analyses were performed in duplicate to assess repeatability. Accuracy was tracked by spiking ten percent of the digests with known amounts of lead. Blank filters were analyzed to check background lead levels. Lead contamination was found to be minimal.

SECTION 4

RESULTS

This section contains the results obtained using the previously described techniques. The data collected through hivol sampling, pole sampling, and cascade impactor sampling are given, as well as the monitoring performed to determine fugitive emissions from the smelter. The results from ground sampling are presented, and the axle counts on the main access road are included. Presentation of meteorological data observed by smelter personnel, as well as that taken by Radian Corporation, are given next. The company operated 5 hivols around the plant. Total particulate and total lead recorded are given last.

HIVOL RESULTS

Measurements done by hivol sampling are summarized in Table 7. The columns shown in this table are the following:

- Hivol Identification
  - Filter number used for internal sample tracking,
  - Hivol number relates instrument number to flow rate calibration data,
  - Date.
- Location
  - Site Number: Relates to sample area indicated in Figure 3,
  - Code: Indicates sampler location and height used in sketches for areas 1 through 5 in Section 5.
- Sampling Time
  - Time on: Time of day at which sampling was started,
  - Time Off: Time of day at which sampling was terminated,
  - Min.: Elapsed time in minutes between Time On and Time Off.
- Sampling Volume
  - Chart Reading: Dimensionless number read off circular chart relating to flow rate through the sampler,

TABLE 7. AREA MONITORING DATA MATRIX - STANDARD HI-VOL SAMPLERS

HiVol Identification			Location		Sampling Time			Sampling Volume		Analytical Data				Total Particulates in Air	Pb Concentration in Air
Filter #	HiVol #	Date	Site #	Code	Time On	Time Off	Min	Chart Reading	Nm^3	W_I(g)	W_F(g)	ΔW(g)	µg Pb/ Filter	µg/Nm^3	µgPb/Nm^3
028247	4169	9/2/81	1	NW 4'	1000	1929	569	41.8	716.0	3.5562	3.6096	0.0534	4070	75	5.7
028249	4170	9/2/81	1	W10'	1009	1941	567	43.5	746.3	3.5416	3.6364	0.0948	18100	127	24.3
028299	4172	9/3/81	1	W10'	1018	1951*	483	63.0	955.2	3.6041	3.7104	0.1063	18700	111	19.6
028295	4169	9/3/81	1	NW 4'	0938	1820	522	50.6	795.2	3.6249	3.6624	0.0375	1140	47	1.4
028296	4170	9/3/81	1	W16'	1020	1951*	481	60.0	873.2	3.6098	3.6840	0.0742	10400	85	11.9
028289	4169	9/4/81	5	W 4'	0910	1838	568	55.5	949.0	3.5957	3.7691	0.1734	52800	183	55.6
028292	4170	9/4/81	5	NW10'	0925	1849	564	59.0	1006.8	3.6121	3.7376	0.1255	26600	125	24.4
028294	4172	9/4/81	5	SE16'	0858	1829	571	47.8	856.8	3.6259	3.7205	0.0946	15700	110	18.3
028285	4171	9/5/81	5	NW16'	0903	1711	488	60.3	894.1	3.5958	3.6698	0.0740	8260	83	9.2
028286	4169	9/5/81	5	W 4'	0843	1705	502	56.5	853.9	3.5998	3.7340	0.1324	20400	155	24.9
028287	4168	9/5/81	5	SE10'	0834	1646	492	58.8	884.7	3.5889	3.6913	0.1024	12600	116	14.2
028279	4169	9/6/81	4	S 4'	1023	1747	444	61.5	822.1	3.5834	3.6434	0.0600	5660	73	6.9
028280	4171	9/6/81	4	E16'	0934	1734	480	53.8	784.6	3.6055	3.8415	0.2360	66200	301	84.4
028282	4168	9/6/81	4	Roof	0900	1717	497	56.8	863.3	3.5853	3.6379	0.0526	4430	61	5.1
028274	4169	9/7/81	4	S 4'	0810	1715	545	61.5	1009.1	3.6141	3.6607	0.0466	3840	46	3.8
028275	4170	9/7/81	4	E10'	0758	1729	571	56.5	976.2	3.5988	3.7455	0.1467	37000	150	37.9
028278	4172	9/7/81	4	Roof	0740	1657	557	53.3	932.0	3.5912	3.8468	0.2526	80200	271	86.1
028268	4172	9/8/81	3/2	S 4'	1001	1418	257	62.0	500.2	3.6064	4.2049	0.5985	19600	1197	39.2
028269	4171	9/8/81	3/2	W10'	0853	1418	325	45.0	444.4	3.6130	3.8095	0.1965	66200	442	149.0
028272	4170	9/8/81	3/2	N10'	0821	1418	357	49.5	534.7	3.6202	3.8643	0.2441	69600	457	130.2
028263	4172	9/9/81	3/2	N 4'	0946	1824	518	59.3	964.3	3.3238	3.4021	0.0783	11100	81	11.5
028265	4168	9/9/81	3/2	S10'	0929	1810	521	57.3	912.9	3.6190	4.0417	0.4227	180000	463	197.2
028266	4169	9/9/81	3/2	W16'	0824	1753	569	57.5	985.0	3.6184	3.8369	0.2185	78200	222	79.4
028258	4172	9/10/81	3/2	N 4'	0912	1802	530	57.5	956.7	3.4374	3.6055	0.1681	43000	176	44.9
028259	4171	9/10/81	3/2	W10'	0826	1751	565	57.0	978.5	3.3518	3.6374	0.2856	97900	292	100.1
028261	4168	9/10/81	3/2	S10'	0803	1739	576	64.0	1127.3	3.3394	3.9301	0.5907	309000	524	274.1

*Down for 90 minutes.

- Nm^3: Sample volume obtained from relating chart reading to calibration curve for sampler at standard conditions, (25°C, 760 mmHg).

- Analytical Data

  - W_I(g): Initial weight (in grams) of the filter,
  - W_F(g): Final weight (in grams) of the filter,
  - ΔW(g): Difference (in grams) between W_F and W_I,
  - µgPb/filter: Results of chemical analysis for lead performed on the filter.

- Total Particulates/Nm^3: Total particulate loading of sampled air determined from ΔW and Nm^3,

- Pb Concentration in Air µgPb/Nm^3: Total lead in sampled air, determined from µgPb/filter and Nm^3.

General sampling showed no peculiarities with the exception of 9/3/81 1W10' and 1W16' where gasoline generator supplying power was shut down for 90 minutes. Generators were used with unleaded gasoline in Area I only.

CASCADE IMPACTOR RESULTS

Hivol data necessary for the determination of total particulate and total lead concentrations were complemented by measurements utilizing standard hi-vols fitted with Sierra 5 stage cascade impactors. The evaluation of the field data is documented in Table 8. The meaning of the individual columns is as follows:

- Cascade Impactor Identification

  - Filter #: Number of filter used for internal sample tracking,
  - Hivol #: Relates instrument number to flow rate calibration data,
  - Cascade Impactor #: Relates impactor number to flow rate calibration data,
  - Stage #: Relates filter number to particle size fraction,
  - Date

- Location

  - Site #: Relates to sample area indicated in Figure 3,
  - Code: Same code is used to indicate sampler location and height used in sketches for areas 1-5 in Section 5.

- Sampling Time

  - Time On: Time of day at which sampling was started,
  - Time Off: Time of day at which sampling was terminated,
  - Min.: Elapsed time in minutes between Time On and Time Off.

TABLE 8. AREA MONITORING DATA MATRIX - CASCADE IMPACTOR SUBSTRATES

Cascade Impactor Identification					Location		Sampling Time			Sampling Volume			Analytical Data			
Filter #	Hivol #	Cascade Impactor #	Stage #	Date	Site #	Code	Time On	Time Off	Min	Chart Reading	Actual	Nm^3	W_I(g)	W_F(g)	ΔW(g)	μg Pb/ Filter
000194	4171	4143	1	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	1.4364	1.4496	0.0132	2730
195	4171	4143	2	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	1.4202	1.4346	0.0144	2700
196	4171	4143	3	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	1.3942	1.4000	0.0058	960
197	4171	4143	4	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	1.4048	1.4093	0.0045	838
198	4171	4143	5	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	1.4143	1.4165	0.0022	606
028248	4171	4143	HiVol	9/2/81	1	W10'	1000	1936	576	34.0	592.1	595.0	3.5559	3.5798	0.0239	3180
000189	4171	4142	1	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	1.4186	1.4248	0.0062	1410
190	4171	4142	2	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	1.4342	1.4413	0.0071	1230
191	4171	4142	3	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	1.4230	1.4260	0.0030	567
192	4171	4142	4	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	1.4582	1.4630	0.0048	567
193	4171	4142	5	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	1.4088	1.4141	0.0053	373
028298	4171	4142	HiVol	9/3/81	1	W10'	1020	1951*	481	37.3	544.0	545.1	3.6108	3.6462	0.0354	1390
000145	4168	4143	1	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	1.4132	1.4234	0.0102	1340
146	4168	4143	2	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	1.4080	1.4190	0.0110	1280
147	4168	4143	3	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	1.3725	1.3787	0.0062	4610
148	4168	4143	4	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	1.3947	1.4010	0.0063	446
149	4168	4143	5	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	1.3947	1.4030	0.0083	322
028297	4168	4143	HiVol	9/3/81	1	W16'	1018	1951*	483	42.5	626.4	627.7	3.6299	3.6272	0.0027	1600
000135	4171	4142	1	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	1.3981	1.4167	0.0186	3580
136	4171	4142	2	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	1.4040	1.4246	0.0206	3400
137	4171	4142	3	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	1.3903	1.4012	0.0109	1200
138	4171	4142	4	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	1.4006	1.4099	0.0093	701
139	4171	4142	5	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	1.4132	1.4224	0.0112	335
028291	4171	4142	HiVol	9/4/81	5	NW16'	0925	1844	559	39.5	668.6	670.9	3.6087	3.6237	0.0150	960
000140	4168	4143	1	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	1.3975	1.4172	0.0197	2770
141	4168	4143	2	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	1.3969	1.4150	0.0211	2910
142	4168	4143	3	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	1.4247	1.4348	0.0101	130
143	4168	4143	4	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	1.3958	1.4066	0.0108	106
144	4168	4143	5	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	1.3897	1.3996	0.0099	560
028293	4168	4143	HiVol	9/4/81	5	SE10'	0903	1825	566	42.5	733.1	735.6	3.6229	3.6470	0.0241	2470
000130	4170	4142	1	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	1.3966	1.4086	0.0120	138
131	4170	4142	2	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	1.4154	1.4287	0.0133	127
132	4170	4142	3	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	1.4041	1.4119	0.0078	499
133	4170	4142	4	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	1.4130	1.4228	0.0098	470
134	4170	4142	5	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	1.4101	1.4213	0.0112	223
028284	4170	4142	HiVol	9/5/81	5	NW10'	0905	1711	486	40.0	577.5	588.2	3.5924	3.6047	0.0123	588
000125	4172	4143	1	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	1.4200	1.4338	0.0138	1310
126	4172	4143	2	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	1.4091	1.4244	0.0153	1180
127	4172	4143	3	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	1.4085	1.4173	0.0088	522
128	4172	4143	4	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	1.3978	1.4090	0.0112	470
129	4172	4143	5	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	1.4115	1.4240	0.0125	246
028288	4172	4143	HiVol	9/5/81	5	NW10'	0834	1646	492	44.5	674.8	687.3	3.5928	3.6125	0.0197	780
000115	4170	4142	1	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	1.4077	1.4448	0.0371	9630
116	4170	4142	2	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	1.4127	1.4469	0.0342	7560
117	4170	4142	3	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	1.4181	1.4372	0.0191	3950
118	4170	4142	4	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	1.3849	1.4076	0.0227	4400
119	4170	4142	5	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	1.4080	1.4300	0.0220	3260
028281	4170	4142	HiVol	9/6/81	4	E10'	0928	1734	486	37.8	545.7	549.0	3.5999	3.6325	0.0326	3890

- Continued

TABLE 8. AREA MONITORING DATA MATRIX - CASCADE IMPACTOR SUBSTRATES (Continued)

Cascade Impactor Identification					Location		Sampling Time			Sampling Volume			Analytical Data			
Filter #	Hivol #	Cascade Impactor #	Stage #	Date	Site #	Code	Time On	Time Off	Min	Chart Reading	Actual	Nm^3	W_I(g)	W_F(g)	ΔW(g)	µg Pb/ Filter
000120	4172	4143	1	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	1.4197	1.4277	0.0080	472
121	4172	4143	2	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	1.3825	1.3917	0.0092	493
122	4172	4143	3	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	1.4240	1.4315	0.0075	299
123	4172	4143	4	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	1.4160	1.4270	0.0110	324
124	4172	4143	5	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	1.4044	1.4109	0.0065	240
028283	4172	4143	HiVol	9/6/81	4	Roof	0900	1717	497	42.3	656.0	660.0	3.5861	3.5980	0.0113	816
000105	4171	4142	1	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	1.4131	1.4277	0.0146	3040
106	4171	4142	2	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	1.3866	1.3979	0.0113	2010
107	4171	4142	3	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	1.4027	1.4104	0.0077	796
108	4171	4142	4	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	1.4038	1.4134	0.0096	689
109	4171	4142	5	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	1.3891	1.3977	0.0086	415
028276	4171	4142	HiVol	9/7/81	4	E16'	0758	1729	571	33.0	564.8	572.5	3.6096	3.6256	0.0160	2050
000110	4168	4143	1	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	1.3962	1.4328	0.0366	9740
111	4168	4143	2	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	1.4025	1.4337	0.0312	8320
112	4168	4143	3	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	1.3940	1.4102	0.0162	3980
113	4168	4143	4	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	1.3970	1.4171	0.0201	4680
114	4168	4143	5	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	1.4065	1.4249	0.0184	3220
028277	4168	4143	HiVol	9/7/81	4	Roof	0740	1657	557	41.3	694.0	703.5	3.5969	3.6391	0.0422	6420
000100	4168	4143	1	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	1.4036	1.4337	0.0301	8290
101	4168	4143	2	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	1.4165	1.4413	0.0248	5560
102	4168	4143	3	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	1.4209	1.4345	0.0136	2680
103	4168	4143	4	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	1.3909	1.4035	0.0126	2150
104	4168	4143	5	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	1.3996	1.4112	0.0116	1470
028273	4168	4143	HiVol	9/8/81	3/2	N16'	0823	1417	354	37.0	398.2	400.5	3.6080	3.6406	0.0326	7810
000094	4169	4142	1	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	1.4341	1.4588	0.0247	7390
095	4169	4142	2	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	1.4122	1.4319	0.0197	6040
096	4169	4142	3	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	1.4221	1.4320	0.0099	3000
097	4169	4142	4	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	1.4275	1.4381	0.0106	3170
098	4169	4142	5	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	1.4362	1.4423	0.0061	1860
028271	4169	4142	HiVol	9/8/81	3/2	W16'	0853	1418	325	42.5	413.4	415.8	3.6073	3.6470	0.0397	6440
000084	4171	4142	1	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	1.4275	1.4724	0.0449	15000
085	4171	4142	2	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	1.4000	1.4166	0.0166	5400
086	4171	4142	3	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	1.4388	1.4487	0.0099	3470
087	4171	4142	4	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	1.4453	1.4546	0.0093	3920
088	4171	4142	5	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	1.3968	1.4026	0.0058	2390
028267	4171	4142	HiVol	9/9/81	3/2	W10'	0824	1753	569	39.5	677.5	682.9	3.6152	3.6478	0.0326	11700
000089	4170	4142	1	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	1.4212	1.4565	0.0353	15400
090	4170	4142	2	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	1.4281	1.4515	0.0234	10200
091	4170	4142	3	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	1.4313	1.4423	0.0110	5320
092	4170	4142	4	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	1.4301	1.4457	0.0156	6840
093	4170	4142	5	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	1.4490	1.4601	0.0111	4800
028264	4170	4142	HiVol	9/9/81	3/2	S16'	0932	1810	518	43.5	676.4	681.8	3.6169	3.7280	0.1111	29300
000074	4170	4142	1	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	1.4077	1.4411	0.0334	13700
075	4170	4142	2	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	1.4532	1.4785	0.0253	9200
076	4170	4142	3	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	1.4167	1.4314	0.0147	6120
077	4170	4142	4	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	1.4459	1.4656	0.0197	6920
078	4170	4142	5	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	1.4286	1.4480	0.0194	7000
028262	4170	4142	HiVol	9/10/81	3/2	S16'	0803	1739	576	40.0	687.2	697.1	3.3688	3.5095	0.1407	53800

- Continued

TABLE 8. AREA MONITORING DATA MATRIX - CASCADE IMPACTOR SUBSTRATES (Continued)

Cascade Impactor Identification					Location		Sampling Time			Sampling Volume			Analytical Data			
Filter #	Hivol #	Cascade Impactor #	Stage #	Date	Site #	Code	Time On	Time Off	Min	Chart Reading	Actual	Nm^3	W_I(g)	W_F(g)	ΔW(g)	µg Pb/ Filter
000079	4169	4143	1	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	1.4137	1.4356	0.0219	6640
080	4169	4143	2	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	1.4326	1.4475	0.0149	4480
081	4169	4143	3	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	1.4269	1.4361	0.0092	2480
082	4169	4143	4	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	1.3889	1.3968	0.0079	2400
083	4169	4143	5	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	1.4410	1.4481	0.0071	1670
028260	4169	4143	HiVol	9/10/81	3/2	W16'	0826	1751	565	39.5	662.4	671.9	3.3312	3.3831	0.0519	8540

WI - Initial filter weight.
WF - Final filter weight.
* - Down for 90 minutes.

- Sampling Volume

  - Chart reading: dimensionless number read off circular chart relating to flow rate through the sampler,
  - Actual: volume of air sampled under on-site conditions,
  - Nm^3: Sample volume obtained from relating chart reading to calibration curve for sampler at standard conditions (25°C, 760 mmHg).

  Analytical Data

  - W_I(g): Initial weight in grams of the substrate or filter,
  - W_F(g): Final weight in grams of the substrate or filter,
  - ΔW(g): Difference in grams between W_F and W_I,
  - μgPb/Filter: Results of chemical analysis for lead performed on the substrates or filter.

POLE SAMPLER RESULTS

Further monitoring of lead concentrations in air was achieved by means of Millipore Aerosol Monitors (# MAWP037A0) mounted on telescoping poles at heights of 10 feet, 20 feet, and 30 feet, connected to vacuum pumps on the ground. The filters contained in the monitors (henceforth referred to as "pole samplers") were then analyzed for lead content.

The data obtained by this method is listed in Table 9. The columns in this table are as follows:

- Pole Sampler Identification

  - Filter #: Assigned number used for internal sample tracking,
  - Site #: relates to sample area indicated in Figure 3,
  - Date,
  - Monitor Pole ID & Height: Indicates position within sample area and height used in sketches of Areas 1 through 5 in Section 5.

- Sampling Time

  - Time On: Time of day at which sampling was started,
  - Time Off: Time of day at which sampling was terminated,
  - Min.: Elapsed time in minutes between Time On and Time Off.

TABLE 9. AIR MONITORING DATA MATRIX - POLE SAMPLERS

Filter #	Site #	Date	Monitor Pole ID & Height	Sampling Time			Pole Sampler Calibration			Analytical Data µg/Pb/Filter	Pb Concentration in Air (µg/Nm³)
				Time On	Time Off	Min	Rotameter Reading	m³/min	Nm³ Sampled		
101	1	9/2/81	SE 30'	1410	2245	515	26.0	.00606	3.12	<10	<3.2
102	1	9/2/81	SE 20'	1410	2245	515	25.5	.00594	3.06	<10	<3.3
103	1	9/2/81	SE 10'	1410	2245	515	25.5	.00594	3.06	<10	<3.3
104	1	9/2/81	SW 30'	1015	2015	600	21.0	.00483	2.90	<10	<3.5
105	1	9/2/81	SW 20'	1015	2015	600	20.5	.00471	2.83	56	19.8
106	1	9/2/81	SW 10'	1015	2015	600	21.0	.00483	2.90	<10	<3.5
107	1	9/2/81	W 30'	1009	1950	581	19.5	.00447	2.60	<10	<3.9
108***	1	9/2/81	W 20'	1009	1950	581	21.0	.00483	2.81	13.2	4.7
109***	1	9/2/81	W 10'	1009	1950	581	20.5	.00471	2.73	25	9.2
110	1	9/2/81	NW 30'	0940	1931	591	20.5	.00471	2.78	<10	<3.6
111	1	9/2/81	NW 20'	0940	1931	591	20.0	.00459	2.71	<10	<3.7
112	1	9/2/81	NW 10'	0940	1931	591	20.0	.00459	2.71	40*	14.7
116	1	9/3/81	NW 30'	0938	1821	523	20.0	.00459	2.40	<10	<4.17
117	1	9/3/81	NW 20'	0938	1821	523	19.5	.00447	2.34	<10	<4.3
118	1	9/3/81	NW 10'	0938	1821	523	20.0	.00459	2.40	<10	<4.2
119	1	9/3/81	W 30'	1015	1829	494	20.0	.00459	2.27	<10	<4.4
120***	1	9/3/81	W 20'	1015	1829	494	20.5	.00471	2.33	28	12.0
128***	1	9/3/81	W 10'	1015	1829	494	19.0	.00434	2.14	19	9.0
122	1	9/3/81	SW 30'	0945	1836	531	20.5	.00471	2.50	68	27.2
123	1	9/3/81	SW 20'	0945	1836	531	20.0	.00459	2.44	107	43.9
124	1	9/3/81	SW 10'	0945	1836	531	20.0	.00459	2.44	65	26.7
125	1	9/3/81	SE 30'	0947	1843**	500	23.5	.00545	2.73	<10	<3.7
126	1	9/3/81	SE 20'	0947	1843**	500	24.0	.00557	2.79	<10	<3.6
127	1	9/3/81	SE 10'	0947	1843**	500	26.0	.00606	3.03	<10	<3.3
131	5	9/4/81	SE 30'	0856	1828	572	20.5	.00471	2.69	44*	16.3
132***	5	9/4/81	SE 20'	0856	1828	572	20.0	.00459	2.69	12	4.5
133***	5	9/4/81	SE 10'	0856	1828	572	20.0	.00459	2.62	29	11.0
134	5	9/4/81	SW 30'	0856	1831	575	20.5	.00471	2.71	<10	<3.7
135***	5	9/4/81	SW 20'	0856	1831	575	19.5	.00447	2.57	14	5.4
136***	5	9/4/81	SW 10'	0856	1831	575	20.5	.00471	2.71	21	7.6
137***	5	9/4/81	NW 30'	0937	1852	555	20.0	.00459	2.55	22	8.4
138***	5	9/4/81	NW 20'	0937	1852	555	20.5	.00471	2.61	21	8.1
139***	5	9/4/81	NW 10'	0937	1852	555	19.0	.00434	2.41	19	8.0
140	5	9/4/81	NE 30'	0947	1845	538	25.0	.00582	3.13	175	55.9
141	5	9/4/81	NE 20'	0947	1845	538	25.5	.00594	3.20	164	51.3
142	5	9/4/81	NE 10'	0947	1845	538	26.0	.00606	3.26	347	106.4
143	5	9/5/81	SE 30'	0838	1646	488	20.5	.00471	2.30	<10	<4.4
144***	5	9/5/81	SE 20'	0838	1646	488	19.5	.00447	2.18	2.9	1.4
145	5	9/5/81	SE 10'	0838	1646	488	-	-	-	<10	-
146	5	9/5/81	SW 30'	0852	1708	496	20.5	.00471	2.34	<10	<4.3
147***	5	9/5/81	SW 20'	0852	1708	496	20.0	.00459	2.28	2.7	1.2
148***	5	9/5/81	SW 10'	0852	1708	496	20.5	.00471	2.34	4.3	1.8
149	5	9/5/81	NW 30'	0911	1718	487	20.5	.00471	2.29	<10	<4.4
150***	5	9/5/81	NW 20'	0911	1718	487	20.5	.00471	2.29	3.6	1.6
151***	5	9/5/81	NW 10'	0911	1718	487	19.5	.00447	2.18	8.0	3.7
152	5	9/5/81	NE 30'	0920	1727	487	25.0	.00582	2.83	47*	16.6
153	5	9/5/81	NE 20'	0920	1727	487	25.0	.00582	2.83	66	23.3
154	5	9/5/81	NE 10'	0920	1727	487	25.0	.00582	2.83	99	35.0
155	4	9/6/81	W 30'	0813	1723	550	20.5	.00471	2.59	209	81.0
156	4	9/6/81	W 20'	0813	1723	550	20.0	.00459	2.52	159	63.0
157	4	9/6/81	W 10'	0813	1723	550	20.5	.00471	2.59	75	29.0
158	4	9/6/81	E 30'	0829	1715	526	20.5	.00471	2.48	106	43.0
159	4	9/6/81	E 20'	0829	1715	526	20.0	.00459	2.41	148	61.0
160	4	9/6/81	E 10'	0829	1715	526	20.5	.00471	2.48	185	75.0
161	4	9/6/81	N 30'	0915	1732	497	25.0	.00582	2.89	102	35.0
162	4	9/6/81	N 20'	0915	1732	497	25.0	.00582	2.89	968	335.0
163	4	9/6/81	N 10'	0915	1732	497	26.0	.00607	3.01	501	166.0
164	4	9/6/81	S 30'	1000	1750	470	20.5	.00471	2.22	<10	<4.5
165	4	9/6/81	S 20'	1000	1750	470	20.5	.00471	2.22	<10	<4.5
166	4	9/6/81	S 10'	1000	1750	470	19.5	.00447	2.10	<10	<4.8
001	4	9/7/81	N 30'	0752	1653	541	25.0	.00582	3.15	316	100.0
002	4	9/7/81	N 20'	0752	1653	541	25.0	.00582	3.15	606	192.0
003	4	9/7/81	N 10'	0752	1653	541	26.0	.00607	3.28	522	159.0
004	4	9/7/81	W 30'	0805	1658	533	20.0	.00459	2.45	72*	29.0
005	4	9/7/81	W 20'	0805	1658	533	20.0	.00459	2.45	110	45.0
006	4	9/7/81	W 10'	0805	1658	533	20.0	.00459	2.45	122	50.0
007	4	9/7/81	E 30'	0816	1703	527	20.5	.00471	2.48	167	67.0
008	4	9/7/81	E 20'	0816	1703	527	20.0	.00459	2.42	61	25.0

TABLE 9. AIR MONITORING DATA MATRIX - POLE SAMPLERS (Continued)

Filter #	Site #	Date	Monitor Pole ID & Height	Sampling Time: Time On	Sampling Time: Time Off	Sampling Time: Min	Pole Sampler Calibration: Rotameter Reading	Pole Sampler Calibration: m^3/min	Pole Sampler Calibration: Nm^3 Sampled	Analytical Data µg/Pb/Filter	Pb Concentration in Air ($\mu g/Nm^3$)
009	4	9/7/81	E 10'	0816	1703	527	20.0	.00459	2.42	31*	13.0
010	4	9/7/81	S 30'	0830	1709	519	20.5	.00471	2.45	<10	<4.1
011	4	9/7/81	S 20'	0830	1709	519	20.5	.00471	2.45	<10	<4.1
012	4	9/7/81	S 10'	0830	1709	519	19.5	.00447	2.32	<10	<4.3
038	3/2	9/9/81	W 30'	1018	1823	485	20.0	.00459	2.23	49*	22.0
039	3/2	9/9/81	W 20'	1018	1823	485	19.5	.00447	2.17	133	61.0
040	3/2	9/9/81	W 10'	1018	1823	485	20.0	.00459	2.23	240	108.0
035	3/2	9/9/81	E 30'	1010	UNKNOWN	VOID	VOID	VOID	VOID	VOID	VOID
036	3/2	9/9/81	E 20'	1010	UNKNOWN	VOID	VOID	VOID	VOID	VOID	VOID
037	3/2	9/9/81	E 10'	1010	UNKNOWN	VOID	VOID	VOID	VOID	VOID	VOID
041	3/2	9/9/81	N 30'	1031	1830	479	20.0	.00459	2.20	<10	<4.5
042	3/2	9/9/81	N 20'	1031	1830	479	20.0	.00459	2.20	<10	<4.5
043***	3/2	9/9/81	N 10'	1031	1830	479	20.0	.00459	2.20	7.5	3.5
032	3/2	9/9/81	SW 30'	1001	1805	484	24.0	.00557	2.70	206	76.0
033	3/2	9/9/81	SW 20'	1001	1805	484	24.0	.00557	2.70	381	141.0
034	3/2	9/9/81	SW 10'	1001	1805	484	25.0	.00582	2.82	808	287.0
028	3/2	9/9/81	SE 30'	1001	1805	484	21.0	.00484	2.34	255	109.0
029	3/2	9/9/81	SE 20'	1001	1805	484	20.5	.00471	2.28	888	389.0
030	3/2	9/9/81	SE 10'	1001	1805	484	19.5	.00447	2.16	324	150.0
044	3/2	9/10/81	N 30'	0823	1736	553	20.0	.00459	2.54	<10	<3.9
045	3/2	9/10/81	N 20'	0823	1736	553	19.5	.00447	2.47	33*	13.4
046	3/2	9/10/81	N 10'	0823	1736	553	20.0	.00459	2.54	39*	15.4
047	3/2	9/10/81	SE 30'	0901	1748	527	20.0	.00459	2.42	148	61.0
048	3/2	9/10/81	SE 20'	0901	1748	527	19.5	.00447	2.35	234	99.0
049	3/2	9/10/81	SE 10'	0901	1748	527	19.5	.00447	2.35	215	91.0
050	3/2	9/10/81	SW 30'	0901	1756	535	20.0	.00459	2.46	228	93.0
051	3/2	9/10/81	SW 20'	0901	1756	535	20.0	.00459	2.46	215	88.0
052	3/2	9/10/81	SW 10'	0901	1756	535	19.5	.00447	2.39	219	92.0
053	3/2	9/10/81	E 30'	0914	1805	531	24.5	.00570	3.03	228	75.0
054	3/2	9/10/81	E 20'	0914	1805	531	24.5	.00570	3.03	185	61.0
055	3/2	9/10/81	E 10'	0914	1805	531	25.0	.00582	3.09	291	94.0
056	3/2	9/10/81	W 30'	0924	1813	529	20.0	.00459	2.43	<10	<4.1
057	3/2	9/10/81	W 20'	0924	1813	529	20.5	.00471	2.49	91	36.0
059	3/2	9/10/81	W 10'	0924	1813	529	19.5	.00447	2.36	120	51.0

*Indicates level is within 5 times minimum detection limit.
**Down for 30 minutes.
***Analyzed by graphite furnace attachment, all other values by flame A.A.

- Pole Sampler Calibration

  - Rotameter Reading: Reading of flow rate through sampler by a calibrated rotameter,
  - m^3/min: Flow rate in m^3/min from rotameter calibration curve,
  - Nm^3 Sampled: Normal cubic meters drawn through sampler during sampling period.

- Analytical Data - µg Pb/Filter

  - Results of chemical analysis for lead performed on pole sampler filter.

- Pb Concentration in Air (µg Pb/Nm^3)

  - Calculated concentration of lead in air volume sampled.

SMELTER AREA SAMPLER RESULTS

Monitoring of lead concentrations in air around and from the smelter building was achieved by mounting Millipore Aerosol Monitors (# MAWP037A0) at strategic positions in openings to the smelter. The samplers were connected to vacuum pumps with vacuum hose. The filters contained in the monitors were then analyzed for lead content.

The data obtained from this series of tests is listed in Table 10. The columns in this table are as follows:

- Sampler Identification

  - Filter #: Assigned number used for internal sample tracking,
  - Site: Smelter building
  - Date,
  - Location: Position of sampler at smelter building (see Figure 5). Numbers refer to sampling points indicated in Figure 5.

- Sampling Time

  - Time On: Time of day at which sampling was started,
  - Time Off: Time of day at which sampling was terminated,
  - Min.: Elapsed time in minutes between Time On and Time Off.

- Sampler Calibration

  - Rotameter Reading: Reading of flow rate through sampler by a calibrated rotameter,
  - m^3/min: Flow rate in m^3/min from rotameter calibration curve,
  - Nm^3: Normal cubic meters drawn through sampler during sampling period.

TABLE 10. AIR MONITORING DATA MATRIX - SMELTER AREA SAMPLERS

Filter #	Site #	Date	Location	Sampling Time: Time On	Time Off	Min	Sampler Calibration: Rotameter Reading	m³/min	Nm³ Sampled	Anatylitcal Data µgPb/Filter	Pb Concentration in Air (µg/Nm³)
061	Charging Area	9/11/81	Charging Area (1)	0926	1215						
			Entry 6'	1335	1457	251	20.0	.00459	1.15	1150	1000
062	Charging Area	9/11/81	Charging Area (2)	0926	1215						
			Opening 10'	1335	1457	251	20.0	.00459	1.15	851	740
063	Smelter Bldg.	9/11/81	5: Bottom Inlet								
			S8'	0930	1501	331	40.0	.00936*	3.10	305	98
064	Smelter Bldg.	9/11/81	4: Bottom Inlet								
			N8'	0930	1501	331	40.0	.00936*	3.10	750	242
068	Smelter Bldg.	9/11/81	7: Lead Well W End 8'	0933	1504	331	20.0	.00459	1.52	632	416
069	Smelter Bldg.	9/11/81	6: Lead Well E End 5'	0933	1504	331	20.0	.00459	1.52	491	323
070	Charging Area	9/11/81	Charging Area (1)								
			Entry 6'	1500	2046	346	20.0	.00459	1.59	838	527
071	Charging Area	9/11/81	Charging Area (2)								
			Opening 10'	1500	2046	346	20.0	.00459	1.59	689	433
072	Smelter Bldg.	9/11/81	5: Bottom Inlet S 8'	1503	2051	348	40.0	.00936*	3.26	1040	319
073	Smelter Bldg.	9/11/81	4: Bottom Inlet N 8'	1503	2051	348	40.0	.00936*	3.26	884	271
075	Smelter Bldg.	9/11/81	7: Lead Well W 8'	1505	2052	347	20.0	.00459	1.59	293	184
074	Smelter Bldg.	9/11/81	6: Lead Well E 5'	1505	2052	347	20.0	.00459	1.59	293	184
077	Smelter Bldg.	9/11/81	1: Penthouse N Top	1515	1753	158	40.0	.00936*	1.48	1790	1290
076	Smelter Bldg.	9/11/81	3: Penthouse S Top	1515	1753	158	40.0	.00936*	1.48	1680	1135
078	Smelter Bldg.	9/11/81	2: Penthouse Bottom	1515	1753	158	40.0	.00936*	1.48	1690	1142

*10 LPM orifice. All others 4.9 LPM.

- Analytical Data - µg Pb/Filter

  - Results of chemical analysis for lead performed on pole sampler filter.

- Pb Concentration in Air (µgPb/Nm^3)

  - Calculated concentration of lead in air.

Flow into and out of smelter building were obtained by means of a wind velometer. Measured values are listed in the table notated "Air Flow" in Figure 5.

GROUND SAMPLE RESULTS

Dust loading in Areas 1 through 5 was determined by sweeping five areas of several m^2 with a paintbrush and dustpan. Five stripes across the road in Area 5 were collected. Samples were kept in airtight plastic bottles and transported back to the laboratory. Percent moisture was determined by weighing the samples, drying them by heating to 105°C for eight to ten hours, and reweighing. The difference was compared to the first weighing.

Next the samples were sieved using a 200 mesh sieve to determine their respective fractions of <75 µm (200 mesh). The size fraction <75 µm is defined in the literature as percent silt in dust loading. Particles in this range are potentially entrained by wind and vehicular traffic. Smaller than 200 mesh fractions were analyzed for lead. Results are given in percent by weight of dry sample in Table 11.

TRAFFIC COUNTER RESULTS

An estimate of vehicular traffic through the plant was obtained by means of using a rubber tubing axle counter placed across the paved road in two different locations. The locations were next to the main personnel building and in the center of Area 5 next to the SLI building. The following observations were made:

Personnel Building -

From 9/2/81 0900 to 9/3/81 0949 - 802 counts/25 hr

SLI Building -

From 9/4/81 1053 to 9/5/81 0958 - 668 counts/23 hr
From 9/8/81 1045 to 9/9/81 1135 - 687 counts/25 hr

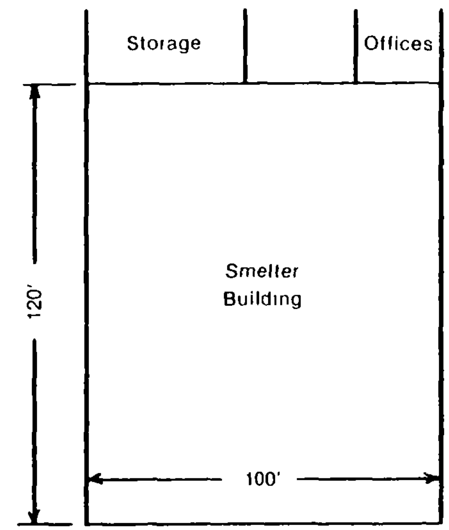
These figures translate to 770 axles/day at the personnel building and 697 and 660 at the SLI building. The difference of about 90 axles can be accounted for by forklifts transporting reverb slag from the south side of the smelter to the charge make-up area at the north side. The average 680 axles/day measured at the SLI plant are accounted for as follows:

KEY
•Aerosol Analysis Monitors

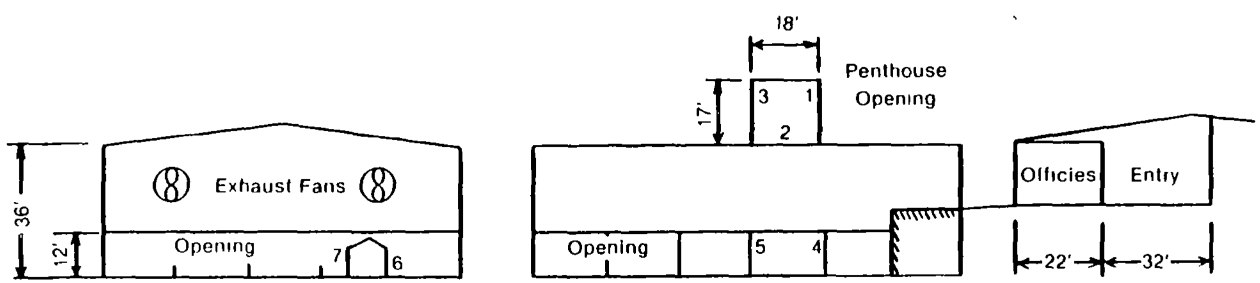
AIR FLOW

	Sampling Location — Point in Drawing	Air Flow m/sec	
Penthouse Top	1 & 3	1 5	out*
Penthouse Bottom	2	0 35	out*
Bottom Inlet N & S	4 &5	0 40	in*
Leadwell E6	6	0 10	in*
Leadwell W	7	0 40	in*

*Refers to air flow out of or into smelter building



PLAN VIEW



SOUTH ELEVATION **EAST ELEVATION** **NORTH ELEVATION**

Figure 5. Sampling Locations for Smelter Building Sept. 11, 1981.

TABLE 11. GROUND SAMPLE RESULTS

Area	Surface Area (m^2)	Wt. (g) Pre Dry	Wt. (g) Post Dry	% by Wt. H_2O	Wt. (g) <200 mesh	% by Wt. <200 mesh	% by Wt. <200 mesh dry	% Lead
1	7.4	72.3	71.9	0.55	14.7	20.3	20.4	20
2	7.4	132.8	132.0	0.60	41.7	31.4	31.6	18
3	-	807.0	794.3	1.57	269.8	33.4	34.0	21
4	5.6	156.6	155.5	0.70	36.1	23.1	23.2	12
5	7.4	96.4	95.7	0.73	13.7	14.2	14.8	27

5 axle 18 wheelers	- 52%
Pick-ups and cars	- 17%
4 axle 14 wheelers	- 27%
3 axle trucks	- 4%
	100%

METEOROLOGICAL DATA

The company operates a 24-hr weather station located on the roof of the main personnel building. This station supplies information on wind speed and wind direction at a height above all the buildings in the facility. Besides wind speed and direction, this station monitors temperature, barometric pressure, relative humidity, and amount of rainfall. The data recorded during the time of sampling are shown in Figures 6, 7, and 8 in the Appendix.

Local wind direction and wind speed was also recorded by Radian Corporation by means of a portable weather station. This station consisted of a wind vane and cup anemometer mounted at a height of twenty feet and located within the area being monitored. The purpose of the use of this station, in addition to the company's station, was to record disturbances within the area being sampled. Such disturbances can be caused by obstructions such as tall buildings, hills, and trees. These data are reduced in Table 12.

COMPANY HIVOL DATA

The company routinely measures the particulate and lead concentrations in ambient air at five locations around the plant. Hivol Station Number One is positioned to the south of the plant close to the pumphouse and parking lot. Station Number Two is also to the south, positioned between south access road and the warehouse. Hivols Number Three and Four monitor the air to the East. Number Three is located behind the motorcycle battery building, and Hivol Number Four is north of the motorcycle battery building. Station Five monitors the air quality on the West side of the plant, located on the ground of the Monastery.

These positions are marked on the plot plan for the Smelter shown in Figure 1.

The company made available their hivol air sampling data measured during the period from August 31 through September 11. The data are reduced in Table 13. These data can be compared with predictions obtained by modeling. The meteorological data described in the previous sub-section, point source emissions, and the contributions of the areas monitored will be inputs to a potential modeling effort.

TABLE 12. REDUCED ON-SITE METEOROLOGICAL DATA

Date	Hour	Wind Speed (mph)	Wind Direction (degrees)	Date	Hour	Wind Speed (mph)	Wind Direction (degrees)
9/2/81	0830	4.5	165	9/6/81	0800	2.2	240
	0930	4.2	175		0900	3.0	235
(Area 1)	1030	4.5	150	(Area 4)	1000	4.0	240
	1130	5.0	165		1100	3.5	265
	1230	4.2	145		1200	4.0	295
	1330	5.0	165		1300	4.5	255
	1430	5.1	160		1400	3.5	250
	1530	3.5	160		1500	3.5	250
	1630	4.0	125		1600	4.0	225
	1730	3.5	120		1700	4.5	225
	1830	5.3	170		Avg.	3.7	250
	1930	5.5	170				
	2030	5.0	165	9/7/81	0730	2.0	130
	2130	6.0	120		0830	2.5	135
	Avg.	4.7	155		0930	3.0	130
				(Area 4)	1030	4.0	180
9/3/81	1000	6.0	135		1130	4.2	165
	1100	6.8	120		1230	5.0	135
(Area 1)	1200	5.5	115		1330	6.0	185
	1300	5.2	120		1430	6.0	185
	1400	5.2	130		1530	6.6	210
	1500	5.0	125		1630	6.3	195
	1600	5.0	130		Avg.	4.6	165
	1700	6.0	120				
	1800	6.5	120	9/8/81	0800	4.0	180
	1900	6.0	125		0900	6.0	185
	Avg.	5.7	125	(Area 2-3)	1000	6.0	180
					1100	8.0	180
9/4/81	0900	3.0	65		Rain		
	1000	3.6	220				
(Area 5)	1100	4.2	220	9/9/81	1000	4.0	310
	1200	4.0	240		1100	4.0	320
	1300	3.3	240	(Site 2-3)	1200	5.5	335
	1400	3.6	65		1300	7.0	330
	1500	4.0	110		1400	6.0	325
	1600	3.6	100		Avg.	5.3	325
	1700	2.8	180				
	1800	2.8	65	9/10/81	0800	1.5	310
	Avg.	3.5	125		0900	3.0	260
				(Site 2-3)	1000	4.0	250
9/5/81	0900	2.0	240		1100	5.0	260
	1000	2.0	235		1200	5.5	260
(Site 5)	1100	3.5	240		1300	6.0	280
	1200	3.0	180		1400	6.0	285
	1300	3.5	200		1500	6.0	280
	1400	3.0	235		1600	5.5	290
	500	3.0	240		1700	4.5	300
	1600	2.5	210		Avg.	4.7	275
	1700	2.5	310				
	1800	2.2	240				
	Avg.	2.7	235				

TABLE 13. HIGH VOLUME AIR SAMPLING DATA 8/31/81 THROUGH 9/11/81

Date	Site 01		Site 02		Site 03		Site 04		Site 05	
	TP	TL	TP	TL	TP	TL	TP	TL	TP	TL
8/31/81	47.4	1.46	44.6	0.57	36.2	0.20	33.8	0.24	51.3	4.41
9/01/81	45.4	0.75	53.7	0.53	39.4	0.14	36.8	0.19	63.6	2.88
9/02/81	47.6	1.05	50.8	0.63	40.2	0.10	36.0	0.10	61.5	4.23
9/03/81	57.4	1.85	69.9	0.95	48.0	0.19	46.3	0.19	70.8	6.15
9/04/81	59.3	1.18	74.4	0.94	52.5	0.29	50.1	0.35	74.6	6.57
9/05/81	--	--	--	--	--	--	--	--	--	--
9/06/81	--	--	--	--	--	--	--	--	--	--
9/07/81	41.6	0.40	41.4	0.29	36.7	0.12	36.1	0.25	--	--
9/08/81	44.3	2.36	42.0	4.49	29.4	1.38	28.8	1.56	--	--
9/09/81	48.1	2.71	46.2	2.56	33.2	0.96	36.1	1.85	55.3	7.53
9/10/81	62.7	2.01	75.3	1.49	57.2	1.92	55.4	2.41	76.9	8.53
9/11/81	94.2	3.51	96.2	1.38	86.2	1.94	80.1	1.05	140.3	28.89

All values $\mu g/m^3$
TP = Total particulate.
TL = Total lead

SECTION 5

DATA EVALUATION

Data presented in the previous section are used to estimate the lead emissions from Areas 1 through 5 by applying a ventilation model. The fugitive lead emissions from the smelter building are calculated from air velocities and concentrations at the openings to the building. Data obtained from cascade impactors are evaluated to determine the particle size distribution and lead concentration as a function of particle size.

VENTILATION MODEL

The results of the area measurements can be bracketed, assuming two extremes:

- The vertical concentration gradient is a linear function of height, or
- The lead concentration in vertical direction is constant.

The first approach approximates conditions where the wind flow is not obstructed, the second approach describes the experimental data better in these cases where tubulences caused by topography and buildings create vertical mixing effects.

A mathematical description in case of a linear decreasing lead concentration gradient can be derived based on the definitions illustrated in Figure 10. The lead emissions per unit time are assumed to equal the lead concentration contained in a rectangle defined by a ventilation base (Vb) on the X-axis, the wind speed (v) on the Y-axis and the height (h_{max}) on the Z-axis, which is selected in such a way that the vertical lead concentration gradient approaches zero.

The ventilation base is a horizontal line perpendicular to the wind direction, and is generally a cross section of the area being monitored. In the case of irregularly shaped areas, this quantity was chosen as the square root of the total area.

The wind vector (v) on the Y-axis of the ventilated volume is defined as the wind speed and direction averaged over the sampling period.

The lead concentration at any height is defined as a function of that height

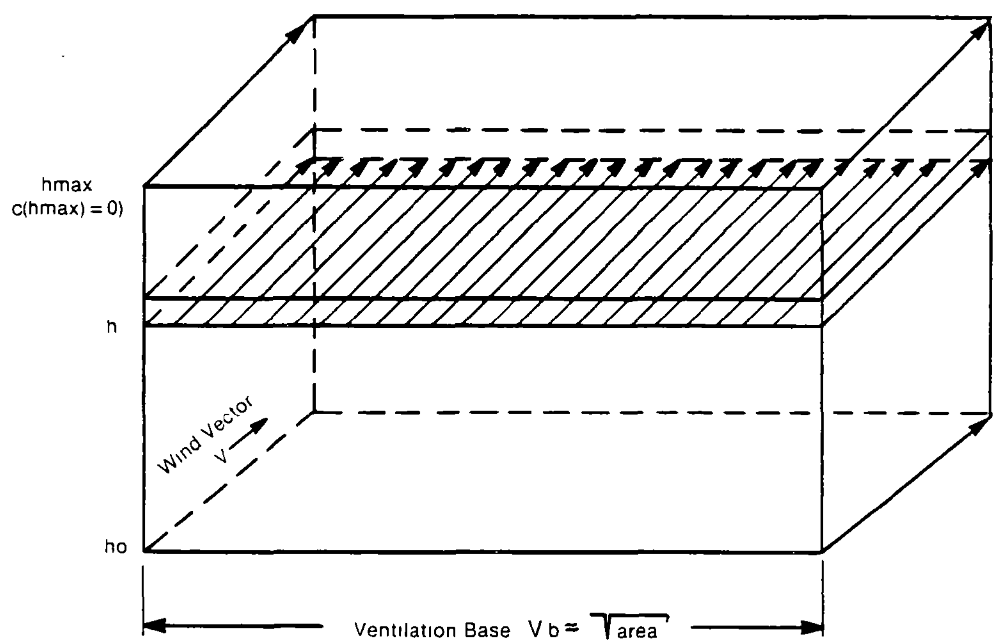


Figure 10. Ventilation Model

$$C = f(h)$$

and decreases with increasing height.

With these definitions the contribution of a horizontal slice at height h and the thickness Δh can be described as follows:

$$\Delta AE_{h,h+\Delta h} = C(h) \cdot \Delta h \cdot v \cdot Vb \ [\mu gPb/sec] \tag{1}$$

where $\Delta AE_{h,h+\Delta h}$ = Area emissions contribution from the ventilated slice between height h, and h+Δh [μgPb/sec]

v = wind vector [m/sec]

Vb = ventilation base [m]

C(h) = lead concentration at height h [$\mu gPb/m^3$]

Δh = vertical dimension of ventilated slice [m]

The measured lead concentrations as function of height pointed in some cases to the following functional relationship between C and h:

$$h = a + b\ C \tag{2}$$

where C = lead concentration at height h

b = slope

a = h_{max} = height where lead concentration drops to zero.

The total contribution of the ventilated volume can now be calculated by combining equations (1) and (2) and integrating the resulting expression from h_o to h_{max}.

$$AE = \int_{h=o}^{h_{max}} C(h) \cdot v \cdot Vb \cdot dh$$

$$= \frac{1}{b} \left(\frac{1}{2} h_{max}^2 - a\ h_{max}\right) \cdot v \cdot Vb \tag{3}$$

or:

$$\boxed{AE = 1/2\ C_{h_o} \cdot h_{max} \cdot v \cdot Vb \left[\frac{\mu gPb}{sec}\right]} \tag{4}$$

This means that the Area Emission (AE) is equal to half the product of the lead concentration at ground level (C_{h_o}), the maximum height (h_{max}), the wind vector (v), and the ventilation base (Vb), where lead concentration at height zero (C_{h_o}) and the maximum height are determined by experimental data.

The second extreme assumes a well mixed volume this means constant concentration at any height up to h_{max}:

$$C(h) = \text{Const} = \overline{C} \tag{5}$$

Substitution of (5) into (3) and integration gives:

$$AE = \int_{h=o}^{h_{max}} \overline{C} \cdot v \cdot Vb \cdot dh$$

$$\boxed{AE = \overline{C} \cdot v \cdot Vb \cdot h_{max} \quad [\mu gPb/sec]} \tag{6}$$

Values for C_{h_o} and h_{max} were determined by plotting experimental data for each area on a graph of concentration versus height. These data points were then fitted to the optimum linear equation by the least squares method. The optimum values a and b in the equation

$$h = a + b\ C$$

are given by

$$a = \frac{\sum_{i=1}^{n} h_i C(h_i) \cdot \sum_{i=1}^{n} C(h_i) - \sum_{i=1}^{n} h_i \cdot \sum_{i=1}^{n} C(h_i) \cdot C(h_i)}{\sum_{i=1}^{n} C(h_i) \cdot \sum_{i=1}^{n} C(h_i) - n\sum_{i=1}^{n} C(h_i) \cdot C(h_i)} \tag{7}$$

$$b = \frac{n\sum_{i=1}^{n} h_i\ C(h_i) - \sum_{i=1}^{n} h_i \cdot \sum_{i=1}^{n} C(h_i)}{n\sum_{i=1}^{n} C(h_i) \cdot C(h_i) - \sum_{i=1}^{n} C(h_i) \cdot \sum_{i=1}^{n} C(h_i)} \tag{8}$$

In a similar fashion, optimum average concentration, $\overline{C}$, is obtained in the case of a well mixed volume.

$$\overline{C} = 1/n \sum_{i=1}^{n} C(h_i) \tag{9}$$

Fugitive Emissions from Area 1

Measurements in this area were made on September 2 and 3, 1981. Sampler locations and results are shown in Figures 11 and 12. On both days the wind came from the south southeast to the east southeast directions. The upwind poles at the southeast corner showed values below the detection limit of the analytical method. The company's hivol results from Sampler #4 were used as upwind data. These values were 0.10 μgPb/Nm^3 and 0.19 μgPb/Nm^3 on September 2 and 3, respectively.

Pole data obtained upwind in the southwest corner can be considered influenced by emissions from Area 2. They were, therefore, not considered in the following evaluation. The remaining two upwind stations at the west and northwest locations show different vertical gradients. Data from the west side are much greater than those recorded in the northwest corner. This difference can be explained by the fact that most of the daily traffic is concentrated in the southern half of the area. The halves of the area were therefore evaluated separately. Data from both sampling days in this area were combined and evaluated together, justified by the fact that wind speed and direction were virtually identical on these days.

Area 1 - South

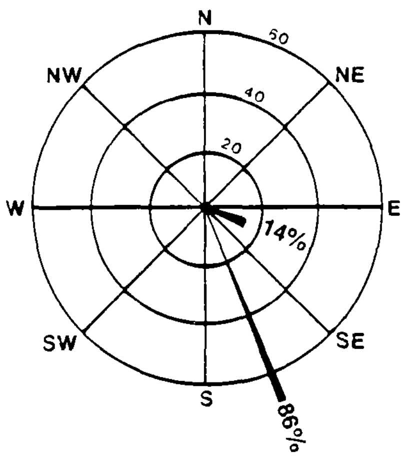
h	C(h)
10 ft	24 μgPb/Nm^3
10	9.2
20	4.7
10	19
16	12
10	9
20	12

Area 1 - North

h	C(h)
4 ft	5.7 μgPb/Nm^3
4	1.4
[10	14.7]

The values are plotted in Figure 13.

The pole sampler on September 2 at Location NW10' in Area 1 showed a lead concentration of unreasonably high magnitude when compared to the hivol at that location. The reason for this anomaly could not be found, so the hivol data was given much greater statistical value in determining emission rates.



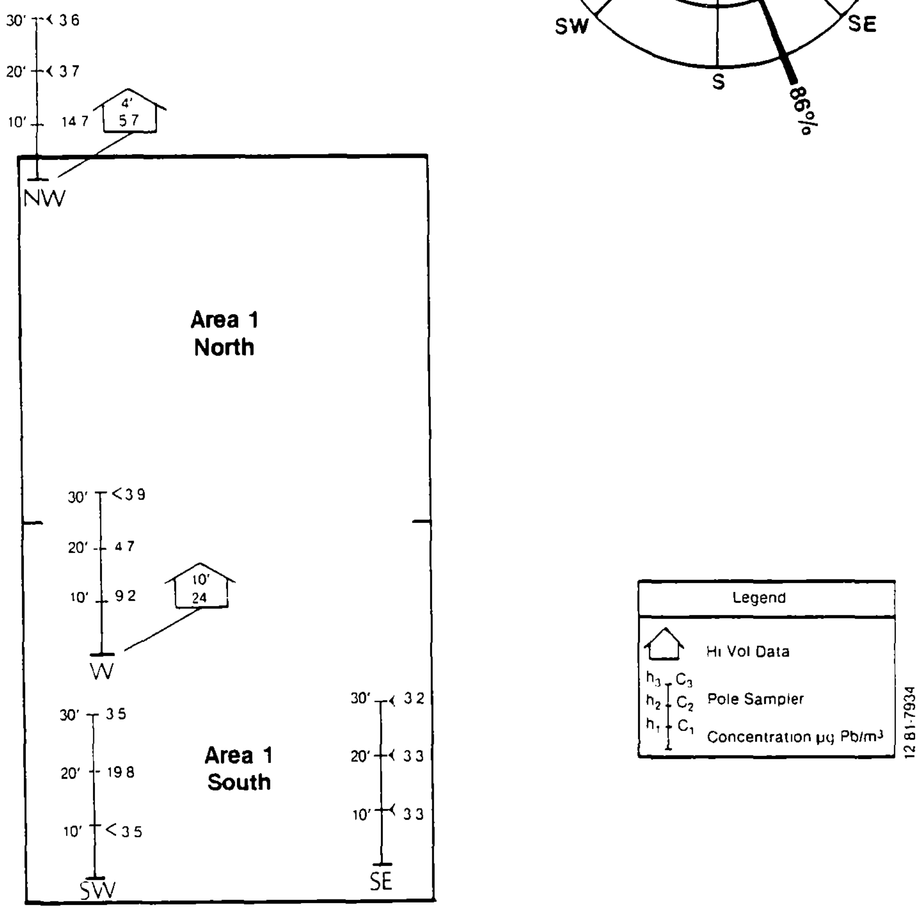


Figure 11: Wind Rose and Lead Concentration [μg/m3] as a Function of Height. Area 1 Sept. 2, 1981

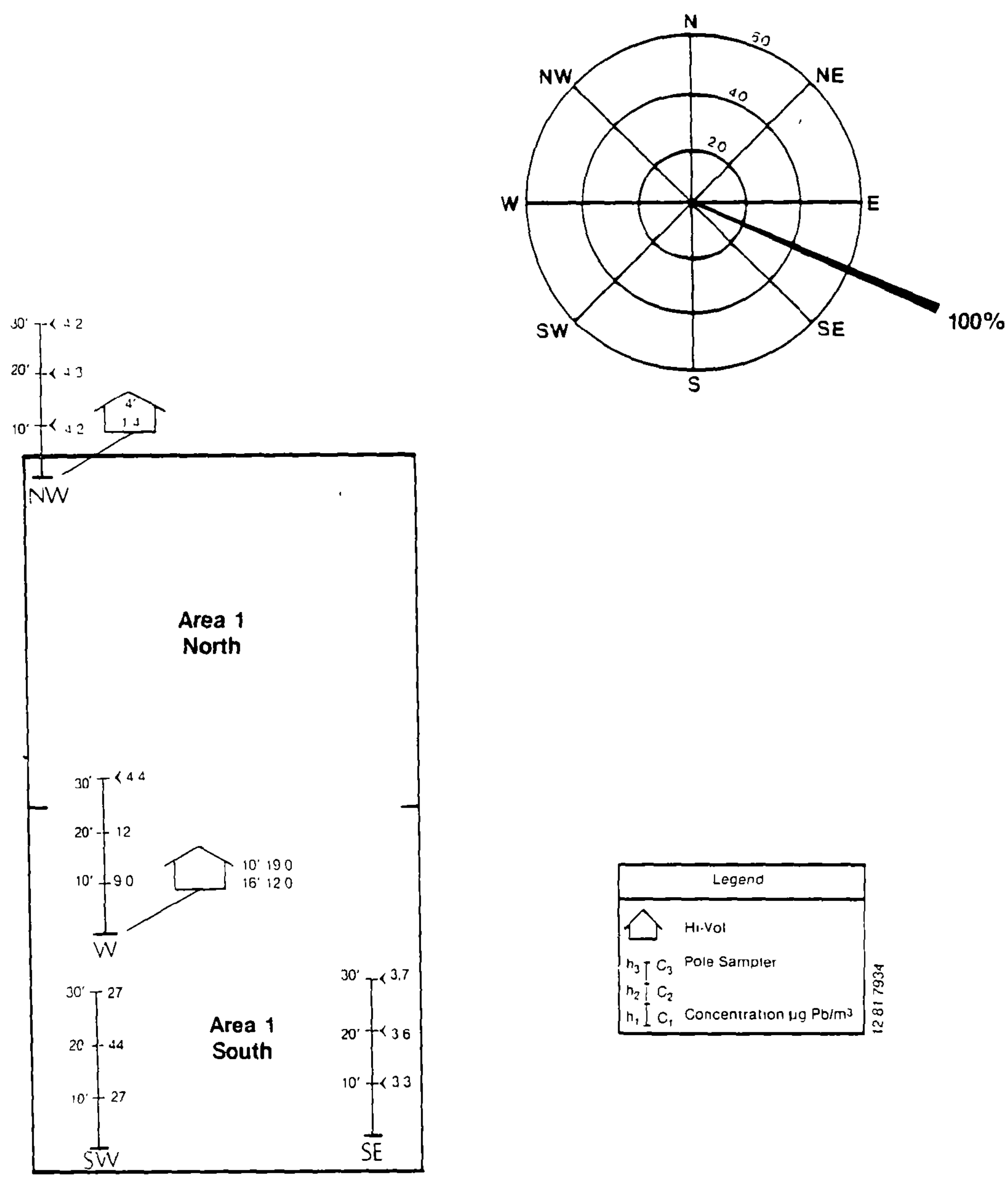


Figure 12: Wind Rose and Lead Concentration, Area 2.
Sept. 3, 1981

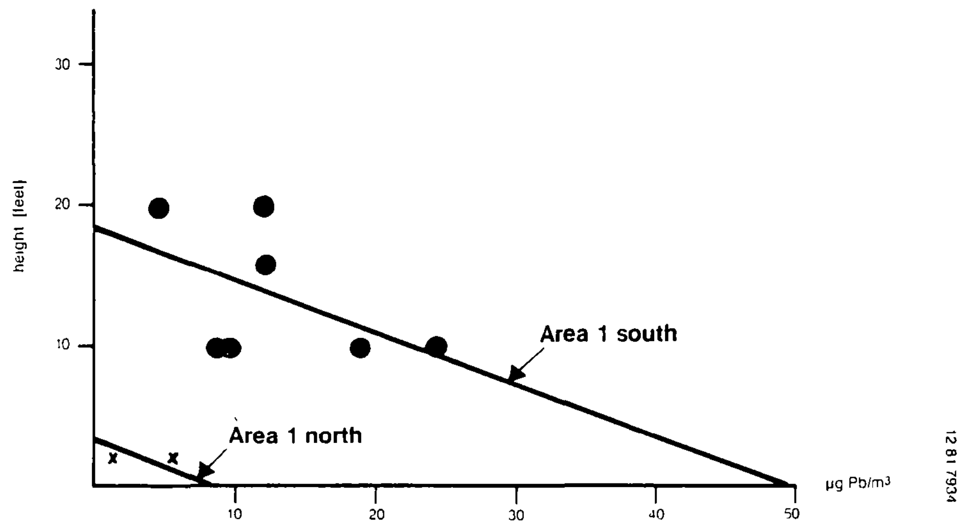


Figure 13. Vertical Lead Concentration Gradient
at Area 1 South and Area 1 North.

The slope of the vertical concentration gradient in Area 1 north was assumed to be the same as that in Area 1 south. The ground concentration, $C(h_o)$, and maximum height, h_{max}, were determined to be as follows:

	Area 1 - North	Area 1 - South
$C(h_o)$	8.0 μgPb/Nm³	49.7 μgPb/Nm³
h_{max}	3.5 ft = 1.1 m	18.4 ft = 5.6

The areas of both sections of Area 1 are 8400 m² each which indicates a ventilation base of 91 m by square root method. The wind speed was 2.25 m/sec. This leads to the following emission rates:

$$\text{Area 1 South} = 103 \frac{\text{gPb}}{\text{hr}}$$

$$\text{Area 1 North} = 3 \frac{\text{gPb}}{\text{hr}}$$

The upwind contributions were neglected due to the low values measured at hivol #4.

Fugitive Emissions from Area 2, September 9, 1981

Favorable winds for the determination of emission rates from Area 2 prevailed on September 9, 1981. The wind direction on this day was from the north northwest. The following data were recorded (see Figure 14).

Upwind:

12 μgPb/m³ at 4' = 1.2 m height and 3.5 μg at 3.0 m

Downwind:

10 ft	108 μgPb/m³
16 "	79 "
20 "	61 "
30 "	22 "

From these data optimum values for a and b in the equation

$$h = a + bc$$

according to the least square method were

$$a = 10.6 \text{ m}$$

$$b = -0.0711 \frac{\text{m}}{\mu\text{gPb/m}^3}$$

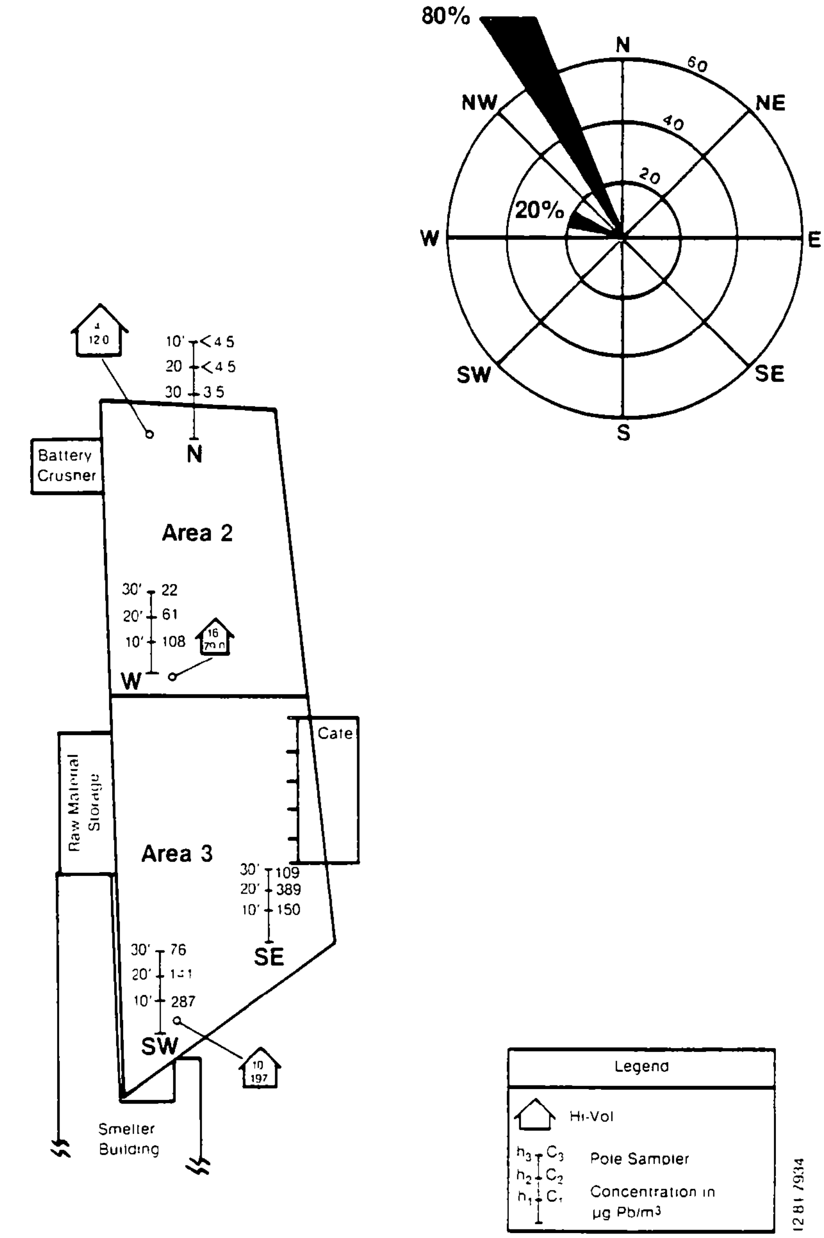


Figure 14. Wind Rose and Lead Concentration (µg/m3) as a Function of Height. Areas 2, 3, Sept 9, 1981

The lead concentration as function of height is shown graphically in Figure 15.

These values give the following input data for Equation (5):

Parameter	Upwind	Downwind
Total area	1600 m^2	1600 m^2
Ventilation base Vb	40 m	40 m
h_{max}	11" = 3.4 m	34.7" = 10.6 m
C(h=o)	20 μgPb/m^3	149 μgPb/m^3
Wind speed v	2.4 m/sec	2.4 m/sec

The lead emission out of the area are

$$Pb_{out} = 1/2 \cdot h_{max} \cdot C(0)_{downwind} \cdot Vb \cdot v = 273 \frac{gPb}{hr}$$

and the lead blown into the area is

$$Pb_{in} = 1/2 \cdot h_{max} \cdot C(0)_{upwind} \cdot Vb \cdot v = 12 \frac{gPb}{hr}$$

The net emission from area 2 is $\simeq 260 \frac{gPb}{hr}$

Fugitive Emissions from Area 3

September 9, 1981--

The values measured on this day are shown in Figure 14. The downwind data from Area 2 are the upwind data for Area 3. Lead concentrations obtained are as follows:

Upwind Data h[ft]	Upwind Data C[μgPb/Nm^3]	Downwind Data h[ft]	Downwind Data C[μgPb/Nm^3]
10	108	10	197
16	79	10	150
20	61	[20	389]
30	22	30	109
		10	287
		20	141
		30	76

If the reading of 389 μgPb/Nm^3 at the SE20' location were included, an unreasonably high ground level Pb concentration of 727 μgPb/Nm^3 would be indicated. Therefore, the following calculations omit that data point. The high reading at that location could not be explained.

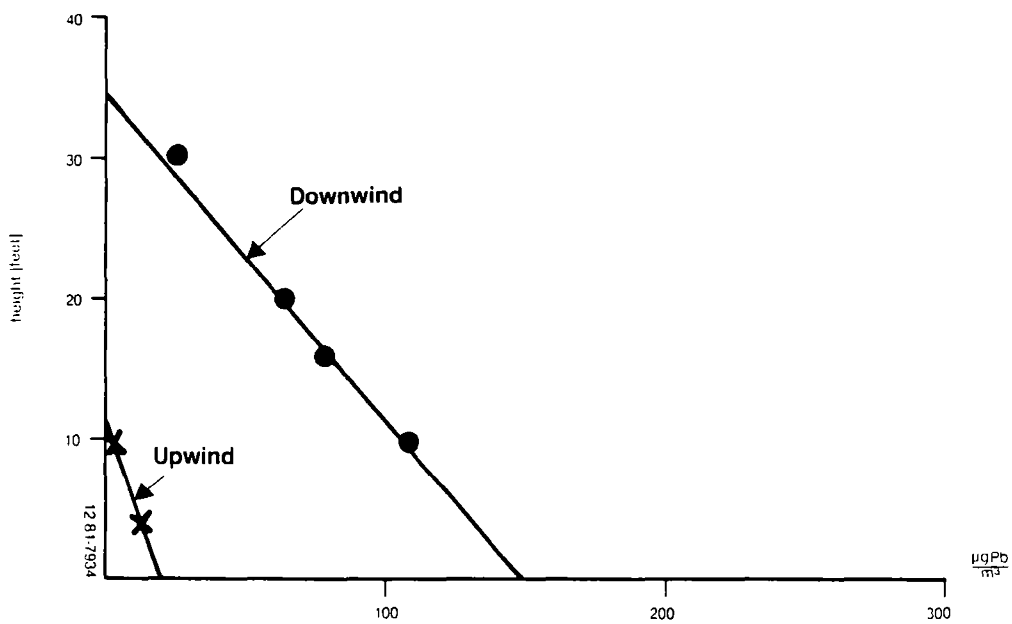


Figure 15: Lead Concentration as Function of Height. Upwind and Downwind Data. Area 2, Sept. 9, 1981

Optimum values for a and b were determined by least squares routine

$a = 10.7\ m$

$b = -0.0320\ \frac{m}{\mu gPb/m^3}$

The lead concentration as function of height is shown graphically in Figure 16.

The data scattered more than in Area 2, probably due to more turbulence generated by buildings surrounding the area.

The lead emission rate for Area 3 is calculated by input of the following data into the ventilation model.

Parameter	Downwind
Total Area	1900 m^2
Ventilation Base Vb	43.6 m
h_{max}	35 ft = 10.7 m
$C(h = o)$	334 $\mu gPb/Nm^3$
Wind speed v	2.4 m/sec

We find total $Pb_{out} \cong$ 720 gPb/hr. The amount of lead coming in from Area 2 (upwind) was found to be 260 gPb/hr. The net emission rate for Area 3 was therefore determined to be 460 gPb/hr.

September 10, 1981--

The second measurement of Area 3 was conducted on the above date. The wind direction was from the west. Turbulence was caused by the charge make-up building and charge storage on the west and the main personnel building on the east.

The data shown in the following table and in Figure 17 indicate a well mixed volume with homogeneous lead concentration.

h[feet]	C(h) $\mu gPb/m^3$
10	100
10	51
20	36
10	94
20	61
30	75
10	91
20	99
30	61
10	274
10	92
20	88
30	93

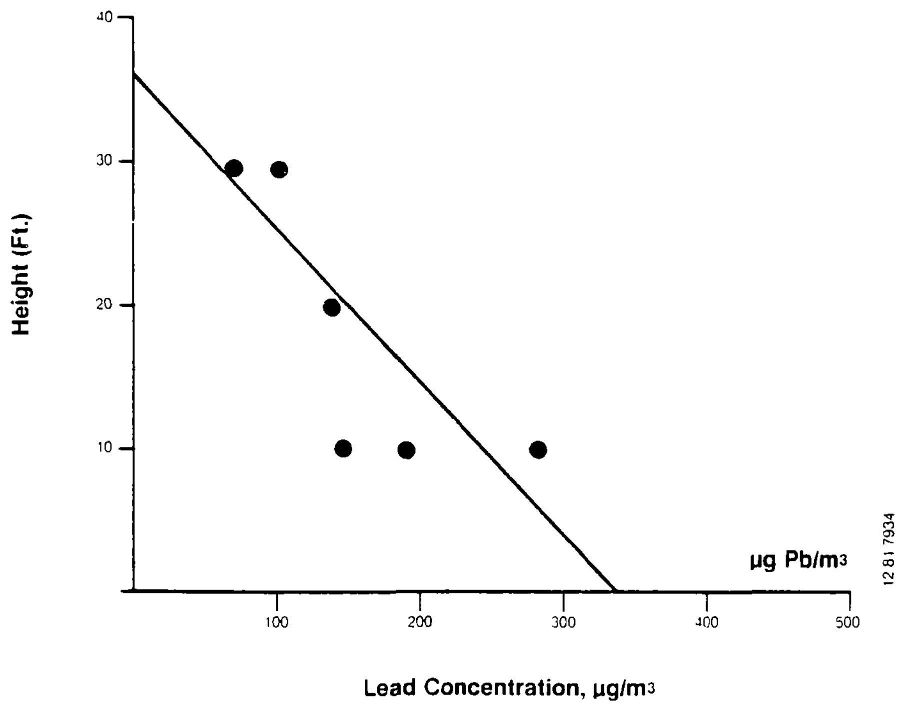


Figure 16. Lead Concentration as Function of Height. Downwind Data Only Area 3, Sept 09, 1981

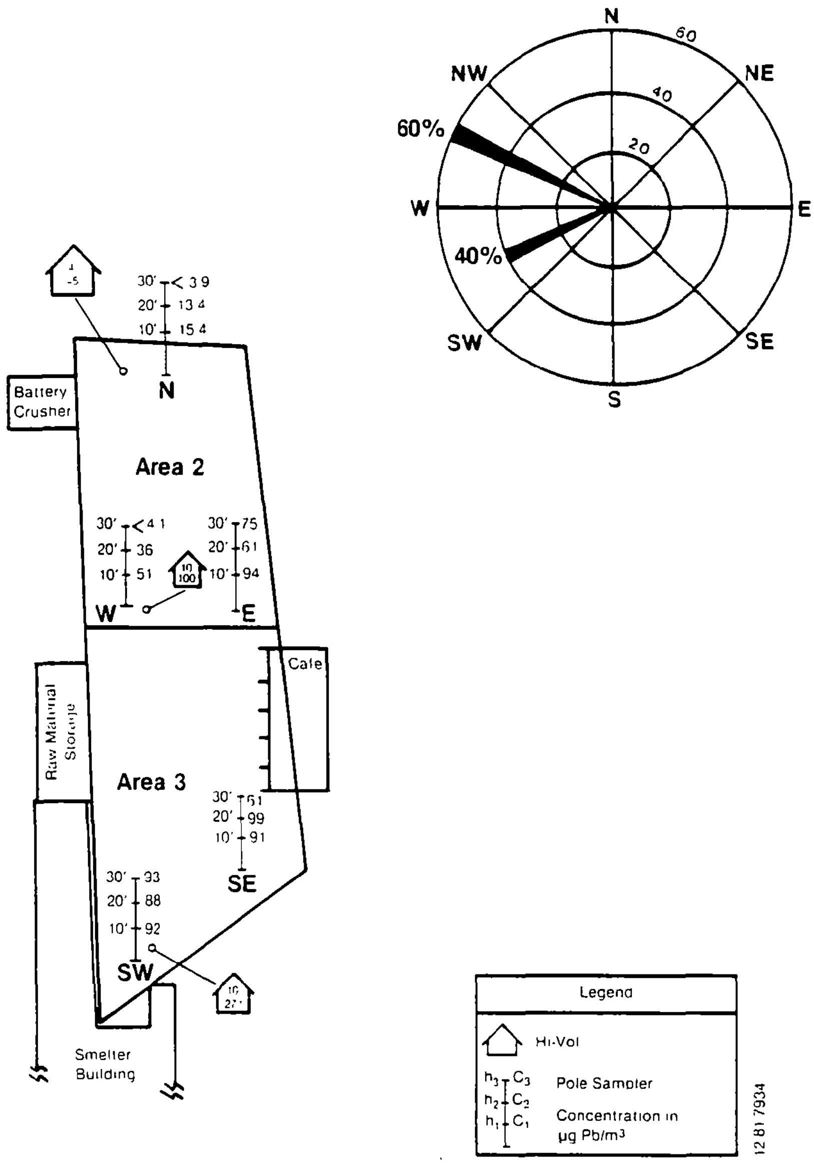


Figure 17. Wind Rose and Lead Concentration (µg/m3) as a Function of Height. Area 3, Sept 10, 1981

The values are plotted in Figure 18. The hivol value of 274 μgPb/m³ at SW10' falls outside the rest of the data. It was, however, included to determine average concentration by the equation

$$\overline{C} = 1/n \sum_{i=1}^{n} C(h_i) = 93.5 \ \mu gPb/Nm^3$$

The lead emission rate for Area 3 is calculated by input of the following data into Equation (6)

Total Area	1900 m^2
Ventilation Base Vb	43.6 m
h_{max}	40 ft = 12.2 m
$\overline{C}$	93.5 $\mu gPb/Nm^3$
Wind Speed v	2.1 m/sec

From the above data a value of 376 gPb/hr was calculated. h_{max} was determined to be approximately 40 ft or 12.2 meters which is the average height of the surrounding buildings.

Data measured by the company at Site 5 is chosen as upwind lead concentration. From this, an upwind emission rate of 34 gPb/hr was determined. Subtracting this quantity from the above downwind value yielded a net lead emission of approximately 340 gPb/hr.

September 8, 1981--

On this date the wind was from the south. Figure 19 contains a wind rose and hivol data for that day. The upwind sampler showed a lead concentration of 39 $\mu gPb/Nm^3$ at 4' elevation and the downwind sampler indicated a concentration of 149 $\mu gPb/Nm^3$ at 10' elevation. Due to rain, the pole samplers were disabled and all runs cut short.

The lack of pole sampler data prevented the calculation of a gradient with respect to height, so the hivol data could not be evaluated quantitatively.

However, a qualitative interpretation of the two hivol data points may be made under the assumption that the vertical concentration gradient is the same as for September 9. This assumption is reasonable because ventilation of the area to the north is relatively unobstructed by buildings (see Figure 1). Accepting this, values of h_{max} = 26 ft = 7.9 m and $C(h_o)$ = 240 $\mu gPb/Nm^3$ downwind; and h_{max} = 8 ft = 2.4 m and $C(h_o)$ = 60 $\mu gPb/Nm^3$ upwind are generated. The wind speed was 2.7 m/sec and the ventilation base was chosen at a value of 30 m. This gives estimated lead emission rates of

Pb_{out}	276 gPb/hr
Pb_{in}	-21 gPb/hr
Net Pb_{out}	255 gPb/hr

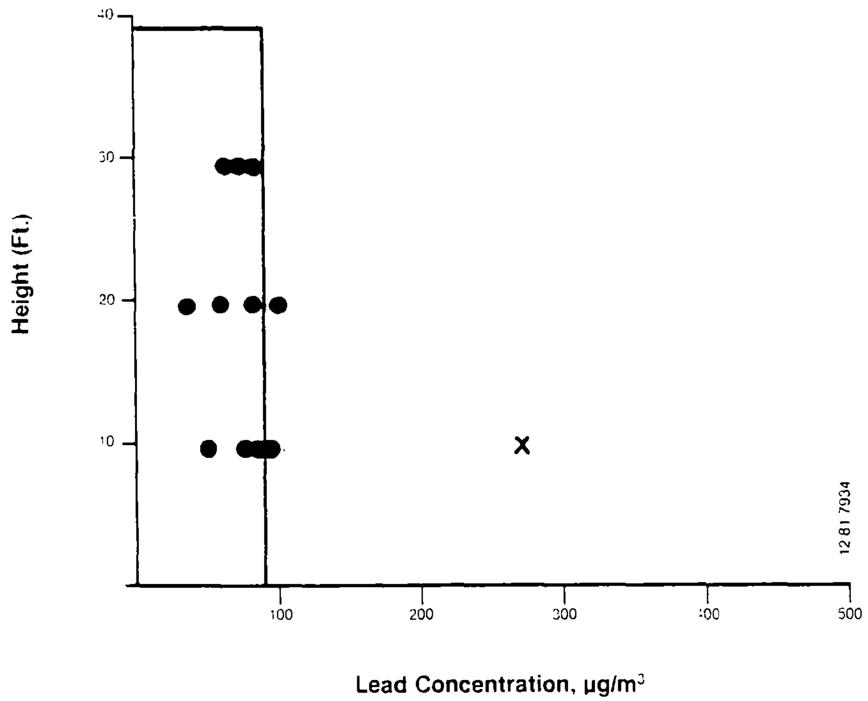


Figure 18. Lead Concentration Profile, Area 3, Sept.-10-81. Data have Been Approximated Using the Homogeneously Mixed Ventilation Model.

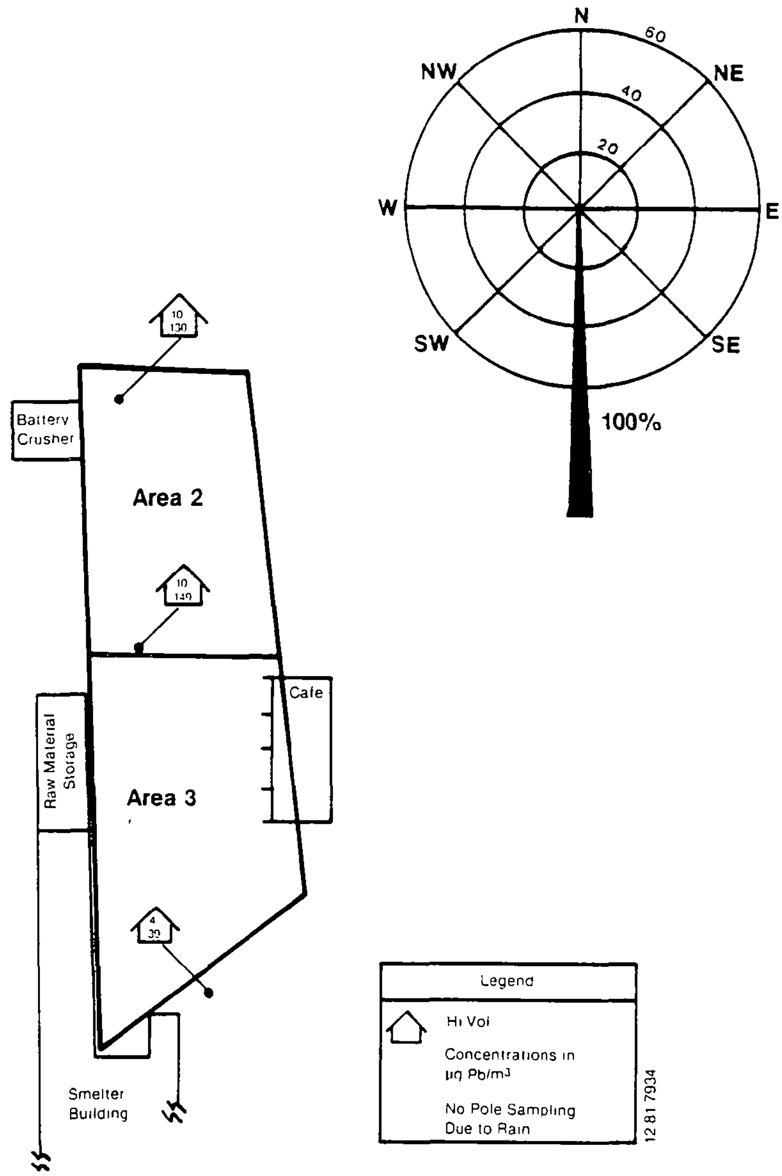


Figure 19. Wind Rose and Up Wind Down Wind Results.
Area 2, 3. Sept 8, 1981

This result appears to be reasonable compared to the values of 340 gPb/hr on September 10 and 460 gPb/hr on September 9 because wetting down of the area would be expected to significantly reduce emissions.

Fugitive Emissions from Area 4

Emissions from Area 4 were measured on September 6, 1981 and September 7, 1981. Wind direction on September 6 was from the west southwest, providing a relatively unobstructed ventilation to the east northeast. In contrast, on September 7, the wind oscillated from the south southwest to the east southeast. In the first case, data was fitted to the ventilation model with a linear Pb concentration gradient with respect to height. In the second case, a homogeneous mixture was assumed due to turbulence caused by interference of the wind by the slag storage and smelter buildings. Uniform lead concentration was assumed from ground level to roof height.

September 6, 1981--

A wind rose and sampler data for Area 4 on September 6, 1981 are shown in Figure 20. Pole sampler data and hivol data from the east location within the area alone were used for downwind emissions, as the north and west pole sampler locations were interfered with by the slag storage building. Hivol data from the south location indicating a concentration of 6.9 $\mu gPb/Nm^3$ at a height of 4 ft were used for upwind determinations.

This gives us the following downwind data:

h[ft]	C(h) [$\mu gPb/Nm^3$]
10	75
16	84
20	61
30	43

The upwind gradient was assumed to be the same as that measured at the east location. The data are plotted in Figure 21.

The height (h_{max}) was determined to be 46 ft = 14 m downwind with a ground level concentration $C(h_o)$ of 112 $\mu gPb/Nm^3$. Corresponding values upwind were h_{max} = 2.2 m and $C(h_o)$ = 16 $\mu gPb/Nm^3$. A ventilation base of 43 m was chosen by square root method. Wind speed was 1.7 m/sec. These values, when substituted into Equation (5) yield the following results.

Pb_{out}	207 gPb/hr
Pb_{in}	-9 gPb/hr
Net Pb_{out}	≈200 gPb/hr

September 7, 1981--

Measured data in Area 4 on September 7, 1981 are summarized in Figure 22. As mentioned earlier, the wind on this date oscillated from the east

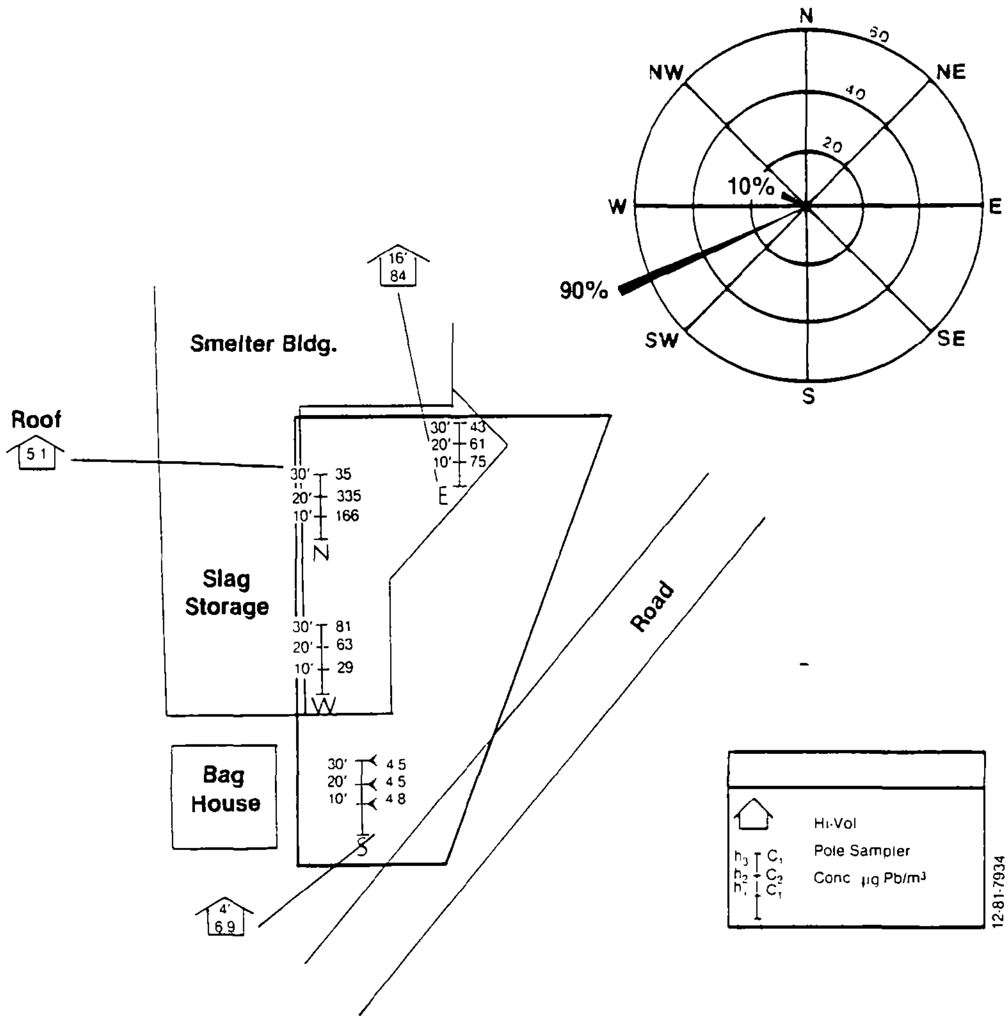


Figure 20: Wind Rose and Upwind Down Wind Lead Concentrations. Area 4. Sept. 6, 1981

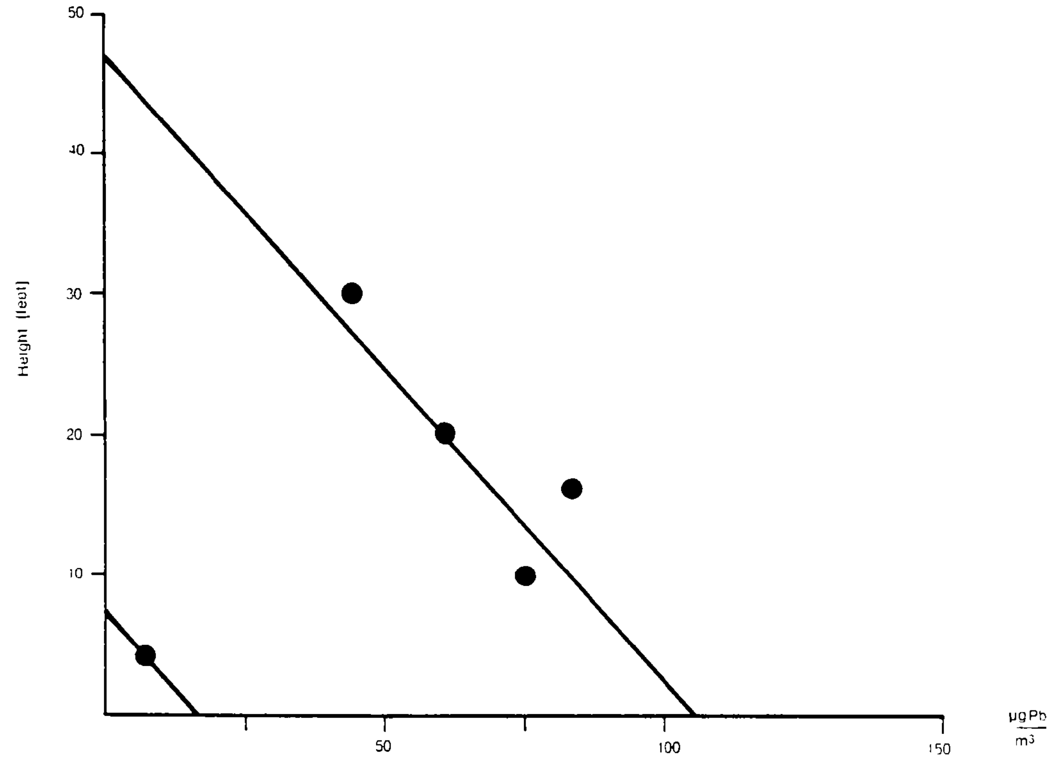


Figure 21: Upwind & Downwind Concentration Gradients
Area 4, Sept. 6 1981.

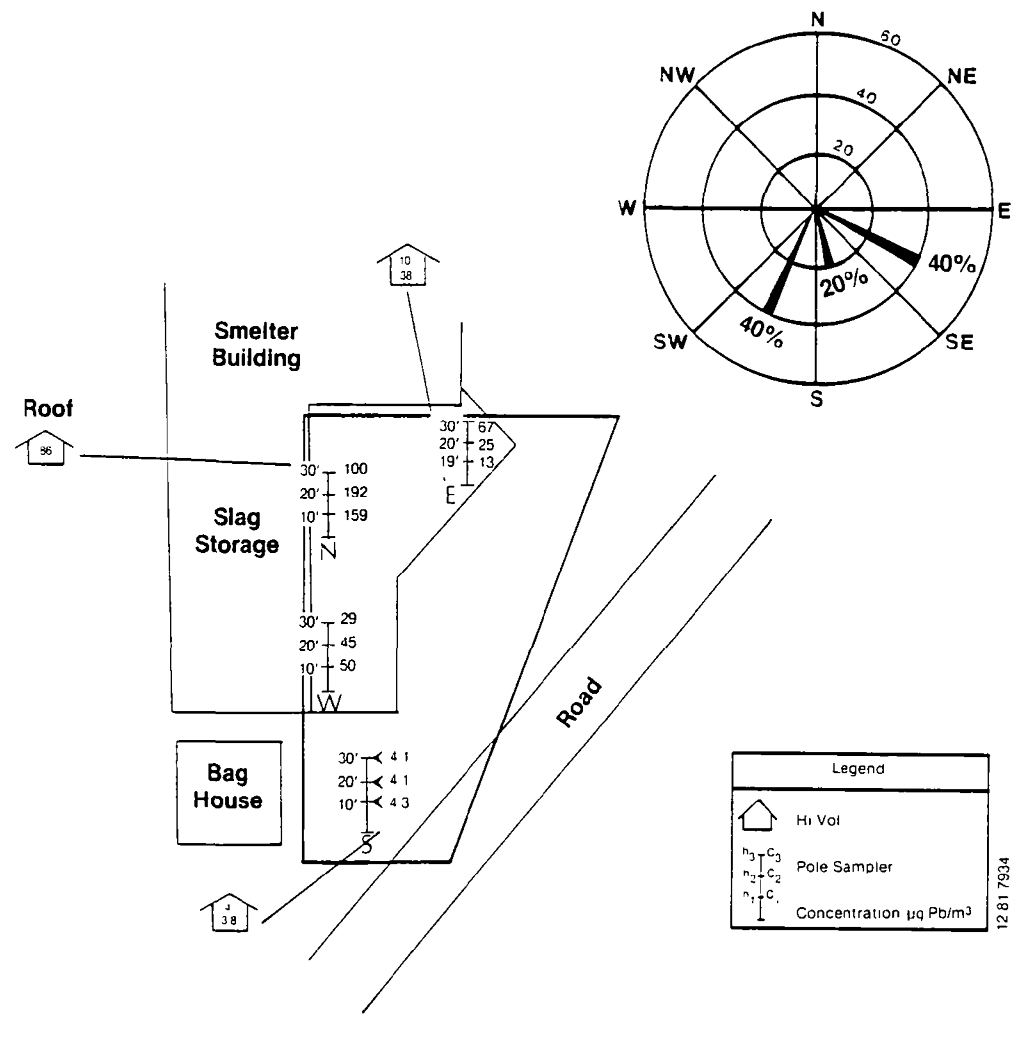


Figure 22: Wind Rose and Lead Concentration as a Function of Height. Area 4. Sept. 7, 1981

southeast to the south southwest. The slag storage building and the smelter building interfered with ventilation of the area, causing mixing of the air within the area. Data from the pole samplers at the east, north, and west locations as well as hivol data from the east location and the roof were used to determine the average lead concentration within the area. The numerical values of these data are as follows:

h'	C(h)	h'	C(h)
10	38	10	50
10	13	20	45
20	25	30	29
30	67	Roof 40	86
10	159		
20	192		
30	100		

They are plotted in Figure 23.

Concentration of 3.8 μgPb/Nm^3 was measured by an upwind hivol with elevation of 4'.

Substituting the downwind data into Equation (9) gives the result $\bar{C}$ = 73 μgPb/Nm^3. The ventilation height h_{max} was set as 40 ft = 12.2 m, the height of the adjacent buildings. With a wind speed of 2.0 m/sec and ventilation base of 43 m, Equation (6) yields the result $Pb_{out} \approx$ 276 gPb/hr.

The incoming lead was assumed to be of the same order of magnitude as on September 6 so that the net emissions are approximately 270 gPb/hr.

Fugitive Emissions from Area 5

Samples along the smelter access road between the SLI office building on the south and the SLI manufacturing building on the north were collected on Friday, September 4 and Saturday, September 5. While the smelter was in operation on both days, the SLI building was in operation only on the 4th.

Another marked difference was the amount of traffic along this part of the road, as reflected by the axle count. 531 axle counts were recorded on Friday, while only 151 were recorded on Saturday.

The wind was channeled on both days along the valley through the major axis of Area 5. This is enhanced by the buildings on the east of the access road, which vary in height from 20 to 30 feet, and by a heavily wooded ridge on the west, rising to a height of from 40 to 60 feet. The overall wind direction on Friday, as recorded by Radian Corporation, was from the east northeast and the south southwest.

Therefore, results from hivol sampler No. 1, which recorded 1.8 μgPb/Nm^3, and No. 4, which recorded 0.35 μgPb/Nm^3 were used as upwind data. The company

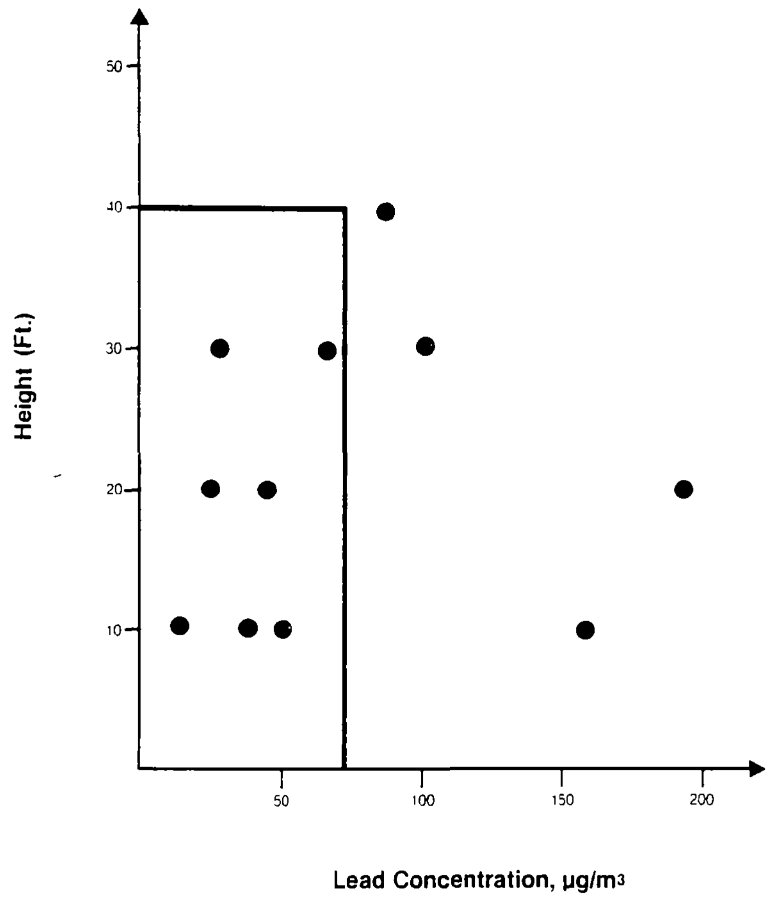


Figure 23. Lead Concentration as Function of Height in Area 4 on Sept-07-81.

did not operate hivols on Saturday. The predominant wind direction on this day was from the south southwest. Similar wind conditions were recorded on September 7, and the hivol No. 1 recorded 0.40 μgPb/Nm^3. It was assumed, considering the lack of data, that similar low values prevailed upwind on Saturday, September 5, 1981.

Radian Corporation's meteorological station, showed frequent intermittent wind shifts in the valley. This indicates turbulent conditions throughout the sampling period of both days. The air in the area under consideration can therefore be assumed to be well mixed. The data were evaluated using the well mixed ventilation model, Equation (6).

Abnormalities were noted in the pole sampler results at the NE location on both days, notably higher on Friday, when the SLI building was in operation. The pole at this location was located eight feet from a large access door into the SLI building and about 25 feet from a vent about 20 feet high on the side of the SLI building. Data at this point were greatly influenced by exhaust from the SLI building and were not included in evaluating emission rates for Area 5.

Data Evaluation for Friday, September 4--

Position of samplers and measured data as function of height are given in Figure 24. Values recorded are as follows:

h	C(μgPb/Nm^3)	h	C(μgPb/Nm^3)
16	18	4	55
10	11	10	26
20	4.5	10	8
30	16	20	8.1
10	7.6	30	8.4
20	5.4		

Lead concentrations as function of height are plotted in Figure 25. In view of the observed turbulence, the ventilation model applied to well-mixed volume was used. The average concentration was calculated by Equation (9) and was determined to be 15.3 μgPb/Nm^3. The maximum ventilation height (h_{max}) was estimated to be 35 ft = 10.7 m. The average of lead concentrations recorded by hivols No. 1 and 4 (1.18 μgPb/Nm^3 and 0.44 μgPb/Nm^3) was used as upwind data. The width between the building and the wooded ridge was chosen to be the ventilation base, Vb, and was 150 ft = 46 m. Wind speed: 1.6 m/sec.

Accepting these values, the following lead emission rates were calculated.

Pb_{out}	43.4	gPb/hr
Pb_{in}	2.3	gPb/hr
Net Pb_{out}	≈ 41	gPb/hr

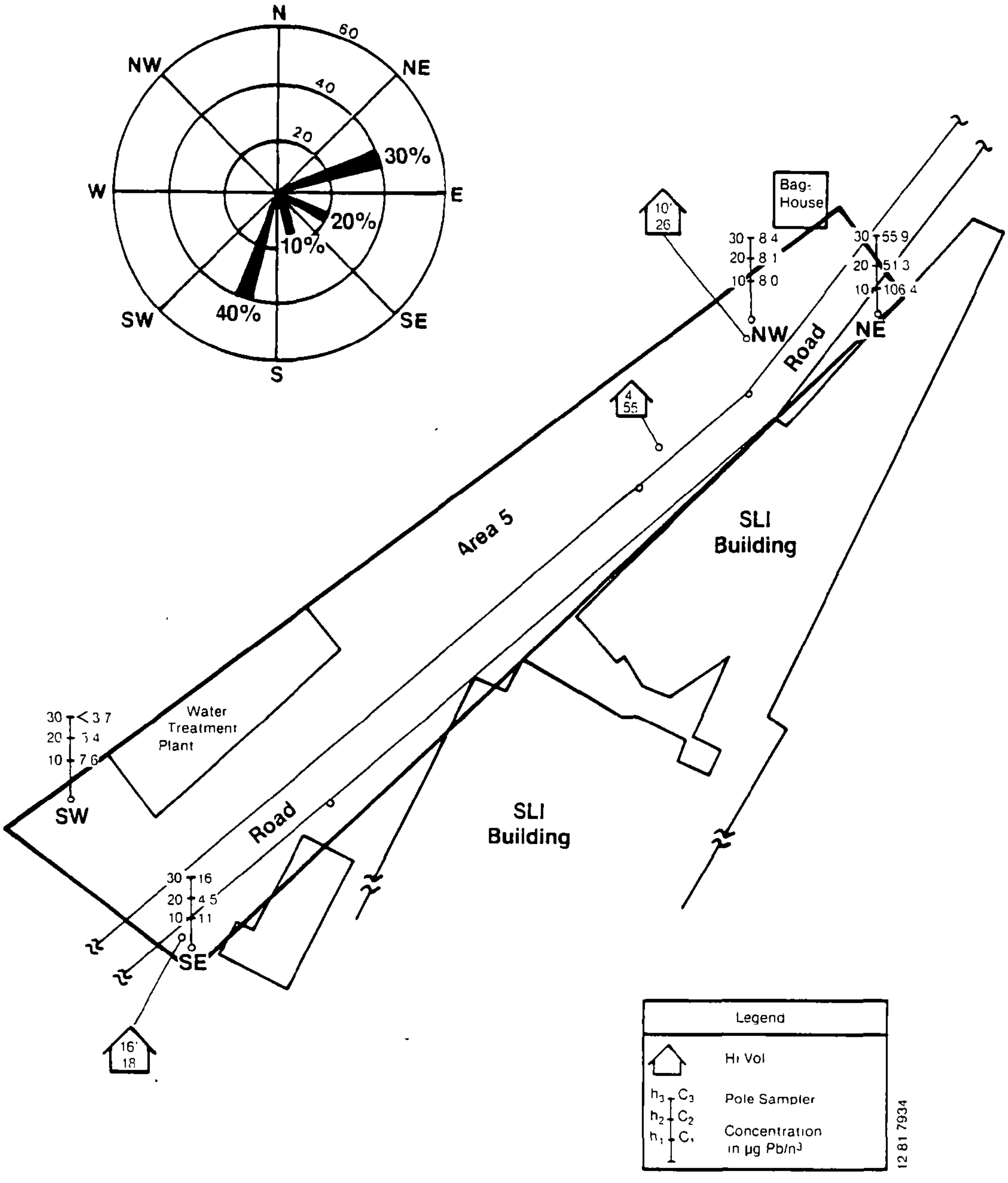


Figure 24. Wind Rose and Lead Concentration as a Function of Height. Area 4, Sept 4, 1981

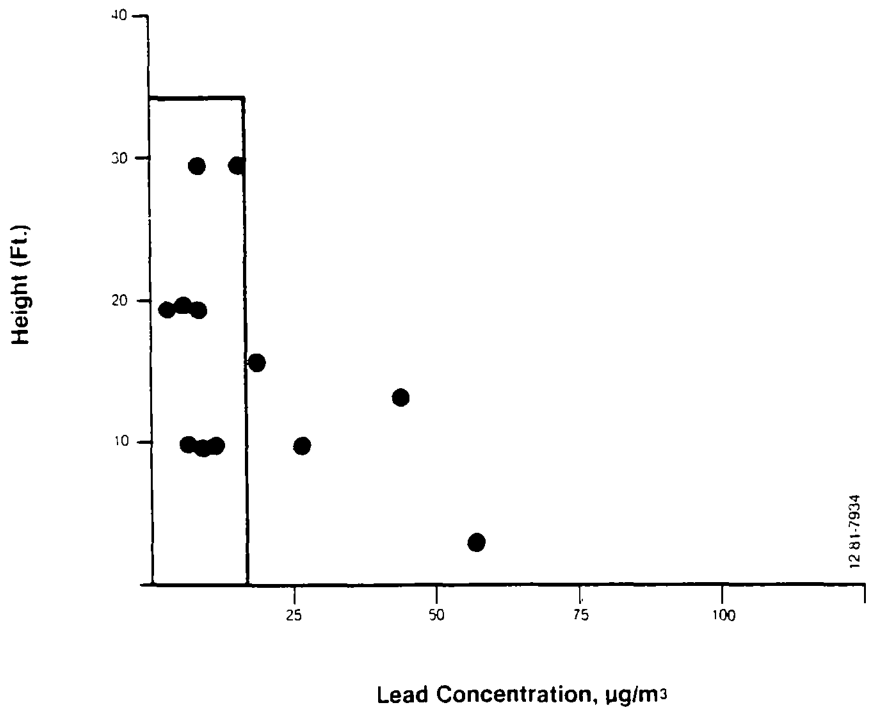


Figure 25. Lead Concentration as Function of Height, Sept-04-81, Area 5.

Data Evaluation for Saturday, September 5, 1981--

Sampler position was the same as on the previous day. The data are shown in Figure 26 and are as follows:

h[ft]	C(μgPb/Nm^3)	h[ft]	C(μgPb/Nm^3)
10	14	4	24
20	1.4	20	9.2
10	1.8	10	3.7
20	1.2	20	1.6

The above data points are plotted in Figure 27 on a chart of concentration as a function of height. As on the previous day, the wind direction varied widely, indicating turbulence in the area. The ventilation model applied to well mixed volume was again applied. The average concentration was determined, by Equation (9), to be 7.1 μgPb/Nm^3. The maximum ventilation height, h_{max} was chosen to be 25 ft = 7.6 m. The ventilation base Vb, of 46 meters and the wind speed of 1.2 m/sec were input data to the following calculations. As mentioned earlier, an upwind concentration of 0.40 μgPb/Nm^3 was used due to the similar wind conditions on September 7 to that on September 5.

Utilizing the above values, the following lead emission rates were calculated:

Pb_{out}	10.7	gPb/hr
Pb_{in}	0.6	gPb/hr
Net Pb_{out}	$\cong$ 10	gPb/hr

A ratio R of the lead emission rate for Area 5 to the axle count was calculated for both September 4 and September 5. These values are as follows:

$$R_{Sept.\ 4} = \frac{41}{531} = 0.08\ \frac{g\ Pb/hr}{Axle}$$

$$R_{Sept.\ 5} = \frac{10}{151} = 0.07\ \frac{gPb/hr}{Axle}$$

The above values suggest a linear relationship between lead entrainment and traffic intensity.

FUGITIVE LEAD EMISSIONS FROM THE SMELTER BUILDING

The smelter building has major openings at ground level in the east and south walls. The major opening in the top of the building is the penthouse opening, which is near roof level, pointing towards the east. The west side of the building is completely closed, and the only opening to the north is a stairway door. Its contribution towards fugitive emissions was considered negligible.

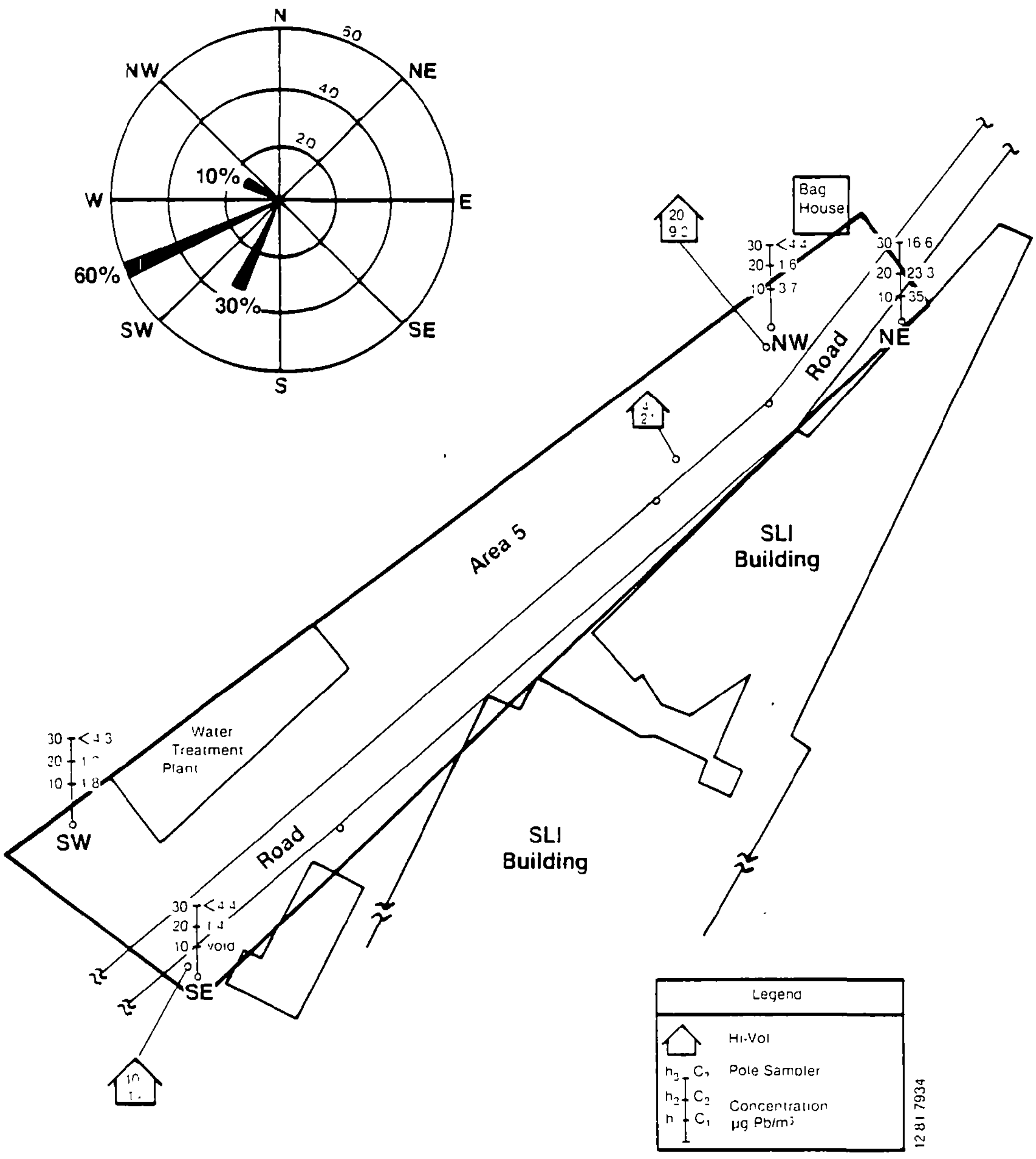


Figure 26. Wind Rose and Lead Concentration as a Function of Height. Area 5, Sept 05, 1981

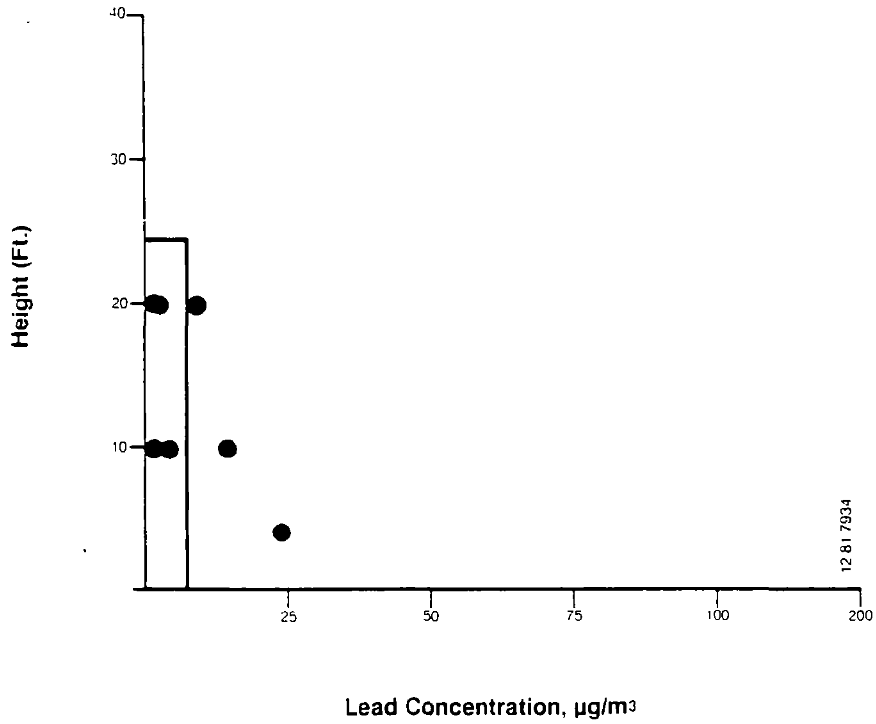


Figure 27. Lead Concentration as Function of Height, Area 5 Sept.-05-81.

Flow measurements made with a velometer indicated that air flowed into the building through the ground level openings in the south and east walls (see Figure 5). The thermal draft within the building generated by the warming of the air inside the smelter by smelting and refining operations caused an air flow to emanate from the penthouse opening in the east wall. This flow pattern was visually verified by utilizing a smoke source and observing the movement of the smoke.

In the following, the total fugitive emissions are calculated by multiplying the air flow rate from the penthouse opening by the lead concentration observed. The contribution of the intake at ground level can be found by multiplying the air flow rate out of the penthouse opening by the lead concentrations recorded at points 4, 5, 6, and 7 at ground level. The difference between those values is the fugitive lead emission rate generated by the smelter building itself.

The dimensions, flow rates, and lead concentrations measured at the penthouse opening are described in Figure 28.

Since the flow rates are very different in the upper and lower halves of the penthouse opening, emission rates were calculated for them separately.

Air flow through upper half:

$= 17 \cdot 0.3048(\text{m}) \cdot 9 \cdot 0.3048(\text{m}) \cdot 1.5\ \text{m/sec}$

$= 21.3\ \text{m}^3/\text{sec}$

Air flow through lower half:

$= 17.0 \cdot 0.3048(\text{m}) \cdot 9 \cdot 0.3048(\text{m}) \cdot 0.35\ \text{m/sec}$

$= 5.0\ \text{m}^3/\text{sec}$

Pb emissions from upper half:

$= 21.3\ \text{m}^3/\text{sec} \cdot 1213\ \mu\text{gPb/m}^3 = 93\ \text{gPb/hr}$

Pb emissions from lower half

$= 5.0\ \text{m}^3/\text{sec} \cdot 1142\ \mu\text{gPb/m}^3 = 21\ \text{gPb/hr}$

Total emissions from penthouse opening

$= 114\ \text{gPb/hr}$

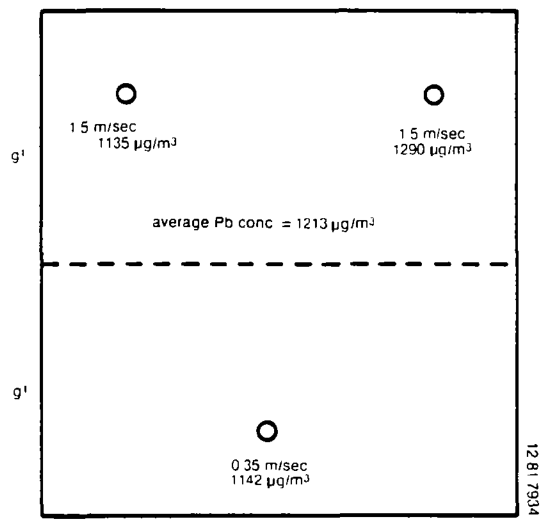


Figure 28: Penthouse Opening, with Exit Air Velocities and Concentrations.

Concentrations measured at ground level were as follows:

Point 4 (bottom inlet north)	242 $\mu gPb/Nm^3$
	271
Point 5 (bottom inlet south)	98
	319
Point 6 (lead well east)	323
	184
Point 7 (lead well west)	416
	184
Average Pb concentration at ground level intake points	255 $\mu gPb/Nm^3$

Contribution to penthouse emission caused by the intake through the ground level openings is

$$26.3\ m^3/sec \cdot 255\ \mu gPb/m^3 = 24\ gPb/hr$$

Fugitive emissions generated by smelting and refining operations are as follows:

Pb_{out}	114 gPb/hr
Pb_{in}	-24 gPb/hr
Net Pb_{out}	90 gPb/hr

These values are estimated to double if both blast and reverberatory furnaces are in operation.

PARTICLE SIZE DISTRIBUTION AND LEAD CONCENTRATION AS FUNCTION OF PARTICLE SIZE

The weight gain of the impactor filters was the basis for the determination of the particle size distribution. The data were plotted as the weight % material as function of particle size (probability x 2 log cycles). The weight fractions >7.5μ, 7.5-2.5μ, and <2.5μ are found from these plots by interpolation. The data are summarized in Table 14.

In addition, each impactor filter was analyzed for lead. The weight % lead in the same size fraction ranges was then derived. These data are also summarized in Table 14.

The results indicate that more than 80% of the particulate matter collected is in the aerodynamic size range of <7.5μ. The lead analysis data show that in general the lead content increases with decreasing particle size. More than 70% of the airborne lead is found in particles with a diameter <7.5μ.

These facts have a great impact on the transport of the lead bearing particles since the settling velocities are proportional to the particle diameter:

$$v = \frac{(\rho_P - \rho_{air})\, d^2 \cdot g}{18 \cdot \eta} \approx \frac{g}{18\eta} \cdot \rho_P \cdot d^2$$

v = settling velocity (cm/sec)

ρ_P = particle density [g/cm^3]

ρ_{air} = density of air [g/cm^3]

d = particle diameter [μ]

g = gravity constant 9.81 [m/sec^2]

η = viscosity of air 1.8 x 10^{-5} [Dyn · sec/m^2]

m = mass of particle [g]

The correlation between the aerodynamic diameter (ρ=1) and actual diameter ($\rho = \rho_{particle}$) is

$$d_{real} = \frac{d_{aerodynamic}}{(\rho_{real})^{1/2}}$$

Assuming a particle density of ρ = 9 g/cm^3, an aerodynamic diameter of 7.5μ corresponds to an actual particle diameter of 7.5:3 = 2.5μ. Settling velocities of lead particles of this size range are a few millimeters/second only. An example of the data evaluation procedure is given in Tables 15 and 16 and in Figure 29.

TABLE 14. PARTICLE SIZE DISTRIBUTION (AMBIENT CASCADE IMPACTORS)

Date	Position	Weight % Particles			W % Lead in Particles		
		>7.5	7.5-2.5μ	<2.5μ	>7.5	7.5-2.5μ	<2.5μ
	Area 1						
9/2/81	W10'	9	38	53	11	42	47
9/3/81	W10'	9	14	77	23	28	49
9/3/81	W16'	10	17	73	14	20	66
	Area 2/3						
9/8/81	N16'	21	26	53	26	26	48
9/8/81	W16'	14	28	58	16	34	50
9/9/81	W10'	21	32	47	29	21	50
9/9/81	S16'	12	17	71	15	22	63
9/10/81	W16'	17	17	66	21	23	56
9/10/81	S16'	10	14	76	11	14	75
	Area 4						
9/6/81	E10'	19	27	54	25	31	44
9/6/81	Roof	8	27	65	12	27	61
9/7/81	Roof	15	28	57	18	34	48
9/7/81	E16'	20	22	58	32	28	40
	Area 5						
9/4/81	SE10'	14	31	55	24	39	37
9/4/81	NW16'	18	31	51	28	44	28
9/5/81	SE16'	11	26	63	19	38	43
9/5/81	NW10'	14	27	59	6	10	84

TABLE 15. COMPUTER OUTPUT WITH INTERPOLATED VALUES - SAMPLE 1-W10', SEPTEMBER 2, 1981

IMPACTOR RESULTS SUMMARY - SPLINE FIT OF EXPERIMENTAL DATA
SAMPLE IDENT: TSP1

SAMPLING LOCATION: 1-W10'
TYPE OF IMPACTOR: SIERRA CASCADE
IMPACTOR SUBSTRATE: GELMAN GLASS
DATE: 9/ 2/81 (MMDDYY) TIME START: 10: 0 (HHMM) TIME FINISH: 19:36 (HHMM)

INTERVAL #	INTERVAL ENDPOINT	MASS FRACTION	MASS FRACTION LESS THAN	INTERVAL GEOMETRIC MIDPOINT	DM/DLOG DP DRY STAND. CONDITIONS UG/M3
1	10.00	.0910	.9090	22.3607	.140+003
2	7.50	.1151	.7938	8.6596	.991+003
3	5.62	.0821	.7117	6.4938	.707+003
4	4.22	.0826	.6292	4.8697	.711+003
5	3.16	.0630	.5661	3.6517	.542+003
6	2.37	.0458	.5204	2.7384	.394+003
7	1.78	.0303	.4901	2.0535	.260+003
8	1.33	.0395	.4507	1.5399	.340+003
9	1.00	.0425	.4082	1.1548	.365+003
10	.75	.0220	.3862	.8660	.189+003
11	.56	.0097	.3765	.6494	.835+002
12	.42	.0025	.3741	.4870	.212+002

RESPIRABLE LIMIT: 2.50 UM
MASS FRACTION LESS THAN: .528
MASS LESS THAN: 567.951 UG/M3

TABLE 16. RAW DATA INPUT TO COMPUTER SAMPLE 1-W10', SEPTEMBER 2, 1981

IMPACTOR RESULTS SUMMARY
SAMPLE IDENT: TSP1

NOMINAL MASS CONCENTRATION .108+004 UG/M3

STAGE #	STAGE DP50 (INTERVAL ENDPOINT)	MASS FRACTION	MASS FRACTION LESS THAN	INTERVAL GEOMETRIC MIDPOINT	DM/DLOG DP DRY, STAND, CONDITIONS UG/M3
1	7.50	.2060	.7940	19.3649	.269+003
2	3.20	.2250	.5690	4.8990	.654+003
3	1.60	.0910	.4780	2.2627	.325+003
4	1.00	.0700	.4080	1.2649	.369+003
5	.50	.0340	.3740	.7071	.122+003
FINAL FILTER	.	.3730	.0000	.1581	.401+003

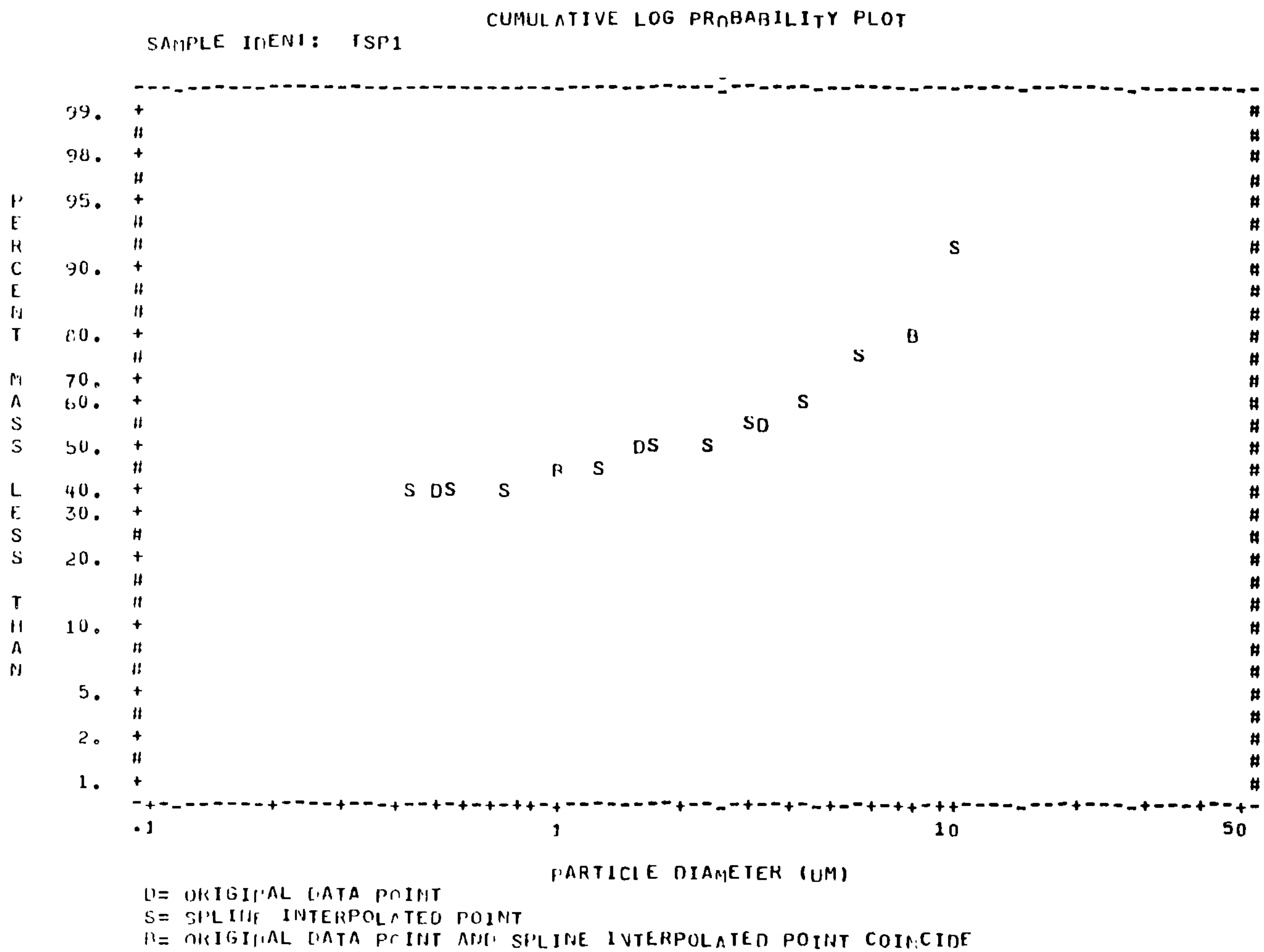


Figure 29. Cumulative Probability Plot

REFERENCES

1. Radian Corporation, "Program Plan for Study of Secondary Lead Smelters in Pennsylvania," EPA Contract No. 68-02-3513, Work Assignment 4, 9 January 1981.

APPENDIX

METEOROLOGICAL DATA

Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 Through September 14, 1981.

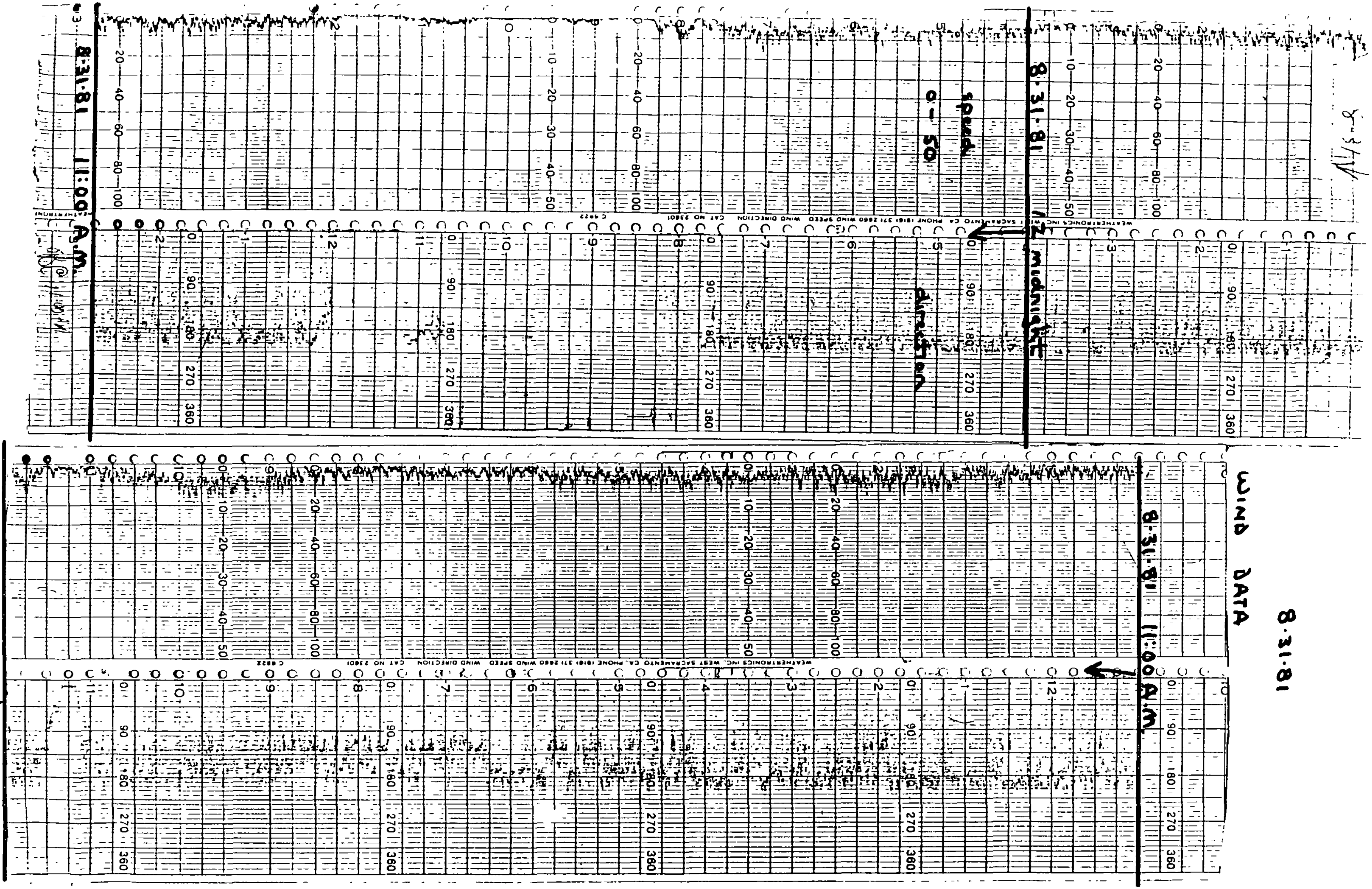


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981.

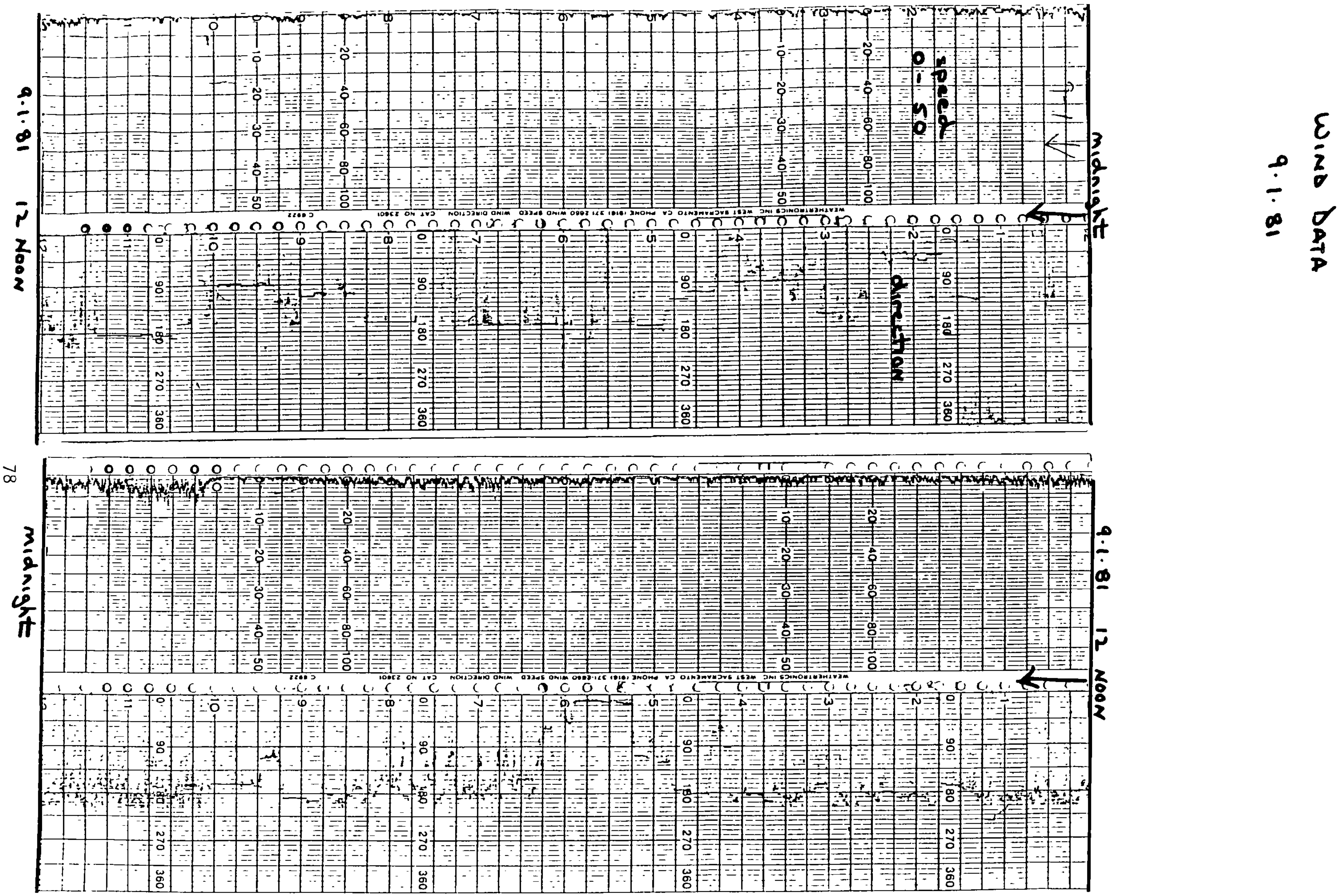


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

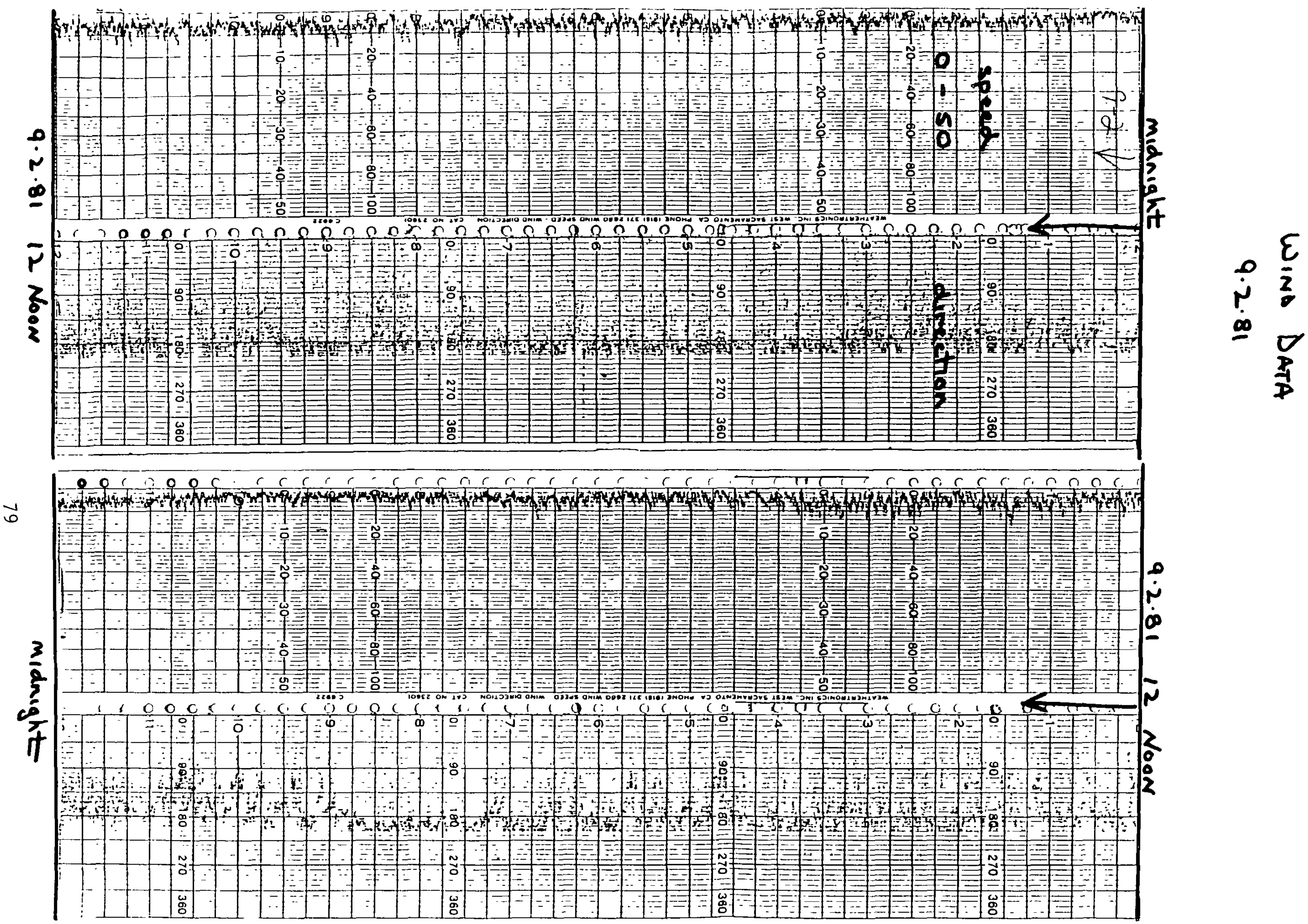


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

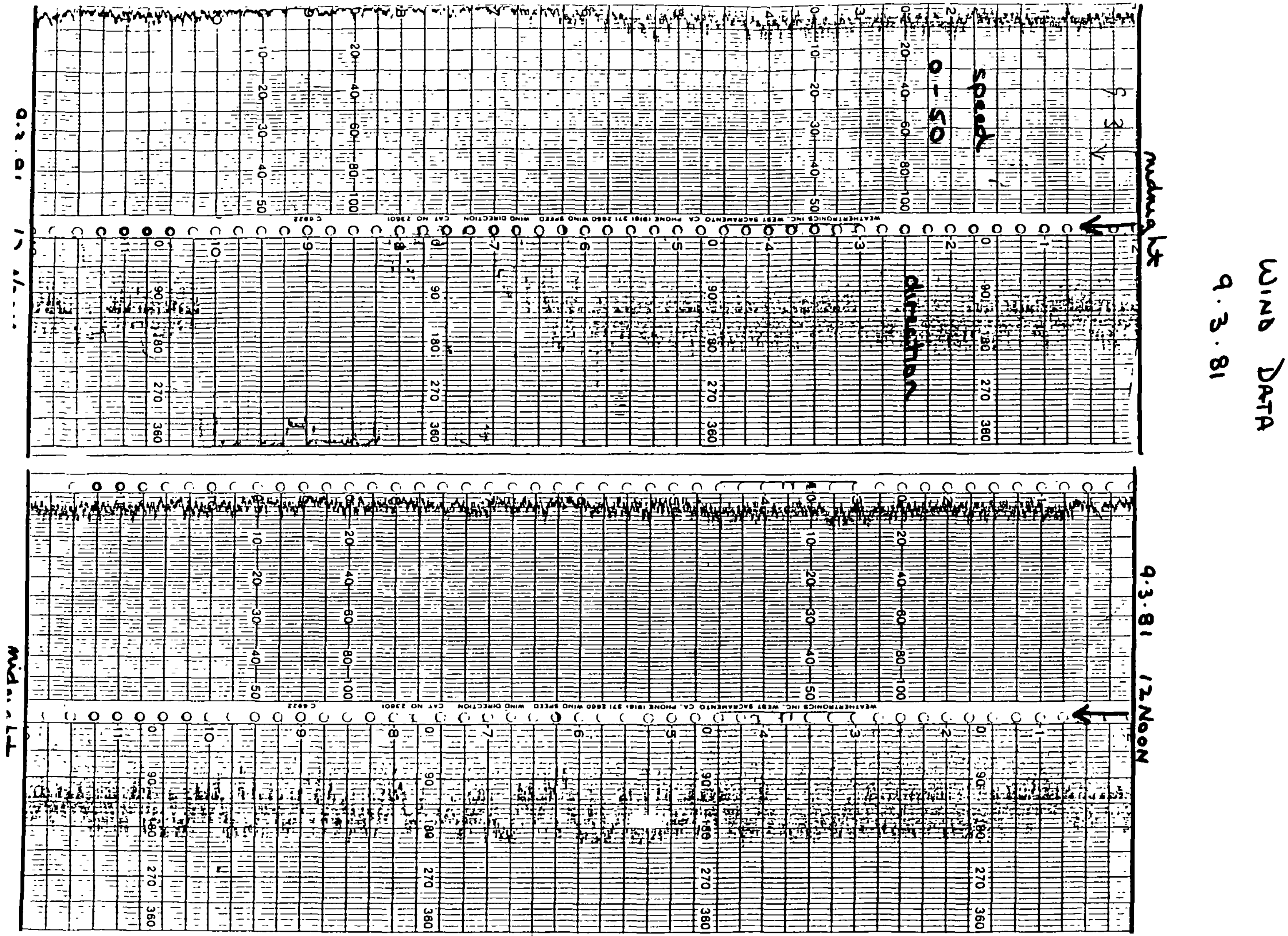


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

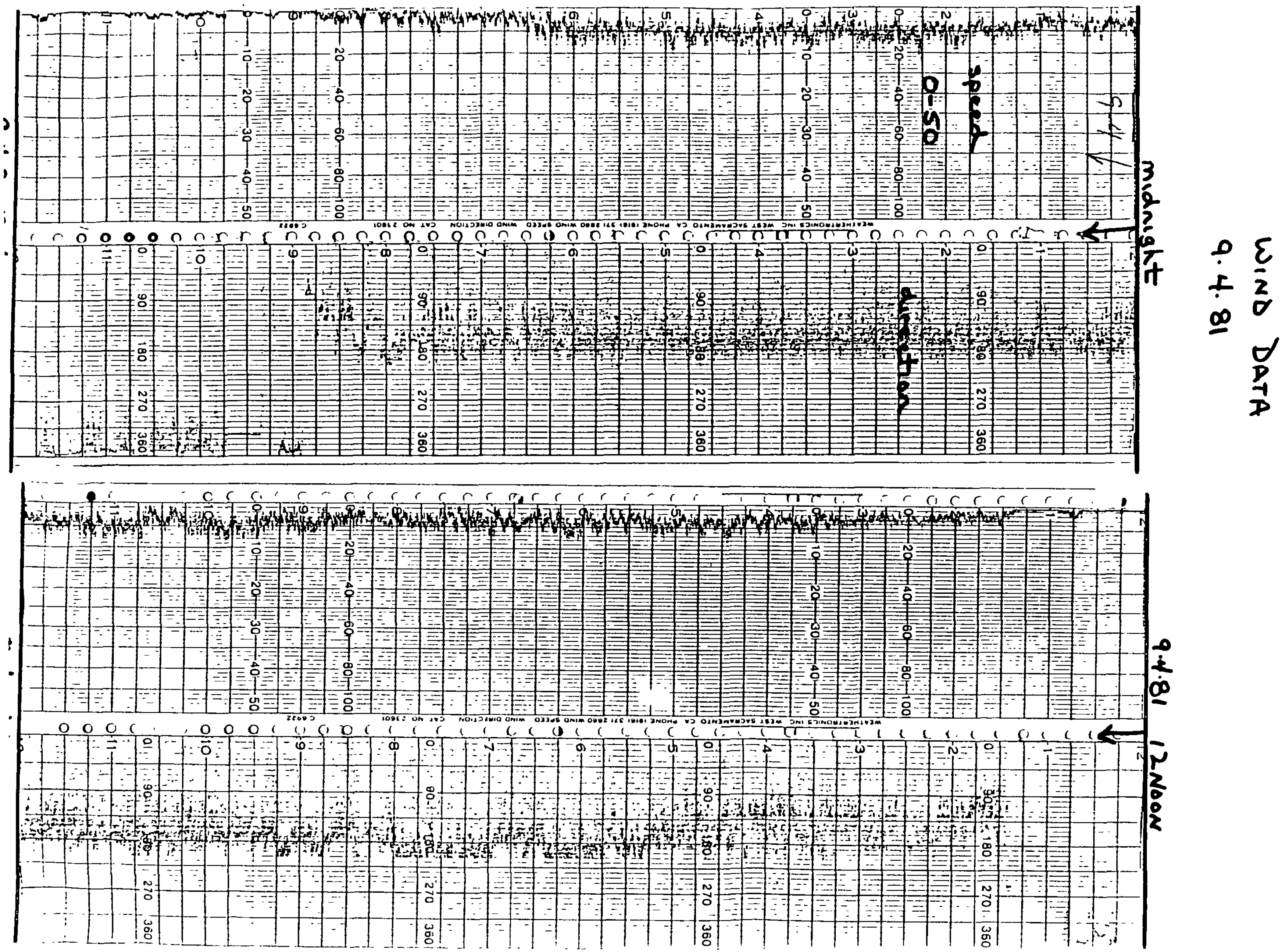


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

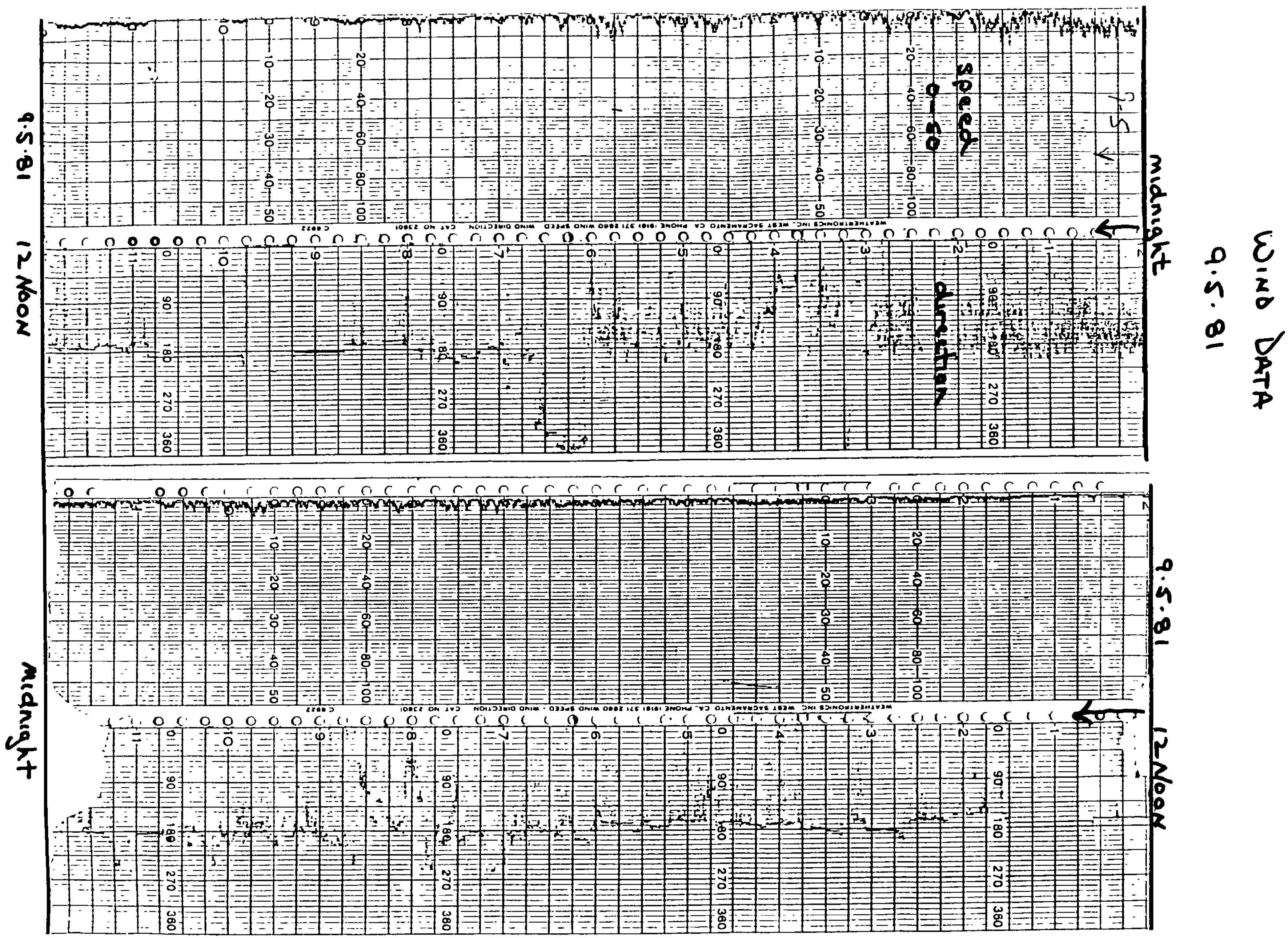


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued)

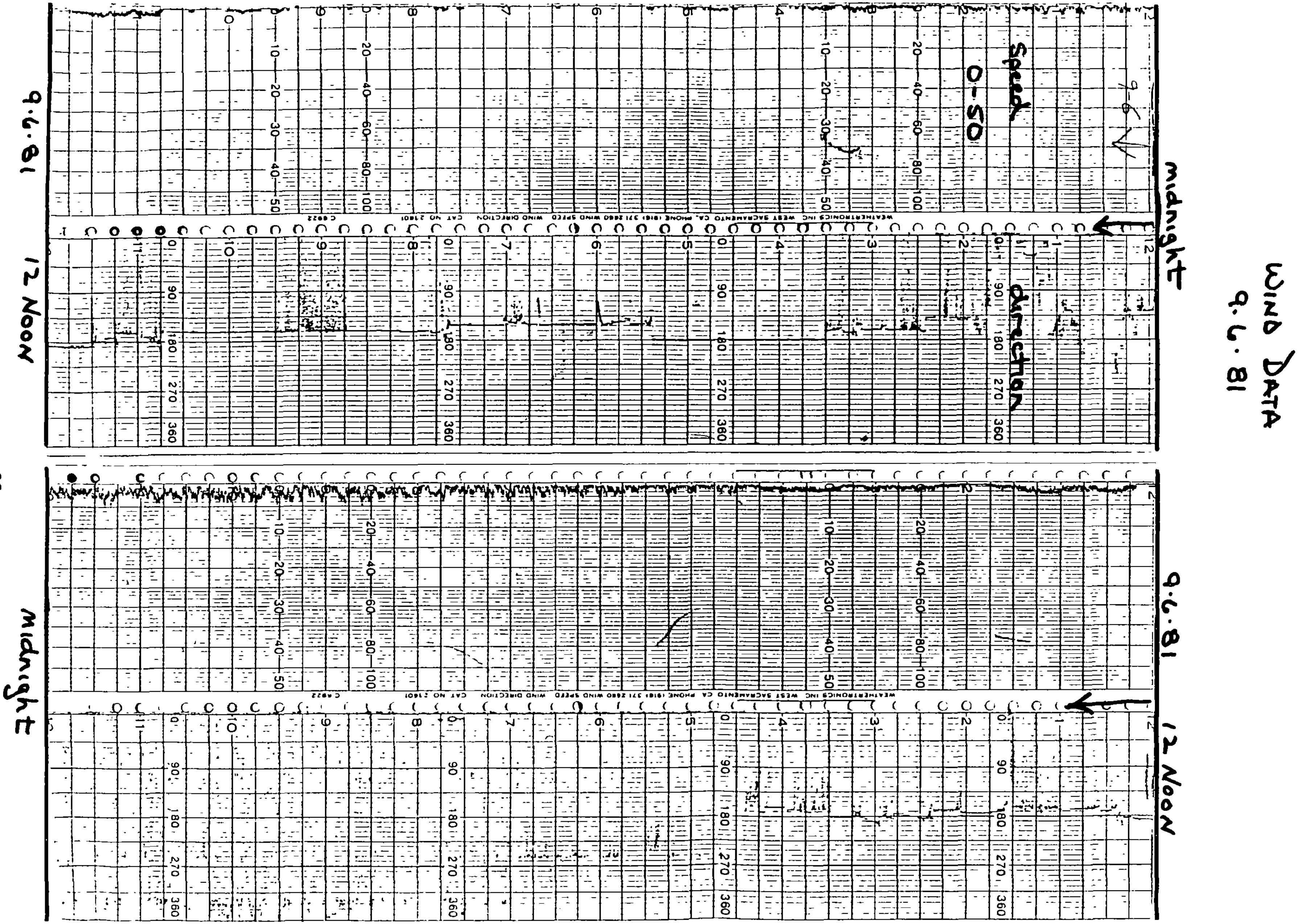


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

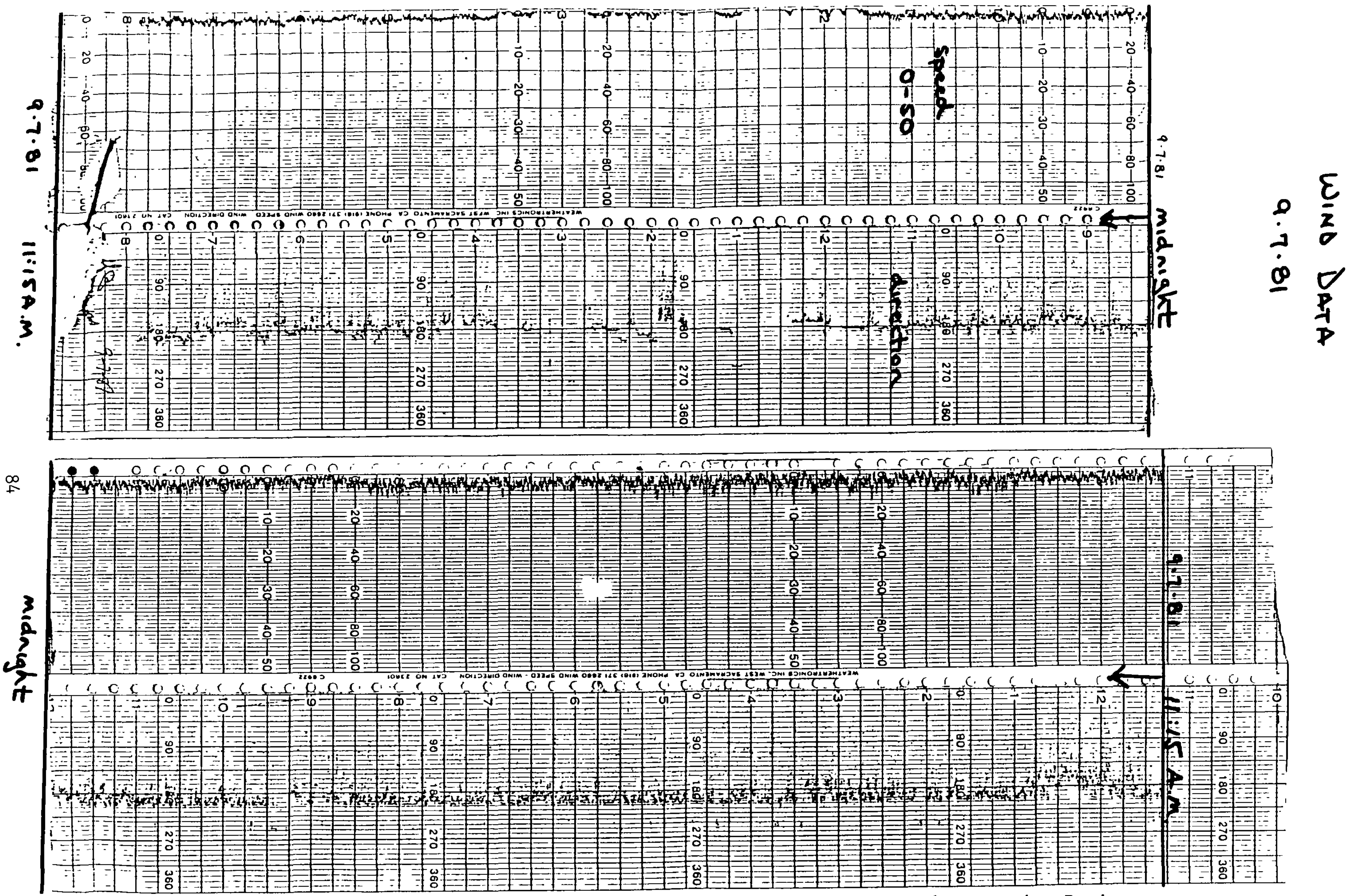


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

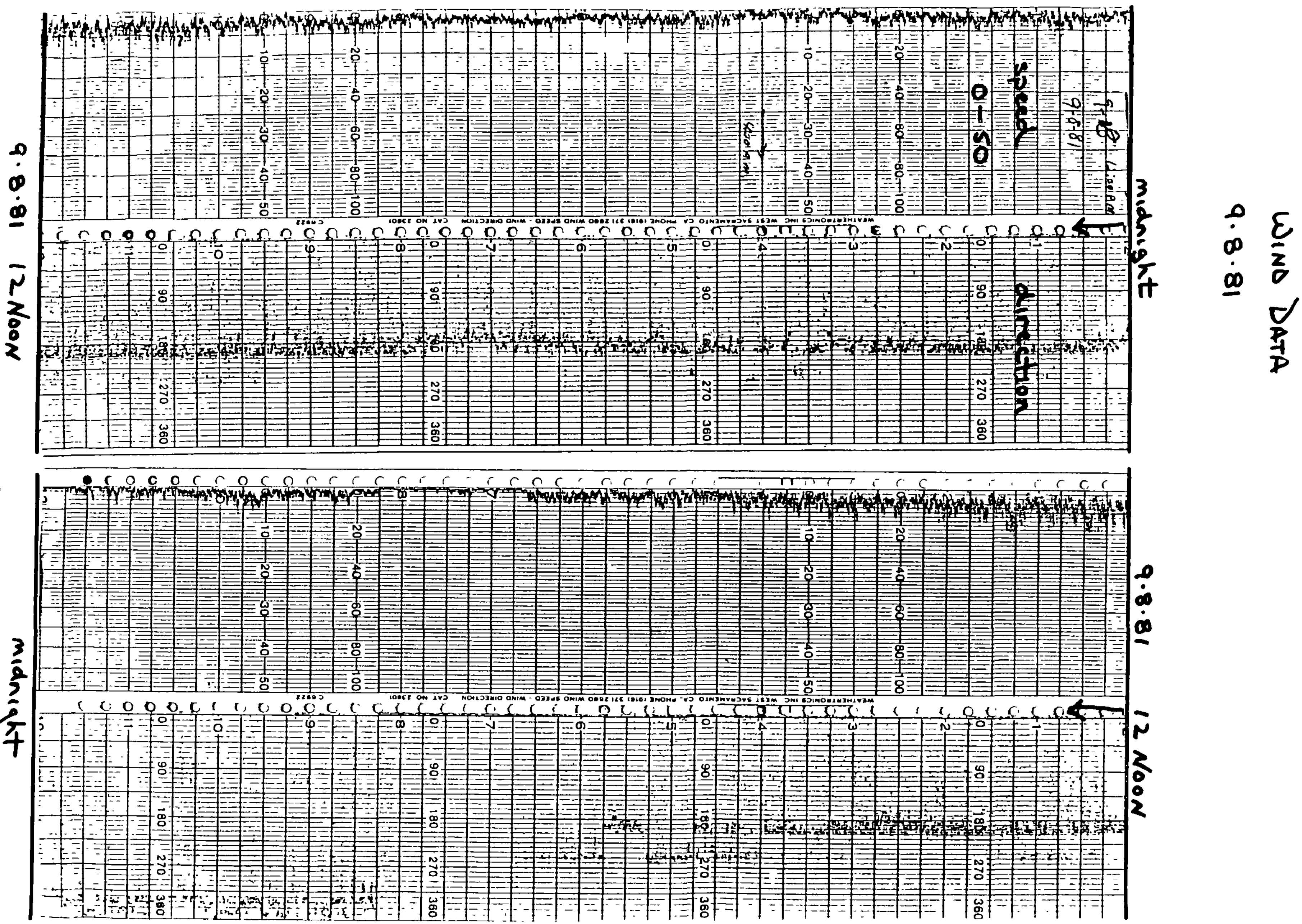


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

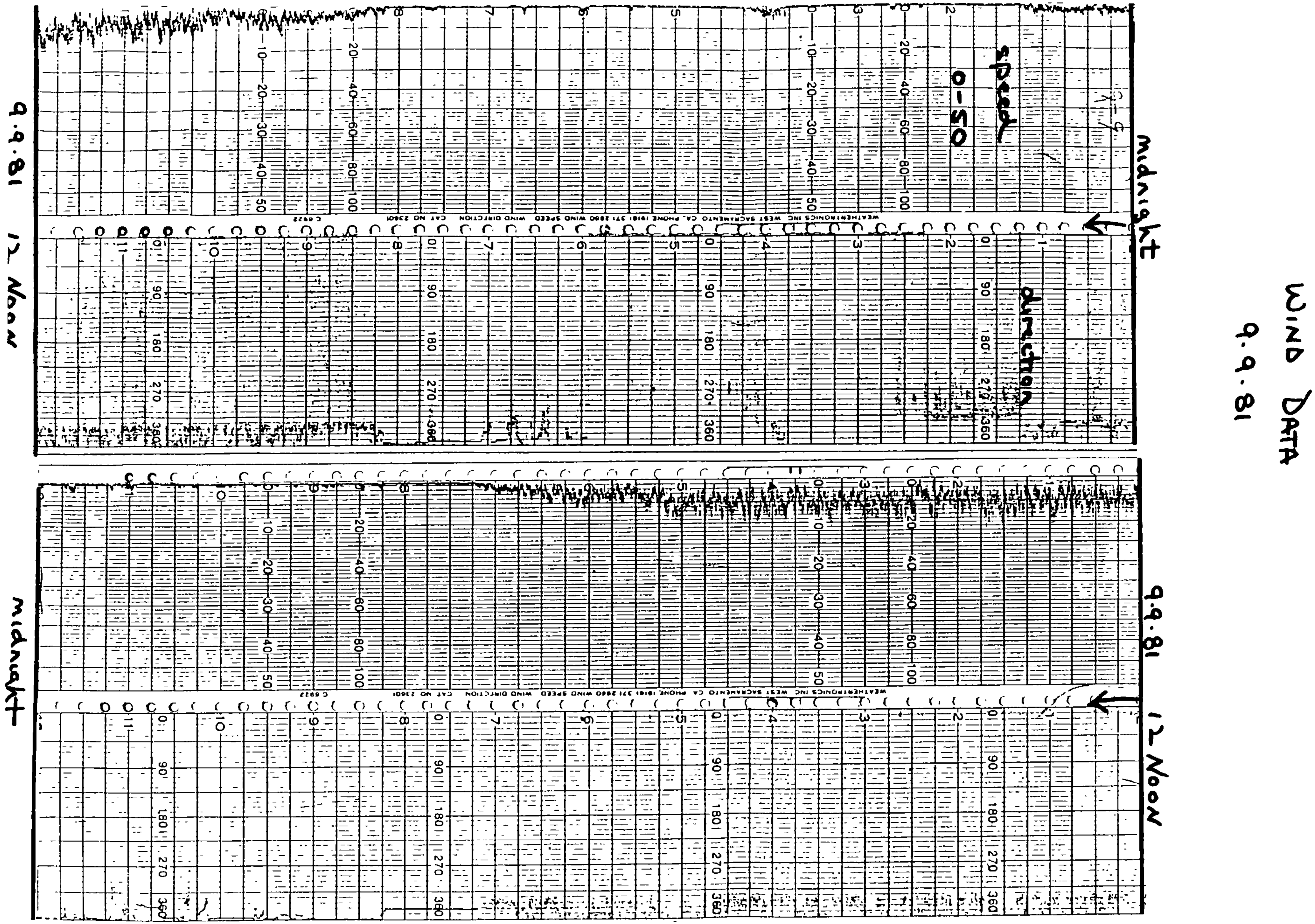


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

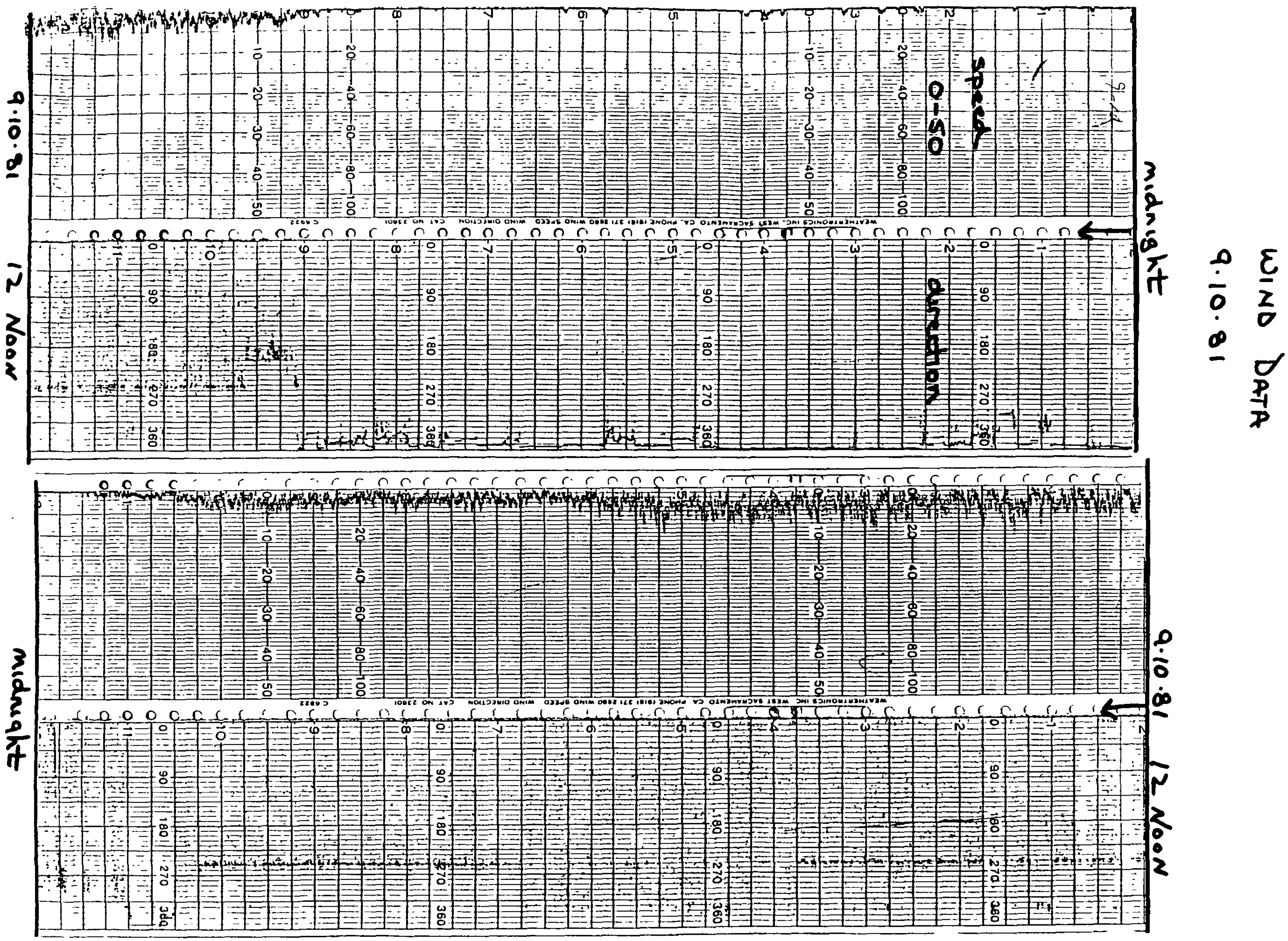


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

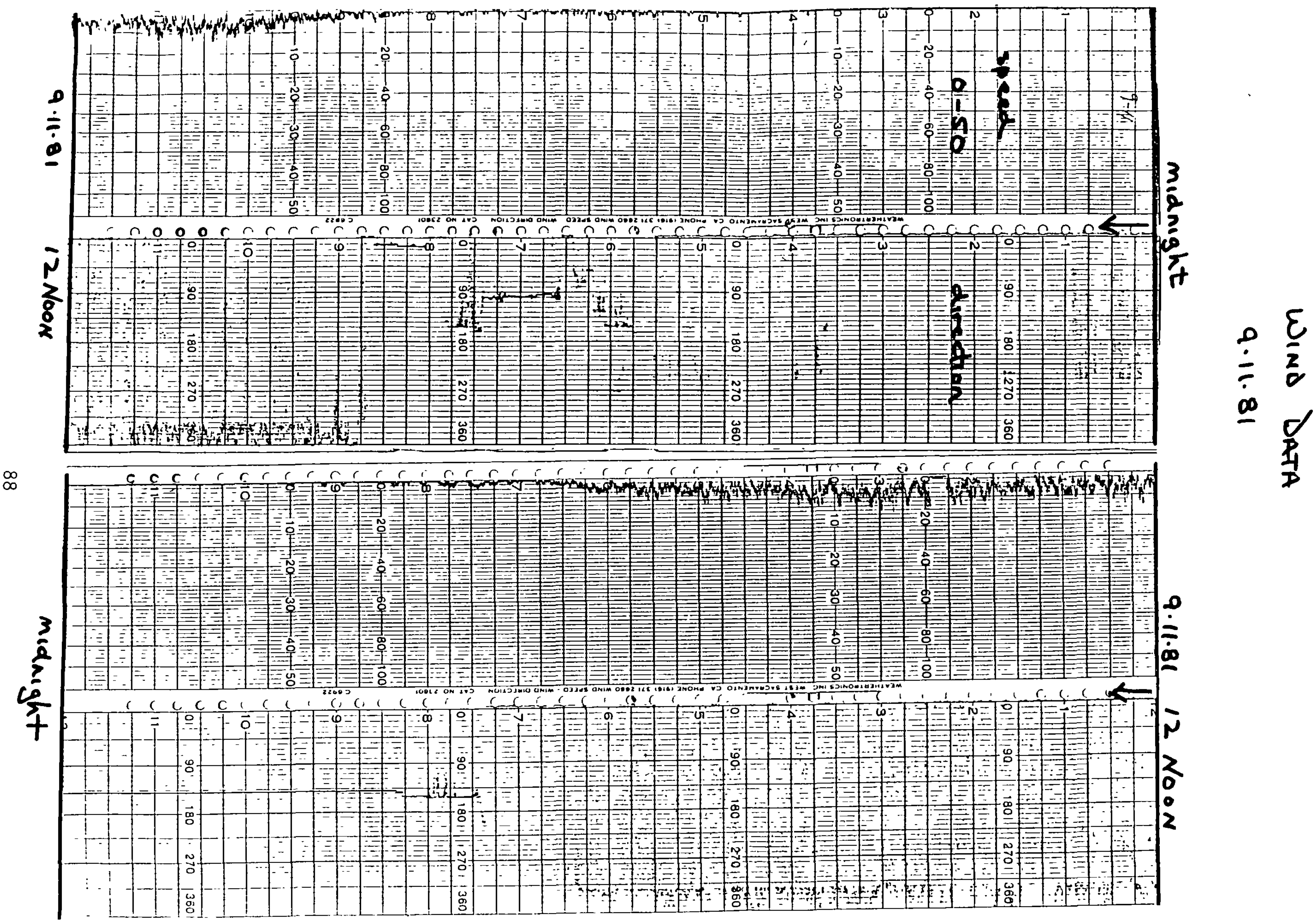


Figure 6. Wind Speed and Wind Direction Measured at the Company Weather Station During August 31 through September 14, 1981 (continued).

Figure 7. Temperature, Relative Humidity and Barometric Pressure During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station.

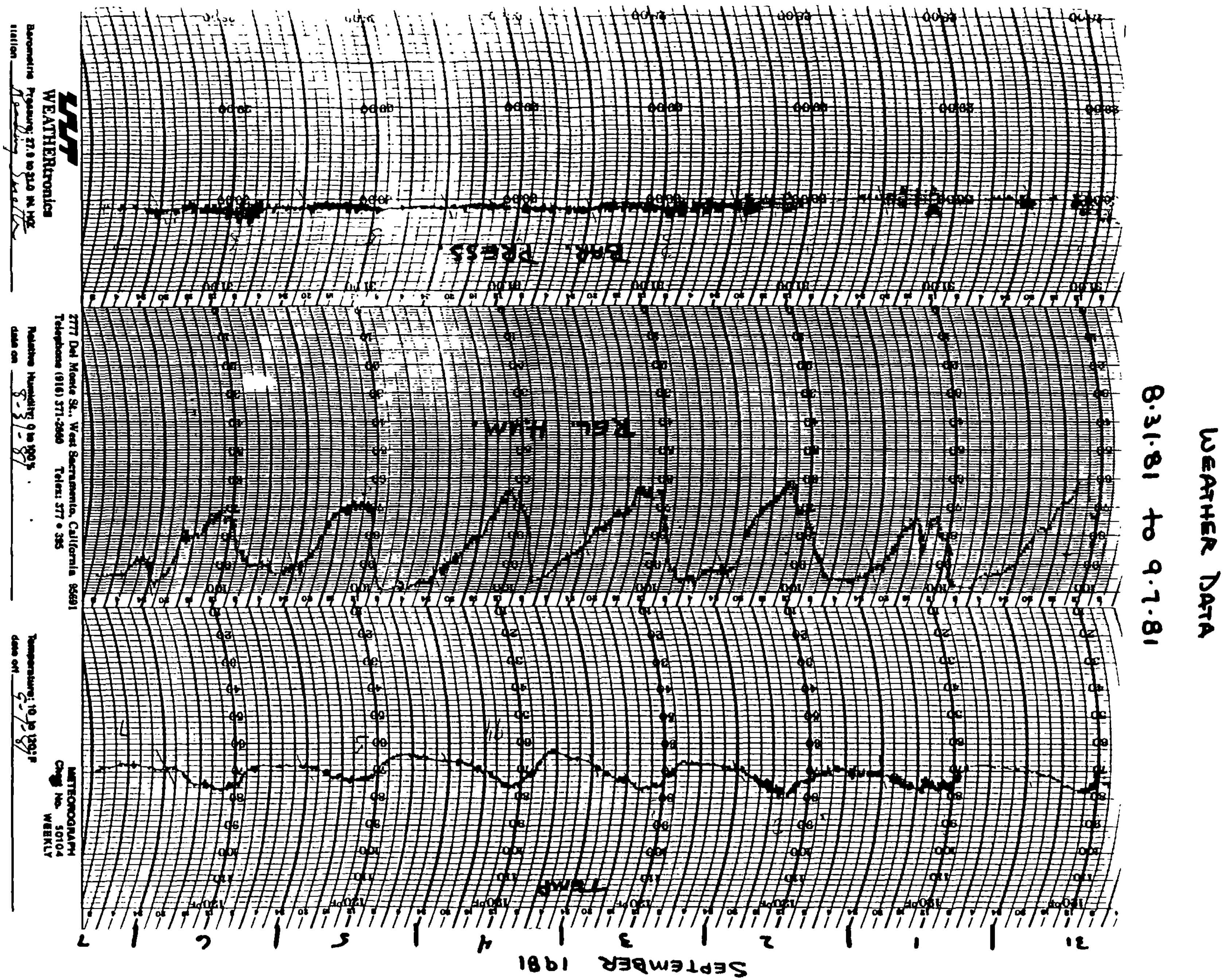


Figure 7. Temperature, Relative Humidity and Barometric Pressure During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station.

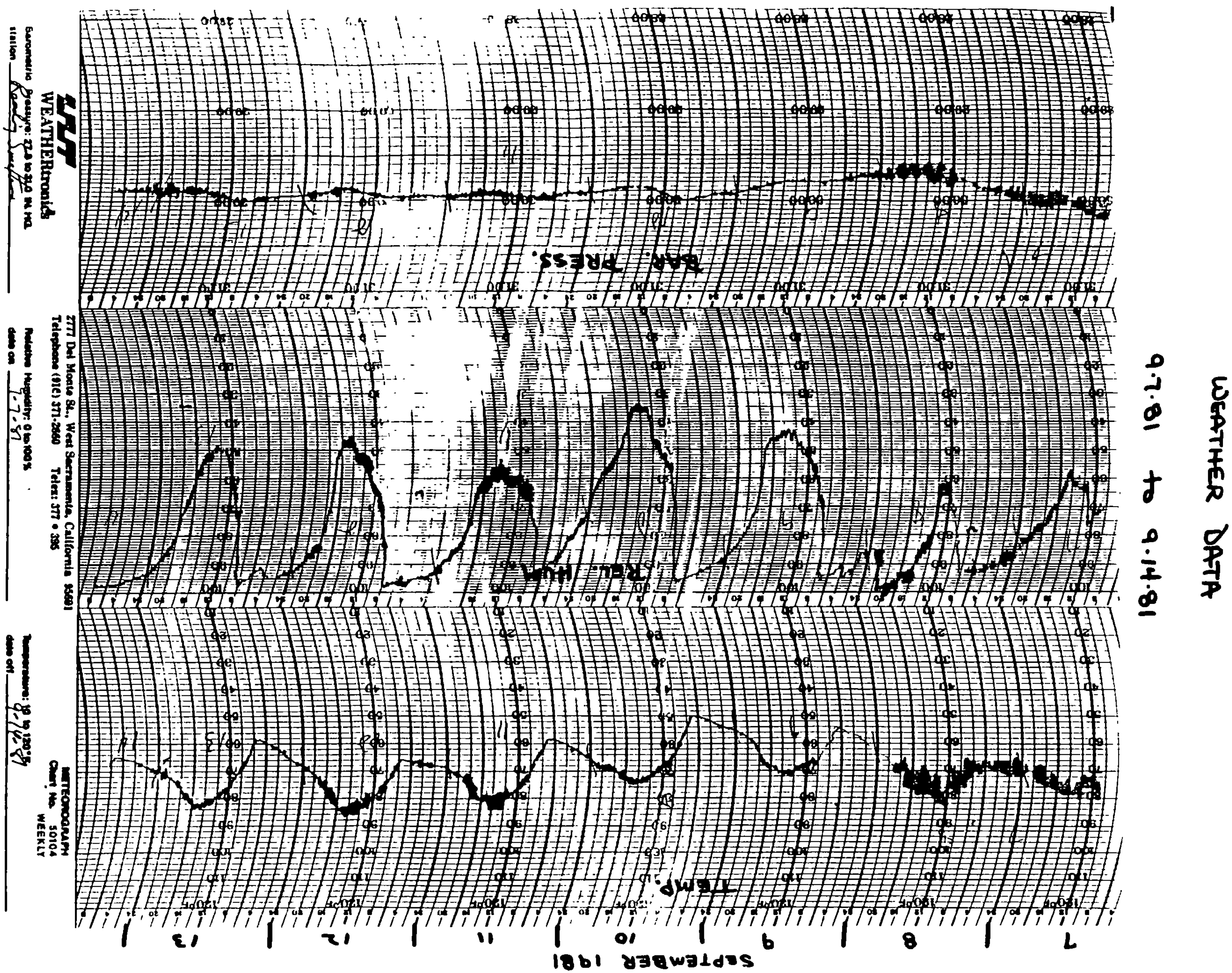


Figure 7. Temperature, Relative Humidity and Barometric Pressure During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station (continued).

Figure 8. Rainfall During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station.

RAIN DATA

8·31·81 to 9·7·81

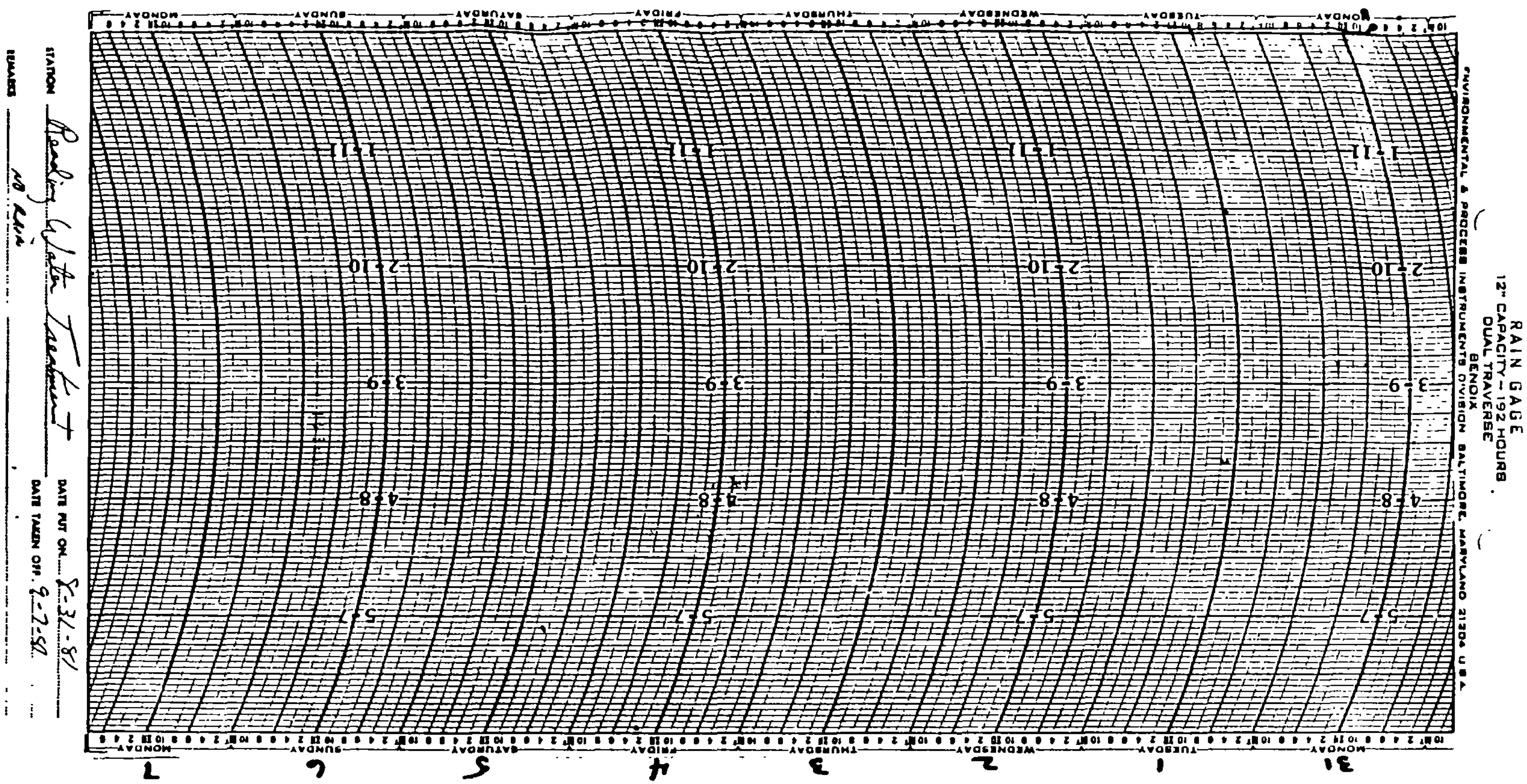


Figure 8. Rainfall During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station.

RAIN DATA

9-7-81 to 9-14-81

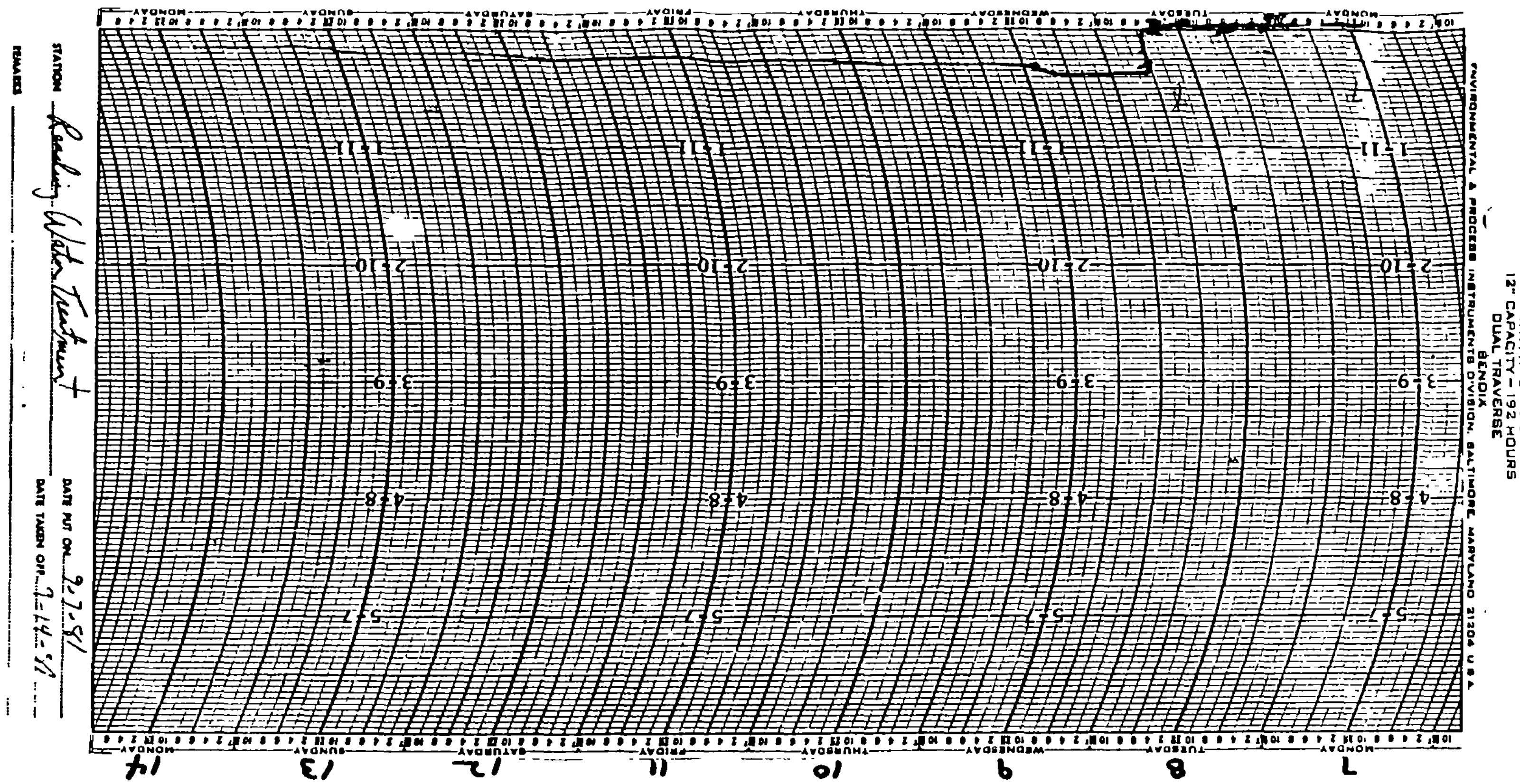


Figure 8. Rainfall During the Period of August 31 Through September 14, 1981 Measured at the Company Weather Station.

Figure 9. Area Wind Measurements - September 2 Through September 11, 1981

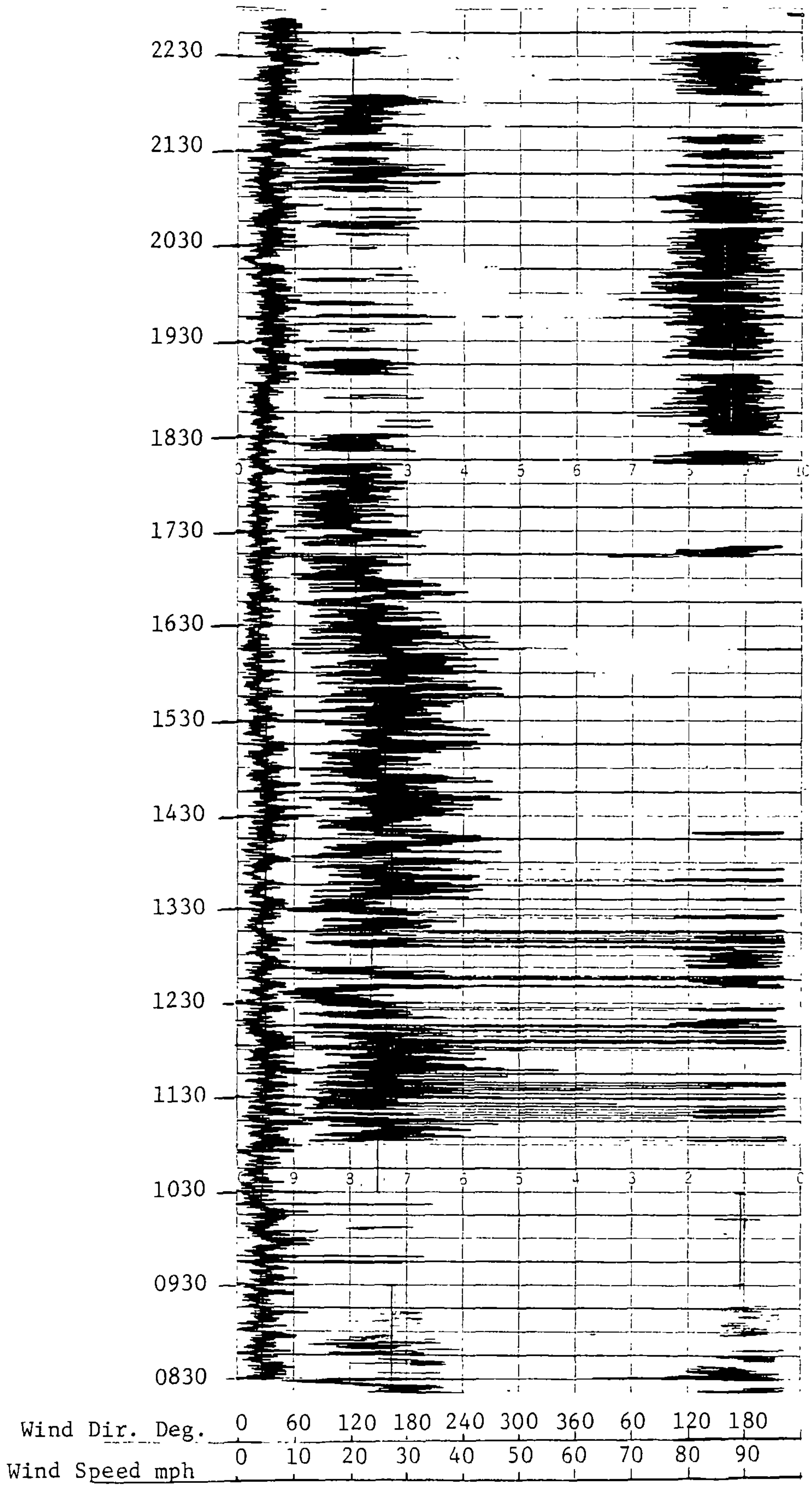


Figure 9. Area Wind Measurements - September 2, 1981.

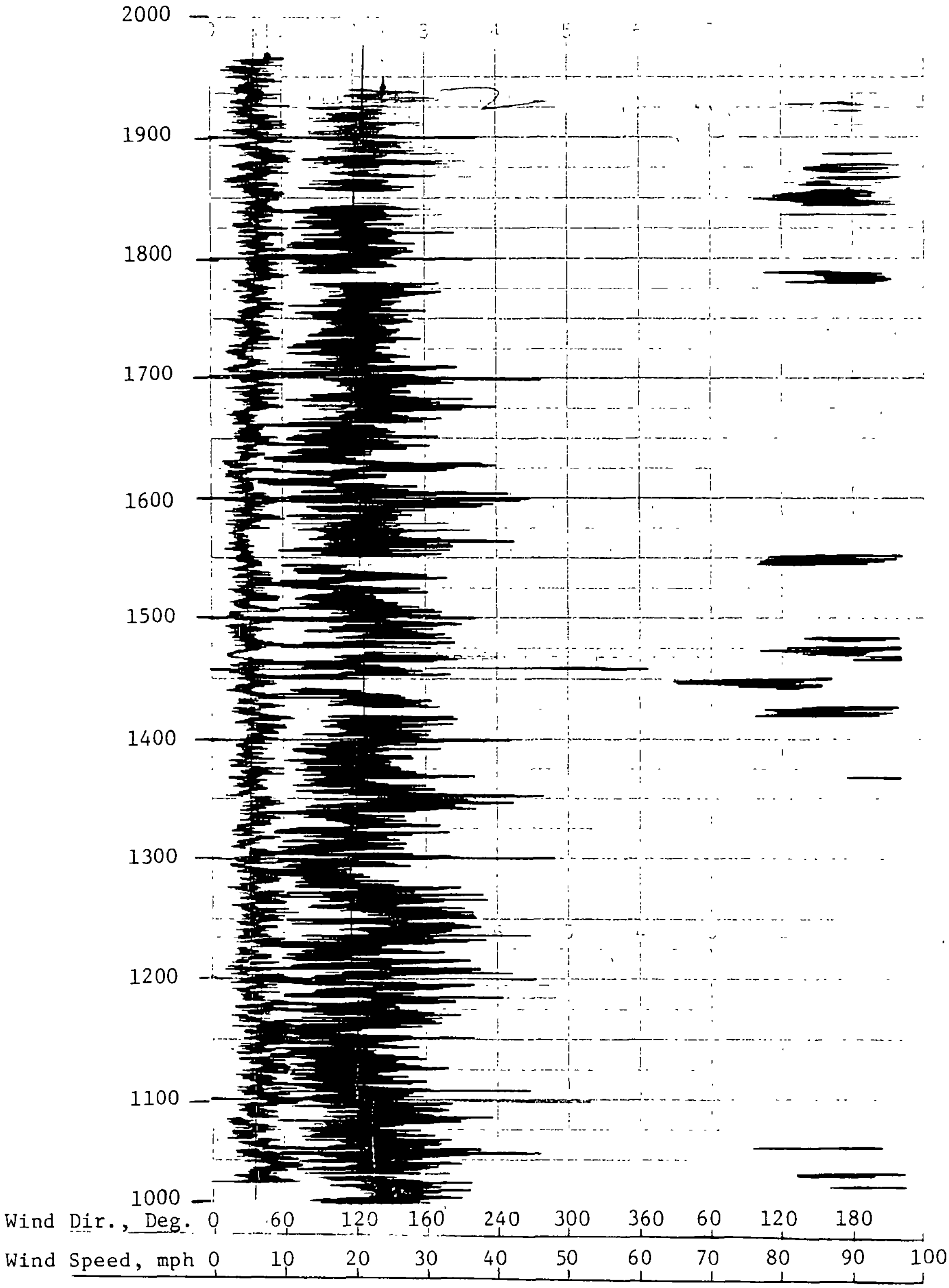


Figure 9. Area Wind Measurements - September 3, 1981.

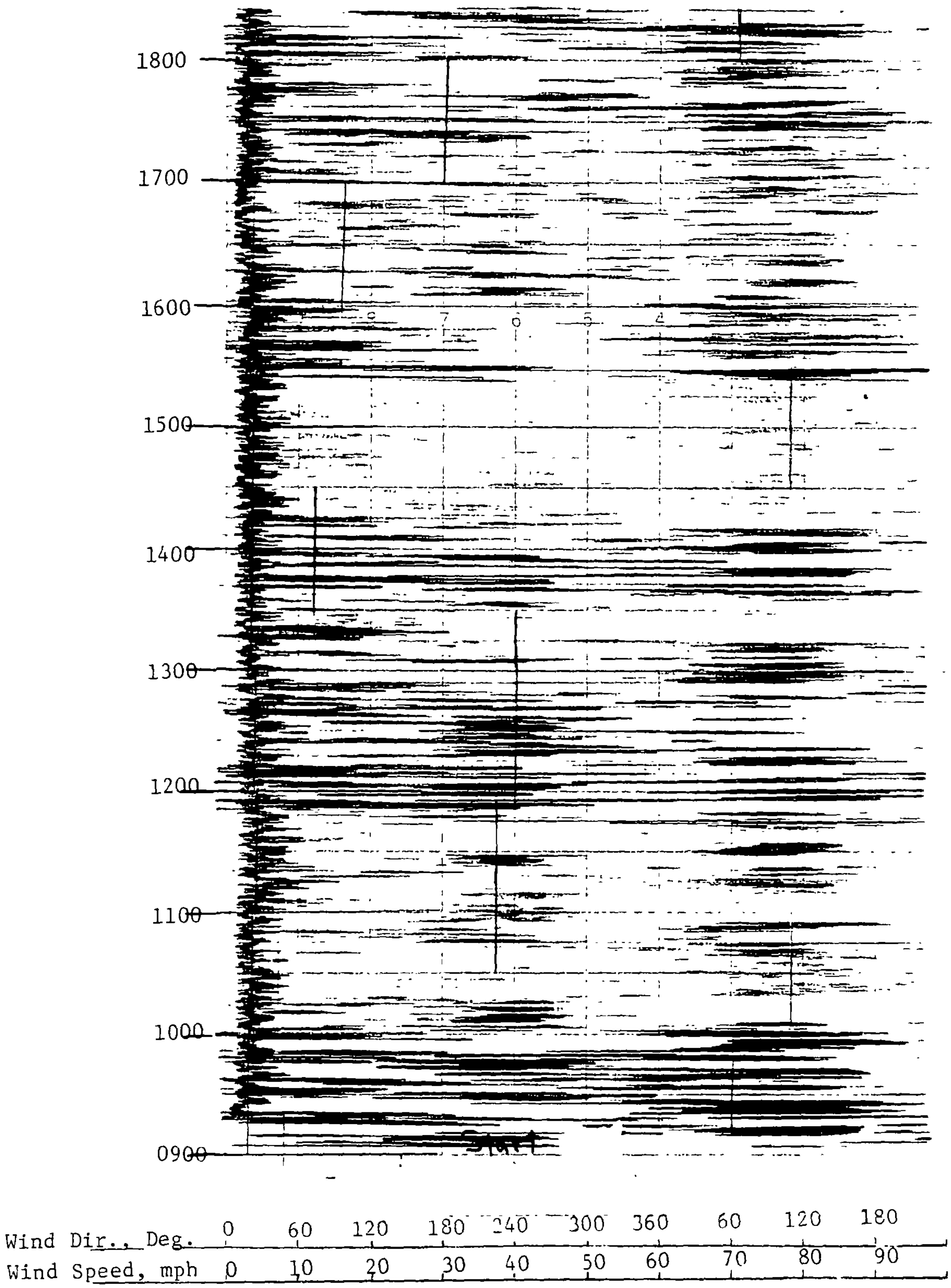


Figure 9. Area Wind Measurements - September 4, 1981.

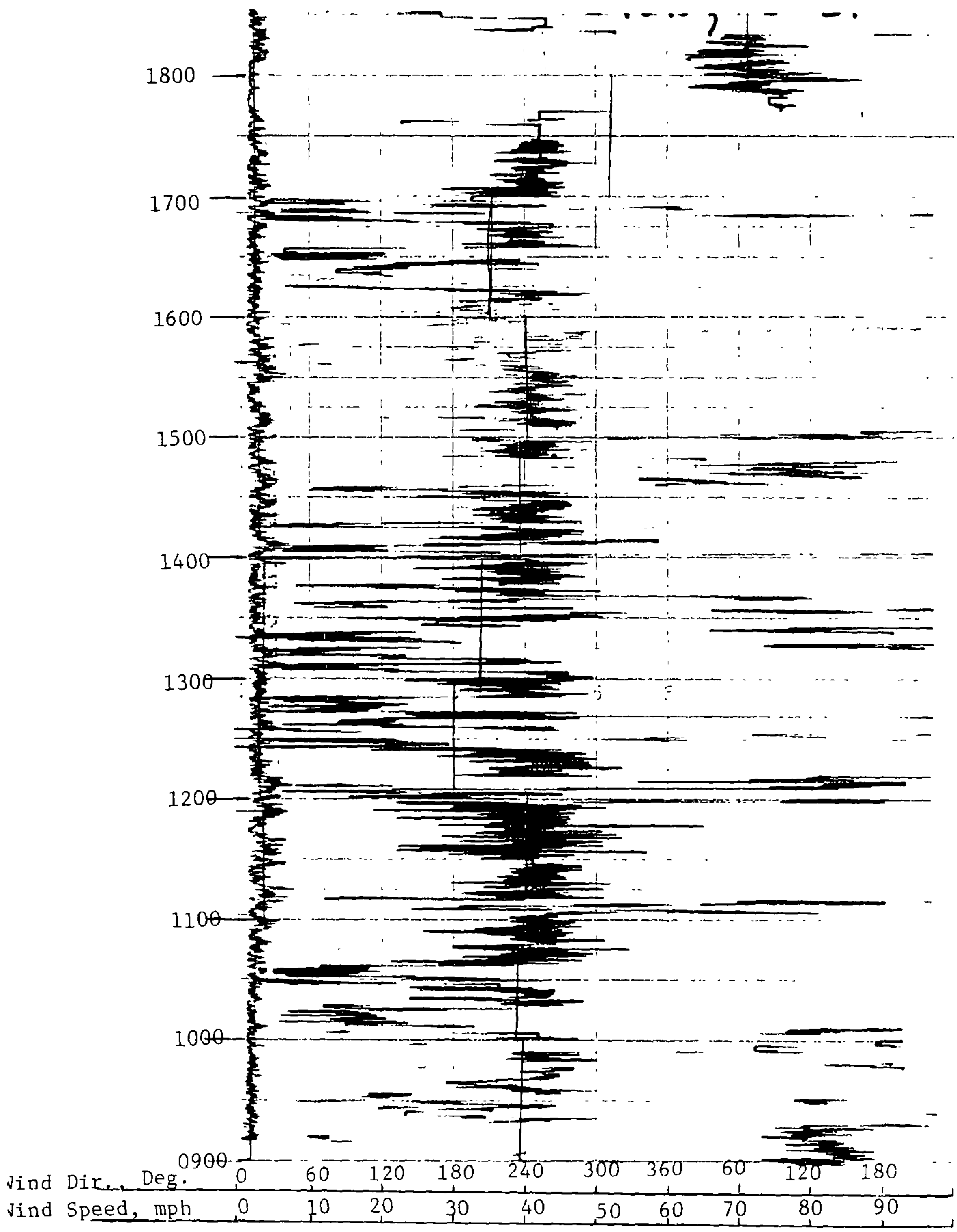


Figure 9. Area Wind Measurements - September 5, 1981.

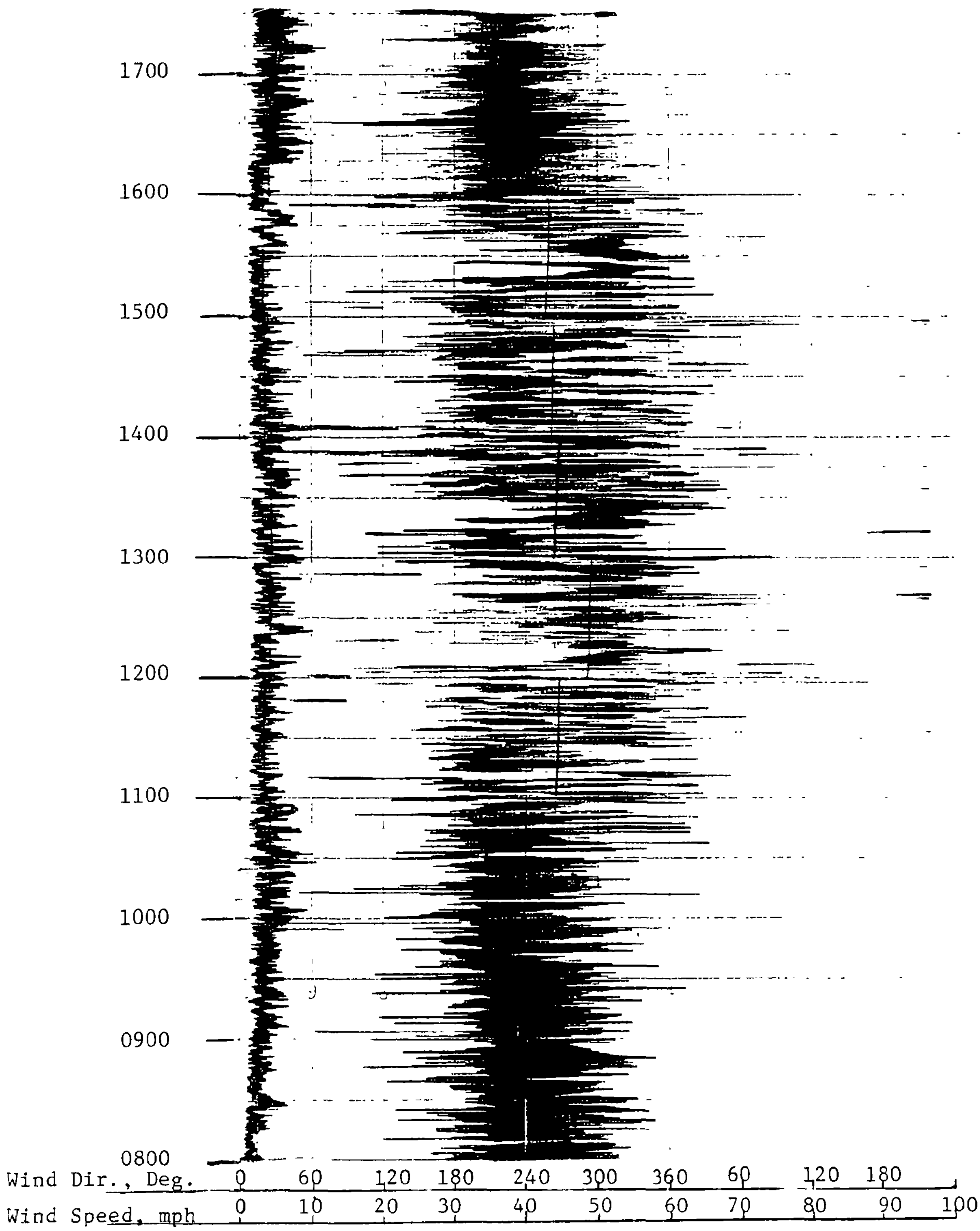


Figure 9. Area Wind Measurements - September 7, 1981.

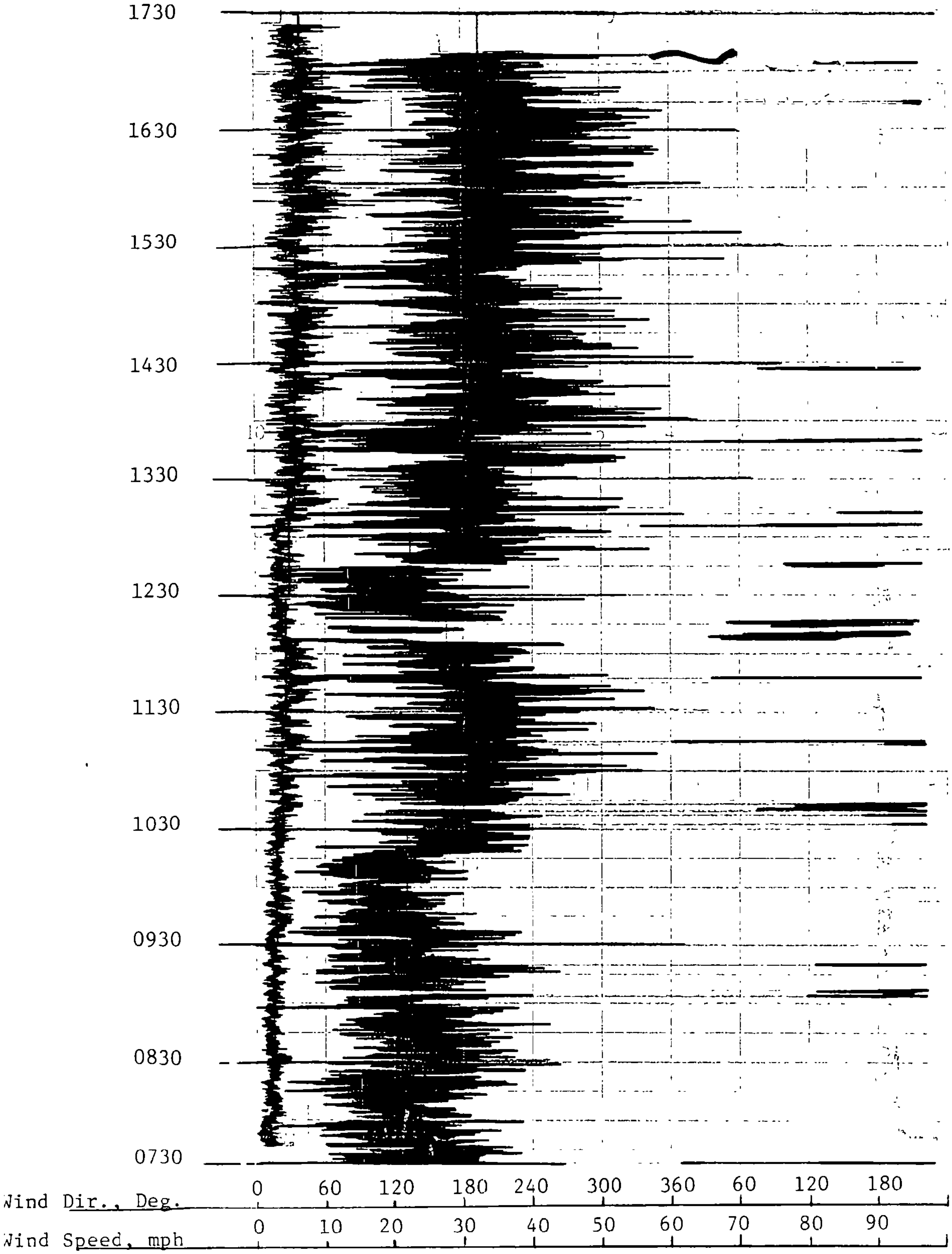


Figure 9. Area Wind Measurements - September 8, 1981.

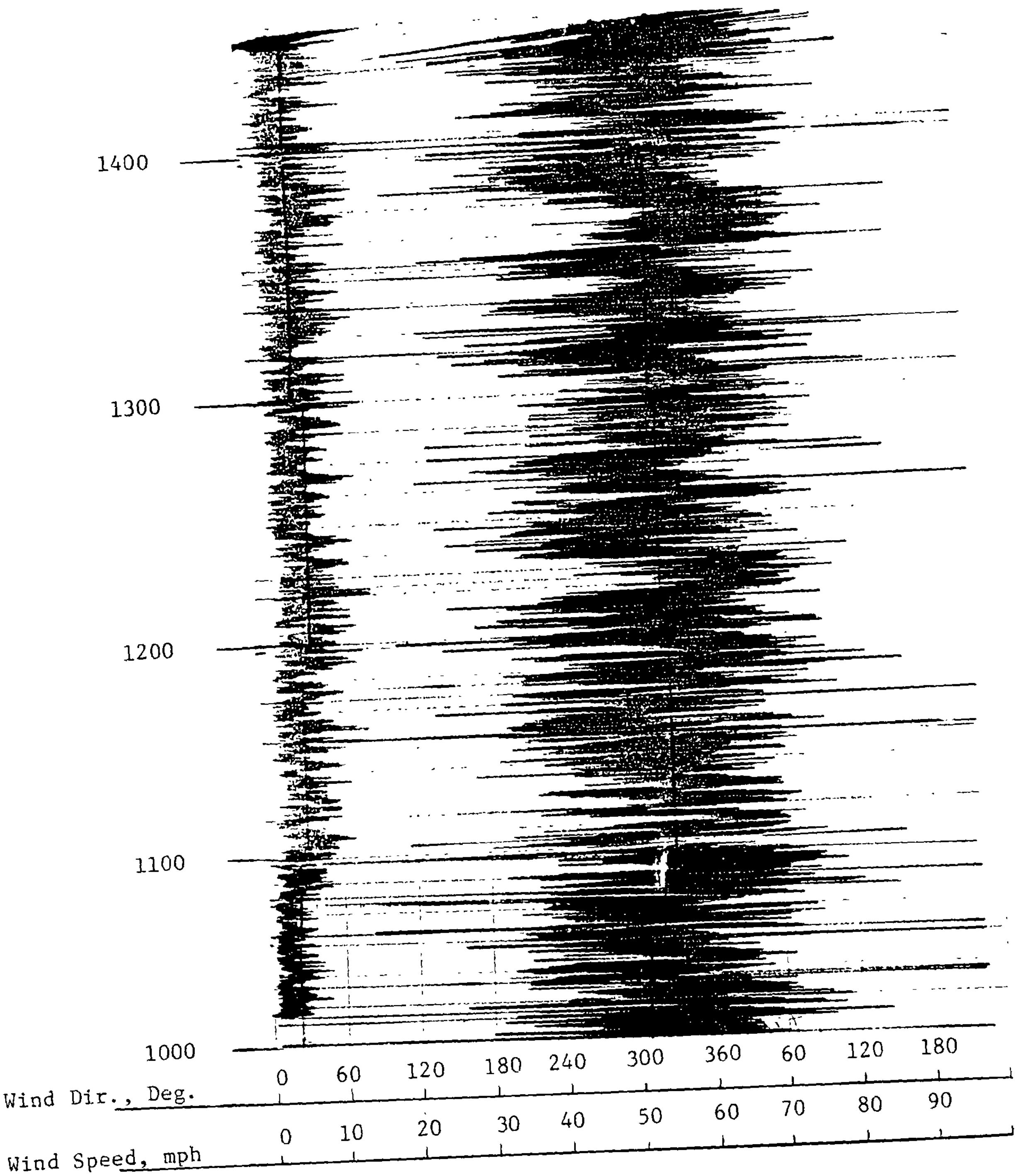


Figure 9. Area Wind Measurements - September 9, 1981.

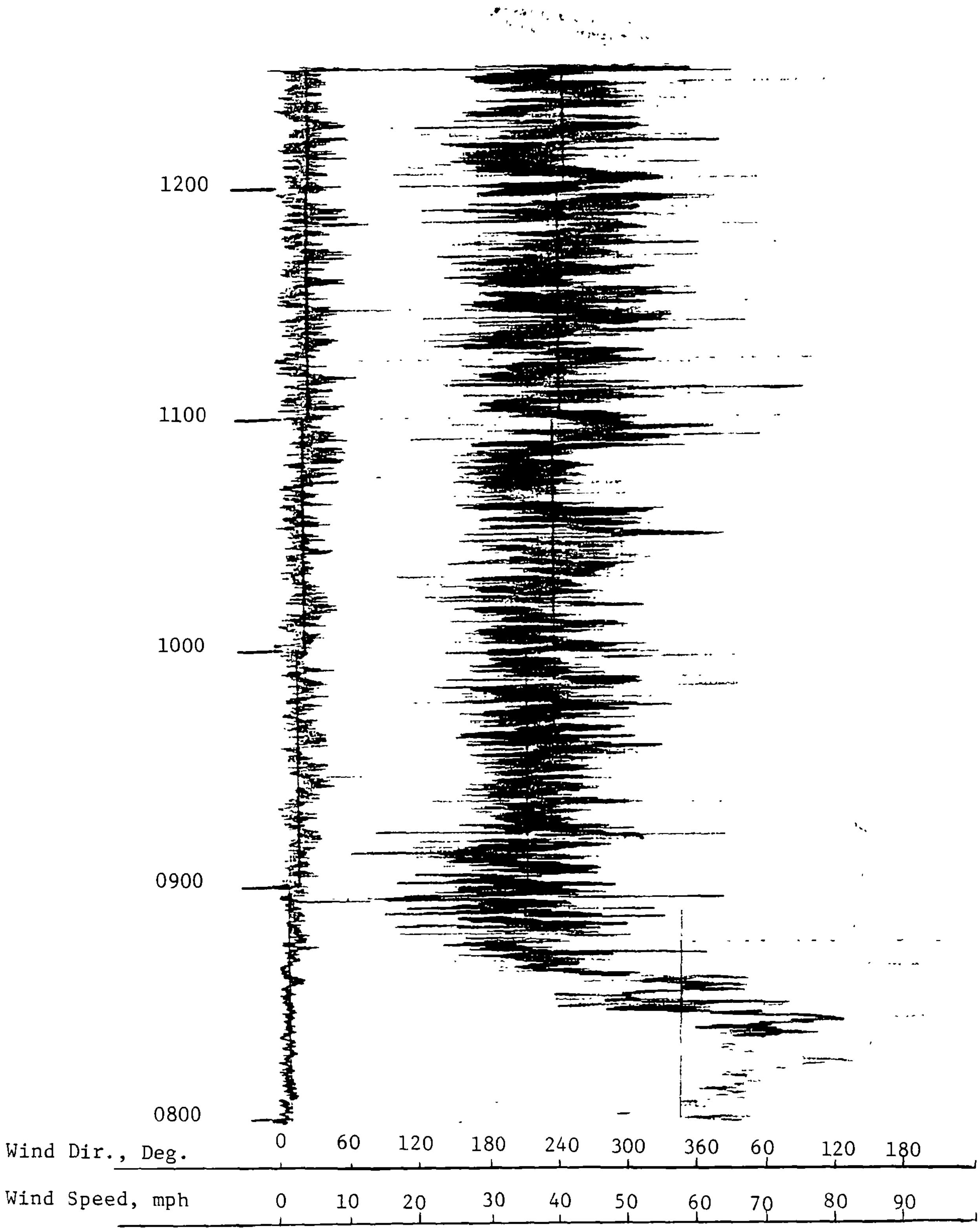


Figure 9. Area Wind Measurements - September 10, 1981.

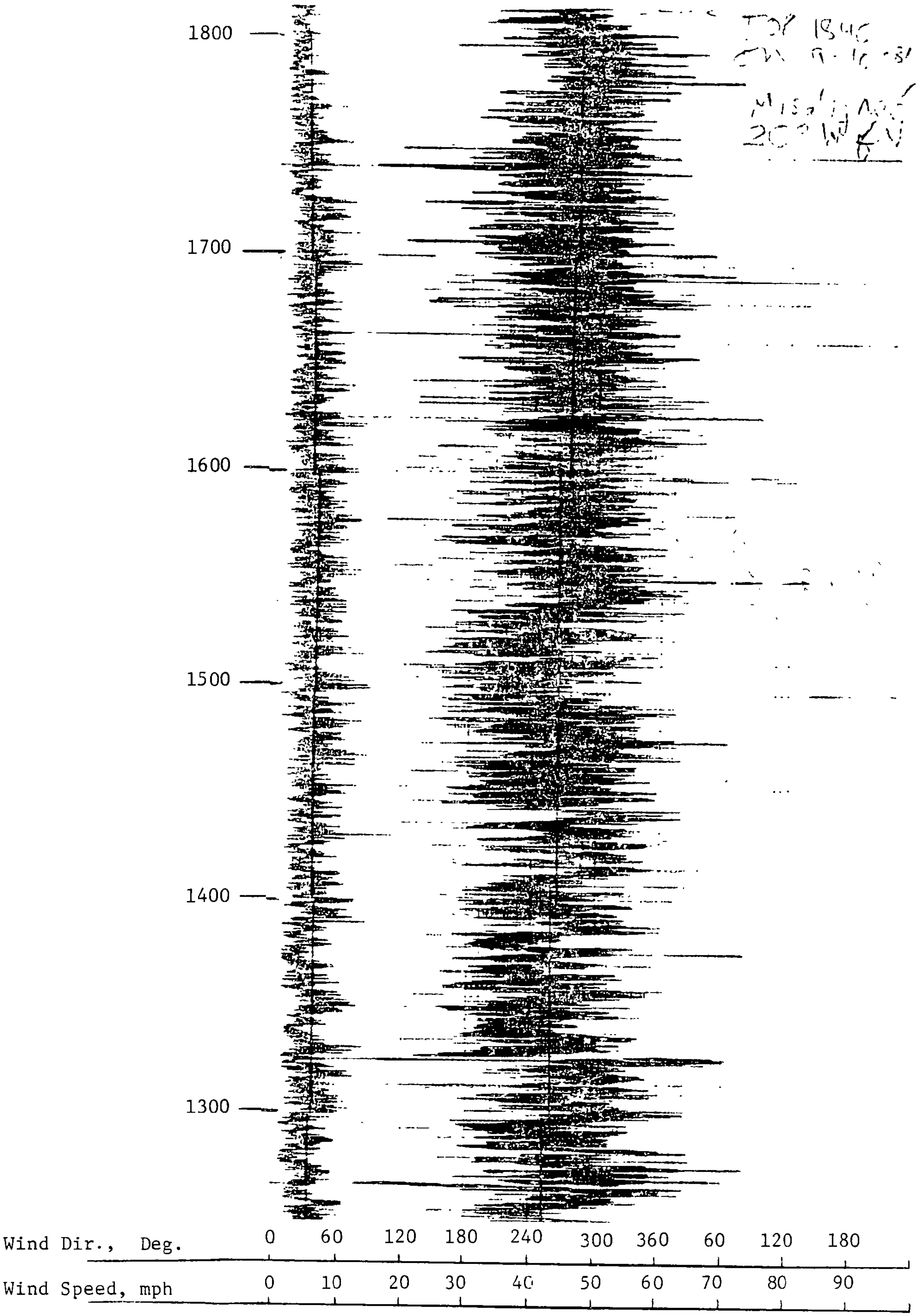


Figure 9. Area Wind Measurements - September 11, 1981.