DRIFT STUDIES FROM THE AERIAL APPLICATION OF DEF AND FOLEX IN FRESNO AND MERCED COUNTIES, CALIFORNIA 1979

by

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Abstract

The Environmental Hazards Assessment Program monitored DEF and Folex drift from selected sprayed cotton fields in Fresno County, California during September and October 1979. Three daylight and a single night aerial applications were studied using a monitoring period coinciding with actual application. The three day studies also included monitoring a post-application period after spraying was terminated. Additionally, two DEF intrusion studies were implemented in Fresno and Merced counties in an attempt to detect the defoliant in residential areas of concern and in fields of non-target crops. An evaluation of Meloy Total Sulfur Analyzers to monitor sulfur containing compounds associated with DEF and its breakdown products was completed. A study to evaluate the effectiveness of Airdrop, an additive to control drift, was also attempted.

The monitoring teams detected very low levels of DEF drift from cotton fields during aerial applications. Drift levels varied from a maximum of 14,500 ng/m^3, a calculated mean of 1.1 parts per billion (ppb, weight/volume), immediately downwind from the field (30 meters) to 953 ng/m^3, a calculated mean of 73 parts per trillion (ppt, weight/volume) 400 meters downwind from an application field. Aerial defoliant applications on monitored cotton fields produced essentially identical drift patterns despite significant differences in temperature and humidity and day or night applications. The night application did, however, produce higher levels of drift but only relatively so. Absolute levels of DEF drift did not exceed 1 ppb during the night application. Drift levels stabilized at very low concentrations by a distance of about 200 meters downwind where further dilution continued at an extremely slow rate. Only very low levels of DEF (<0.5 ppb) were detected during post-application monitoring although fields maintained higher levels than the background samples taken before application.

No DEF was detected in both the residential and non-target crop intrusion studies. The Airdrop evaluation experiment did not produce definitive results and is viewed with some skepticism because of an atypical application technique. The Meloy Total Sulfur Analyzer appeared to have potential for actively monitoring DEF and its degradation products.

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Introduction

Chemical defoliation is a production practice used on virtually all of the California cotton crop. Mechanical picking of cotton generally requires the use of a defoliant to reduce the volume of vegetative material passing through the picker head., Defoliation also reduces the incidence of green leaf stain on the cotton lint as a result of contact between lint and leaves during picking.

Three general chemical types of cotton defoliants are currently available - phosphates, chlorates, and arsenicals. The phosphate defoliants tributyl phosphorotrithioate (DEF) and tributyl phosphorotrithoite (Folex) have found widespread use in California. Unfortunately, use of DEF and Folex have generated an increasing number of complaints. These complaints have ranged from damage to non-target crops planted in the vicinity of cotton acreage to adverse effects on community health in urban centers located in the cotton growing areas of the State. The damage to non-target crops is suspected of being a direct result of the off-target movement of the harvest aids during aerial applications, Unfortunately, very little data is available on the extent of off-target movement of the harvest aids during typical aerial applications. The complaints of adverse effects on community health in urban centers have taken on new importance in light of the suspected neurotoxicity of the cotton harvest aids,DEF and Folex. The main complaints regarding adverse health effects are closely associated with the presence of butyl mercaptan, the major breakdown product of DEF and Folex.' The number of complaints throughout the cotton harvest season appears to correlate with increased use of the defoliants.

The California Department of Food and Agriculture (CDFA), in response to these complaints, has enacted strict regulations governing the use of DEF and Folex

1/ P. R. Datta, Environmental Fate Profile: DEF, United States Environmental Protection Agency, Environmental Fate Branch, Hazards Evaluation Division, Office of Pesticide Programs, July 1979.

on cotton acreage adjacent to urban areas. However, even with these new regulations complaints have persisted and increased. The Environmental Hazards Assessment Program conducted a study of the drift characteristics of DEF and Folex in Fresno County during the 1979 harvest season to define the field problems associated with the use of these defoliants. This study was a cooperative effort with the offices of the Agricultural Commissioners of Fresno and Merced counties.

The purpose of this study was fourfold:

1. The study attempted to determine in a quantitative manner the existence and/or extent of any off-target movement of the cotton harvest aids during aerial applications.
2. The study attempted to detect intrusion of the harvest aids into field's non-target crops.
3. The study attempted to detect intrusion of the harvest aids into residential areas.
4. The study provided a testing ground for the evaluation of instrumentation which may, in the future, provide real time detection of the harvest aids in air.

I. Materials and Methods

A. Study Locations

This study was conducted in Fresno and Merced counties in the San Joaquin Valley of Central California. All experimental sites were selected cooperatively with personnel from the Agricultural Commissioner's office the owner/grower, and appropriate staff of the Environmental Hazards Assessment Program (EHAP). In each case the Agricultural Commissioner was first consulted to indicate possible cooperators and potential sites. The landowner/grower was then contacted to solicit their permission and cooperation. The appropriate Pest Control Advisor (PCA) or Pest Control Operator (PCO) was then contacted to solicit his cooperation. All portions of this study using privately owned land were conducted with the full consent and cooperation of the owner/grower.

1. Drift Study Sites

Cotton defoliants have historically been aerially applied in the study area because of the extensiveacreages involved. In order to accurately represent potential drift from application sites, this study concentrated exclusively on aerial applications. Five separate drift studies were conducted during the course of the study period. The characteristics of each site and aerial applications are summarized in Table 1. Figures 1 and 2 present the actual orientation of monitoring equipment at each of the sites.

2. Residential Intrusion Sites

A school in Mendota, California and a high school in Dos Palos, California were selected as residential intrusion study sites., The Mendota school was monitored from 9/25/79 to 10/23/79, and the Dos Palos school from 10/1/79 to 10/23/79.

3. Non-target Crop Intrusion Sites

Four lettuce fields, all located adjacent to cotton plantings, were monitored for cotton defoliants. One static sampler was placed in each field from 10/5/79 to 10/23/79 and a low volume sampler placed near the headquarters of the cooperators. The four lettuce fields were located near Huron, California.

B. Monitoring Methods

1. Drift Monitoring

General Metal Works high volume air samplers (HiVol) equipped with Kurz Instruments constant flow controllers were used to monitor drift from application sites. HiVols were powered by gasoline powered portable Honda generators. HiVols use a cartridge, adapted from Lewis, et. al. (3), and Woodrow, and Seiber (8) which consisted of a pre-cleaned Gelman A/E glass fiber filter followed by a 30 to 40 gram bed of pre-cleaned XAD-4 macroreticular resin (Rohm and Haas). All HiVols were calibrated to operate at a flow of 0.93 m^3/min.

A background air sample was collected in the cotton field prior to defoliant aerial application, Actual monitoring occurred: 1) During the entire aerial application (Application Period); 2) A period of time several hours after the aerial application was completed (Post-Application Period). HiVols were placed at locations downwind of the application field shortly before the initiation of the defoliant spraying. The orientation of the downwind samplers is discussed in the experimental design section, Two types of static falloutsamplerswere utilized. One pint wide-mouth glass Mason jars (fallout jars) and 8x10" Gelman A/E glass fiber filters (fallout filters) were used adjacent to each other to compare effectiveness. The fallout jars were attached to the top of 5 ft. metal stakes. The fallout filters were contained in paper frames stapled to cardboard sheets and also fastened to the top of 5 ft. metal stakes.

2. Residential Intrusion Monitoring

Samples were collected using a low volume sampler (LoVol) calibrated at a flow of 5.5 ℓ/min. A 17 mm I.D. glass tube containing a 3 inch bed of XAD-4 resin was used to trap defoliants. The flow was controlled using a critical orifice., These samplers were similar to those utilized by Robinson and Fox (4) and Woodrow and Seiber (8). Gas phase sulfur compounds were detected by a Meloy. Industries Total Sulfur Analyzer using a flame photometric sensor. These were calibrated by the California Air Resources Board Mobile Calibration Team using EPA recommended procedures.

3. Non-target Crop Intrusion Monitoring

Static samplers consisted of a metal cone 12" in diameter at the base, 4" in diameter at the top, and 6" high with 12 to 15 grams of XAD-4 resin trapped between two fine mesh screens. The cones were placed in the lettuce fields on 1 ft. stakes oriented so the face of the 12" diameter base was up and parallel to the soil- surface. Samplers were placed 100 ft. into the lettuce fields from the side adjacent to the cotton plantings.

C. Analytical Methods

All XAD-4 resin used in this study was pre-cleaned by Soxhlet extraction for 8 hours using a 1:1:1 (v/v/v) mixture of hexane, acetone and methanol (distilled in glass). The resin was subsequently dried in a vacuum oven. All glass fiber filters were pre-washed with distilled water and fired at 450°C for 5 hours before use. Resin and glass fiber filters were then stored in either sealed glass jars or plastic bags prior to use. After collection the XAD-4 resin was again sealed in glass jars with teflon lid liners. Glass fiber filters were sealed in aluminum foil and stored in manila envelopes. Both resin and filters were stored at 0°C after collection until transported to the laboratory, then transferred to a freezer set at -70°C until extraction. Filter and resin extracts were also stored at -70°C in the laboratory until anaiysis.

1. Extraction Procedures

Glass fiber filters were extracted using a 1:1:1 (v/v/v> hexane, acetone, and methanol mixture. Fiiters were sonicated in the extraction solvent mixture in '250 ml erlenmyer flasks for 1 hour, then filtered through sharkskin filter paper into a 200 ml beaker, The glass fiber filter was then rinsed with two 25 ml aliquots of extraction solvent mixture which were also subsequently filtered and added to the 20 ml beaker., The solvent volume was reduced by evaporation at room temperature and then transferred to either a 5 ml or 50 ml volumetric flask, The beaker was rinsed twice and the rinses added to the volumetric flask. The volumetric flask was then brought up to volume with additional solvent mixture,

Resin samples were extracted using 125 ml of the 1:1:1 (v/v/v> hexane, acetone, and methanol solvent mixture. The resin-solvent mixture was sonicated for 1 hour, filtered, concentrated and increased to volume using the same procedures previously described for glass fiber filters.

The static samplers used for intrusion monitoring into lettuce fields were extracted using the same resin technique previously described coupled with an additional rinsing of the metal cones. The interior of the metal cones were rinsed 3 times using 25 ml aliquots of the previously described solvent mixture. The rinses were added to the solvent extraction from the resin and processed using the same techniques used for the resin.

2. Analysis

DEF and Folex samples were analyzed using a Perkin-Elmer model Sigma 2 gas chromatograph with a phosphorus specific detector (thermoionic) and employing a 6 ft., 2 mm I.D. glass column packed with 4% OV-101 on Gas Chrom Q (100/120 mesh), Nitrogen was used as the carrier gas (30 ml/min.). The injector operated at 225°C and and the column at 220°C. The presence of DEF or Folex was confirmed by mass spectrometry,

D. Experimental Design

1. Drift Studies

The physical orientation of HiVol samplers and fallout samplers incorporated into the experimental design of the drift studies is generalized in Figure 3. HiVols were placed in 2 vectors (A&B) downwind of the application area. Instrument positions along the vectors represent replicate distances downwind and are presented numerically increasing with distance away from the field.

The experiment was run as a complete 2x4 factorial with 2 replications of each treatment combination. An analysis of variance was performed on the data to evaluate the effect of the 2 factors, distance and media on concentration. Duncan's pairwise comparison procedure was used to test for differences among treatments, When necessary, Yates' formula' was used to estimate missing units in order to complete the analysis of variance,

The comparison of the effectiveness of the glass fiber fallout filters and fallout jars utilized the following procedures. An F test[2] was used to compare the variances of the two samples. In all cases, the assumption of equality of variances was justified. Based on this result, a two-sample t test[3] with a pooled variance estimate was used to test for a difference in the two methods of collection,

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1/ $$Y_{ij} = \frac{bB + tT - G}{(b-1)(t-1)}$$

where: b = # of blocks (replicates)
t = # of treatments
B = sum of observations in the i^{th} block
T = sum of observations in the j^{th} treatment
G = sum of all observations

2/ $$\frac{S_1^2}{S_2^2} \sim F^{(n_1-1)}_{(n_2-1)} (\alpha)$$

where: S_1^2 = larger sample variance
n_1 = size of sample with largest variance
S_2^2 = smaller sample variance
n_2 = size of sample with smallest variance
α = level of significance

3/ $$\frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \quad t_{n_1+n_2-2} (\alpha)$$

where: $\bar{x}_1$ = mean of sample 1 (FFs)
S_1^2 = variance of sample 1
n_1 = size of sample 1
x_2 = mean of sample 2 (FJs)
S_2^2 = variance of sample 2
n_2 = size of sample 2
α = level of significance

The data processing procedures are summarized in Figure 4. Fallout and drift sampler data were of necessity treated independently. Table 2 summarized conversions used in the calculations of DEF data for both fallout and HiVol samplers.

E. Meteorological Data

Meteorological variables were monitored using a Weather Measure mobile weather station. Wind speed and direction, air temperature, relative humidity, and barometric pressure were recorded. The wind sensing system consisted of a low-threshold stainless steel cup anemometer and lightweight directional vane, both mounted on a pre-wired crossarm attached to the top of a 20 ft. telescoping tower. The other meteorological variables were monitored with a meteorgraph enclosed in a shelter.

F. Computation of Sorbent Extraction Efficiencies and Area Estimates

The formulas used to compute the extraction efficiencies of DEF from glass fiber filters and XAD-4 resin are presented in Table 3. Mean areas were calculated for fallout glass fiber filters and glass fallout jars for use in data calculations (Table 4).

II, Results

9-17-79 (Site 1)

A positive background level of DEF calculated to be 606 ng/m^3, a calculated mean of 46.4ppt wt/v was detected before the field application occurred and eliminated from subsequent calculated drift levels. The meteorological variables and pertinent statistics characterizing the monitoring of the application and the post-application periods were summarized in Table 5. Both temperature and relative humidity data for these periods were not available due to the malfunctioning of a chart recorder.

A, Application Period 0846 to 1046

A total of 272 kgs (active) DEF was aerially applied to the selected cotton field. Field coverage was monitored by 2 methods using glass fiber filters and glass jars. The statistical comparison indicated that the fallout jars collected more DEF than the glass fiber filters (Table 6). Results from the drift design using 2 downwind vectors of 4 instruments per vector indicated that there was significant DEF drift downwind of the applied field (Table 7). Actual drift levels were low varying from 14,500 ng/m^3 30 meters downwind to 953 ng/m^3 400 meters downwind. The trapping efficiency of the resin and filters on the Hivol samplers varied with distance downwind but the significant media x distance interaction term was not a factor in monitoring since the DEF levels were calculated by summing the material on the resin with that on the filter. Drift downwind from the field decreased with distance to 2Q0 meters (Table 8). A plot of the downwind levels is presented in Figure 5.

B. Period Following Application 1500 to 1700

The same cotton field used in the drift study was monitored for a 2-hour period in the afternoon to determine whether detectable levels of DEF would continue to drift after application was terminated, Only low levels of DEF were detected during this monitoring period (Table 9). The analysis indicated that DEF concentrations were equivalent over distances downwind. Monitored DEF levels at 200 and 400 meters downwind were below background and produced negative data, Low levels (1 ng/m^3) were substituted in order to run the analysis.

C. Following Day (g-18-79)

A background HiVol sample taken at 0846-1046 on the following day (761 ng/m³) was nearly equivalent to the background sample taken before application on 9-17-79 (606 ng/m³). However, another 2 hours background sample taken from 1500-1700 indicated that the calculated DEF concentration had almost doubled (1137 ng/m³).

9-21-79 (Site 2)

Although a monitoring study was completed, the results are not presented due to the lack of resin in the HiVol sampling apparatus. The other studies included in this report clearly show that resin is required to effectively trap the DEF that passes through the HiVol samplers. Presentation of only the filter data would serve no purpose.

Y-26-79 (Site 3)

This experiment was initiated to determine whether Airdrop fortified DEF applications from an aircraft would reduce drift. This was not a commerical application. An artificial situation was created to allow a direct comparison of DEF drift with and without Airdrop. The meterological variable and pertinent statistics characterizing the day the monitoring was carried out was summarized in Table 10. Examination of these data indicated that the periods of application were essentially uniform.

A. Airdrop Fortified Application 1100 to 1145

An application of 5.20 kgs of an Airdrop fortified DEF formulation was applied to the experimental area. Spray coverage was monitored by glass fiber filters and glass jars. The glass jars collected significantly more of the DEF application per unit area than the glass fiber filters (Table 11). The same general drift design using two downwind vectors was utilized to monitor drift. Drift levels were extremely low ranging from a high of 338 ng/m^3 29 meters downwind from the application to a low of 87.0 ng/m^3 805 meters downwind.

B. Application Without Airdrop 1145 to 1230

An identical application of 5.20 kgs of DEF without Airdrop was' applied to the same experimental area. Spray coverage was almost identical with the glass jars again collecting significantly more than the glass fiber filters (Table 11). Drift levels were again low ranging from 455 ng/m^3 at 29 meters downwind to 76.6 ng/m^3 805 meters downwind.

C. Comparison of DEF Drift With and Without Airdrop-

Although DEF driftdownwind of the application area was significant during both the Airdrop plus and Airdrop minus applications, the amount of drift was not influenced by the presence of the additive (Table 12). Furthermore, drift levels had dispersed to a uniform level 260 meters downwind of the application (Table 13) and were statistically equivalent at the HiVols 805 meter downwind, The mean concentrations of DEF monitored in the comparison were extremely close, 560 ng/m^3 with Airdrop and 683 ng/m^3 without Airdrop,

A comparison of trapping efficiencies of the resin and glass fiber filters in the HiVols again varied with distance. The significant interaction term was not a factor because the DEF levels were calculated by summing the amounts collected on the resin and filters.

9-28-79 (Site 4)

Pre-application monitoring detected a positive background level of DEF 537 ng/m^3. This background was eliminated from subsequent calculated values. Table 14 summarized the meteorological variables and other pertinent information which characterized this monitoring study. This effort was designed to detect drift during a night aerial application.

A. Night Application 2345 to 0130

A total of 81.60 kgs (active) DEF was aerially applied to the selected cotton field. A field coverage comparison using glass fiber filters and glass fallout jars indicated that the glass jars collected more DEF when compared in terms of deposit per unit area (Table 15).

A drift design using 2 replicate downwind vectors from the application and 3 HiVols per vector was utilized, This design detected significant DEF drift from the application area (Table 16). Actual levels ranged from 4670 ng/m^3 14 meters downwind to 1120 ng/m^3 300 meters downwind. DEF drift appeared to stabilize by 145 meters at concentrations considerably higher than previously monitored (Table 17). The DEF level was 1120 ng/m^3 300 meters downwind of the application site, approximately twice the background level. This drift is depicted in Figure 6. The trapping efficiency of the resin and glass fiber filters on the HiVols also varied but no interaction with distance downwind was detected.

10-1-79 (Site 5)

No background levels of DEF or Folex were calculated because of missing data for the resin portion of the HiVol samples. The previous studies had indicated that a substantial amount of DEF passes through the glass fiber fitters and requires the presence of resin to ensure an accurate estimation of the amount present. The relationship of the resin to filter trapping efficiencies for DEF could not be adequately defined from previous studies to estimate the proportion of DEF which would have been trapped by the resin, especially when the meteorological variables present for each study varied. As a result, the data presented for this study is relative to the unknown background level and cannot be directly compared to the other studies, The meteorological variables and other pertinent data which characterized this study are summarized in Table 18. This monitoring effort was conducted under the highest temperatures and lowest humidities encountered during the total monitoring period.

A. <u>Application Period 1100 to 1410</u>

A total of 286 kg (active) Merphos (Folex) was aerially applied to the selected cotton field. The oxidation of the Folex to DEF (5) was apparently completed quite rapidly since the dual analysis of all samples yielded DEF in the absence of Folex. Field coverage was again monitored by both glass fiber filters and glass fallout jars, No statistical difference was detected between the deposits on both filters and jars (Table 19).

The same 2 vector design with 4 HiVols per vector was used. The analysis indicated that significant drift was observed varying from 3180 ng/m^3 45 meters downwind to 433 ng/m^3 at a distance of 350 meters downwind (Table 20). The dispersion of the DEF drift decreased to very low concentrations by a distance of 210 meters downwind (Table 21). No difference in the collection efficiency of the glass fiber filters and resin was detected, The media x distance interaction term also was not significant.

B. Period Following Application 1500 to 1700

The same cotton field used in the morning Folex application was monitored for a 2-hour period in the afternoon. The analysis indicated that a significant level of DEF was collected within the field, 4020 ng/m^3 (Table 22) but no differentiation of concentrations occurred downwind (Table 23). Care must be taken not to identify monitored levels as drift or background because of the absence of pre-study background information. A comparison of the application and post-application periods is presented in Figure 7.

C. Following Day (10-2-79)

Background HiVol samples were taken between 1000 to 1200 on the following day and produced a 1085 ng/m^3 level of DEF. This was about the same as sampled during the afternoon of 9-18-79, also the day following an aerial application.

IIa. Results

A. Residential Intrusion Study

No DEF was detected on LoVol samplers at schools in either Mendota or Dos Palos during the course of the monitoring. The Meloy Total Sulfur Analyzer did show some promise as a possible monitor for DEF and its breakdown products but did not produce useful results in its present state. The Meloy detected spikes of sulfur containing compounds during the period it was monitoring but these were not necessarily related to DEF or its breakdown products since other sulfur containing compounds may have caused the positive readings, After evaluating the Meloy data, it was proposed that an adaptation using a chromatographic column to separate compounds before entering the instrument was a realistic measure that should be tested in the future.

B. Non-target Crop Intrusion Study

No DEF was detected on either of the static samplers or the LoVol sampler located on 2 of the 4 lettuce fields near Huron, California, Additionally, no injury to lettuce which could be attributed to DEF was reported during the sampling period.

The intrusion study at the remaining 2 lettuce fields encountered irreversible problems. The static samplers in both lettuce fields were missing when the sampling period terminated. A search by project personnel proved to be fruitless. Also, the LoVol sample had to be discarded after problems with an unreliable electrical power source, No DEF injury was reported during the monitoring period.

III, Discussion

Extremely low positive background levels of DEF (606 to 537 ng/m^3) appear to be present in cotton growing areas in Fresno County during the study season. These levels convert to a calculated mean of about 45 parts DEF per trillion parts of air on a weight per volume basis, This background was detected both during daylight hours (g-17-79) and at night (g-28-79). Other aerial applications of

DEF and Folex in the immediate area were the most probable sources of these background levels.

Actual DEF drift monitored during aerial applications during both daylight and night periods never exceeded a calculated concentration of 1.1 parts per billion. DEF levels ranged from 4670 ng/m^3 (45 meters) to 14,500 ng/m^3 (30 meters) immediately downwind of application fields to levels approximating background beyond 200 meters. Monitoring studies conducted during daylight hours on 9-17-79 and 10-1-79 were indicative of the potential for statistically significant downwind DEF drift. Only extremely low concentrations were detected and these appeared to become diluted far below a calculated part per billion level by 200 and 350 meters respectively (Tables 8, 23). These levels were within a factor of 2 of positive background levels monitored before applications on 9-17-79 and 9-28-79. Actual drift levels on 10-1-79 stablized 350 meters downwind of the application field at 433 ng/m^3 (calculated mean of 33.1 ppt) on a warm, dry day (Table 23) which would be condusive to volatilization and drift. This was of special significance since no background level was sampled for this study and the low 433 ng/m^3 included whatever background was present,

Only very low levels of DEF (<0.5 ppb) could be detected from sprayed cotton fields during monitoring periods following the termination of daylight aerial application, Both monitoring studies on 9-17-79 and 10-1-79 produced equivalent analyses.

The drift study of the night DEF application on 9-28-79 did not produce serious alterations to the pattern of DEF drift already characterized by the daylight monitoring studies but did produce higher overall drift levels downwind from the application field, Only the stabilized drift level at 14.5 and 300 meters downwind proved to be higher (85 ppt) than the stabilized levels monitored during daylight hours. This increased level was nevertheless extremely low in absolute terms and never approached lppb.

Actual field application appeared to be best monitored by the use of glass fallout jars. In comparisons of glass fiber filters and glass 1 pint Mason jars, the glass jars consistently trapped an equivalent or greater amount of DEF per unit area than the filters, Only a single application (10-1-79) produced no statistical difference between deposits on the jars and filters. The glass fiber filters are characterized by a much larger surface area for absorption and therefore have a greater potential for revolatilization and/or chemical reactions than glass jars. Also, the cardboard filter holders were observed to be wet beneath the fiiters indicating some of DEF may have been lost as the filters became overly saturated. The data does not, however, define the reasons for the differences in collection efficiencies and care must be taken not to reach unwarranted conclusions.

The results from the experimental comparison of DEF drift with and without the additive Airdrop (g-26-79) were disappointing, Monitoring data from both Airdrop and no Airdrop applications were virtually identical. Based upon the previous favorable results published for Nalcotrol, Airdrop and other additives (1,2,6), the probability that a problem existed when the formulation was mixed in the aircraft spray tank appeared high. This was reinforced by personal observations of program staff and a discussion with the PCO after this monitoring study. The extremely low levels of DEF monitored downwind of this experimental application should not be compared to drift levels monitored from cotton field applications because the total amount of DEF applied to the commercial operations were orders of magnitude greater than the 5.20 kgs applied to the experimental area.

The use of glass fiber filters alone in high volume samplers to trap DEF drift was clearly evaluated as unacceptable despite the low volatility of the defoliant. Significant amounts of DEF were found in the resin beneath the glass fiber filters in every instance. Resin or a substitute sorbent must be utilized when monitoring DEF.

The Meloy Total Sulfur Analyzer appears to have good potential as a real time monitor for DEF if modified with a chromatographic column for sulfur compound separation. EHAP will explore this possibility in future studies.

No DEF was detected in either the residential or non-target crop intrusion studies. This was not surprising considering the low levels of drift monitored during the study.

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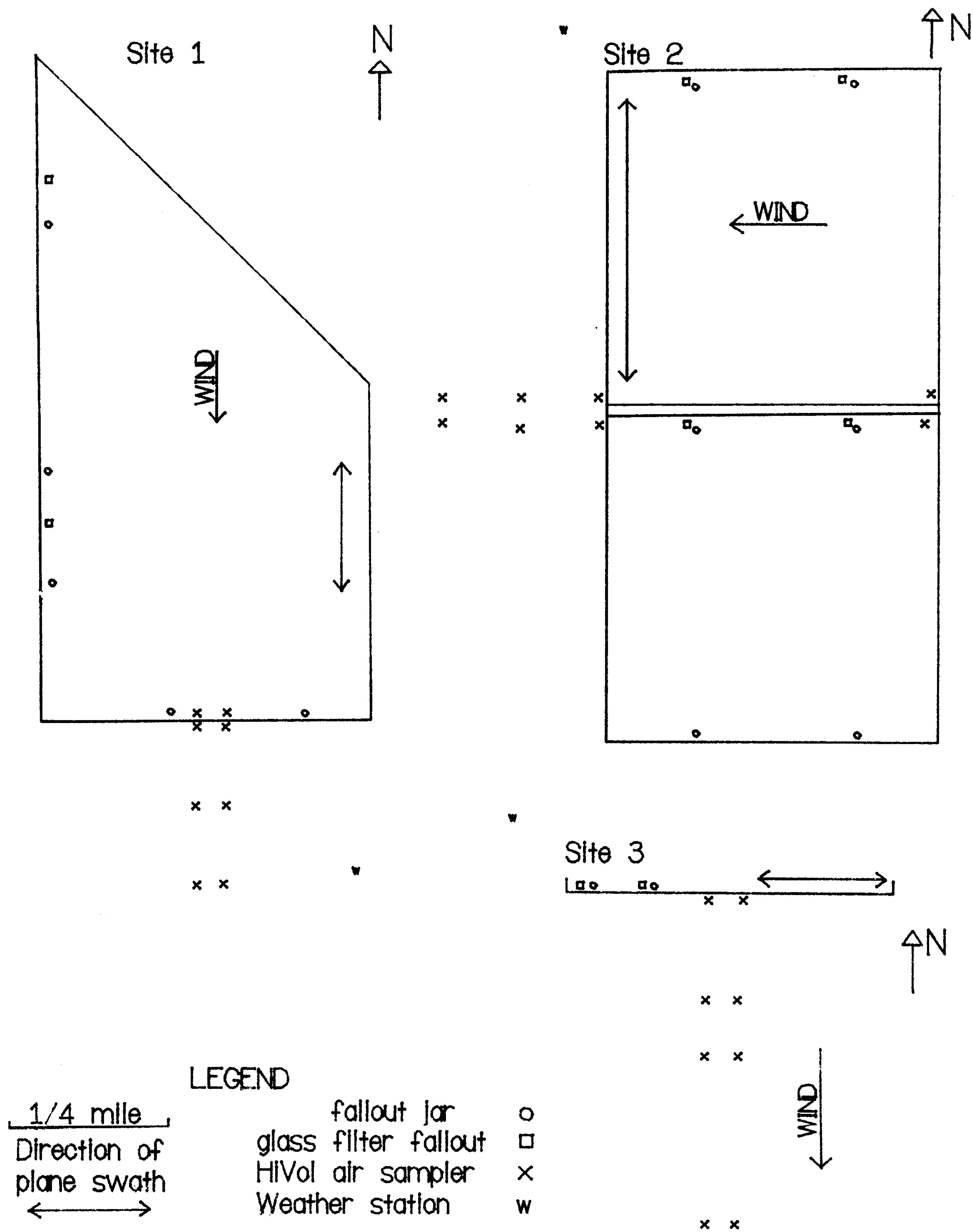


Fig. 1. Drift Study Sites. Site 1 (9-17-79); Site 2 (9-21-79); Site 3 (9-26-79).

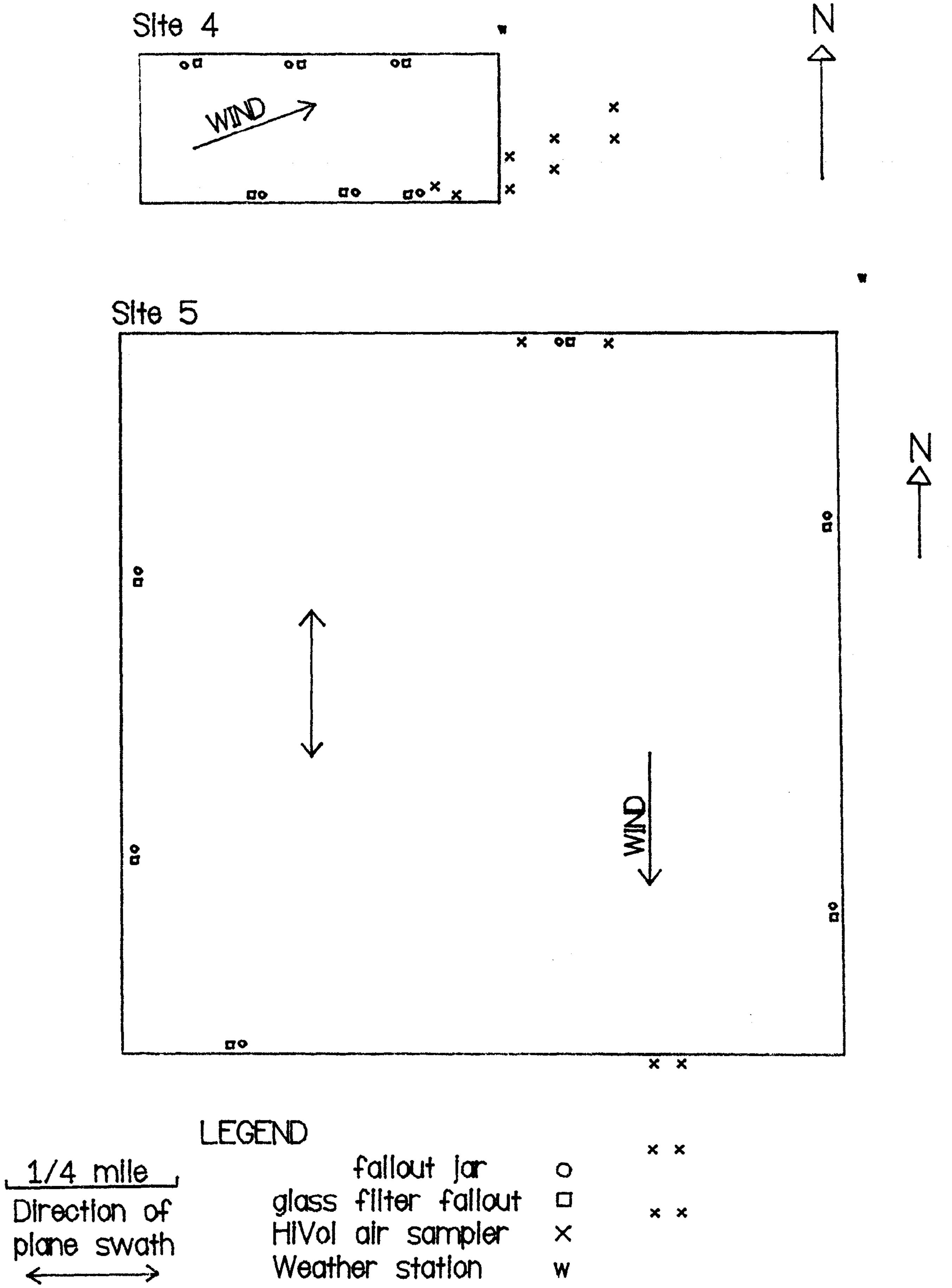


Fig. 2. Drift Study Sites. Site 4 (9-28-79); Site 5 (10-1-79).

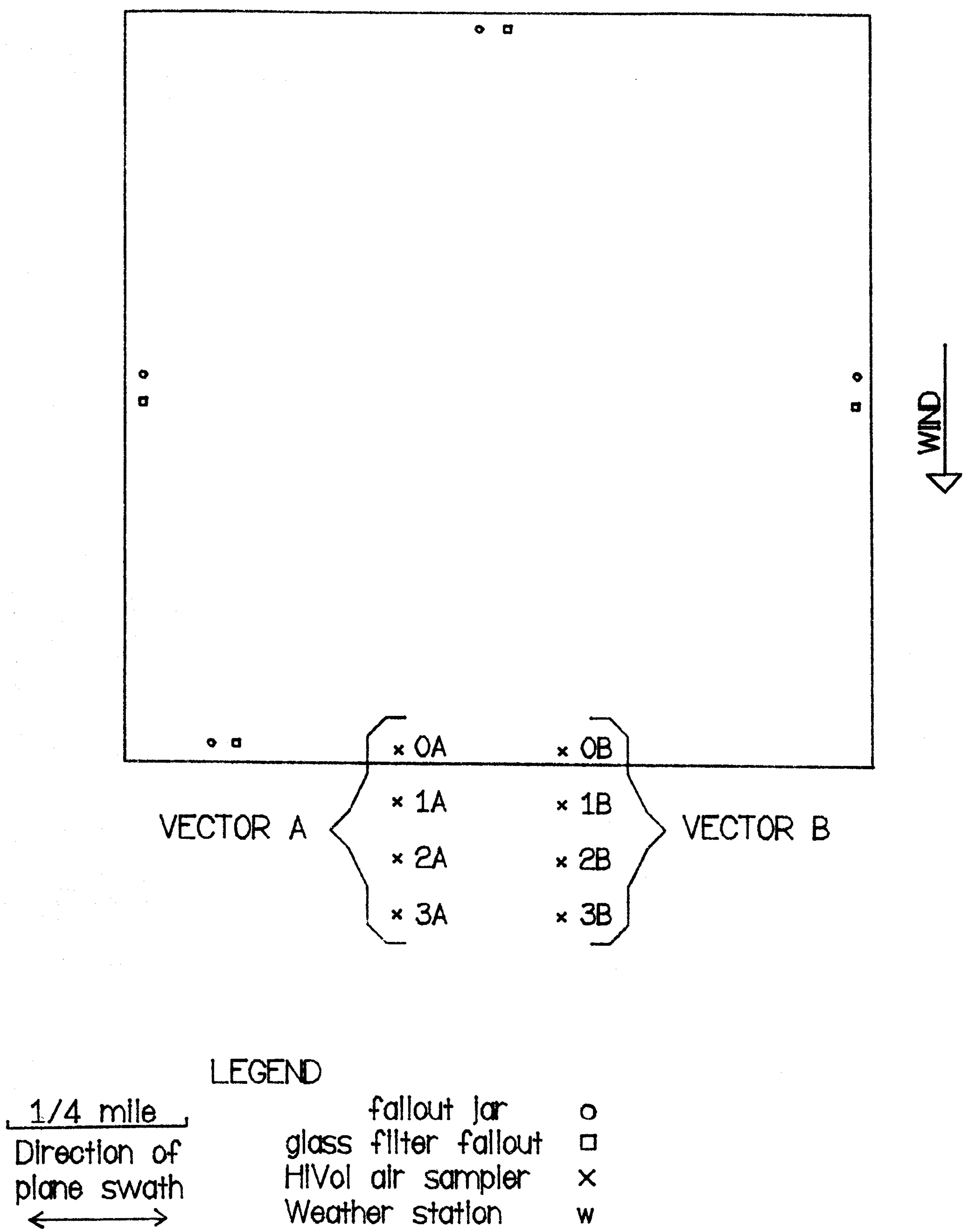
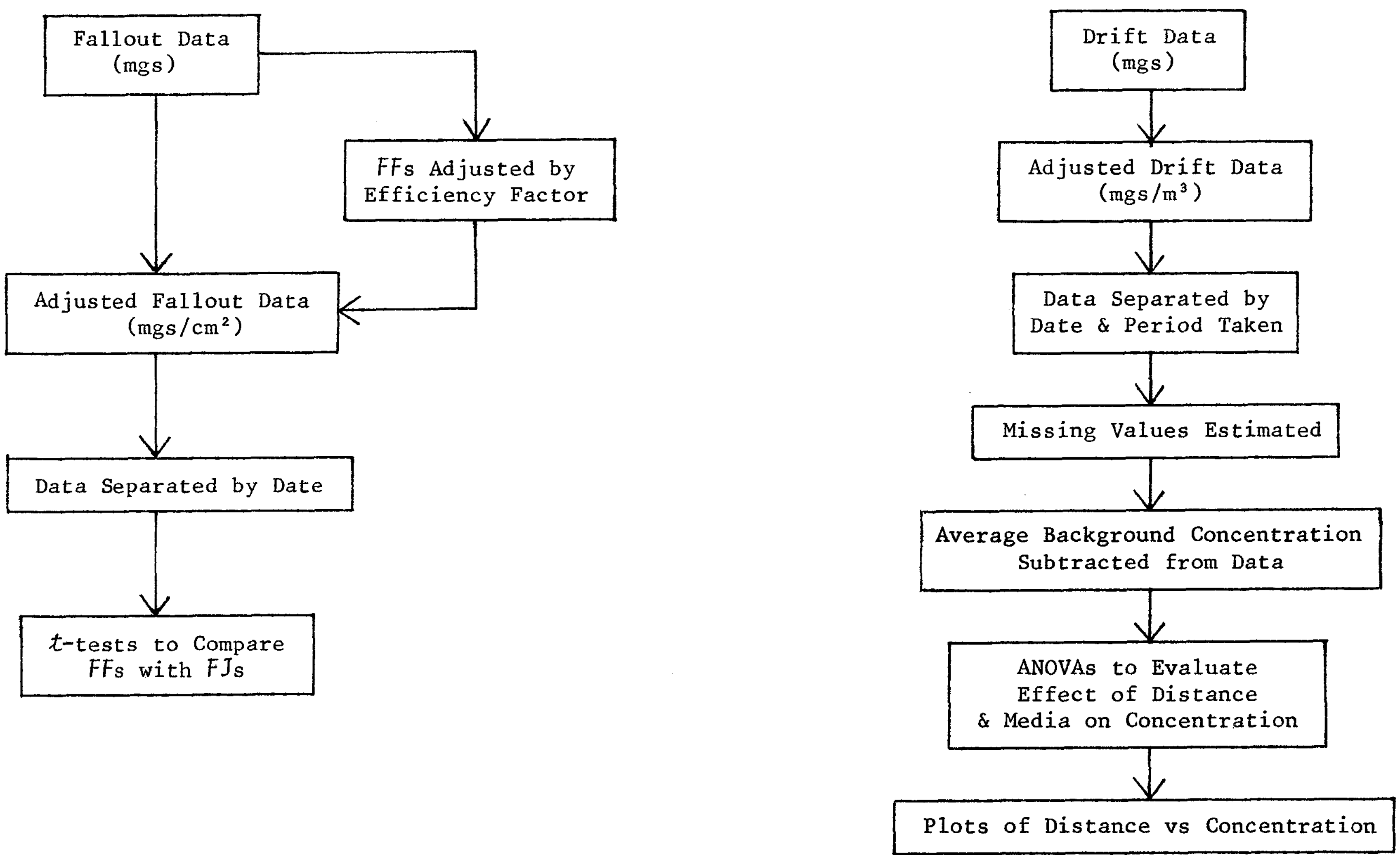


Fig. 3. Generalized Design for Drift Studies.

Fig. 4. Data Flow Charts for Processing DEF Raw Data.



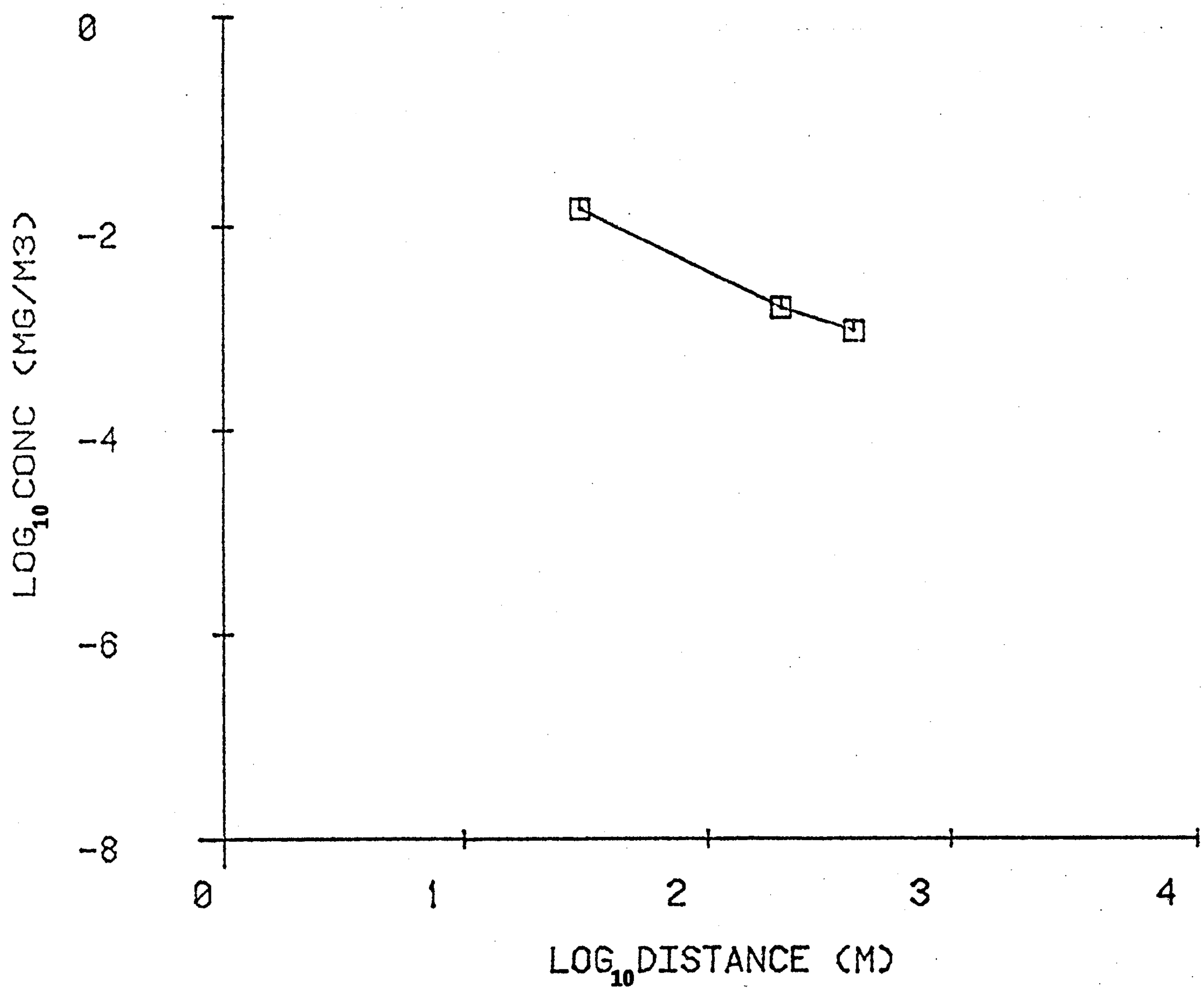


Fig. 5. Downwind Concentrations of DEF Monitored During Application as a Function of Distance from the Sprayed Field (9-17-79).

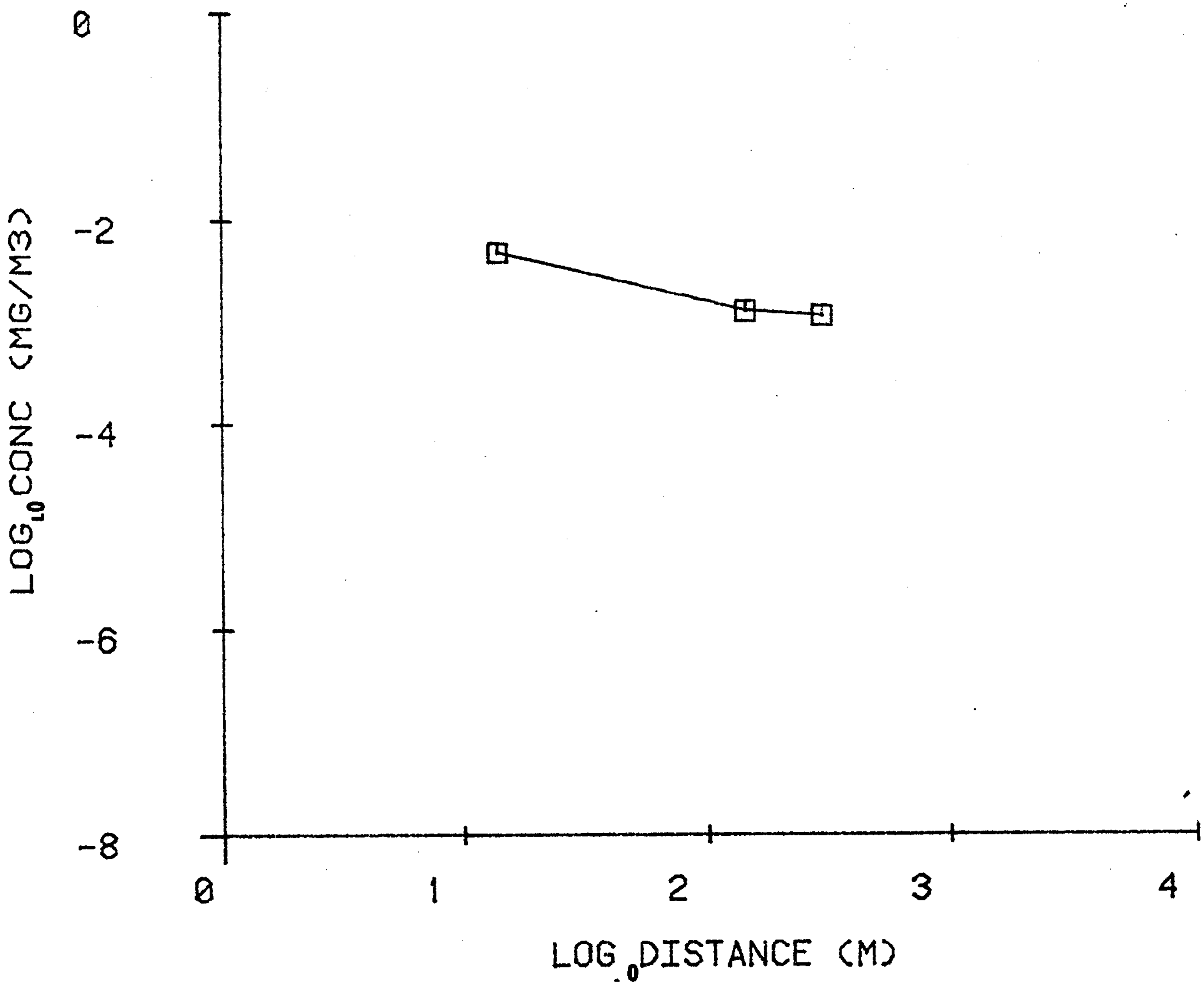


Fig. 6. Downwind Concentrations of DEF Monitored During Application as a Function of Distance from the Sprayed Field (9-28-79).

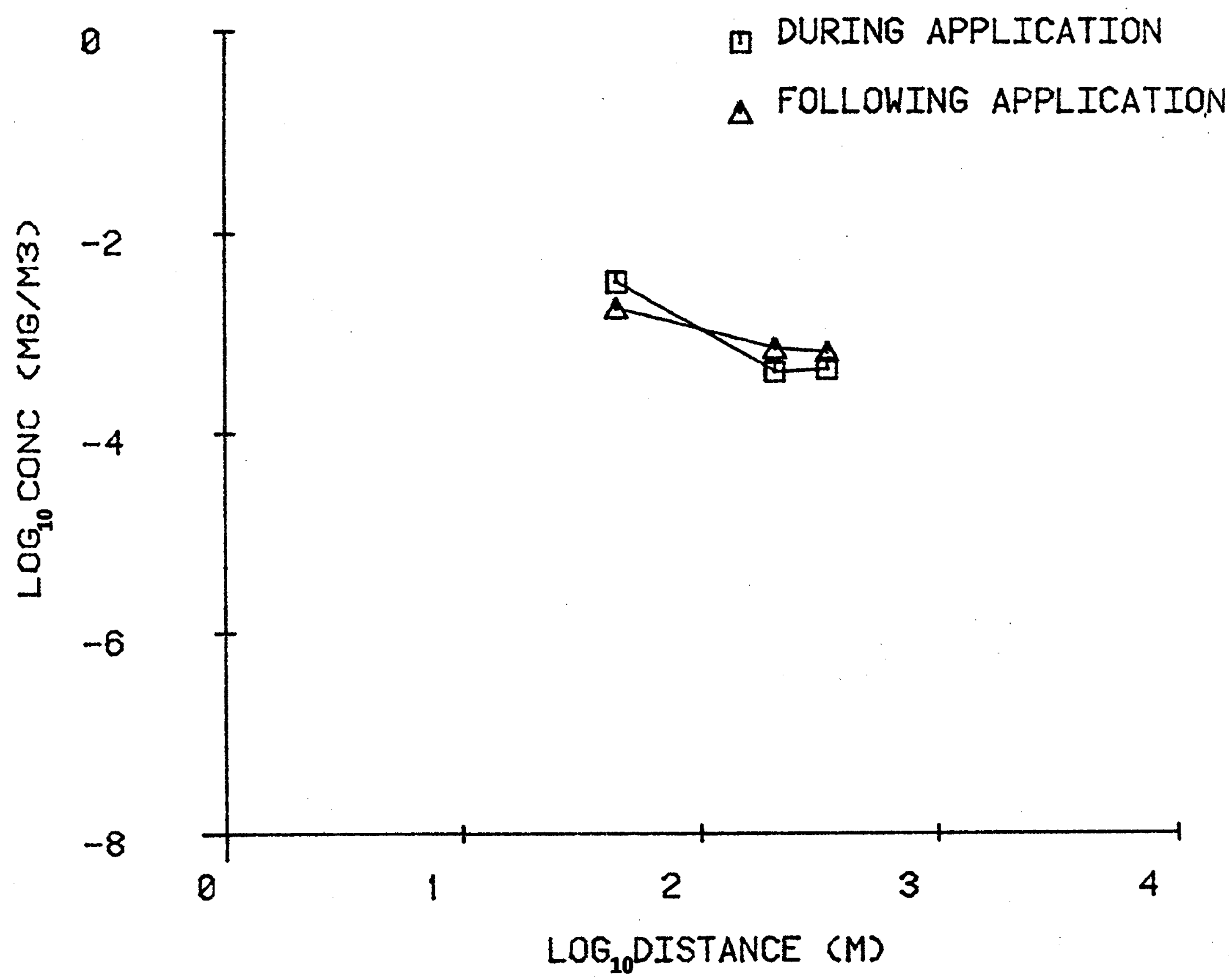


Fig. 7. Downwind Concentrations of DEF Monitored During Application and Following Application as a Function of Distance from the Sprayed Field (10-1-79).

Table 1. Summary of Statistics Characterizing Drift Studies in Fresno County.

Parameters	Drift Study Dates 9/17/79	9/21/79	9/26/79	9/28/79	10/1/79
Acres	240	315	42'x2640'	80	640
Defoliant (gal/acre)	DEF 6 (.42)	DEF 6 (.26)	DEF 6 (.38)	DEF 6 (.38)	Folex (.16)
Visco-Elastic Agent (gal/acre)	Nalco-Trol II (.0083)	Nalco-Trol I (.0350)	Airdrop (.0063)	Nalco-Trol I (.0031)	Nalco-Trol I (.0036)
Activator-Spreader (gal/acre)	Accelerate (.250)	NA (.100)	NA (.013)	Accelerate (.031)	Accelerate (.053)
Nozzle Size (inches)	0.125	0.125	0.125	0.125	0.125
Boom Length (feet)	42	42	42	42	42
Boom Pressure (lbs/in sq)	18	19	17	NA	34
Plane Speed (miles/hr)	>100	>100	>100	>100	>100

Table 2. Conversions Used in DEF Data Calculations.

(1) To convert sample weight (mgs) to fallout (mgs/cm²) for a fallout filter:

$$\frac{\text{wt (mgs)}}{\bar{E}_{FF} \cdot \bar{A}_{FF}} = \frac{\text{wt (mgs)}}{(.7809)\ (407.6\text{cm}^2)} = \text{fallout (mgs/cm}^2\text{)}$$

(2) To convert sample weight (mgs) to fallout (mgs/cm²) for a fallout jar:

$$\frac{\text{wt (mgs)}}{\bar{A}_{FF}} = \frac{\text{wt (mgs)}}{(44.42\text{cm}^2)} = \text{fallout (mgs/cm}^2\text{)}$$

(3) To convert sample weight (mgs) to concentration (mgs/m³) for a HiVol glass fiber filter:

$$\frac{\text{conc(mgs) (35.3145ft}^3\text{/m}^3\text{)}}{\bar{E}_{GFF}\text{(32ft}^3\text{/min) (\#min)}} = \frac{\text{conc(mgs) (35.3145ft}^3\text{/m}^3\text{)}}{\text{(.7809) (32ft}^3\text{/min) (\#min)}} = \text{conc(mgs/m}^3\text{)}$$

(4) To convert sample weight (mgs) to concentration (mgs/m³) for a HiVol resin jar:

$$\frac{\text{conc(mgs) (35.3145ft}^3\text{/m}^3\text{)}}{\bar{E}_{RES}\text{(32ft}^3\text{/min) (\#min)}} = \frac{\text{conc(mgs) (35.3145ft}^3\text{/m}^3\text{)}}{\text{(.4208) (32ft}^3\text{/min) (\#min)}} = \text{conc(mgs/m}^3\text{)}$$

Table 3. Extraction Efficiency Estimates for XAD Resin and Glass Fiber Filters.

$$\bar{E} = \frac{1}{N} \sum_{i=1}^{N} X_i / Y_i$$

X_i = milligrams recovered
Y_i = milligrams spiked
N = number of runs
$\bar{E}$ = mean extraction efficiency

(1) $\bar{E}_{RES}$ = .4208

i	X_i	Y_i
1	.0290	.0777
2	.0300	.0777
3	.0198	.0777
4	.0520	.0777

(2) $\bar{E}_{FF}$ = $\bar{E}_{GFF}$ = .7809

i	X_i	Y_i
1	.0510	.0518
2	.0600	.0518
3	.0380	.0518
4	.0440	.0518
5	.0292	.0518
6	.0362	.0518
7	.0491	.0518
8	.0065	.0518
9	.4200	.5180
10	.4500	.5180
11	.4400	.5180

Table 4. Area Estimates for Fallout Glass Fiber Filters and Fallout Jars.

(1) $$\bar{A}_{FF} = \overline{LW} = \frac{\sum_{i=1}^{8} L_i W_i}{8}$$

$$= 407.50$$

i	L_i	W_i
1	23.0	17.9
2	22.8	17.6
3	23.1	17.9
4	22.9	17.9
5	22.8	17.7
6	23.0	17.8
7	22.8	17.6
8	23.0	17.8

Where:

$\bar{A}_{FF}$ = mean area of glass fiber filter

L = length

W = width

(2) $$\bar{A}_{FJ} = \overline{\pi r^2} = \left(\frac{\sum_{i=1}^{10} \pi r_i^2}{10} \right)$$

$$= \left(\frac{\pi \sum_{i=1}^{3} f_i r_i^2}{\sum_{i=1}^{3} f_i} \right)$$

$$= 44.42$$

i	f_i	r_i
1	7	3.750
2	2	3.775
3	1	3.800

Where:

$\bar{A}_{FJ}$ = mean area of fallout jar opening

r = radius of fallout jar opening

f = frequency

Table 5. Meterological Data Summary for DEF Monitoring on 9-17-79.

Parameter	During Application	Following Application
1. Start (24-hr clock)	0846	1500
2. End (24-hr clock)	1046	1700
3. Duration (min)	120	120
4. Formulation (mgs/field)	2.72E08[1]	2.72E08
5. Average temperature (°C)[2]	-	-
6. Average relative humidity (%)[2]	-	-
7. Average wind speed (m/h)[3]	2.77	7.11
8. Maximum wind speed (m/h)[3]	4.00	12.00
9. Minimum wind speed (m/h)[3]	2.00	3.00
10. Average wind direction (degrees)[3]	250.00	114.44
11. Average solar radiation ($cal/cm^2/min$)[2]	568.20	568.20

1/ Presented using a positive exponent ($E08=10^8$).

2/ Recorded in 30-minute intervals.

3/ Recorded in 15-minute intervals.

Table 6. Comparison of DEF Deposits on Glass Fiber Filters (FF) and Glass Fallout Jars (FJ) within the Applied Cotton Field on 9-17-79.

Date	Media	Sample Size	Mean	Standard Deviation	F_{calc}[1]	$F_{crit(.05)}$	t_{calc}[2]	$t_{crit(.05)}$
9-17-79	FF	3	0.381E-02[3]	0.443E-02	2.28*ns*[4]	$F^3_2 = 39.17$	-2.81*[5]	$t_5 = 2.57$
	FJ	4	0.136E-01	0.469E-02				

1/ Test for unequal variance.

2/ Test for mean separation.

3/ Data is presented in mg/cm² using a negative exponent (E-02 = 10^{-2}).

4/ *ns* = not significant.

5/ * denotes significance at .05.

Table 7. Calculated Means and Analysis of Variance of High Volume Sampler DEF During Application on September 17, 1979. The Following Symbols are Used: R=Replicate; M=Media; D=Distance; GFF=Glass Fiber Filter; RES=Resin.

Combination	Count Per Mean	Subclass R	Subclass M	Subclass D	Means
R	8				
Vector A		1	0	0	0.114E-01[1]
Vector B		2	0	0	0.109E-01
M	8				
GFF		0	1	0	0.491E-02
RES		0	2	0	0.175E-01
D	4				
0 METERS		0	0	1	0.277E-01
30 METERS		0	0	2	0.145E-01
200 METERS		0	0	3	0.159E-02
400 METERS		0	0	4	0.953E-03
MXD	2				
GXO		0	1	1	0.944E-02
RXO		0	2	1	0.459E-01
GX1		0	1	2	0.657E-02
RX1		0	2	2	0.224E-01
GX2		0	1	3	0.193E-02
RX2		0	2	3	0.125E-02
GX3		0	1	4	0.169E-02
RX3		0	2	4	0.211E-03

Analysis of Variance (Concentration During App.)

Source of Variation	DF	SS	MS	F		CV
R	1	0.107E-05	0.107E-05			
M	1	0.629E-03	0.629E-03	51.10	***[2]	
D	3	0.192E-02	0.640E-03	51.94	***	
MXD	3	0.954E-03	0.318E-05	25.84	**	
ERROR	5	0.616E-04	0.123E-04			31.4%
TOTAL	13	0.356E-02				

1/ Data is in mg/m³ using a negative exponent (E-01=10^{-1}).

2/ ** Denotes significance at .01. *** denotes significance at .001.

Table 8. Duncan's Multiple Range Test of High Volume Sampler Mean Differences for DEF During Application on September 17, 1979.

Significance at 5 Percent, Ranked Means			
No.	Name	Mean	Homogeneous Sub-Group
1	0 Meters	0.277E-01 [1]	X [2]
2	30 Meters	0.145E-01	Y
3	200 Meters	0.159E-02	Z
4	400 Meters	0.953E-03	Z
LSD	0.638E-02		

1/ Data is in mg/m^3 using a negative exponent ($E\text{-}01=10^{-1}$).

2/ Means which have letters under the same sub-group are not significantly different.

Table 9. Calculated Means and Analysis of Variance of High Volume Sampler DEF Following Application on September 17, 1979. The Following Symbols are Used: R=Replicate; M=Media; D=Distance; GFF=Glass Fiber Filter; RES=Resin.

Combination	Count Per Mean	Subclass R	Subclass M	Subclass D	Means
R	8				
Vector A		1	0	0	0.249E-02 [1]
Vector B		2	0	0	0.741E-03
M	8				
GFF		0	1	0	0.135E-02
RES		0	2	0	0.188E-02
D	4				
0 METERS		0	0	1	0.335E-02
30 METERS		0	0	2	0.311E-02
200 METERS		0	0	3	0.100E-05
400 METERS		0	0	4	0.100E-05
MXD	2				
GXO		0	1	1	0.310E-02
RXO		0	2	1	0.359E-02
GX1		0	1	2	0.228E-02
RX1		0	2	2	0.393E-02
GX2		0	1	3	0.100E-05
RX2		0	2	3	0.100E-05
GX3		0	1	4	0.100E-05
RX3		0	2	4	0.100E-05

Analysis of Variance (Concentration Following App.)

Source of Variation	DF	SS	MS	F	CV
R	1	0.122E-04	0.122E-04		
M	1	0.114E-05	0.114E-05	0.20	
D	3	0.417E-04	0.139E-04	2.47	
MXD	3	0.182E-05	0.607E-06	0.11	
ERROR	7	0.394E-04	0.562E-05		147.0%
TOTAL	15	0.962E-04			

1/ Data is presented in mg/m³ using a negative exponent ($E\text{-}02=10^{-2}$).

Table 10. Meteorological Data Summary for DEF Monitoring on 9-26-79.

Parameter	With Airdrop	Without Airdrop
1. Start (24-hr clock)	1100	1145
2. End (24-hr clock)	1145	1230
3. Duration (min)	45	45
4. Formulation (mgs/Field)	5.20E06[1]	5.20E06
5. Average temperature (°C)[2]	21.50	22.00
6. Average relative humidity (%)[2]	69.00	63.50
7. Average wind speed (m/h)[3]	4.75	4.75
8. Maximum wind speed (m/h)[3]	6.00	5.00
9. Minimum wind speed (m/h)[3]	4.00	4.00
10. Average wind direction (degrees)[3]	272.50	260.00
11. Average solar radiation ($Cal/cm^2/min$)[2]	848.00	699.50

1/ Presented using a positive exponent ($E06=10^6$).

2/ Recorded in 30-minute intervals.

3/ Recorded in 15-minute intervals.

Table 11. Comparison of DEF Deposits on Glass Fiber Filters (FF) and Glass Fallout Jars (FJ) During a Comparison of Aerial Applications with Nalco-Trol and without Nalco-Trol on 9-26-79.

Date	Media	Sample Size	Mean	Standard Deviation	F_{calc}[1]	$F_{crit}(.05)$	t_{calc}[2]	$t_{crit}(.05)$
9-26-79 (1100 to 1145)	FF	2	0.158E-01[3]	0.410E-02	4.61 *ns*[4]	F_1^1 = 647.80	-7.30*[5]	t_2= 4.30
	FJ	2	0.392E-01	0.191E-02				
9-26-79 (1145 to 1230)	FF	2	0.127E-01	0.707E-04	169.00 *ns*	F_1^1 = 647.80	-15.49**[5]	t_2= 4.30
	FJ	2	0.228E-01	0.919E-03				

1/ Test for unequal variance.

2/ Test for mean separation.

3/ Data is presented in mg/cm^2 using a negative exponent (E-01 = 10^{-1}).

4/ *ns*=not significant.

5/ * denotes significance at .05, ** denotes significance at .01.

Table 12. Calculated Means and Analysis of Variance of High Volume Sampler DEF During Application on September 26, 1979. The Following Symbols are Used: R=Replicate; T=Time; M=Media; D=Distance; GFF=Glass Fiber Filter; RES=Resin.

Combination	Count Per Mean	Subclass R	M	D	T	Means
R	16					
Vector A		1	0	0	0	0.661E-03[1]
Vector B		2	0	0	0	0.582E-03
M	16					
RES		0	1	0	0	0.102E-02
GFF		0	2	0	0	0.228E-03
D	8					
29 METERS		0	0	1	0	0.189E-02
260 METERS		0	0	2	0	0.396E-03
400 METERS		0	0	3	0	0.120E-03
805 METERS		0	0	4	0	0.818E-04
T	16					
W NALCO-TROL		0	0	0	1	0.560E-03
W/O NALCO-TROL		0	0	0	2	0.683E-03
MXD	4					
GXDO		0	1	1	0	0.321E-02
RXDO		0	2	1	0	0.565E-03
GXD1		0	1	2	0	0.496E-03
RXD1		0	2	2	0	0.297E-03
GXD2		0	1	3	0	0.207E-03
RXD2		0	2	3	0	0.341E-04
GXD3		0	1	4	0	0.150E-03
RXD3		0	2	4	0	0.139E-04
MXT	8					
GXT1		0	1	0	1	0.788E-03
RXT1		0	2	0	1	0.332E-03
GXT2		0	1	0	2	0.124E-02
RXT2		0	2	0	2	0.123E-03
DXT	4					
DOXT1		0	0	1	1	0.170E-02
D1XT1		0	0	2	1	0.338E-03
D2XT1		0	0	3	1	0.109E-03
D3XT1		0	0	4	1	0.870E-04
DOXT2		0	0	1	2	0.207E-02
D1XT2		0	0	2	2	0.455E-03
D2XT2		0	0	3	2	0.132E-03
D3XT2		0	0	4	2	0.766E-04

Analysis of Variance (Concentration During App.)

Source of Variation	DF	SS	MS	F	CV
R	1	0.495E-07	0.495E-07		
M	1	0.497E-05	0.497E-05	25.10 ***[2]	
D	3	0.176E-04	0.586E-05	29.58 ***	
T	1	0.123E-06	0.123E-06	0.62	
MXD	3	0.920E-05	0.307E-05	15.49 ***	
MXT	1	0.882E-06	0.882E-06	4.45	
DXT	3	0.173E-06	0.577E-07	0.29	
MXDXT	3	0.153E-05	0.510E-06	2.58	
ERROR	13	0.257E-05	0.198E-06		71.6%
TOTAL	29	0.371E-04			

1/ Data is presented in mg/m^3 using a negative exponent ($E-03=10^{-3}$).

2/ *** denotes significance at .001.

Table 13. Duncan's Multiple Range Test of High Volume Sampler Mean Differences for DEF During Application on September 26, 1979.

Significance at 5 Percent, Ranked Means

No.	Name	Mean	Homogeneous Sub-Groups	
1	29 Meters	0.189E-02[1]	Y[2]	
2	260 Meters	0.396E-03		Z
3	400 Meters	0.120E-03		Z
4	805 Meters	0.818E-04		Z
LSD	0.480E-03			

1/ Data is presented in mg/m^3 using a negative exponent ($E{-}02=10^{-2}$).

2/ Means which have letters under the same sub-groups are not significantly different.

Table 14. Meteorological Data Summary for DEF Monitoring on 9-28-79.

Parameter	During Application
1. Start (24-hr clock)	2345
2. End (24-hr clock)	0130
3. Duration (min)	105
4. Formulation (mgs/field)	8.16E07[1]
5. Average temperature (°C)[2]	18.00
6. Average relative humidity (%)[2]	62.25
7. Average wind speed (m/h)[3]	5.25
8. Maximum wind speed (m/h)[3]	8.00
9. Minimum wind speed (m/h)[3]	4.00
10. Average wind direction (degrees)[3]	262.50
11. Average solar radiation ($Cal/cm^2/min$)[2]	0.00

1/ Presented using a positive exponent ($E07=10^7$).

2/ Recorded in 30-minute intervals.

3/ Recorded in 15-minute intervals.

Table 15. Comparison of DEF Deposits on Glass Fiber Filters (FF) and Glass Fallout Jars (FJ) within the Applied Cotton Field on 9-28-79.

Date	Media	Sample Size	Mean	Standard Deviation	F_{calc} [1]	F_{crit}(.05)	t_{calc} [2]	t_{crit}(.05)
9-28-79	FF	6	0.132E-01[3]	0.399E-02	2.09 *ns*[4]	$F^5_5 = 7.15$	-1.64* *ns*	$t_{10} = 2.23$
	FJ	6	0.179E-01	0.577E-02				

1/ Test for unequal variance.

2/ Test for mean separation.

3/ Data is presented in mg/cm² using a negative exponent (E-02 = 10^{-2}).

4/ *ns* = Not significant

Table 16. Calculated Means and Analysis of Variance of High Volume Sampler DEF During Application on September 28, 1979. The Following Symbols are Used: R=Replicate; M=Media; D=Distance; GFF=Glass Fiber Filter; RES=Resin.

Combination	Count Per Mean	Subclass R	Subclass M	Subclass D	Means
R	6				
Vector A		1	0	0	0.164E-02[1]
Vector B		2	0	0	0.305E-02
M	6				
GFF		0	1	0	0.422E-02
RES		0	2	0	0.465E-03
D	4				
14 METERS		0	0	1	0.467E-02
145 METERS		0	0	2	0.124E-02
300 METERS		0	0	3	0.112E-02
MXD	2				
GX1		0	1	1	0.822E-02
RX1		0	2	1	0.112E-02
GX2		0	1	2	0.228E-02
RX2		0	2	2	0.196E-03
GX3		0	1	3	0.215E-02
RX3		0	2	3	0.840E-04

Analysis of Variance (Concentration During App.)

Source of Variation	DF	SS	MS	F	CV
R	1	0.592E-05	0.592E-05		
M	1	0.423E-04	0.423E-04	21.71 **[2]	
D	2	0.325E-04	0.162E-04	8.34 *	
MXD	2	0.169E-04	0.843E-05	4.32	
ERROR	5	0.975E-05	0.195E-05		59.6%
TOTAL	11	0.107E-03			

1/ Data is presented in mg/m^3 using a negative exponent (E-02=10^2).

2/ * denotes significance at .05. ** denotes significance at .01.

Table 17. Duncan's Multiple Range Test of High Volume Sampler Mean Differences for DEF during Application on September 28, 1979.

Significance at 5 Percent, Ranked Means

No.	Name	Mean	Homogeneous Sub-Groups
1	14 Meters	0.467E-02 [1]	Y [2]
2	145 Meters	0.124E-02	Z
3	300 Meters	0.112E-02	Z
LSD	0.254E-02		

1/ Data is presented in mg/m^3 using a negative exponent ($E-02=10^{-2}$).

2/ Means which have letters under the same sub-groups are not significantly different.

Table 18. Meteorological Data Summary for DEF Monitoring on 10-1-79.

Parameter	During Application	Following Application
1. Start (24-hr clock)	1100	1500
2. End (24-hr clock)	1410	1700
3. Duration (min)	190	120
4. Formulation (mgs/field)	2.86E08[1]	2.86E08
5. Average temperature (°C)[2]	31.00	32.80
6. Average relative humidity (%)[2]	27.29	21.20
7. Average wind speed (m/h)[3]	9.08	9.56
8. Maximum wind speed (m/h)[3]	12.00	13.00
9. Minimum wind speed (m/h)[3]	6.00	6.00
10. Average wind direction (degrees)[3]	294.62	345.56
11. Average solar radiation ($Cal/cm^2/min$)[2]	774.17	497.40

1/ Presented using a positive exponent ($E08=10^8$).

2/ Recorded in 30-minute intervals.

3/ Recorded in 15-minute intervals.

Table 19. Comparison of DEF Deposits on Glass Fiber Filters (FF) and Glass Fallout Jars (FJ) w
Cotton Field on 10-1-79.

Date	Media	Sample Size	Mean	Standard Deviation	F_{calc}[1]	$F_{crit}(.05)$
10-1-79	FF	6	0.917E-02	0.526E-02	4.08 *ns*[4]	$F^{5}_{5} = 7.15$
	FJ	6	0.641E-02	0.260E-02		

1/ Test for unequal variance.

2/ Test for mean separation.

3/ Data is presented in mg/cm^2 using a negative exponent ($E\text{-}02=10^{-2}$)

4/ *ns* = not signficant.

Table 20. Calculated Means and Analysis of Variance of DEF During Application on October 1, 1979. The Following Symbols are used: R=Replicate; M=Media; D=Distance; GFF=Glass Fiber Filter; RES=Resin.

Combination	Count Per Mean	Subclass R	Subclass M	Subclass D	Means
R	8				
Vector A		1	0	0	0.214E-02[1]
Vector B		2	0	0	0.218E-02
M	8				
GFF		0	1	0	0.130E-02
RES		0	2	0	0.303E-02
D	4				
0 METERS		0	0	1	0.463E-02
45 METERS		0	0	2	0.318E-02
210 METERS		0	0	3	0.404E-03
350 METERS		0	0	4	0.433E-03
MXD	2				
GX0		0	1	1	0.223E-02
RX0		0	2	1	0.704E-02
GX1		0	1	2	0.163E-02
RX1		0	2	2	0.473E-02
GX2		0	1	3	0.803E-03
RX2		0	2	3	0.503E-05
GX3		0	1	4	0.543E-03
RX3		0	2	4	0.323E-03

Analysis of Variance (Concentration During App.)

Source of Variation	DF	SS	MS	F	CV
R	1	0.650E-08	0.650E-08		
M	1	0.119E-04	0.119E-04	5.06	
D	3	0.530E-04	0.177E-04	7.51 *[2]	
MXD	3	0.216E-04	0.719E-05	3.06	
ERROR	6	0.141E-04	0.235E-05		70.8%
TOTAL	14	0.100E-03			

1/ Data is presented in mg/m³ with a negative exponent (E-02=10^{-2})

2/ * denotes significance at .05

Table 21. Duncan's Multiple Range Test of Mean Differences for DEF during Application on October 1, 1979.

Significance at 5 Percent, Ranked Means

No.	Name	Mean	Homogeneous Sub-Groups	
1	0 Meters	0.463E-02[1]	Y[2]	
2	45 Meters	0.318E-02	Y	
3	210 Meters	0.433E-03		Z
4	350 Meters	0.404E-03		Z
LSD	0.265E-02			

1/ Data is presented in mg/m^3 using a negative exponent ($E\text{-}02=10^{-2}$).

2/ Means which have letters under the same sub-group are not significantly different.

Table 22. Calculated Means and Analysis of Variance of DEF Following Application on O
The Following Symbols are Used: R=Replicate; M=Media; D=Distance; GFF=Glas
RES=Resin.

Combination	Count Per Mean	Subclass R	Subclass M	Subclass D
R	8			
Vector A		1	0	0
Vector B		2	0	0
M	8			
GFF		0	1	0
RES		0	2	0
D	4			
0 METERS		0	0	1
45 METERS		0	0	2
210 METERS		0	0	3
350 METERS		0	0	4
MXD	2			
GXO		0	1	1
RXO		0	2	1
GX1		0	1	2
RX1		0	2	2
GX2		0	1	3
RX2		0	2	3
GX3		0	1	4
RX3		0	2	4

Analysis of Variance (Concentration Following App.)

Source of Variation	DF	SS	MS	F
R	1	0.744E-06	0.744E-06	
M	1	0.365E-07	0.365E-07	0.02
D	3	0.300E-04	0.100E-04	5.98 *2
MXD	3	0.140E-04	0.465E-05	2.78
ERROR	6	0.100E-04	0.167E-05	
TOTAL	14	0.548E-04		

1/ Data is presented in mg/m³ using a negative exponent (E-02=10^{-2}).

2/ * denotes significance at .05.

Table 23. Duncan's Multiple Range Test of Mean Differences DEF Following Application on October 1, 1979.

Significance at 5 percent, Ranked Means			
No.	Name	Mean	Homogeneous Sub-Groups
1	0 Meters	0.402E-02[1]	Y[2]
2	45 Meters	0.175E-02	Z
3	210 Meters	0.691E-03	Z
4	350 Meters	0.635E-03	Z
LSD	0.224E-02		

1/ Data is presented in mg/m^3 using a negative exponent ($E\text{-}02 = 10^{-2}$).

2/ Means which have letters under the same sub-group are not significantly different.