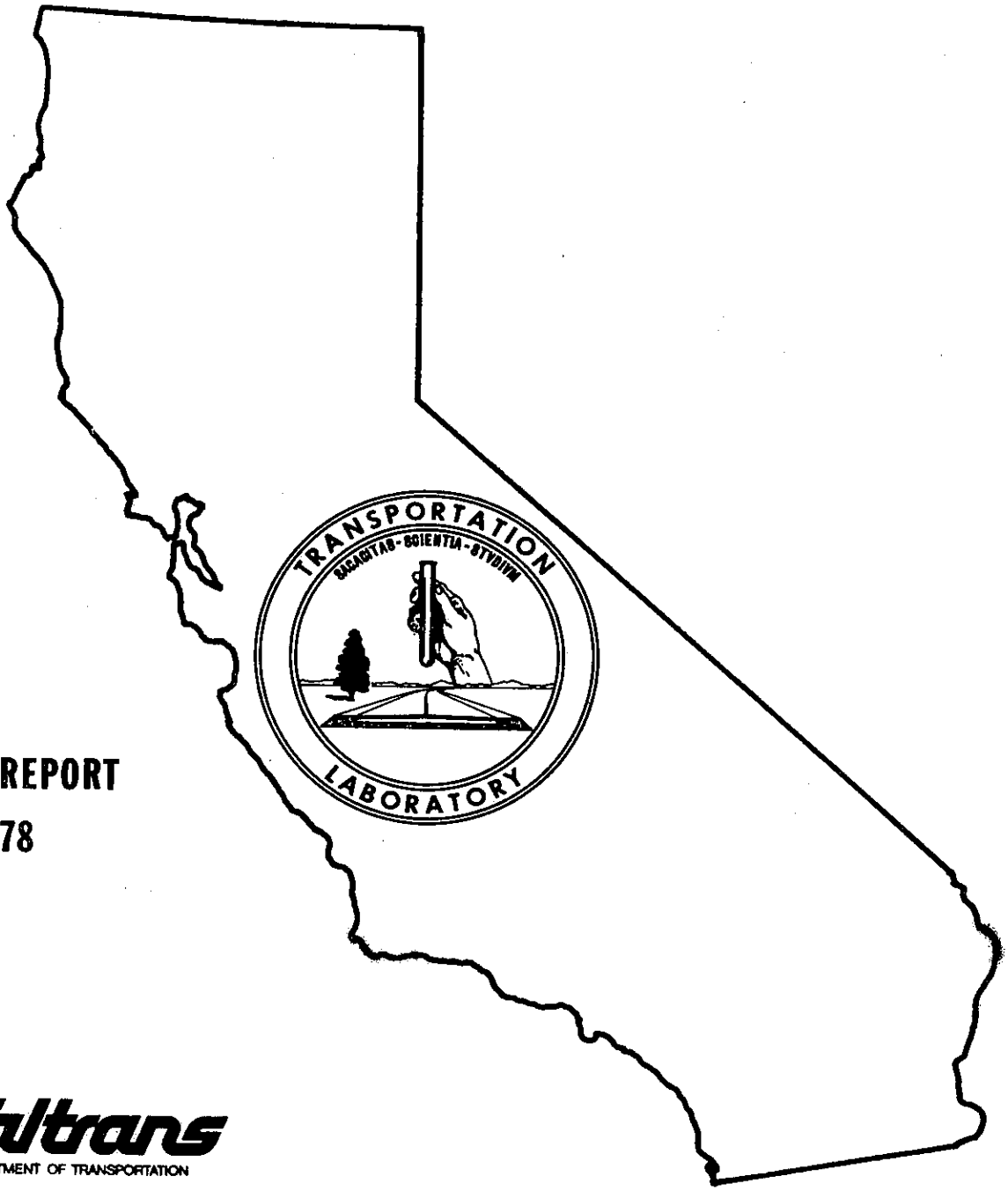
REPORT NO. FHWA-CA-TL-78-12

DUSTFALL ANALYSIS FOR THE PAVEMENT STORM RUNOFF STUDY (1-405 LOS ANGELES)



INTERIM REPORT

APRIL 1978

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

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The study was conducted in cooperation with the United States Department of Transportation, Federal Highway Administration.

16. ABSTRACT

Highway surface runoff contains materials that are removed from the surface by the flushing and solvent action of rainfall. The source of these materials can be traced to vehicles, the highway surface, roadside vegetation, litter, chemical spills, and atmospheric "fallout".

This report discusses a study conducted by the California Department of Transportation Laboratory to determine the concentration of constituents which are impacting the roadway surface as a result of atmospheric "fallout" conditions.

A section of freeway in the Los Angeles area was sampled for air particulates during July-August 1976 and again during February-March 1977.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

April 1978

FWHA No. A-8-20
TL No. 657117

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

DUSTFALL ANALYSIS FOR THE
PAVEMENT STORM RUNOFF STUDY (I-405 LOS ANGELES)

Study made by . . . . . Enviro-Chemical Branch

Under the Supervision of . . . . . Earl C. Shirley, P.E.

Principal Investigator . . . . . Richard B. Howell, P.E.

Co-Investigator . . . . . Richard J. Spring, P.E.

Report Prepared by . . . . . Richard J. Spring, P.E.

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

RJS:lb

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ACKNOWLEDGEMENT

The following individuals are acknowledged for their assistance on the project: John Adams and Joe Pantalone formerly with the Translab Enviro-Chemical Branch; Martin Nolan who coordinated most of the field work; and Jean Smart, James Ito, Clark Gipson, and Eli Greengard, District 07 Environmental Section, for their cooperation and assistance in acquiring the field samples.

In addition, special acknowledgement is also given to Chemists Tom Tanton, formerly with Translab, and Dave Smith of the Translab Chemistry Section for conducting the chemical analyses. Also to Jim Racin and Paul Benson of Translab who performed the statistical analysis on the data.

The information assistance and encouragement of Herb Gregory, FHWA Region 9, and Byron Lord, FHWA Office of Research, on this study are appreciated. The technical review and comments of Richard B. Howell and Earl Shirley are appreciated.

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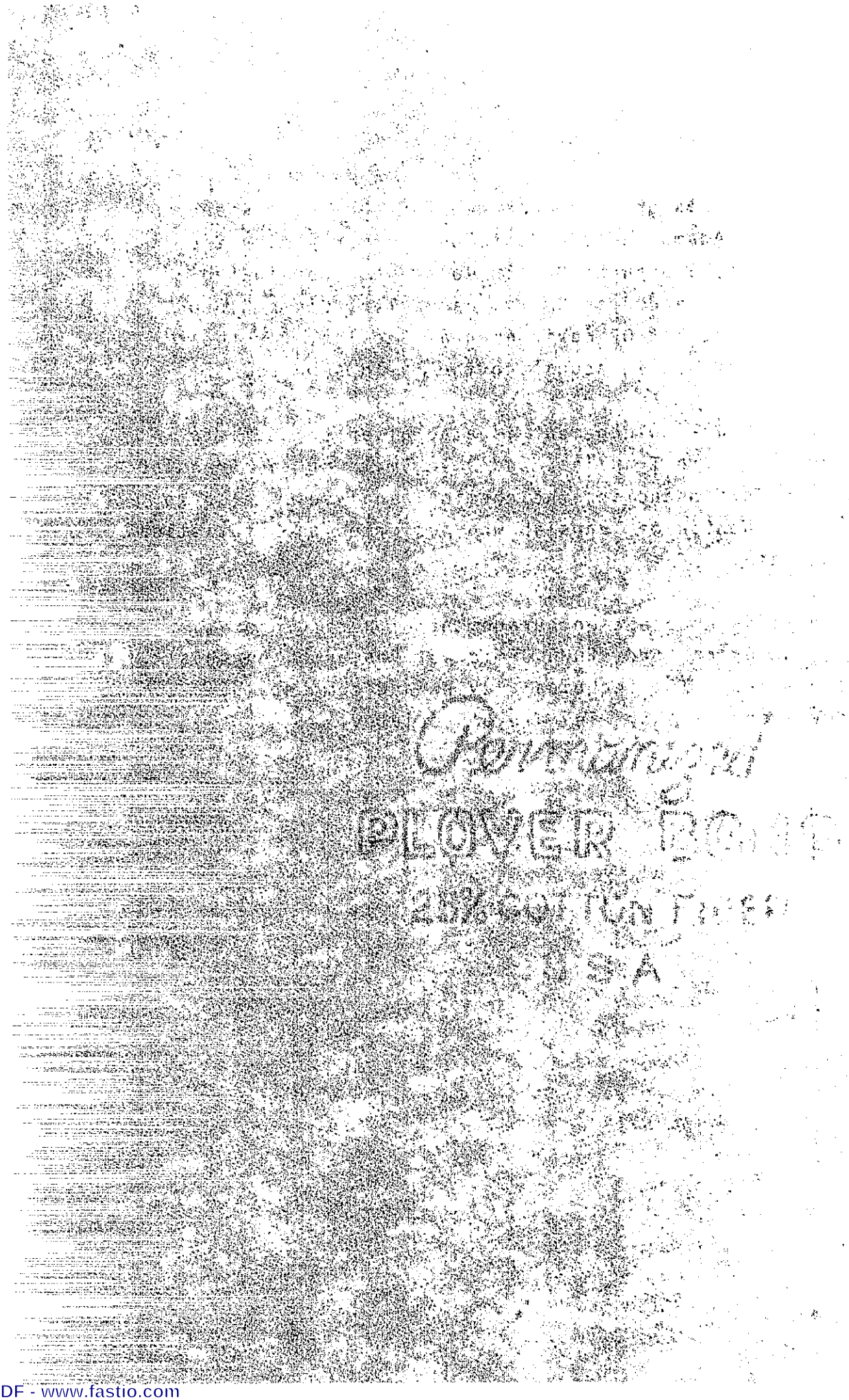

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INTRODUCTION

The Transportation Laboratory is presently engaged in a federally-sponsored HP&R research project titled "Water Pollution Aspects of Particles Which Collect on Highway Surfaces" (A-8-20). The objective of this study is to determine the physical, chemical, and biological nature of constituents of highway surface runoff. In order to accomplish this, roadway runoff samples are being collected during actual storm runoff periods at the following three locations: (1) Los Angeles I-405, (2) Walnut Creek I-680, and (3) Placerville SR-50. These three locations represent Average Daily Traffic Values of 180,000, 65,000 and 20,000, respectively. Pavement runoff samples collected at these sites are being analyzed for some 33 different parameters.

The source of constituents in pavement runoff water may include vehicles, wear of the highway surface, roadside vegetation, animals, chemical spills, and atmospheric dustfall associated with adjacent land use.

This report presents the results of the study on dustfall. The purpose of the dustfall study was to determine the concentration of six constituents in atmospheric fallout over a 30-day time period twice during the year for the Los Angeles site on I-405. One sampling was scheduled during a dry period (July 27-August 26, 1976) and one sampling during a wet period (February 2-March 3, 1977). The ASTM D1739-70 test procedure was followed.

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CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were derived from the dustfall study:

1) The total particulate loading due to dustfall was sufficient to warrant consideration for inclusion in the development of a pavement runoff model.

2) The total particulate loading for the July 27-August 26, 1976 period showed a general increase as the sampling locations progressed from the west side of roadway to the east side of roadway.

3) The total particulate loading for the February 2-March 3, 1977 period indicated higher values than the July 27-August 26, 1976 period.

4) Levels of Phosphate as PO_4(P) and Chromium (Cr) were not significantly high for either of the two test periods.

5) The pH remained fairly constant, due to the copper sulfate added to the sample to prevent algae growth.

6) The levels of Lead (Pb) and Nitrate nitrogen NO_3(N) were higher during the February 2-March 3, 1977 period than that of the July 27-August 26, 1976 test period.

7) The method of conducting the field sampling worked well. However, delays of up to one year were experienced in the laboratory testing. One sample had rust in it as a result of the delay.

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Based on this study, the following recommendations are made:

1) Dustfall sampling be conducted on a quarterly basis in order to identify background levels due to seasonal changes in climatological conditions.

2) Additional sampling locations, to serve as control points, be installed on future studies to insure the accuracy of the background levels.

3) Dustfall data be considered in the development of a pavement runoff prediction model.

4) The chemical analysis of the samples collected be conducted immediately following the sampling period.

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IMPLEMENTATION

The information derived from this dustfall study will be utilized by the Transportation Laboratory to develop loading factors for pollutants in pavement runoff. These loading factors will be incorporated into a prediction model for use in environmental assessment of pavement runoff. This report will be sent to the 11 Transportation Districts for their use in environmental studies.

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SITE LOCATION

Eleven dustfall sampling locations were selected in the area of the pavement runoff site on I-405, PM 18 in Los Angeles. Three samplers were located at 300 foot centers along the west edge of pavement, and identified as W-1, W-2, and W-3; three at 300 foot centers along the east edge of pavement, and identified as E-1, E-2, and E-3; and three at 300 foot centers located in the median between the northbound and southbound lanes, identified as M-1, M-2, and M-3. Two additional locations were selected, one 500 feet west of centerline (W-500) and one 500 feet east of centerline (E-500). The locations are shown on the Location Map in the Appendix. Because a right-of-entry permit could not be obtained for the 500 foot east location, it was necessary to locate this sampling point some 1700 feet north of the other sampling points. It was felt that this would not adversely affect the test results since the same traffic and meteorological conditions exist throughout this section.

Land use adjacent to the Los Angeles sampling site consists of light industrial and residential on the east side of the freeway, and open fields, a nursery and residential on the west side. The Pacific Ocean is located approximately five miles to the west.

WIND PATTERNS

Prevailing winds at the site were identified from an air quality study conducted earlier by Caltrans entitled "Air Pollution and Roadway Location, Design, and Operation" (1). Measurements taken during the peak traffic hours of the morning (0600-0900), midday (1100-1300), and afternoon (1600-1800) periods for August indicated a predominantly west to east air flow. These air flows are typical for conditions that exist during the summer months

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during these hours. The morning period is usually associated with light winds varying in direction. These light breezes are typical for the transition period from a land to sea regime. Strong summer breezes tend to occur after midday, ranging from 10-15 MPH along the coast. These breezes tend to decrease as the distance inland increases (see Figure 1, 2, and 3).

The airflow for the month of December, which is the extreme condition during the winter months, indicates a east to west movement during the morning (0600-0900) period. This is primarily caused by the difference in temperature between the land and the ocean. These breezes range from 4-6 MPH and during this transition period, the surface atmospheric condition is generally regarded as being stable.

During the midday (1100-1300) and afternoon (1600-1800) periods, these breezes tend to reverse and result in a sea breeze regime from the west at approximately 8-10 MPH. Again, the cause is basically due to the temperature differential between the land and ocean (see Figures 4, 5, and 6).

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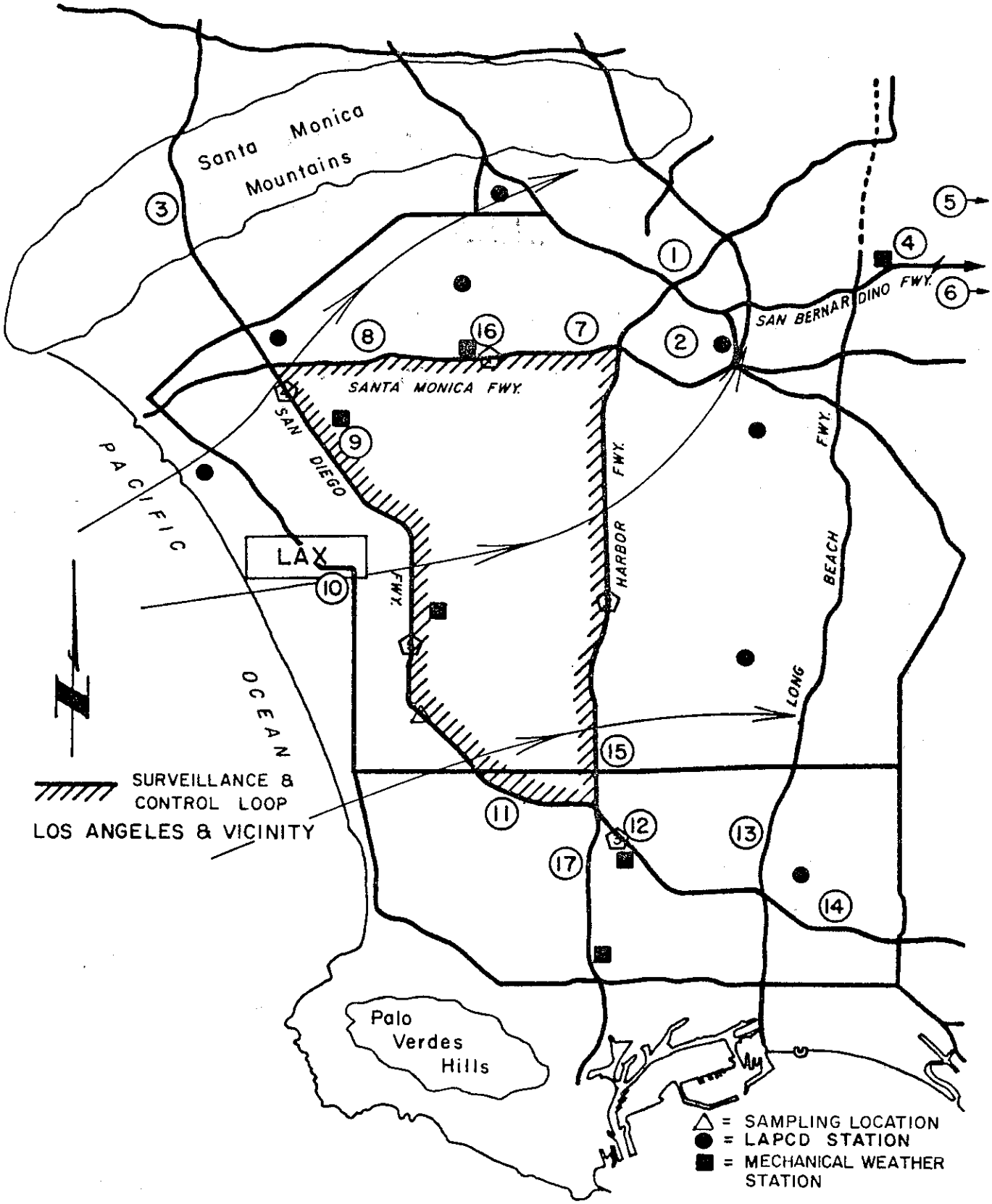

FIG. 1 SURFACE STREAMLINES FOR AUGUST AM
(0600-0900 HOURS)

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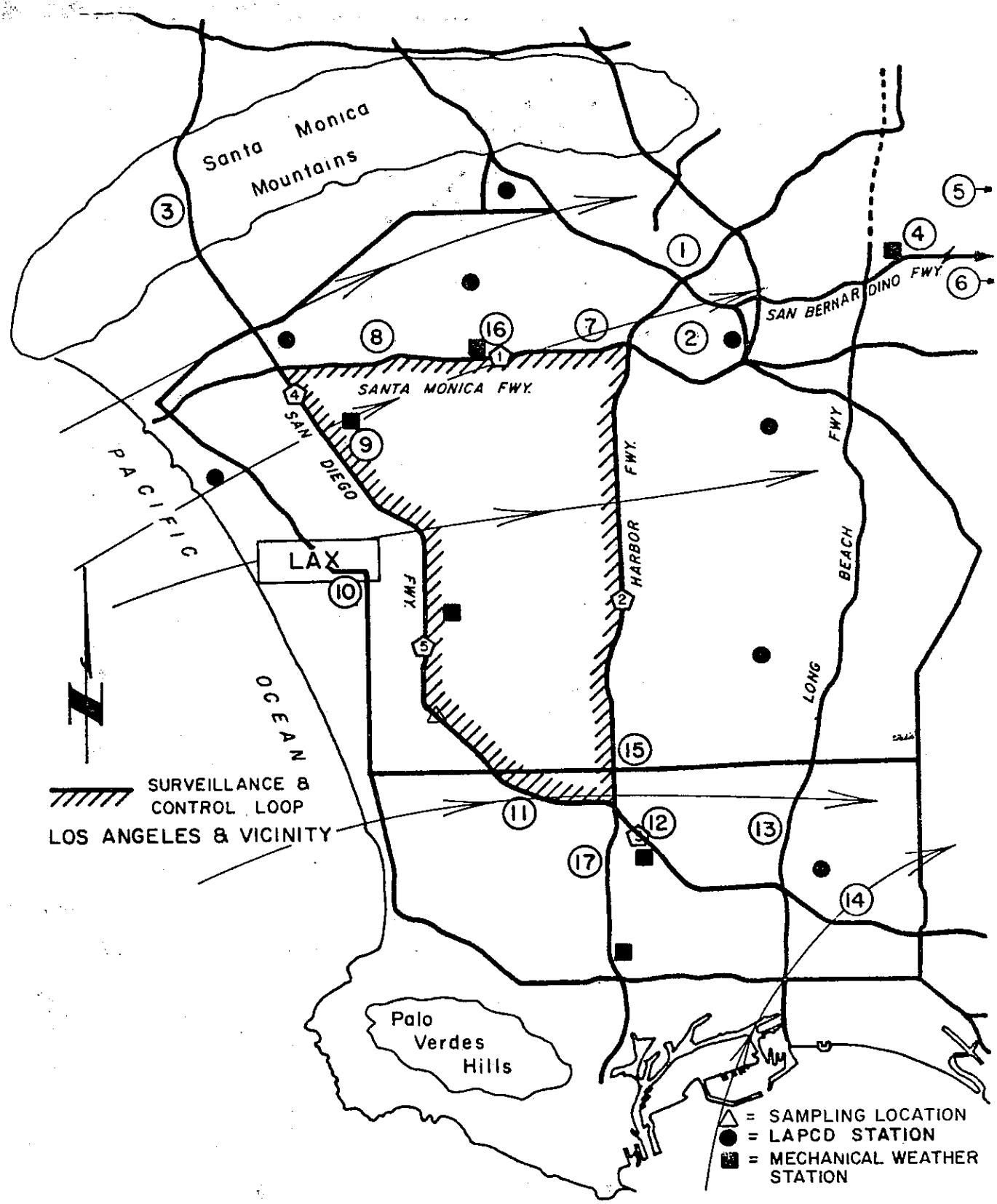

FIG. 2 SURFACE STREAMLINES FOR AUGUST MIDDAY
(1100-1300 HOURS)

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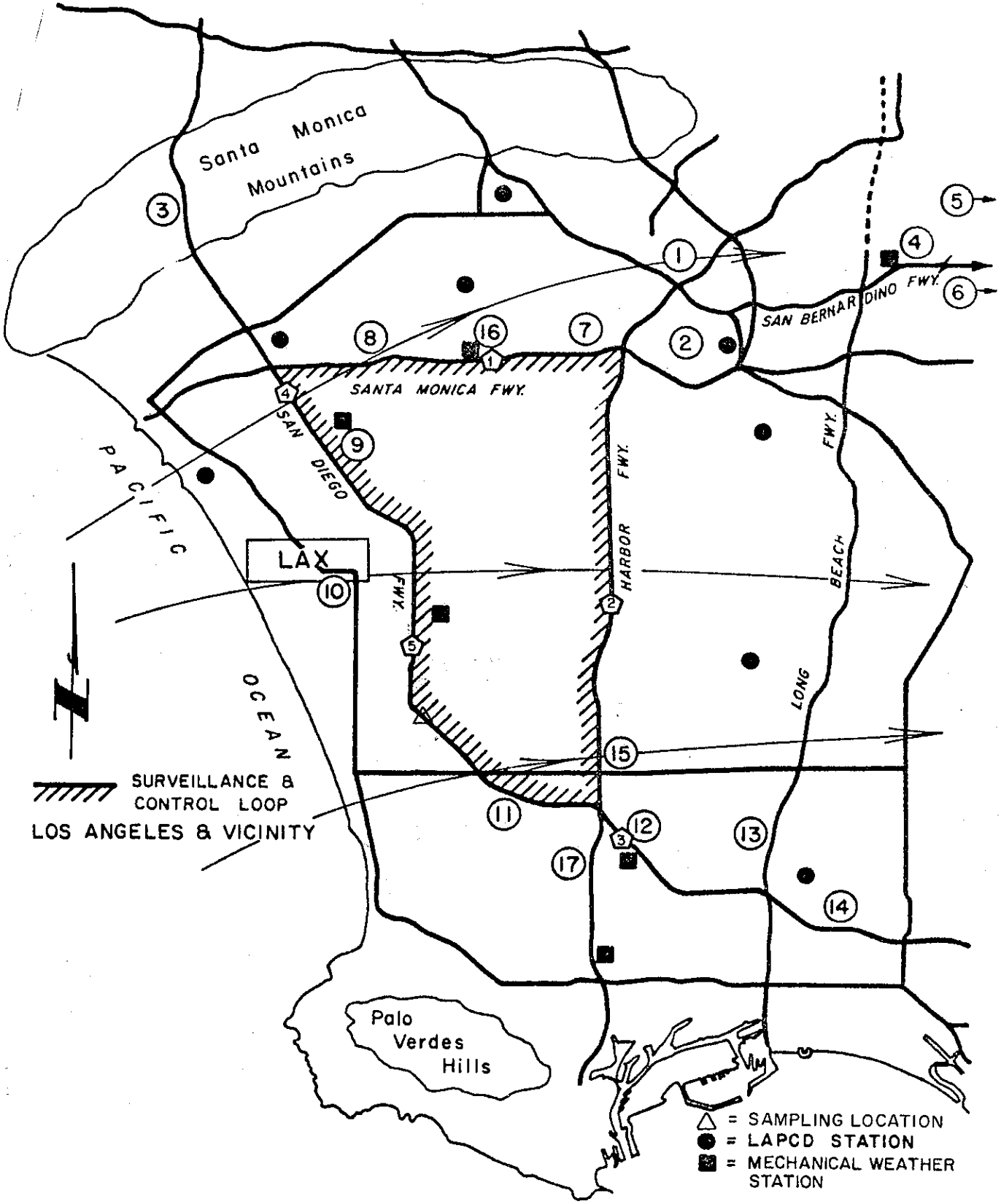

FIG. 3 SURFACE STREAMLINES FOR AUGUST PM
(1600-1800 HOURS)

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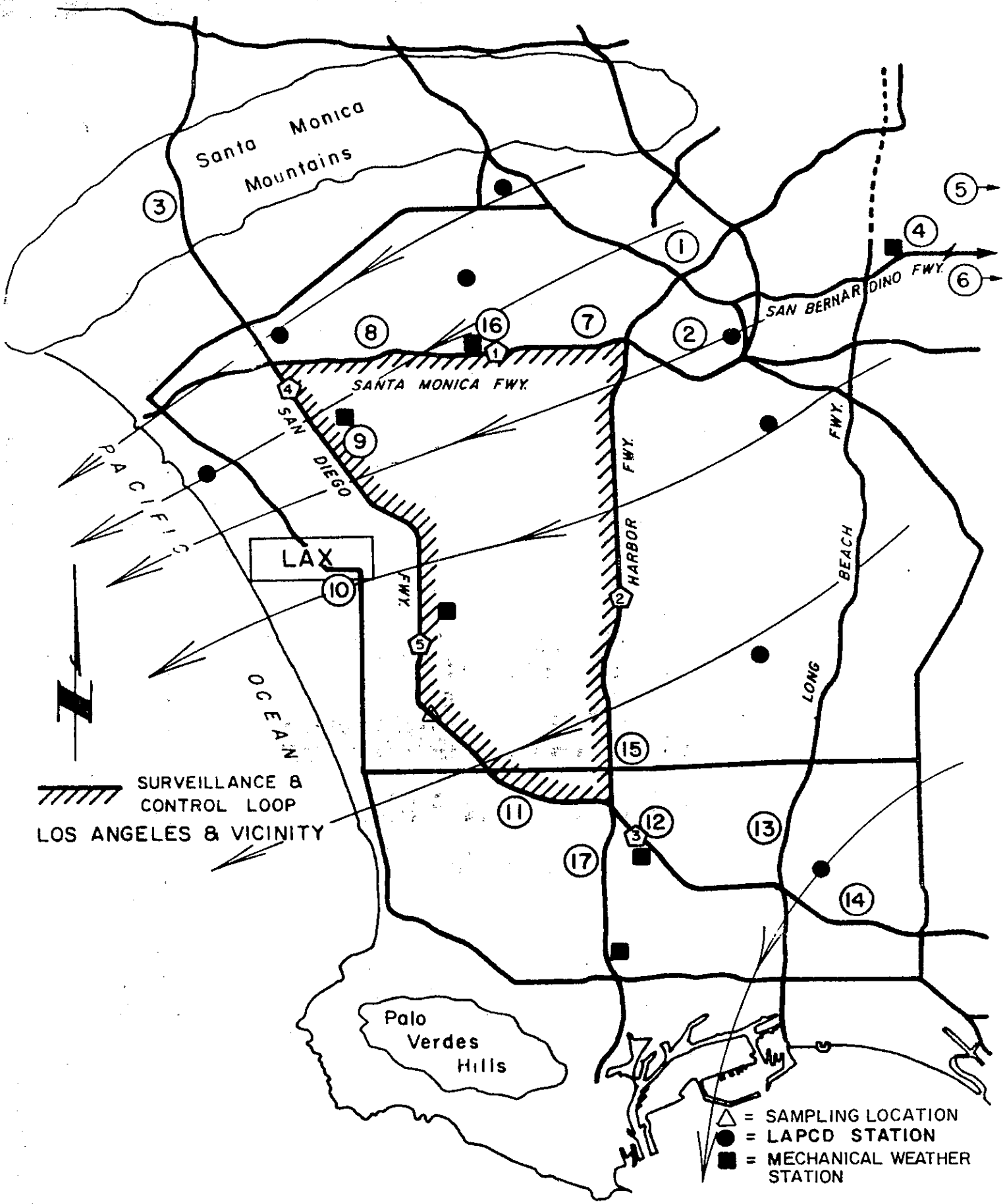

FIG. 4 SURFACE STREAMLINES FOR DECEMBER AM
(0600-0900 HOURS)

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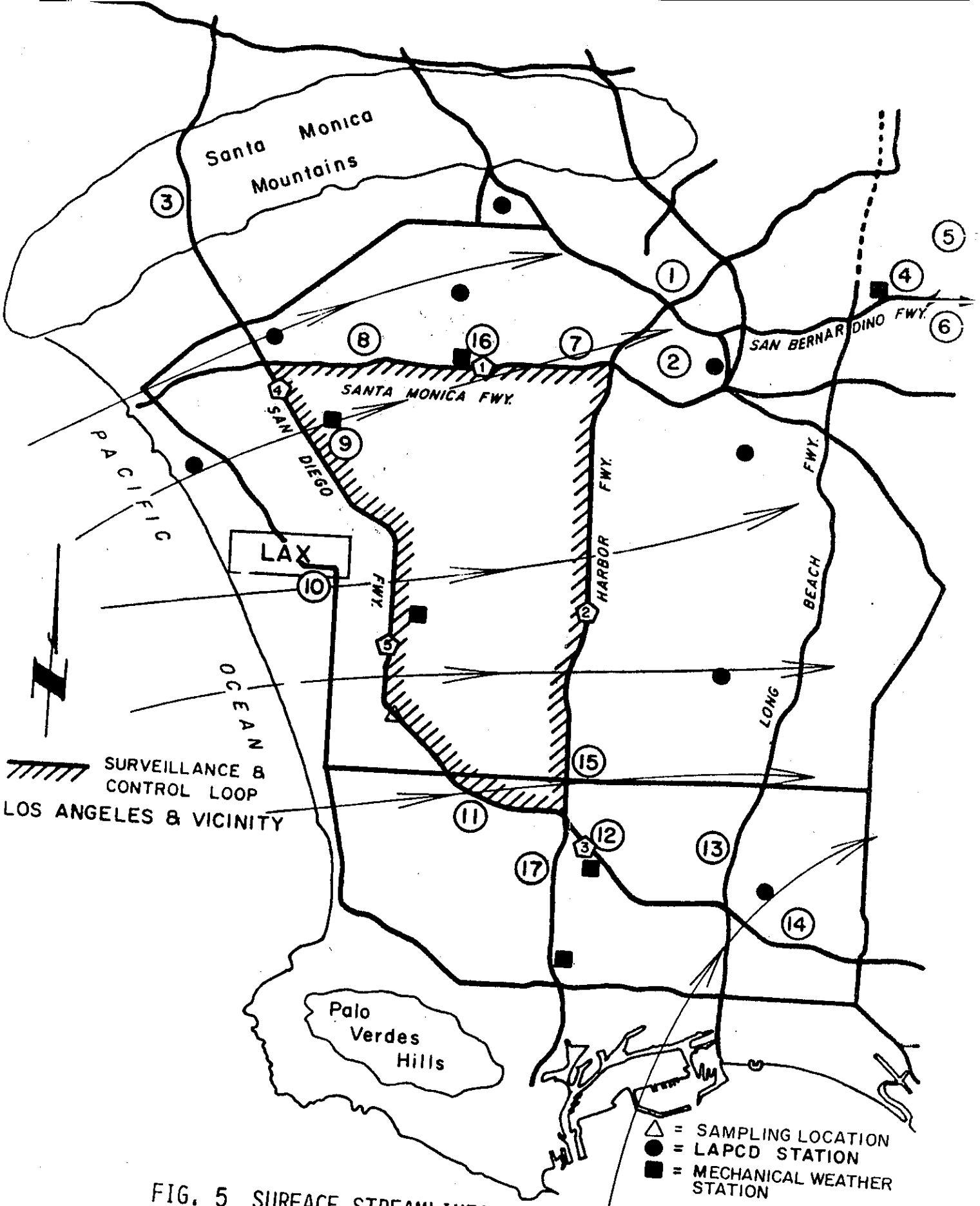

FIG. 5 SURFACE STREAMLINES FOR DECEMBER MIDDAY (1100–1300 HOURS)

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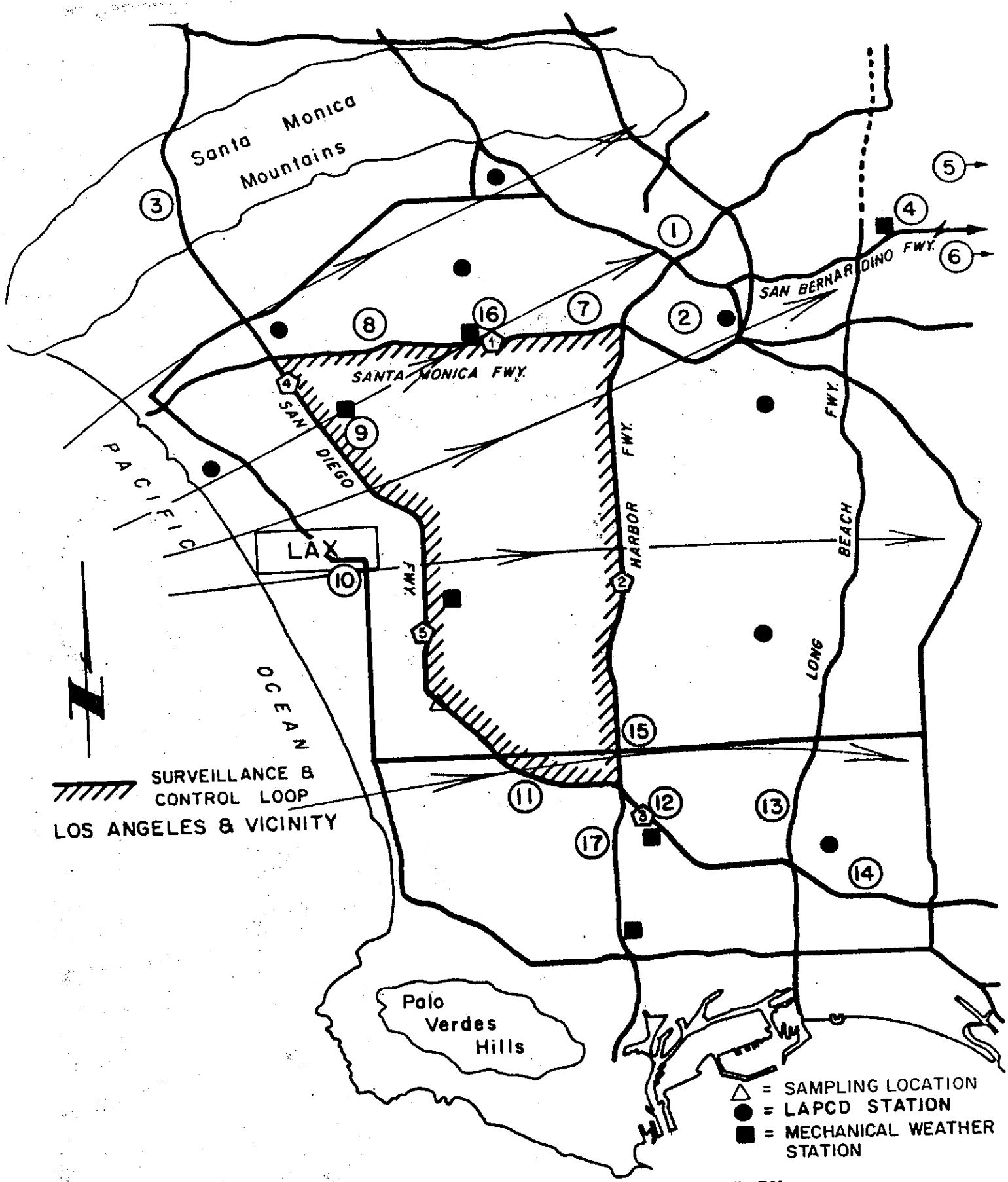

FIG. 6 SURFACE STREAMLINES FOR DECEMBER PM
(1600-1800 HOURS)

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RESULTS

Results of the chemical analysis for samples collected during July 27-August 26, 1976, and February 2-March 3, 1977, are listed in Table 1.

Table 1

July 27-August 26, 1976

Sample No.	Total** Dustfall (mg)	Pb (mg)	Cr (mg)	PO_4(P) (mg)	NO_3(N) (mg)	pH
W-1	200	0.4	<0.1	0.34	0.2	5.0
W-2	215	0.4	<0.1	0.40	0.6	4.5
W-3	75	0.3	<0.1	0.09	<0.1	5.7
Average	163	0.4	<0.1	0.28	0.3	4.84
M-1	270	0.2	<0.1	0.12	1.6	4.2
M-2	275	0.2	<0.1	0.06	1.9	4.7
M-3	300	0.2	<0.1	0.09	0.2	4.4
Average	282	0.2	<0.1	0.09	1.2	4.59
E-1	305	0.6	<0.1	0.12	1.0	4.6
E-2	330	<0.1	<0.1	0.09	0.2	4.7
E-3	295	2.9	<0.1	0.09	0.2	4.6
Average	310	1.2	<0.1	0.10	0.5	4.63
W-500	200	<0.1	<0.1	0.77	0.4	5.1
E-500	373	0.1	<0.1	0.21	3.4	5.5

February 2 March 3, 1977

Sample No.	Total** Dustfall (mg)	Pb (mg)	Cr (mg)	PO_4(P) (mg)	NO_3(N) (mg)	pH
W-1	357	0.6	0.007	0.86	3.6	4.1
W-2	434	0.8	0.012	0.52	4.1	3.7
W-3	482	0.9	0.010	0.49	3.9	3.8
Average	424	0.8	0.010	0.62	3.9	3.84
M-1	470	1.6	0.017	0.64	3.4	3.8
M-2*	643	2.1	0.014	0.86	3.4	3.8
M-3	489	2.1	0.018	0.64	4.8	3.9
Average	534	1.9	0.016	0.71	3.9	3.83
E-1	429	2.2	0.024	1.01	4.6	4.2
E-2	401	1.4	0.011	0.55	4.2	3.9
E-3	392	1.8	0.022	0.67	4.2	4.0
Average	407	1.8	0.019	0.74	4.3	4.02
W-500	499	0.3	0.016	0.83	4.3	4.3
E-500	259	0.4	0.018	0.28	4.4	3.9

*Sample M-2 for February 2-March 3, 1977, contaminated with rust.
**Represents total (mg), per surface area of sampler (182.3 cm^2), per 30 day period.

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All samples were tested for the following parameters:

1)	Total dustfall	
2)	Nitrate nitrogen	$NO_3(N)$
3)	Lead	Pb
4)	Chromium	Cr
5)	Phosphate	$PO_4(P)$
6)	pH	

The method of analysis for total dustfall was that specified in ASTM D1739-70 (see Appendix). Lead (Pb) and Chromium (Cr) were analyzed by Atomic Absorption Spectrophotometry. Results for (Pb) and (Cr) were calculated as total concentrations. Phosphate $PO_4(P)$ and Nitrate nitrogen $NO_3(N)$ were calculated by using test methods 223F and 133A, respectively, from the "Standard Methods for Examination of Water and Wastewater", 13th Edition (2).

The pH was determined in the laboratory by using the electrometric method (pH Meter, Beckman Digital #76).

The data shown in Table 1 were analyzed using a one way test of variance to determine if the differences were statistically significant.

Three parameters, Total Dustfall, Lead, and Nitrate nitrogen were tested separately for the two 30 day sampling periods. Within each test the data were grouped as follows:

3 Locations (West, Median & East)
3 Samples (1, 2, & 3) per location

It is recognized that this is a very small sample size, but it was felt that this would give added support to the test results. For a 95% level of significance, all but two groups showed a statistical significance. These were Total Dustfall for the August 1976 period and Lead (Pb) for the February 1977 period.

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The parameters of Chromium (Cr) and Phosphate PO_4(P) were not analyzed by using the test of variance because of the insignificant levels. The pH was also not analyzed by the test of variance due to the copper sulfate added as the algicide, which has an effect on the overall pH of the sample.

The appendix shows the printout of test of variance.

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DISCUSSION

During the 30-day sampling period from July 27-August 26, 1976, the average maximum temperature in the vicinity of the test site was 75°F with an average minimum for that period of 64°F. Total precipitation amounted to 0.03 inches of rainfall which occurred on August 20.

Rainfall during February 2-March 3, 1977 consisted of 0.26 inches (0.18 inches on the 23rd and 0.08 inches on the 24th of February). Average maximum and minium temperatures for the period were 71°F and 51°F, respectively.

Evaporation was very slight during both sampling periods and distilled water only had to be added twice.

During the July-August sampling period, one sampling container was damaged due to vandalism (see Photo 1).

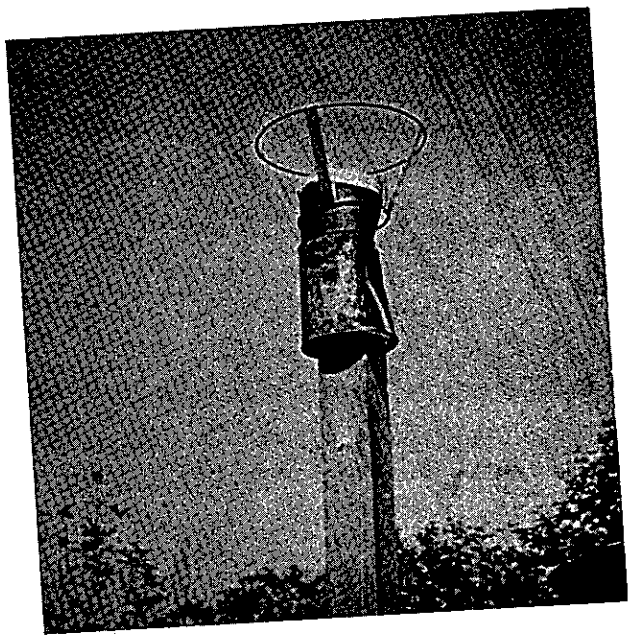

Photo 1 - Damage to Sampler

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The plastic liners were removed from the damaged container after the sampling period and inspected for leaks. After inspection, it was determined that no damage has occurred to the collected sample which would affect the results.

Traffic for the 30 day period of July 27-August 26, 1976, period averaged 199,240 vehicles per day, while the 30 day period of February 2, March 3, 1977 averaged 188,670 vehicles per day. This information was supplied from a traffic counter near the test site.

A discussion of the data for the July 27-August 26, 1976 and February 2-March 3, 1977 period follows.

1) <u>July-August 1976</u>

Results from particulate sampling during July 27-August 26, 1976 indicate an overall increase in the total dustfall as movement occurs from the Westernmost sampling location (W-500) to the Easternmost location (E-500). This is reflected in the average particulate amounts of 163 mg for the three locations along the west side of the roadway (W-1, W-2, and W-3), 282 mg average for the three locations in the median area (M-1, M-2, and M-3) and 310 mg average for the three locations along the east side of the roadway (E-1, E-2, and E-3).

The concentration of lead (Pb) also followed the increasing pattern from a westerly to an easterly location along the roadway. Concentrations at the sampling points of W-500 and E-500 indicated levels of <0.1 mg and 0.1 mg, respectfully. The sampling points (W-1, W-2, and W-3) immediately adjacent to the west edge of the roadway obtained an average level of

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0.4 mg. Those along the east side (E-1, E-2, and E-3) of the roadway increased to an average of 1.2 mg.

One reason for this general trend in higher readings as movement occurred from the West to the East is that following the normal transition period from the land to sea breeze regime during the morning period, the predominate wind flow during the peak traffic hours is in the easterly direction.

The levels of Chromium (Cr) were very low (<0.1 mg) and did not change significantly from the various sampling locations as indicated.

Phosphate PO_4(P) levels were higher at sampling location W-500 (0.77 mg) which is a reflection of the open land use on the west side of the roadway. Normal activities such as fertilization of this open land area would naturally increase the nutrient levels in the area. The PO_4(P) level drops to an average level of 0.28 (mg) along the west side to an average level of 0.10 (mg) along the east side of the roadway. There is a slight increase to 0.21 mg in the PO_4(P) level at sampling location E-500. Again the location of the nearby school athletic field would indicate that nutrients were being increased in this area possibly as a result of fertilization.

The levels of Nitrate nitrogen NO_3(N) also reflect the general trend in lower readings at the westerly sampling locations (0.4 mg at sampling point W-500) to higher readings at the easterly locations (3.4 mg at sampling point E-500). Average levels along the west side of the roadway were slightly less than levels along the east side (0.3 mg average compared to 0.5 mg average). The average median sample reflected an increase to 1.2 mg.

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The pH levels along the west side of the roadway averaged 4.84 which was also reflected in the pH level for sampling point W-500. The pH dropped slightly within the median (4.59 average) and also along the east side of the roadway (4.63 average). However, at sampling point E-500, the pH level again increased to a recorded value of 5.5. These readings of pH were influenced by the copper sulfate which had been added to the containers as an algicide.

The low amount of precipitation during this entire 30 day period (0.03 inches) and the generally strong summer sun breezes occurring after midday in the range of 10 to 15 MPH, aided little in the overall removal of particulates from the air.

2) February-March 1977

Results from the second sampling period of February 2-March 3, 1977 indicated somewhat higher values then those of the first sampling period, even with the average daily traffic being approximately 11,000 vehicles per day less. This may have been due in part to the additional amount of rainfall which occurred during the second sampling period (0.26 inches), as well as the stable surface atmospheric conditions which exist during the peak morning traffic period (AM 0600-0900). In addition the sea breeze regime results in somewhat lighter winds (8 to 10 MPH) than those compared to the first sampling period of 10 to 15 MPH. As a result of the more stable surface atmospheric conditions during the second sampling period, more particles may have been collected due to the reentrainment of these particles during the peak traffic periods.

Total dustfall at location W-500 showed nearly 500 mg compared to a total of 259 mg at E-500. Average dustfall readings were slightly higher for the three locations in the median (534 mg) compared to the average along the west side (424 mg) and the east side (407 mg) of the roadway.

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Concentrations of Lead (Pb) Chromium (Cr), Phosphate PO_4(P) and Nitrate nitrogen NO_3(N), as well as pH levels, indicated an overall increase as movement occurred from west to east. Lead (Pb) averaged 0.8 mg along the west side of the roadway, 1.9 mg along the median, and 1.8 mg along the east side of the roadway. Chromium (Cr) showed an increase from 0.010 mg along the west side, to 0.016 mg in the median, to 0.019 mg along to east side of the roadway. Phosphate PO_4(P) showed similar results, 0.62 mg along the west side, 0.71 mg in the median, and 0.74 mg along the east side. Nitrate nitrogen NO_3(N) indicated 3.9 mg for the west and median sampling points and a slightly higher 4.3 mg value for the east side of the roadway. The pH, as measured in the laboratory, was nearly the same for the west, median, and east sampling location (3.84, 3.83, and 4.02 respectfully). Again the copper sulfate has an effect on these pH readings. Sampling location W-500 showed slightly lower values (Pb = 0.3 mg, Cr = 0.016 mg and NO_3(N) = 4.3 mg) than for sampling location E-500 (Pb 0.4 mg, Cr = 0.018 mg and NO_3(N) = 4.4 mg).

The pH of sampling location W-500 was slightly higher (4.3) than that of the location E-500 (3.9).

Phosphate PO_4(P) was the only parameter to show any dramatic change from the W-500 location to the E-500 location, (0.83 mg to 0.28 mg). This in part may again be attributed to the local land use.

Because of the heavy workload of the Chemistry Section and lack of placing a high priority on this work, the samples collected during February 2-March 3, 1977, were not analyzed until January 1978. There was some concern over the fact the samples would be contaminated. However, inspection of the samples and the containers upon opening indicated only one sample to be visually contaminated. This sample, M-2 contained a considerable amount

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of rust. There was no evidence of the plastic lining in the container being broken and the inside of the metal container was not rusty. Speculation is that some type of small metal object had gotten into the sample during the 30 day test period and proceeded to rust completely during the 12 month period the samples were in storage.

DESIGN OF SAMPLERS

The basic design for the samplers was obtained from ASTM Test Method D1739-70 (see Appendix). Available materials from the Transportation Laboratory were utilized in fabricating the samplers.

Two plastic bags, one within the other, were inserted into a 6" diameter by 12" high metal container. These containers are normally used for fabricating concrete test cylinders. To prevent contamination of the sample as a result of birds sitting on the edge of the container a bird ring was attached to the top of the cylinder (see Photo 2). The cylinder was placed into a 6 1/2" diameter paint can which had been attached to the top of a 4" x 4" wooden post (see Photo 3). The wooden post was set so as to provide a total height of 8'-0" from the ground to the bottom of the container (see Figure 7).

Approximately 6" of distilled water was added to the containers along with an algicide consisting of 5.0 mg of copper sulfate. These samplers were left in place for a 30 day period and additional distilled water was added occasionally to maintain the water at a constant level, as prescribed by the ASTM test method.

Following the 30 day in place collection period, the samples were removed from the post and the tops of the two plastic bags

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tied securely. The samples were then prepared for shipment by attaching a lid to the containers, sealing the end with tape, and air shipping to the Transportation Laboratory in Sacramento for analysis.

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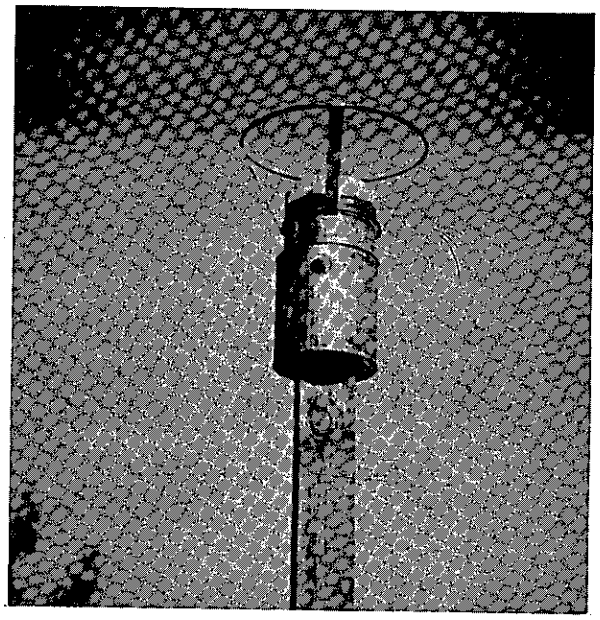

Photo 2

Sampler with Bird Ring Attached

Photo 3

Installing Container
Atop 4"x4" Wooden Post in Median

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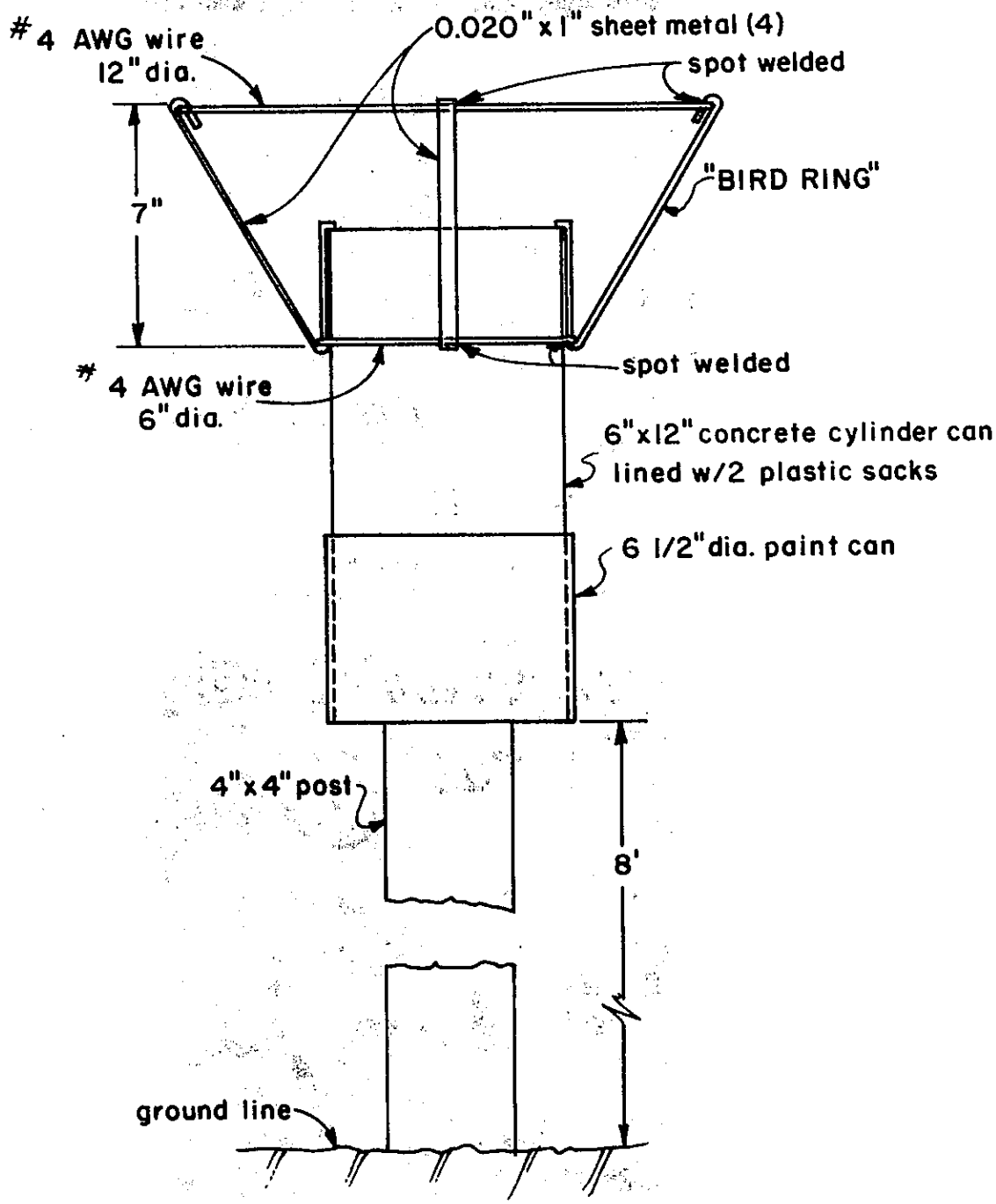

DUST FALL JAR SAMPLER

TRANSPORTATION LABORATORY

DIVISION OF STRUCTURES AND ENGINEERING SERVICES

DEPARTMENT OF TRANSPORTATION

Figure 7

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REFERENCES

1. "Air Pollution and Roadway Location, Design, and Operation - Preliminary Study of Distribution of Carbon Monoxide on and Adjacent to Freeways", Ranzieri, A. J.; Bemis, G. R.; Shirley, E. C.; California Department of Transportation, CA-DOT-TL-7080-2-75-15, May 1975.

2. "Standard Methods For the Examination of Water and Wastewater", 13th Edition, 1971, American Public Health Association, American Water Works Association, Water Pollution Control Federation.

3. "Collection and Analysis of Dustfall (Settleable Particulates)", D1739-70, American Society for Testing and Materials, 1970.

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APPENDIX

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Designation: D 1739 – 70

American National Standard 2116.1 – 1970
American National Standards Institute

Standard Method for COLLECTION AND ANALYSIS OF DUSTFALL (SETTLEABLE PARTICULATES)[1]

This Standard is issued under the fixed designation D 1739; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This method covers a procedure for the field collection of particulates settling from atmosphere, and for preliminary characterization of the sample matter. As further analytical methods are developed for components these will be added to this method.

2. Summary of Method

2.1 Open-top collectors of a specified size and shape are located carefully outdoors to provide particulate samples that are representative of the area being studied. Collected material is taken to the laboratory in a closed container for weighing and analysis. Procedures are described for the determination of pH, total weight of settleable particulates, total water and benzene solubles, and total combustible and noncombustible matter.

3. Definitions

3.1 *settleable particulates*—for this method, any particles, liquid or solid, small enough to pass through a 1-mm screen and large enough to settle in the collector.

3.2 For definitions of other terms used in this method, refer to ASTM Definitions D 1356, Terms Relating to Atmospheric Sampling and Analysis.[2]

4. Interferences

4.1 Care must be taken to avoid matter from trees, bird droppings, and other such deposits. Loss of material from the collector by action of wind must be prevented. If a glass collector is used, protection against breakage by freezing of liquid sample should be provided when necessary. The sample collector should be protected from vandalism. The criteria for selecting the sampling site (see 6.5) must be adhered to.

5. Apparatus and Materials

5.1 *Collector*—The collector shall be an open-topped cylinder with vertical sides and flat bottom. Cylinders shall be not less than 6 in. in diameter. Height of the cylinder shall be from two to three times the diameter dimension. Collectors may be made of glass, plastic, or stainless steel. (Glass, although permitted, is not preferable because of its fragility.) A holder shall be provided to secure and ensure safe positioning of the collector. The top of the collector should be at least 3 in. above any part of the holder. The holder should not interfere with operation of the collector in any way. A bird ring shall be provided on the holder (see Fig. 1).

NOTE 1—No definitive aerodynamic studies have been made of collector design, so the above specifications cannot assure optimum collection. Pending such studies, any network of stations within which comparisons are to be made should use identical collectors. If especially high winds characterize the study area, frequent inspection will reveal obvious reentrainment of dust.

5.2 *Sieve*, No. 18 (1 mm) (chemically inert), conforming to the requirements of ASTM Specification E 11, for Wire-Cloth Sieves for Testing Purposes.[2]

5.3 *Oven*, thermostatically controlled.

[1] This method is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres.

Current edition effective Oct. 15, 1970. Originally issued 1960. Replaces D 1739 – 62 (1967).

[2] *Annual Book of ASTM Standards*, Part 26.

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5.4 *Filter Paper*, soft, open, rapid filtering.

5.5 *Soxhlet Extraction Apparatus* or other efficient extractor.

5.6 *Water*, conforming to ASTM Specifications D 1193, for Reagent Water.[3]

5.7 *Antifreeze*—Isopropyl alcohol reagent grade.

NOTE 2 Ethyl alcohol may be used, provided that the collector is policed with efficient frequency to ensure that it is not permitted to dry out and that the correct concentration of antifreeze is maintained during the sampling period. In areas where organic matter is not being studied ethylene glycol may be used.

6. Sampling

6.1 *General Sampling Principles*—Application of this method shall be guided by ASTM Recommended Practice D 1357, for Planning the Sampling of the Atmosphere.[2]

6.2 *Preparation of the Collector:*

6.2.1 Thoroughly rinse the collector. Place distilled water in the collector so that the level stands at one-half the collector depth when the test is started. In cold weather mix a sufficient volume of antifreeze to prevent freezing with the water. In warm weather add sufficient copper sulfate as an algicide to give 15 mg/liter if the collector fills. Under the latter condition copper cannot be determined.

6.2.2 Collector liquid should be kept at a reasonable level during the testing period (at least 1 in. of water at all times).

6.3 *Sampling Time*—A sampling period shall be 1 calendar month corrected to 30 days. Allowance of ± 2 days is permissible for setting out or collecting sampling jars, or both.

6.4 *Handling Collected Sample*—No attempt shall be made to remove collected particulate sample from the collector at the field site. Collectors shall be covered and taken to the laboratory for analysis of the contents.

6.5 *Selection of Sampling Site* (**2,3**)[4]—The following specific recommendations shall be used as a guide in the selection of a site. If conditions do not permit application of these recommendations, note shall be made of this.

6.5.1 The sampling station shall have a free exposure so that the sample is collected by gravity settling only. It must be free from undue local sources of pollution and free from interference from buildings or other higher objects or structures. Accessibility and security (freedom from tampering) are major considerations in the selection of a site.

6.5.2 The top of the settleable particulates container shall be a minimum of 8 ft and a maximum of 50 ft above the ground. It shall be 4 ft above any other surface, such as a roof. Higher objects, such as parapets, signs, penthouses, and the like, shall not be more than 30 deg from the horizontal, as measured in 6.5.4.

NOTE 3—Available evidence suggests, but does not prove, that the measured particulates will vary markedly over the height limits of 8 to 50 ft. It is recommended, therefore that every attempt be made to keep collector heights as constant as possible within a given network.

6.5.3 Public buildings such as schools, fire stations, and libraries, are most favorable to public agencies because of their accessibility and security.

6.5.4 Take care to avoid undue influence from one chimney, (for example, the chimney on the building of the sampling station). Whenever possible, the sampling container shall be set more than ten stack lengths from an operating stack and upwind from the prevailing wind.

6.5.5 When higher buildings in the immediate vicinity cannot be avoided, the top of any building shall be not more than 30 deg above a sampling point. That is, a line drawn from the sampling jar to the nearest edge of the highest point on any building shall form not more than 30 deg angle with the horizontal.

6.5.6 Sampling shall not be done where there is a possibility of contamination by motor traffic.

6.6 *Number of Sampling Stations* (**1**)—For each area or zone to be tested, a minimum of four sampling stations shall be provided. An orderly spacing of the stations shall be made so that they are approximately equally distant from each other and from boundaries of the area. Record vertical distance from collector to ground for each sampling station.

6.7 *Auxiliary information*—Weather data, including wind velocity and direction, rainfall, snowfall and barometric readings, air pollution information, and other information of interest and value should be recorded during

[3] *Annual Book of ASTM Standards*, Part 31.

[4] The boldface numbers in parentheses refer to a list of references at the end of this method.

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the sampling period.

7. Procedure

7.1 *Total Water Insolubles*—Filtration of the sample and determination of the weight of insolubles, sample volume, and pH may be achieved in common operations. Use a filter paper for filtration. Dry the filter paper in a weighing bottle overnight at 105 C in a properly adjusted oven. After determining the tare weight of the filter paper and weighing bottle seat the paper in the funnel and filter the sample, passing it first through the No. 18 sieve, collecting the liquid in a conveniently sized volumetric cylinder. Discard any material retained on the sieve.

7.1.2 Ascertain the volume of the sample before beginning quantitative washing of any residue that may have adhered to the bottom and sides of the collector. Wet the paper when seating it and assume no significant loss during transfer.

7.1.3 The diameter of the paper and size of the filter funnel are a matter of convenience and will not influence the accuracy of this operation.

7.1.4 Before final quantitative policing of the collector with distilled water, take a portion for determination of pH, or determine the latter by direct immersion of the electrodes in the filtrate.

NOTE 4—Determination of pH is traditional but usually meaningless, since it is affected by rainfall, evaporation, the presence of antifreeze or algicide, or both, and by materials leached from large particles subsequeltly removed by sieve according to the procedure above. On the other hand, really extreme values (below 3 or over 11, for example) can be indicative of hazardous local conditions, so it may be worthwhile to continue making this measurement.

7.1.5 If desired, determine the acidity or alkalinity of the sample by titration of a portion taken at this point. Such determination should be in accordance with ASTM Methods D 1067, Tests for Acidity of Alkalinity of Water.[2] Report these data separately.

7.1.6 Finally, using a rubber policeman, free the walls of the collector from any particles, which should be washed through the sieve with distilled water. Add the washings to the filtrate through the filter. If the filtrate is to be further analyzed for specific components, adjust the volume to a convenient value and remove portions from that. Return the filter paper containing insoluble dustfall to the weighing bottle and dry overnight at 105 C. The net weight after deducting the weight of the paper and weighing bottle represents the total water insoluble dustfall that has settled on a circular area represented by the inside diameter of opening of the collector (after correcting for copper sulfate added as an algicide).

NOTE 5—If antifreeze has been added to the collecting water, the whole sample shall be evaporated to a small volume on a hot plate, or with infrared heating lamps. The remaining evaporation should be made on a steam bath or in a 105 C oven. The residue then should be brought up to volume with distilled water and the mixture boiled and filtered as described in 7.1.

7.1.7 Ascertain all weights to the nearest 1 mg.

7.2 *Benzene Solubles*—Extract the filter paper containing water insoluble residue in a Soxhlet extraction apparatus, Wiley-Richardson Extractor as shown in Fig. 2 of ASTM Method D 494, for Acetone Extraction of Phenolic Molded or Laminated Products, or other suitable extraction apparatus. Introduce 50 ml of reagent grade benzene into a tared extraction flask. Heat over a water bath at a temperature sufficient to maintain a cup loading rate that would permit 10 to 15 changes of solvent in an hour. Continue the extraction for at least 2 h. Cellulose filters contain benzene soluble materials, so that a blank must be extracted and a correction made.

NOTE 6: **Caution**—Because of flammability and toxicity extreme caution must be taken during the manipulations. The extraction must be performed in a fireproof fume hood, away from all flame and open wiring, and with the hood fan in operation.

NOTE 7—The filter paper should be opened, folded upon itself several times in each direction, and secured with a degreased paper clip or length of bare copper wire to prevent mechanical loss of insoluble matter during extraction.

7.2.2 Remove the filter paper and its residue from the cup, and air dry carefully for at least 2 h in the fume hood, and further dry in a drying oven at 105 C. Now weigh the filter paper and record the loss in weight due to extraction by benzene as benzene solubles.

NOTE 8—This quantity may be obtained also by evaporating off the benzene from the extraction flask, using a water bath, and determining the weight of the flask and contents. This weight, less the tare weight of the flask, will yield the total

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weight of benzene solubles. The eluted matter in the flask may be analyzed further after evaporation of the benzene.

7.3 *Combustibles and Volatile Particulates Other than Benzene Solubles*—Ash the filter paper in a tared crucible and report the loss in weight as: "Combustibles and volatile particulates other than benzene soluble."

7.3.1 If further analyses for specific materials are desired, ignite an aliquot of the filter paper and determine "combustibles and volatile particulates other than benzene solubles" from this as in 7.3.1. Use the remaining portion for further analyses.

7.3.2 Take the aliquot as follows: Open and cut the filter paper into eight equal radial segments. Use four alternate segments in this determination, and reserve the other four for the further analyses.

7.4 *Insoluble Matter*—Report the net residue after deducting the weight of the crucible in the above step as "inorganic insoluble particulates." Retain this for further analysis.

7.5 *Total Water Soluble*—Make up the water soluble filtrate to a convenient definite volume in a volumetric flask. Take a suitable aliquot to determine soluble salts. Transfer by means of a pipet to a weighed borosilicate evaporation dish as described in ASTM Method D 381, Existent Gum in Fuels by Jet Evaporation.[5] If fluorides or caustic materials are suspected to be present, conduct the evaporation, in a platinum dish of convenient size. Conduct the evaporation slowly on a hot plate, or under an infrared heat lamp, until the volume is about 25 ml. Complete the evaporation on a steam bath or a thermoregulated hot plate set at a temperature not greater than 99 C. When dry, heat the dish in a 105 C oven for a period of 2 h, cool in a desiccator, and weigh. Continue the drying procedure to constant weight.

7.5.1 Report the gain in weight of the evaporating dish, adjusted for aliquot portion, and correct for any solids present in a distilled water blank as total water solubles.

7.6 *Total Inorganic Particulates*—Report the combined weight of water insolubles and soluble matter corrected for any solids present in a distilled water blank as total inorganic matter.

7.7 *Unit for Data*—Express settleable particulates as "grams per square meter per month."

8. Calculation

8.1 Calculate the settleable particulates, D, in grams per square meter per month as follows:

$$D = W_m / A_c$$

where:

D = settleable particulates, $g/m^2 \cdot$ month,
W_m = total weight of settleable particulates (sum of total insolubles and water solubles) (7.1 and 7.5), and
A_c = sampling area, m^2

NOTE 9—Settleable particulates may be converted to tons per square mile per months by means of the following conversion units:

$$1 \text{ g} = 1.1023 \times 10^{-6} \text{ tons, and}$$
$$1 \text{ m}^2 = 3.8608 \times 10^{-7} \text{ miles.}^2$$

8.2 Express all other data in appropriate units, or as percentage of settleable particulates, D.

[5] *Annual Book of ASTM Standards*, Part 23.

REFERENCES

(1) Meetham, A. R., *Atmospheric Pollution: Its Origin and Prevention*, The Pergamon Press, London 3rd edition, 1964, Chapter 11: Measurements of Air Pollution.

(2) Nader J. S., "Dust Retention Efficiencies of Dustfall Collectors," *Journal of the Air Pollution Central Association*, JPCAA, Vol 8, 1958, pp. 35 to 38.

(3) Recommended Standard Methods for Continuing Dustfall Survey (APM-1, Revision 1), *Journal of Air Pollution Control Association*, JPCAA, Vol 16, No. 7, 1966, pp. 372 to 377.

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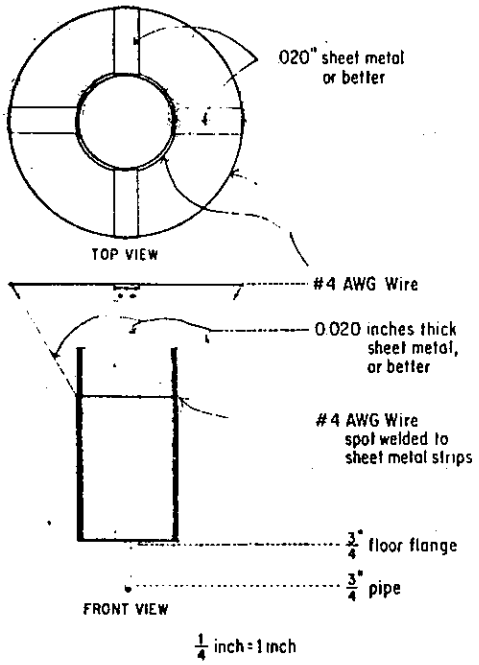

FIG. 1 Dust Fall Jar and Stand

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ONE-WAY ANALYSIS OF VARIANCE

DUSTFALL 76

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	163.33333	5908.33350	76.86568
2	3	281.66666	258.33337	16.07275
3	3	310.00000	325.00000	18.02776

GRAND MEAN = 251.667

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	36316.67187	2	18158.33594	8.39153
RESIDUAL	12983.33398	6	2163.88892	
TOTAL	49300.00391	8	6162.50049	

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ONE-WAY ANALYSIS OF VARIANCE

LEAD 76

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	.36667	.00333	.05774
2	3	.20000	.00000	.00000
3	3	1.20000	2.23000	1.49332

GRAND MEAN = .588889

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	1.72222	2	.86111	1.15672
RESIDUAL	4.46667	6	.74444	
TOTAL	6.18889	8	.77361	

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ONE-WAY ANALYSIS OF VARIANCE

NITRATES 76

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	.30000	.07000	.26458
2	3	1.23333	.82333	.90738
3	3	.46667	.21333	.46188

GRAND MEAN = .666667

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	1.48667	2	.74333	2.01506
RESIDUAL	2.21333	6	.36889	
TOTAL	3.70000	8	.46250	

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ONE-WAY ANALYSIS OF VARIANCE

DUSTFALL 77

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	424.33334	3976.33350	63.05818
2	3	534.00000	9001.00000	94.87360
3	3	407.33334	372.33334	19.29594

GRAND MEAN = 455.222

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	28360.22852	2	14180.11426	3.18662
RESIDUAL	26699.33398	6	4449.88916	
TOTAL	55059.56250	8	6882.44531	

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ONE-WAY ANALYSIS OF VARIANCE

LEAD 77

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	.76667	.02333	.15275
2	3	1.93333	.08333	.28868
3	3	1.80000	.16000	.40000

GRAND MEAN = 1.5

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	2.44667	2	1.22333	13.76250
RESIDUAL	.53333	6	.08889	
TOTAL	2.98000	8	.37250	

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ONE-WAY ANALYSIS OF VARIANCE

NITRATES 77

TREATMENT	OBS	MEAN	VARIANCE	STD. DEV.
1	3	3.86667	.06333	.25166
2	3	3.86667	.65333	.80829
3	3	4.33333	.05333	.23094

GRAND MEAN = 4.02222

ANALYSIS OF VARIANCE TABLE

SOURCE	SUMS OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F RATIO
TREATMENTS	.43555	2	.21778	.84848
RESIDUAL	1.54000	6	.25667	
TOTAL	1.97556	8	.24694	

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