Ambient Air Monitoring And Health Risk Assessment for Suspect Human Carcinogens Around the BKK Landfill in West Covina

By

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CONTENTS

SUMMARY AND CONCLUSIONS

1. The ambient air concentrations of nine volatile compounds were monitored at five residential locations surrounding the BKK Corporations's hazardous waste landfill in the City of West Covina for a three month period (July 19 - October 15, 1982). These concentrations were compared to a control monitor located nine miles from the landfill site in a residential/commercial area of Pico Rivera. Those monitored substances include: chloroethene (vinyl chloride), tetrachloroethene (Perc), trichloroethene (TCE), 1,1-dichloroethene (vinylidene chloride), 1,2-dichloroethane (ethylene dichloride), benzene, chlorobenzene, trichloromethane (chloroform), and trans-1,2-dichloroethene. The California Department of Health Services considers all of these substances potential human carcinogens.

2. There continues to be periodic exceedences of the State Ambient Air Standard for vinyl chloride of 0.01 ppm (10 ppb). The concentrations of vinyl chloride as well as the frequency of exceedences are significantly lower than during the same period in 1981. This may be the result of the mitigation measures taken at the landfill since June 1981.

3. Relative to the Pico Rivera control station, air monitoring in the residential community around the BKK landfill shows elevated levels of chloroethene (vinyl chloride), as well as tetrachloroethene (Perc), trichloroethene (TCE), 1,1-dichloroethene (vinylidene chloride), 1,2-dichloroethane (ethylene dichloride), and benzene. Many of these compounds are found at detectable levels in other areas of the Los Angeles air basin. There is some data available which suggests that Perc, TCE and benzene occur at comparable levels in some areas of the L.A. air basin.

4. Since the stations around the site are not known to be near other sources of emissions of these compounds (dry cleaning establishments, plastics products manufacturers, metal finishing industries, etc.), the data suggest that the BKK site is a source of these compounds. The elevated levels of the chlorinated compounds in particular indicate a need for mitigation measures such as expansion of the landfill gas gathering system, upgraded maintenance programs, and changes in handling of wastes containing these compounds.

5. Further action is also mandated by the continued, periodic exceedences of the State's Ambient Air Quality Standard for vinyl chloride of 0.01 ppm (10 ppb).

6. All of the substances, even at the highest observed concentrations, are

believed to be present in concentrations well below their threshold for toxic, non-carcinogenic action.

7 At the low level of exposure experienced by residents adjacent to the BKK landfill, it is not possible to accurately calculate excess cancer risks. However, worst-case estimates of the individual excess cancer risks (maximizing both the exposure period and the concentrations) suggests that those residents living immediately adjacent to the landfill, and who are also subject to both down wind and air drainage emissions from the site, may have accumulated excess risks to date of 5/100,000. This risk exceeds the level at which the Department attempts to control excess risks (1/1,000,000). Assumptions built into these calculations lead the Department to believe that these numbers represent a maximum risk and that the acutual risk is lower.

8. Based on an estimate of exposed population within a one mile radius of the landfill site boundary, no additional cases of cancer are to be expected from exposure to date.

9. The individual cancer risks are at a relatively low level, and do not constitute a public health emergency.

10. Monitoring should be continued to determine the effectiveness of the remedial actions taken, and to further define: 1) The specific on-site sources of emissions, 2) The diurnal variation of concentrations and, 3) The dilution of these concentrations with distance from the landfill.

INTRODUCTION

BACKGROUND

In October, 1980, odor complaints from residents in the neighborhood surrounding the BKK landfill in West Covina prompted the South Coast Air Quality Management District (SCAQMD) to monitor for odorous organic compounds in the vicinity of the site. In May, 1981, vinyl chloride was detected in the samples from this monitoring. A subsequent air survey confirmed the existence of vinyl chloride at concentrations exceeding the California Air Resources Board (ARB) Ambient Air Quality Standard of 0.01 ppm (24-hour average). The SCAQMD announced its findings in June, 1981.

Because of these exceedences, the California Department of Health Services (DHS) immediately banned further disposal of wastes containing vinyl chloride at the BKK Landfill. An evaluation of the vinyl chloride data by the DHS indicated that although the levels posed no immediate health hazard to the surrounding population, they were of sufficient concern to warrant prompt efforts to reduce these emissions from the landfill.

Also in May, 1981, an interagency task force consisting of the SCAQMD, DHS, City of West Covina, Los Angeles County Health Department, State Solid Waste Management Board, and the California Regional Water Quality Control Board (Los Angeles Region) was formed to develop a program to reduce the odor emissions from the site. This task force implemented a series of actions to expand the landfill's gas recovery system, and to improve the efficiency of the waste gas incineration system. As a result of these efforts, the frequency of exceedences of the vinyl chloride standard, and of odor complaints, decreased significantly through the first half of 1982. These data were presented at a public meeting in the City of West Covina on July 1, 1982.

Continued citizen concerns regarding their exposure to volatile carcinogens from the site and the need to determine the overall effectiveness of the emission mitigation measures prompted a sub-group of the task force consisting of DHS, ARB, and SCAQMD to embark on an expanded monitoring program.

PURPOSE

This study has three purposes: 1) To evaluate the effectiveness of the mitigation measures already taken, and to determine whether or not further measures are necessary to control emissions from the site, 2) To determine if other volatile carcinogens besides vinyl chloride, known to have been disposed at the site in the past, are also present in the community at levels that would represent a public health concern, and 3) To provide a more comprehensive data base for assessment of the health risk posed by emissions of carcinogens from the BKK landfill in West Covina.

COMPOUNDS SELECTED FOR MONITORING

Previous sampling of the landfill gas by SCAQMD, ARB, Euteck, Inc., and the University of Southern California indicated the presence at significant concentrations of suspected or known human carcinogens other than vinyl chloride. As with vinyl chloride, the presence of these compounds can be associated with the prior disposal of hazardous wastes at the site. Nine volatile compounds identified by these organizations were selected for monitoring based on their concentrations, carcinogenic potential, and the analytical capabilities of laboratories involved. These compounds are listed in Table I, along with information on their uses, waste sources, and concentration in the landfill gas. DHS considers all nine compounds to be known or suspect human carcinogens.

METHODOLOGY

SAMPLING STRATEGY

A meteorological survey previously conducted at the BKK landfill and adjacent residential areas indicated that the daytime predominant wind direction was from the southwest to the northeast. However, eddies were observed throughout the landfill, which is located in rough terrain on the south slopes of the San Jose Hills. Radiational cooling results in nighttime air drainage on the north and south slopes of the landfill, with wind flow from the south on the north slopes and from the north on the south slopes.

The data from the meteorological survey were correlated with odor complaints from the residential areas to determine the location of sampling sites which would reflect the maximum exposure of residents to toxic and hazardous gases emitted from the landfill. Six sites were selected and identified alphabetically from A to F (See Figure I). Two (E & F) reflected the daytime transport of contaminants, three (A, B and D) the nighttime transport, and one (C) was a control site nine miles away from the landfll in Pico Rivera.

Sites A and B were located in residential areas on the south side of the landfill and F in a residential area on the northeast side. Stations A and B were established by SCAQMD in May, 1981 as part of its vinyl chloride monitoring program. On August 26, 1982, site F was relocated to a residential area Northwest of the landfill because of odor complaints from this area. Sampling at this site was continued until the end of the program.

Site D was located at the entrance to the landfill on Azusa Avenue to sample emissions diverted by the recently constructed berms on the southerly boundary of the site. These berms were designed to contain emissions while creating mechanical mixing and dilution of the toxic compounds.

Site E was located at the highest elevation within the landfill itself, about 300 yards from the flares.

The control site C was located at the SCAQMD Pico Rivera air monitoring station. This site was selected to reflect contaminant concentrations in an area not influenced by the BKK Landfill. It was also selected because it is the closest monitoring station to the site where more routine data has been collected over a period of years. The data from this site was not intended to reflect ambient air concentrations of these toxic compounds in the Los Angles air basin.

A study period of three months (July 19 - October 15, 1982) was selected to provide an adequate data base. This period covered the warmest part of the year for the West Covina area.

Samples were collected five days per week, Sunday through Thursday. This frequency allowed sampling on one day with no activity on-site (Sunday), and on four days of normal landfill operations. On this schedule, samples were analyzed, during periods of normal laboratory operations with a minimum of storage prior to laboratory analysis.

Samples were collected in Tedlar bags continuously over a 24-hour period. This period was chosen over a shorter 12-hour or 4 hour period because it was necessary to determine the total daily dose of these compounds that one would receive. It is also the time basis for the ARB's ambient air quality standard for vinyl choride: 0.01 ppm. Tedlar bags were selected over other sampling methods such as absorbant tubes because of the greater confidence that the bag samples would provide an accurate picture of these compounds in the air. This sampling period and method allowed comparison of the data from this program with data collected by the SCAQMD from May, 1981 to June, 1982. It is also accepted methodology by the U.S. Environmental Protection Agency, ARB, and SCAQMD for determining compliance with the vinyl chloride standard.

An average of two samples per day were split between the two laboratories, SCAQMD and CARB (Haagen-Smit) Laboratory. Each laboratory withdrew a subsample directly from the septum opening of the Tedlar bag.

The effectiveness of Tedlar bags for sampling chlorobenzene was unknown at the initiation of the study period. Charcoal tubes were consequently selected as the medium for collecting these samples. Availability of equipment and laboratory capacity limited sampling to two per day; one at the control station C and one at Station A or B. Chlorobenzene sampling was initiated about midway through the study period, and analysis was performed by the DHS Air and Industrial Hygiene Laboratory in Berkeley.

ANALYTICAL METHODS

Chloroethene (vinyl chloride) and benzene were analyzed using a gas chromatograph (GC) equipped with a flame ionization detector (FID).

Other chlorinated compounds, 1,1-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloroethane, trichloromethane (chloroform), trichloroethene (TCE) and tetrachloroethene (Perc) were analyzed usng a GC equipped with an electron capture detector (ECD). All compounds were quantified wth an electronic integrator.

RESULTS AND DISCUSSION

METEOROLOGY

Comparison of meteorological conditions during the three-month sampling period with the same period in previous years was necessary in order to determine whether the sampling results were influenced unduly by some abnormal weather condition. Since ambient temperature differentials are responsible for diffusion and wind flow, and temperatures have been recorded by the National Weather Service in the San Gabriel Valley for the past twenty years, this was selected as one of the meteorological variables to examine. Winds at the BKK site also determine the local transport of the contaminants. Therefore, the winds at Site A (because of its exposure to the landfill) were compared for this three-month sampling period to those recorded in 1981.

The temperature study indicated that there was no significant difference between the average temperatures recorded during this three-month period and the 20-year average for the same three-month period.

Frequency distributions for wind direction and speed were computed for the same three months in 1981 and 1982. Those directions which would impact Site A from the landfill were summarized. No significant difference was exhibited between the frequencies for 1981 and 1982.

AMBIENT AIR RESULTS

Table II summarizes all of the data collected during the study period. Chlorobenzene and trans-1,2-dichloroethene were not detected at any of the sampling stations during the study period, and are therefore not listed. The detection limits for each compound are shown in Table III. Statistical analysis of the split sample results revealed that the data from the two laboratories are not well correlated. The differences between the two laboratories was not unexpected, since the concentrations measured in this survey were close to the limit of detection of the analytical methods. Therefore the mean concentration for each compound was calculated separately for each laboratory and station. The first number of each pair merely represents the lower of the two means from the laboratories, and the second number is the higher mean value. Values reported as less than the limit of detection were set equal to the detection limit for purposes of calculating the mean concentrations. This treatment of the data allowed a conservative or worst case estimate of exposure for these compounds. It is recognized that in reality, these values can range anywhere from zero to the limit of detection.

The ratio of the mean ambient air concentrations at stations A-F (those station adjacent to the landfill) to the concentrations at the control station are shown in Table IV. These ratios were calculated separately for data from each laboratory.

Figures II through VIII show the ranges and means for each compound in a formatwhich allows the absolute concentration ranges to be plotted for each compoundstation, and laboratory during the study period.

DISCUSSION

It is apparent from Table IV that the mean concentrations at Stations A, B, and and D are consistently higher than those at the control station for all compounds except chloroform. At Station E, only TCE and ethylene dichloride appear consistantly to exceed the control station value. Satation F concentrations exceed control station averages for Perc, TCE and vinylidene chloride. These trends are also illustrated by Figures II through VIII. It should be noted that such large ranges in concentration are not a reflection of the impercision of the sampling and analytical methods, but are indicative of the wide daily fluctuations of concentrations in the air near the monitoring stations. It should also be noted that the data from station F are actually an equally weighted composite from two locations, F_1 and F_2. These observations suggest that the BKK landfill may be a significant source of emissions of these compounds into the community.

The levels of all compounds detected were consistently higher at stations A, B, and D than at Stations E and F. Since stations A, B, and D are located in areas where nightime air drainage from the landfill is know to occur, it is likely that these elevated concentrations can be attributed to this phenomenon. The low levels at stations E and F, which are located in areas not subject to the same flow patterns, further emphasize the importance of nightime air drainage as the primary mode by which landfill emissions impact the community. This type of air movement does not allow as much dispersion as that which occurs in the daylight hours.

DISCUSSION OF HEALTH EFFECTS

Introduction

What are the expected health effects from exposure to these substances at the concentrations observed in the area directly adjacent to the BKK landfill? For those substances that can give non-carcinogenic acute and chronic toxic effects, such as liver, kidney or nerve damage, for low concentrations there is good evidence for a biological threshold, or a "no observed effect level". This means that concentrations below this threshold do not cause adverse health effects. All of the substances, even at the highest observed concentrations, are believed to be present in concentrations well below their threshold for toxic, non-carcinogenic action. This gives a safety margin of from 100-to-1000 fold in the concentrations before these substances even approach levels which could cause adverse health effects. It is for this reason that this report concentrates solely on the risk of cancer.

Carcinogenic Risk Assessment

The chance of getting cancer is calculated using risk assessment techniques. Risk assessment is a science that predicts the probability or likelihood of an event occurring. It attempts to estimate the chances of cancer occuring in a specified population, from a specified dose of a substance in a given time period. Several facets go into risk assessment: the carcinogenic potency of the substance, calculation of dosage from exposure data and the number of people exposed (population at risk) and their individual dosages.

In order to evaluate the health impact of those emissions due to the BKK site, use was made of the simple difference of the concentrations, i.e., the average concentration of each substance in the Pico Rivera Station was subtracted from the average concentration of that substance in the residential monitoring site. Thus, the derived risks are considered excess risks, or risks in addition to those typically incurred away from the influence of the BKK landfill site.

The stations selected for monitoring were those that in the past gave very high concentrations, suggesting that they are in the path of a drainage channel. In the absence of information on the length, width and depth of the drainage areas, the dilution with distance (both lateral and down-hill), the concentrations of the initial drainages and the fraction of material that is carried by drainage and wind dispersions, it is not possible to accurately estimate either exposures or the population at risk. However, it is possible to estimate the upper limit or bound to this risk using a number of conservative assumptions. Some of the major assumptions are shown in Table V.

The lifetime incremental, worst-case estimated risk for residents adjacent to the BKK site, is based on the maximum possible period of exposure (24 hours/day, 7 days/week and 52 weeks/year). The exposures were projected from the observed 3-month monitoring period (August-October) for a maximum possible

exposure period of seven years. Vinyl chloride is the only compound that air monitoring data is available for preceeding the current monitoring period. In order to adjust the data for both seasonal variations and to correct for the increased control measures that had been installed at the BKK site, the six other compounds were increased in proportion to their ratio to vinyl chloride for the prior monitoring periods.

These calculations suggest that the maximum possible excess risk, is approximately 5 per hundred thousand (5/100,000). This is the maximum increased lifetime risk of contracting cancer for those residents who have been subject to the emissions from the BKK landfill site for the past seven years. Thus, we can say with some certainty that the risk of getting cancer, attributable to exposure from emissions from the BKK landfll is no greater than this; while in fact, the true excess risk of cancer is probably lower.

Population Comparisons

The maximum individual excess risk can be better understood as applied to the exposed population. The accumulated individual excess risk multiplied by the population at risk (the number of people exposed to these concentrations) defines the maximum number of excess cancers expected during the lifetime of the exposed population. This results in an estimation of the additional cases of cancer expected during the lifetime of the exposed population due to the emissions from the BKK landfill site.

The total population, at distances of up to one mile from the BKK property line, were considered to be at risk (a total of approxmately 7700 people). This population was derived by dividing the assessor's plot maps into quadrants, corresponding to Monitoring Stations: A, B, D, and F. The population within each quadrant was estimated using the latest census data of 1980. The exposure of the population within each quadrant was assumed equal to that measured at the respective monitoring station. The total population within each quadrant was multiplied by the mean concentration difference for its respective monitoring station, and the derived excess number of cancers was summed.

These calculations suggest that there should be no additional cases of cancer attributable to exposure from emissions from the BKK landfill during the lifetime of the population from exposure to date.

The Department of Health Services has made a conscientious attempt to calculate the worst-case estimate of risk. In those cases where there are insufficient data, the most conservative assumptions were used. As further information becomes available, such as, drainage patterns and dispersion rates, this additional data will be incorporated into the risk calculations. Although a small possibility exists that further information might increase the risk estimate, to the best of our knowledge, this new information should lower our worst-case risk estimates and provide a more accurate and realistic indication of risk.

It is important that the provided risk estimates NOT be considered as static or "as engraved in stone." They are expected to change as further information become available. These revisions will be made to better refine the risk and not to obscure the true impact. Such refinements wil be communicated to the residents of West Covina as they become available.

Several critical points should be kept in mind:

1. Since the biological mechanism of cancer is not known, mathematical models can only provide a best scientific "guess" of the dose-response relations at dosages much less than those employed in the bioassays. However, it is believed that at very low dosages, the shape of the dose-response curve is concave upward. Thus, a linear model will provide the upper-limit for the risk for the experimental observations (see Figure 1X).

2. The use of the upper-confidence values for the experimental results, then provides an added margin of safety to insure that the upper-risk level is also based on the maximum possible number of cancers that statistically could occur from the experimental studies (see Figure X).

3. It is not possible to calculate the actual risks at these low concentrations. Thus, it is very important that people understand that the presented risk numbers only represent the worst possible risk. It is expected that the true risks are lower than these numbers

4. These worst-case estimates of risk suggest that there should be no additional cases of cancer due to exposure to the emissions from the BKK landfill. The Department of Health Services does NOT recommend any special medical precautions or treatment for those residents adjacent to the landfill site.

TABLE I. COMPOUNDS SELECTED FOR MONITORING

COMPOUND (SYNONYM)	USES AND PROBABLE WASTE SOURCES	CONCENTRATION RANGE IN LANDFILL GAS (ppm)
Chloroethene (Vinyl Chloride)	Manufacture of PVC and other co-polymers; organic synthesis; adhesives for plastics; refregerant; manufacture of vinyl chloride also a significant waste source.	83 - 12800[a]
1,1 - Dichloroethene (Vinylidene Chloride)	Copolymerized with vinyl chloride to manufacture types of saran; adhesives for synthetic fibers.	N.D. - 1200[b]
Trans-1,2-Dichloroethene (Acetylene Dichloride)	General solvent for organic materials, dye extraction, perfumes, lacquers, thermo-plastics, organic synthesis.	N.D. - 800[b]
Trichloroethene (TCE)	Metal degreasing, extraction solvent for oils, fats, waxes; solvent dyeing; dry cleaning; refrigerant and heat exchange fluid; organic synthesis; fumigant; cleaning and drying electronic parts.	N.D. - 1000[b]
Tetrachloroethene (Perc)	Dry cleaning solvent; vapor-degreasing solvent; drying agent for metals; heat exchange medium; manufacture of fluoro-carbons.	N.D. - 1500[b]

TABLE I (CONTINUED)

COMPOUND (SYNONYM)	USES AND PROBABLE WASTE SOURCES	CONCENTRATION RANGE IN LANDFILL GAS (ppm)
1,2-Dichloroethane (Ethylene Dichloride)	Manufacture of vinyl chloride; organic synthesis; anti-knock agent in gasoline; paint, varnish, and finish removers; metal degreasing; soaps and scouring compounds; wetting and penetrating agent; ore flotation.	N.D. - 5000[b]
Trichloromethane (Chloroform)	Manufacture of fluorocarbon refrigerants and propellants; dyes & drugs; general solvent; fumigant; insecticides.	5.1[c] 0.038 (Ambient air)[d]
Benzene	Manufacture of styrene, phenol, synthetic detergents, cyclohexane for nylon, aniline DDT, various other insecticides, funigants; solvent; paint remover; rubber cement; anti-knock agent in gasoline.	10 - 2000[b]
Chlorobenzene	Manufacture of chloronitrobenzene, DDT, aniline; intermediate and solvent for organic synthesis.	N.D. - 500[b]

Footnotes:

a. Analytical Research Laboratories, Inc. "Report for BKK/Stauffer Chemical." June 17, 1981.

b. Euteck, Inc. "BKK Landfill Odor Study Final Report." Prepared for City of West covina. February 27, 1981.

c. South Coast Air Quality Management District. "Report on Vinyl Chloride Emissions from a Class I Landfill Operation." Source Test Report C-81-96 A & B. June 10, 1981.

d. University of Southern California. "Investigation of Odorous and Volatile Compounds for BKK Class I Landfill Site in the City of West Covina." Prepared for BKK Corporation. July, 1981.

TABLE II

Summary of Ambient Air Data[a] (ppb)

	Station					
	A	B	C	D	E	F
Chloroethene (Vinyl Chloride	7.1-7.3	4.5-5.5	2-3	3.8-4.1	2.0-3	2-3
Tetrachloroethene (Perc)	2.1-3.7	1.8-2.9	1.4-2.4	2.3-3.0	1.5-2.1	1.5-3.4
Trichloroethene (TCE)	0.8-1.0	0.8-1.8	0.2-0.3	1.6-1.7	0.6-0.8	0.8-1.2
1,1-Dichloroethene (Vinylidene Chloride)	1.1-1.3	0.7-1.0	0.1-0.3	0.7-0.8	0.1-0.4	0.3-0.4
1,2-Dichloroethane (Ethylene Dichloride)	1.3-3.0	0.8-2.8	0.4-0.7	0.8-2.8	0.7-0.9	0.4-1.1
Trichloromethane (Chloroform)	0.3-0.5	0.3-0.6	0.2-0.6	0.6-1.0	0.2	0.2
Benzene[b]	4.8	4.6	3.6	4.6	3.0	3.0

a. Each pair of values represents the means of the two laboratory data sets calculated for the entire study period. On those days when a compound was not detected, its concentration was assumed to be equal to the limit of detection.

b. One set of data used. All of the second set were below the limit of detection.

TABLE III

Detection Limits for Compounds

Compound	Range of Detectability (ppb)
Chlorethene (Vinyl Chloride)	2-3
Tetrachloroethene (Perc)	0.1-0.2
Trichlorethene (TCE)	0.1-0.2
1,1-Dichloroethene (Vinylidene Chloride)	0.1-0.3
1,2-Dichloroethane (Ethylene Dichloride)	0.2-0.4
Trichloromethane (Chloroform)	0.02-0.1
Trans-1,2-Dichloroethene	1-3
Chlorobenzene	10[a]
Benzene	2-20

a. Sampling by charcoal tube and analysis by one laboratory.

TABLE IV

Ratio of Ambient Air Concentrations of Station A-F to Control Station Station C[a]

	Station					
	A	B	C	D	E	F
Chloroethene (Vinyl Chloride)	2.4-3.6	1.8-2.3	1.0	1.4-1.9	1.0	1.0
Tetrachloroethene (Perc)	1.5	1.2	1.0	1.2-1.6	0.9-1.1	1.4-2.1
Trichloroethene (TCE)	2.9-3.9	3.0-7.2	1.0	6.3-6.6	2.1-3.0	2.8-5.0
1,1-Dichloroethene (Vinylidene Chloride)	3.6-11	2.4-9.3	1.0	2.7-6.5	1.0-1.3	1.5-3.0
1,2-Dichloroethane (Ethylene Dichloride)	3.3-4.5	1.9-4.3	1.0	1.9-4.3	1.3-1.7	1.0-1.7
Trichloromethane (Chlorform)	0.4-2.7	1.0-1.4	1.0	1.7-3.1	0.4-1.1	0.4-1.0
Benzene[b]	1.4	1.3	1.0	1.3	0.8	0.8

a. Ratios are calculated for each laboratory separately and expressed as a range.

b. One laboratory data set available.

Table V

Conservative Assumptions used by the California Department of Health Services to Estimate Cancer Risks from BKK Emissions

Animal Bioassay Studies

1. Use the most sensitive site, sex and animal species.

2. Use the upper 95.7% confidence value for the experimental data.

3. Assume all tumors (benign and malignant) are indicators of carcinogenic risk.

4. Use linear extrapolation for determining the risks at low dosages.

Individual Risk Estimates

1. Use the measured concentration for each station as the human exposure, with no allowance for dilution with distance (down-wind or laterial).

2. Assume an exposure for a full 24 hours/day, 7 days/week, and 52 weeks/year (with no allowance for leaving residence or air conditioning in residence).

3. Assume 100% absorption for human exposure.

4. Selection of monitoring stations in drainage pathways.

Population at Risk

1. Assume maximum housing tract population at time of issuance of permit to occupy.

2. Assume exposure from measured value at each monitoring Station with no allowance for dilution with distance (down-wind or laterial).

3. No allowance for population being outside of expected drainage patterns.

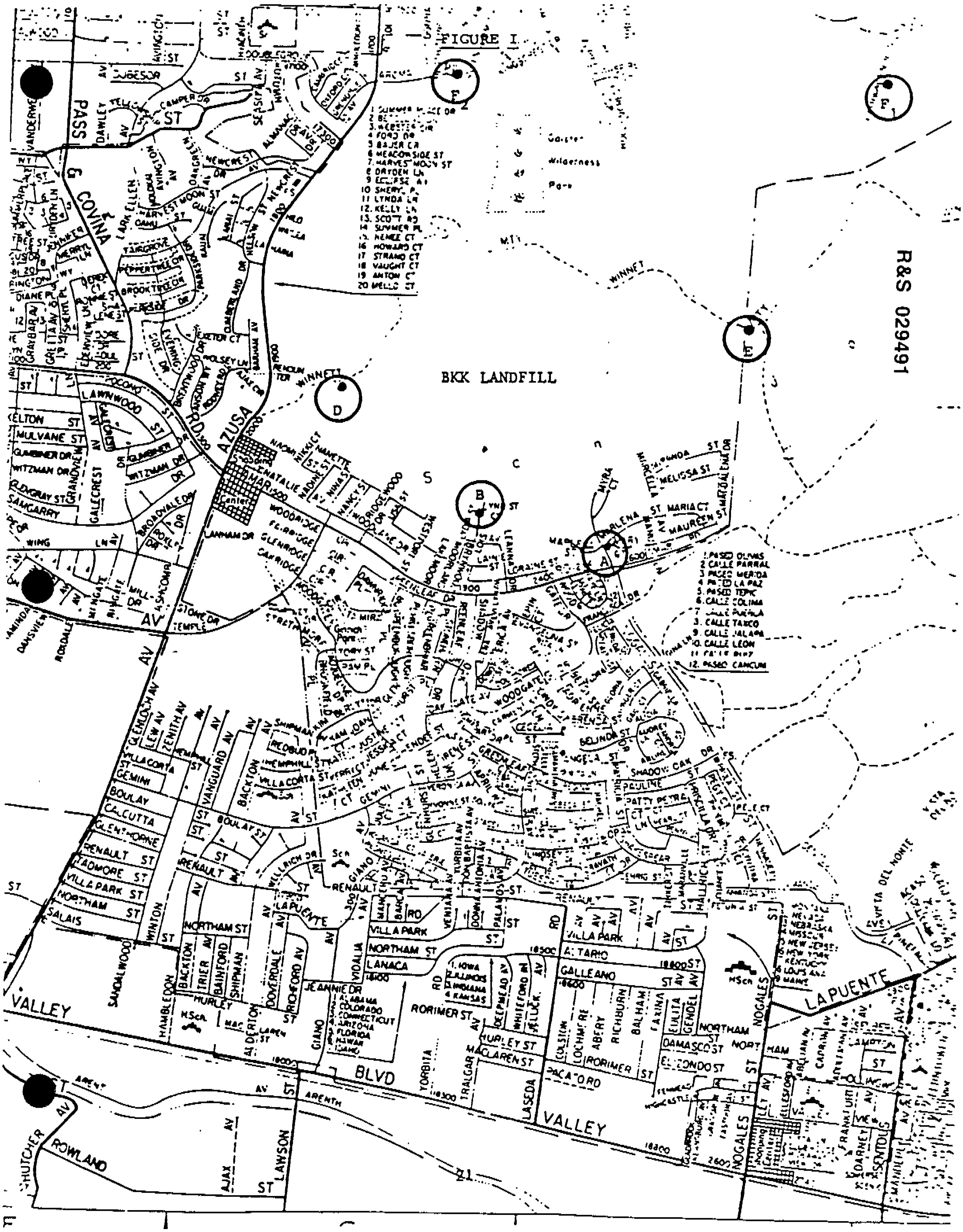
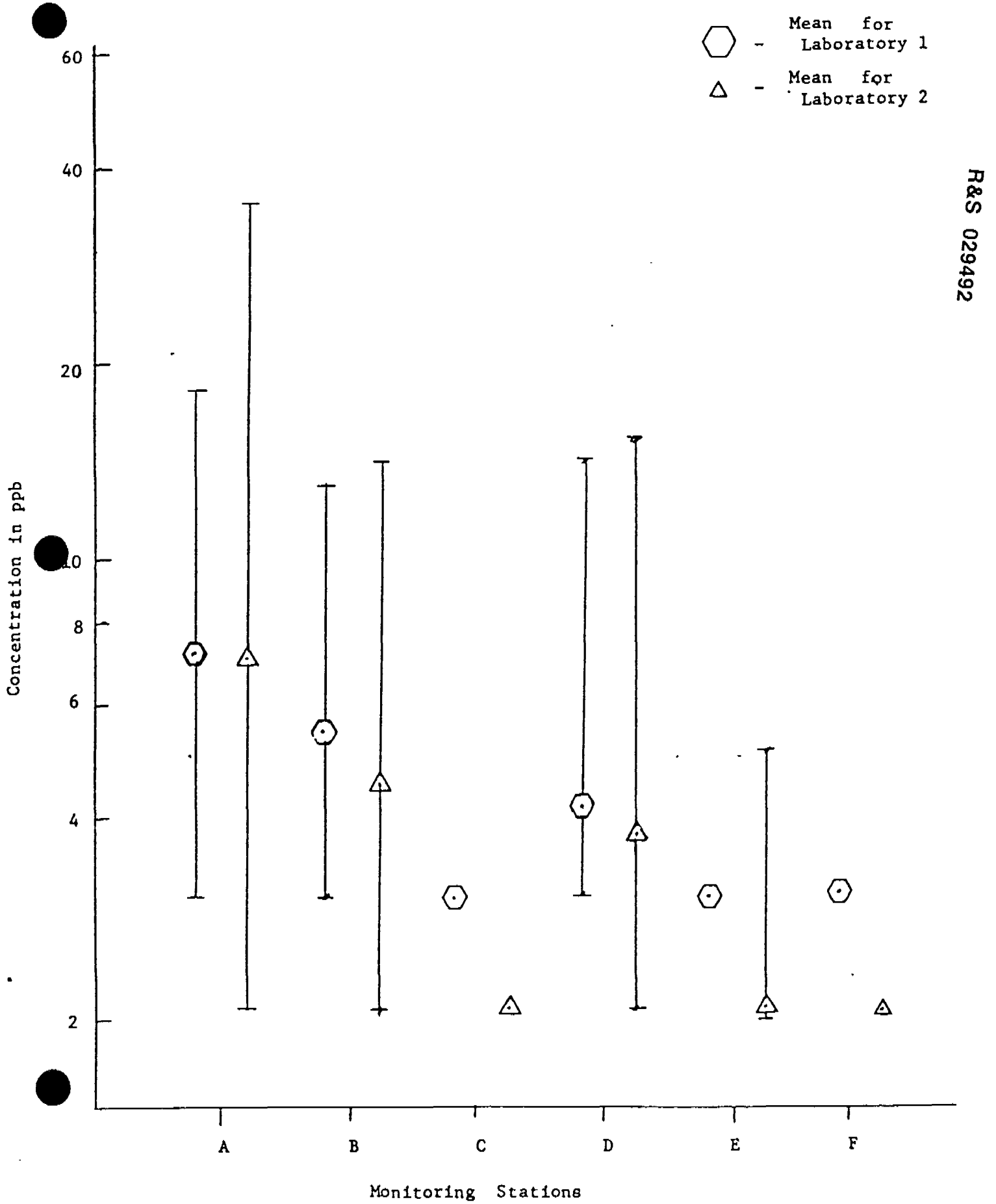


FIGURE I.

Figure II

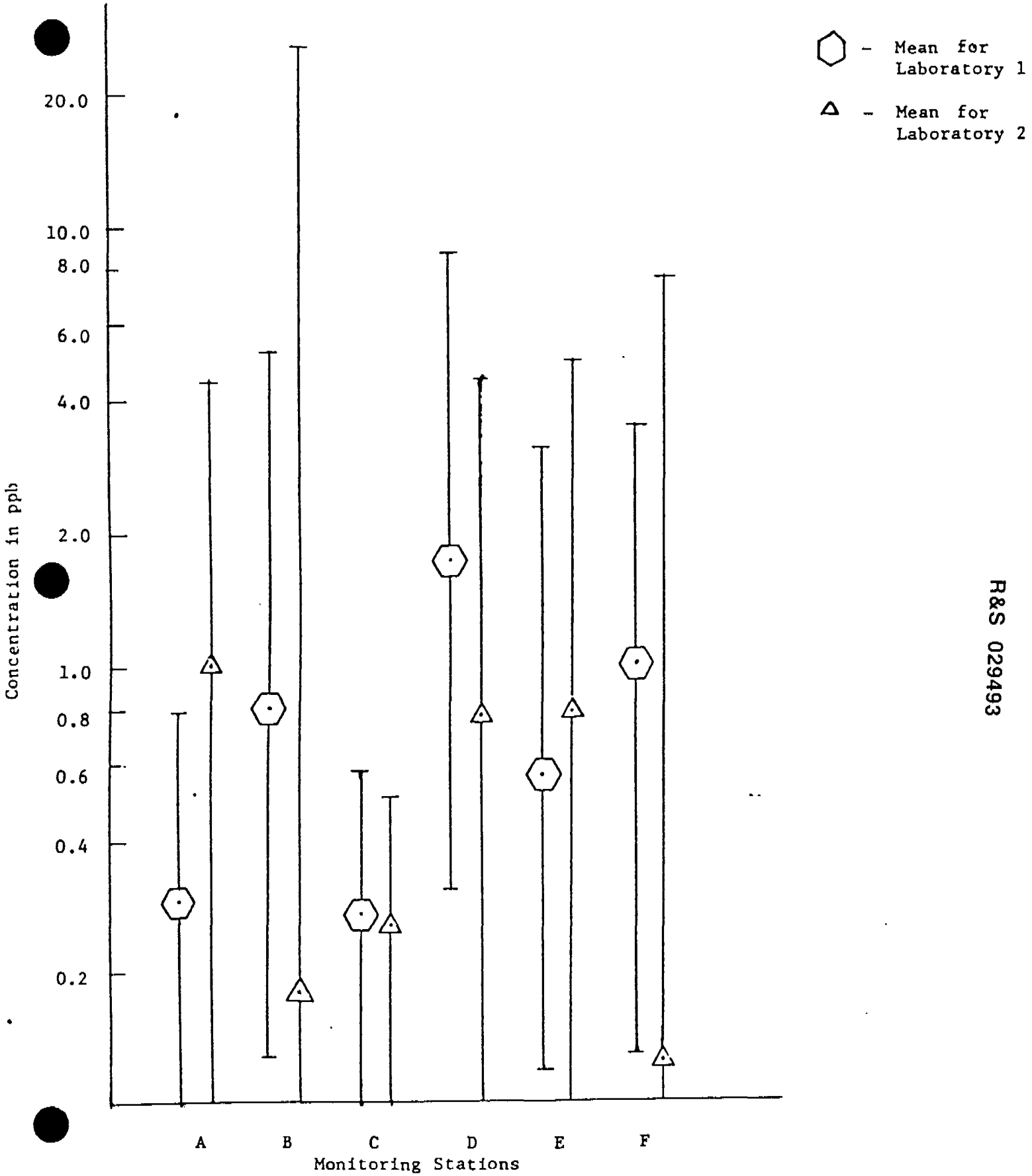
Range and Mean for Vinyl Choride Monitoring



R&S 029492

FIGURE III

Range and Mean for Trichloroethylene (TCE)



R&S 029493

FIGURE IV

Range and Mean for Perchloroethylene (Perc) Monitoring

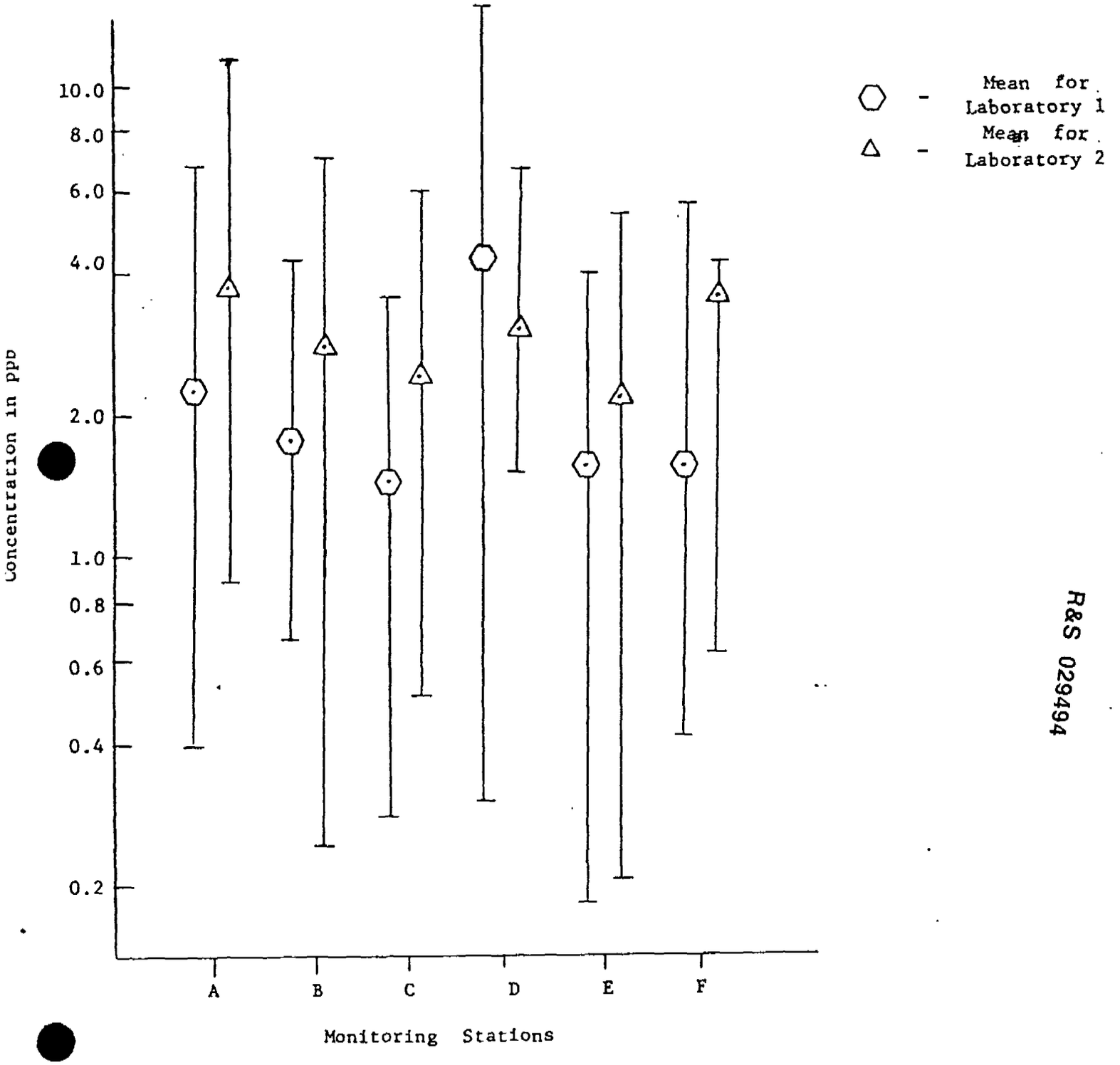


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FIGURE V

Range and Mean for 1,2-Dichloroethene (Vinylidene Chloride)

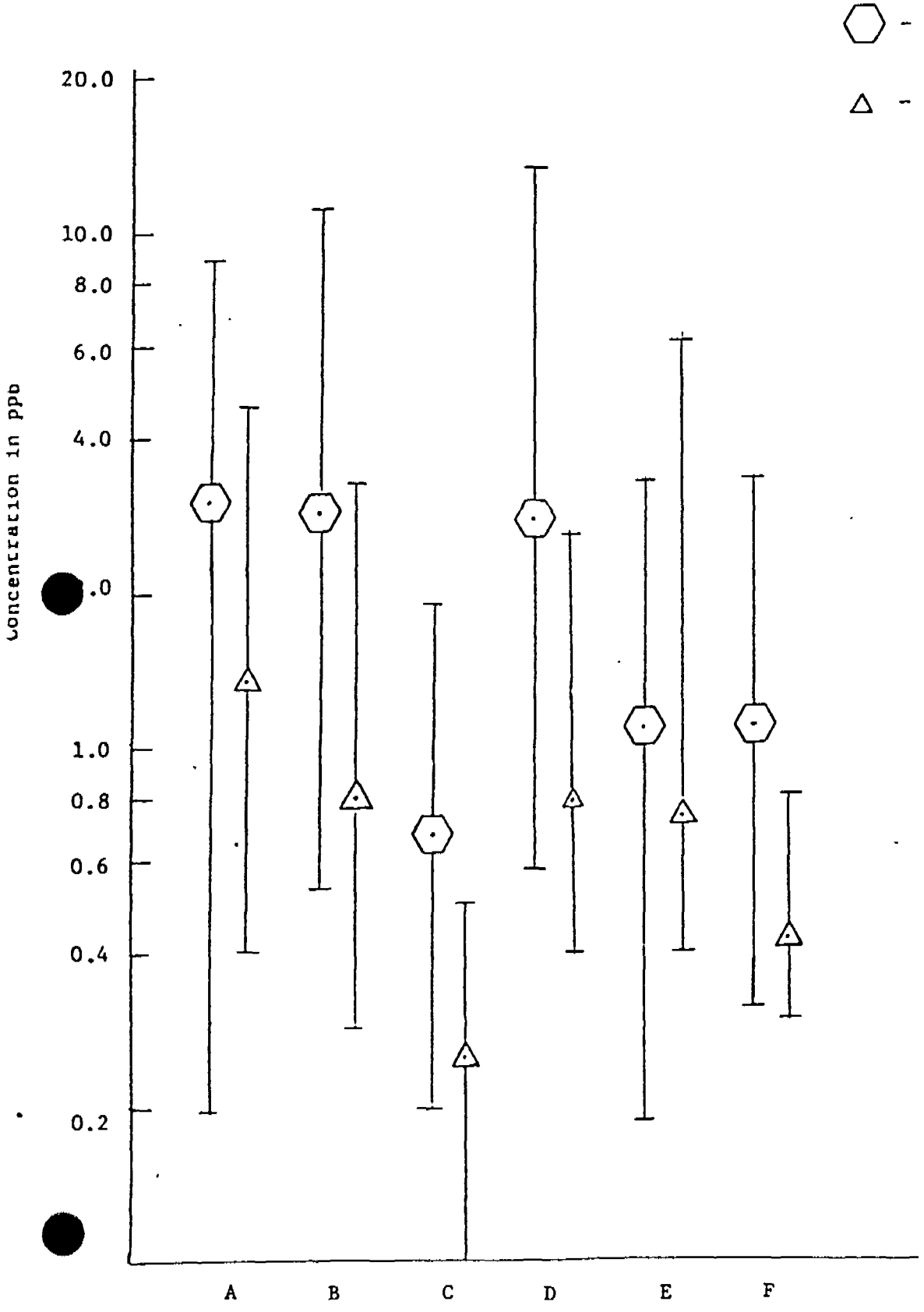
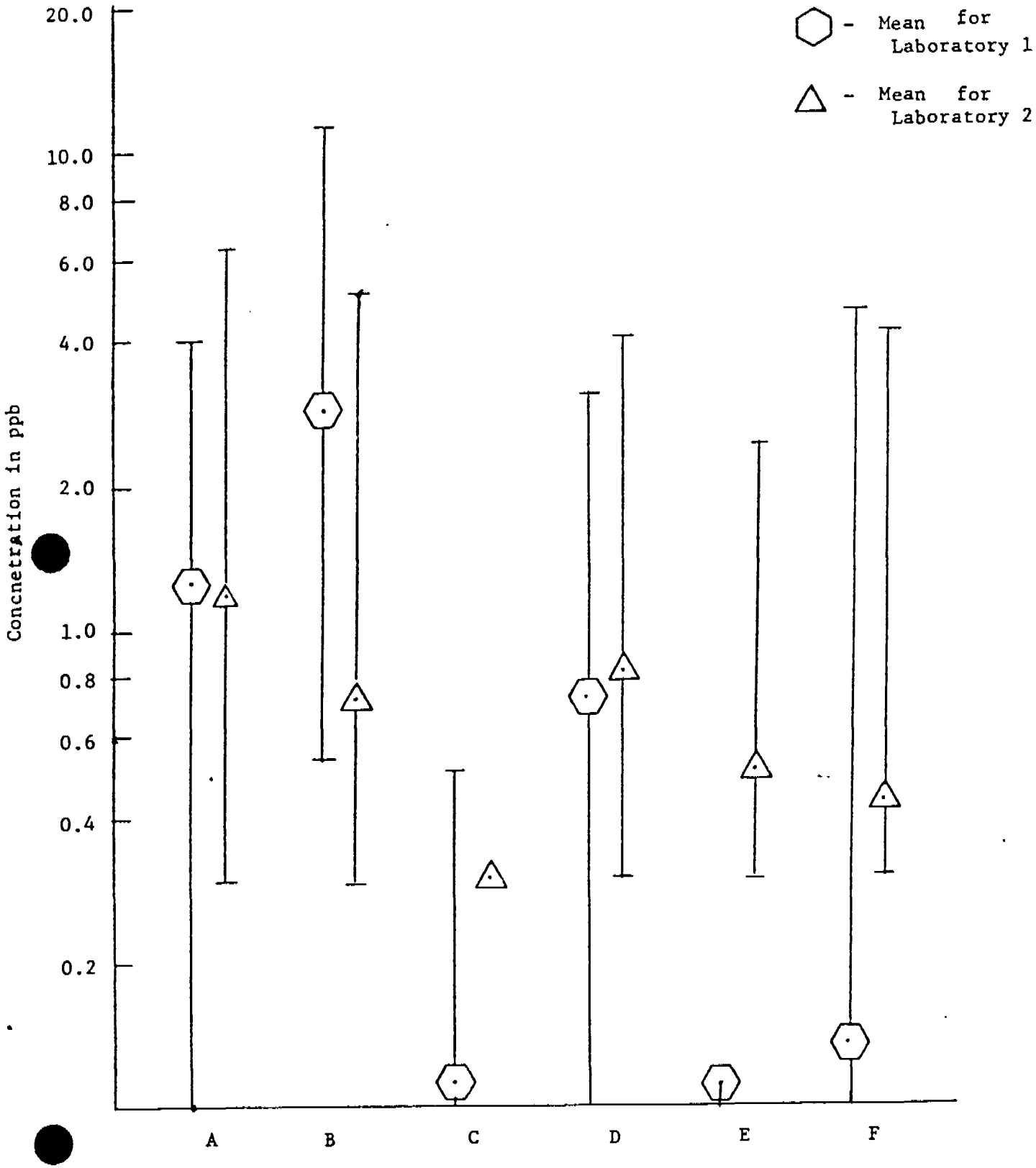


FIGURE VI

Range and Mean for 1,1-dichloroethane (Ethylene Chloride)



R&S 029496

FIGURE VII

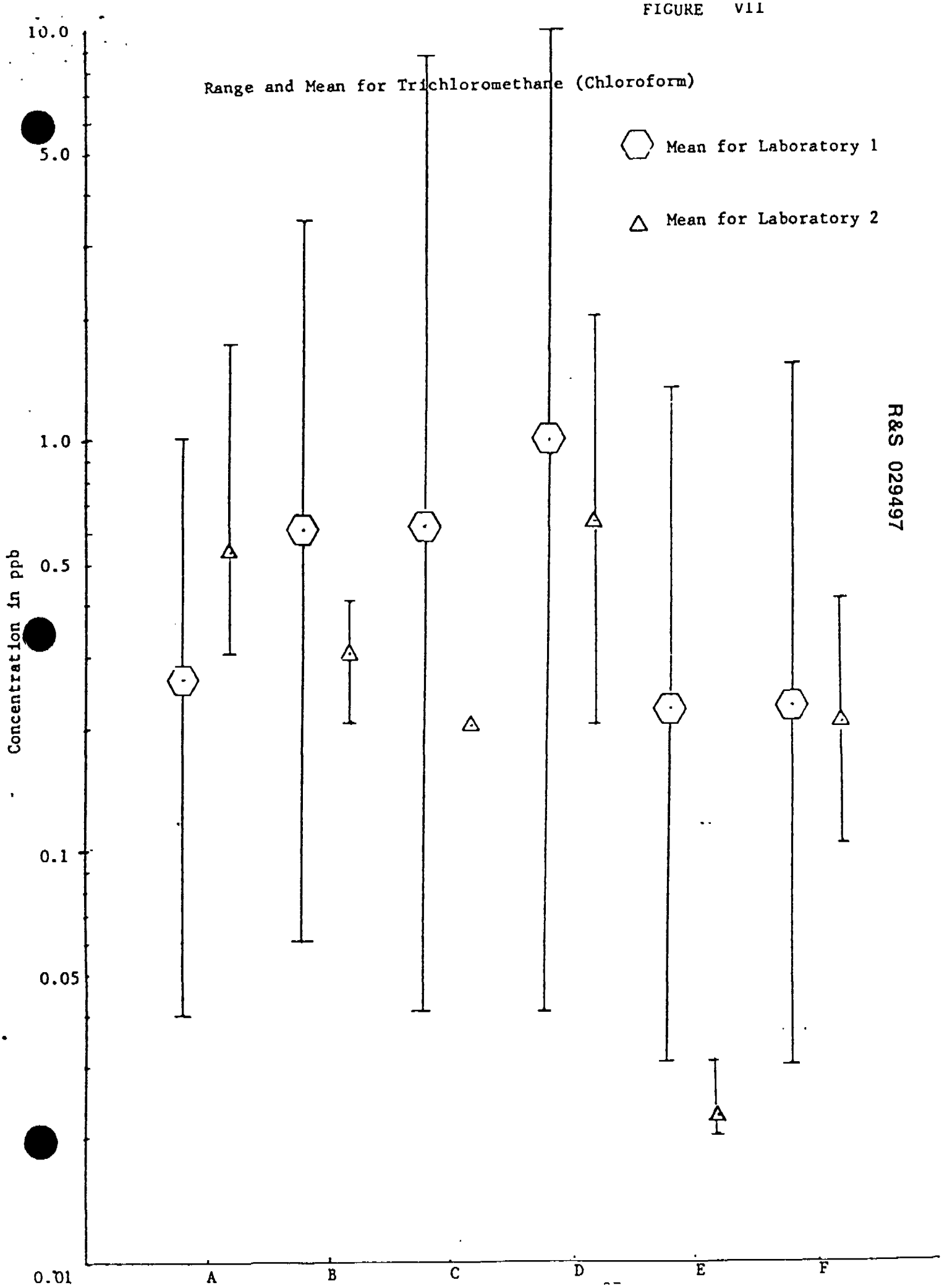
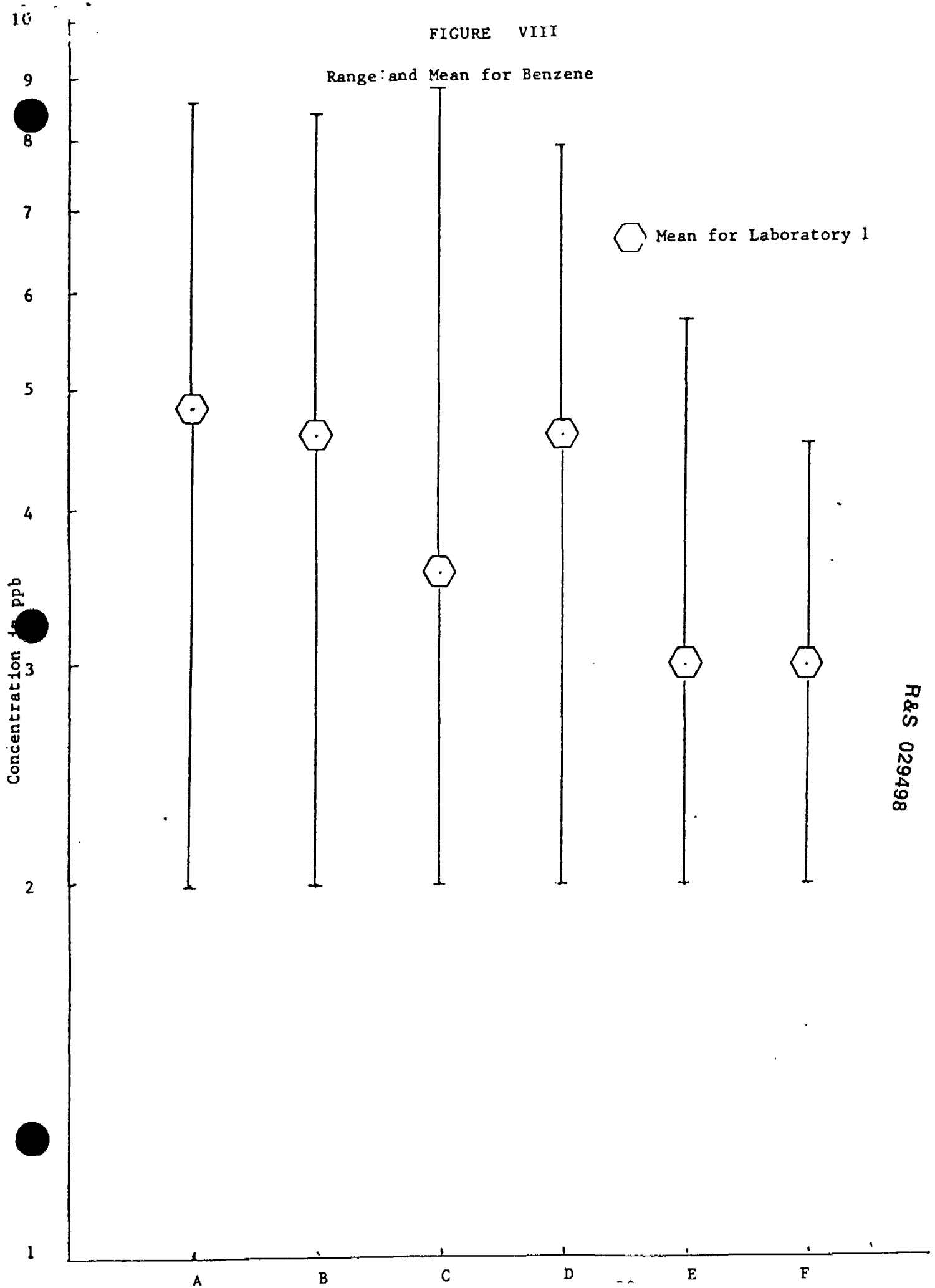

Range and Mean for Trichloromethane (Chloroform)
Mean for Laboratory 1
Mean for Laboratory 2
Concentration in ppb
10.0
5.0
1.0
0.5
0.1
0.05
0.01
A
B
C
D
E
F
R&S 029497

FIGURE VIII

Range and Mean for Benzene



R&S 029498

FIGURE IX

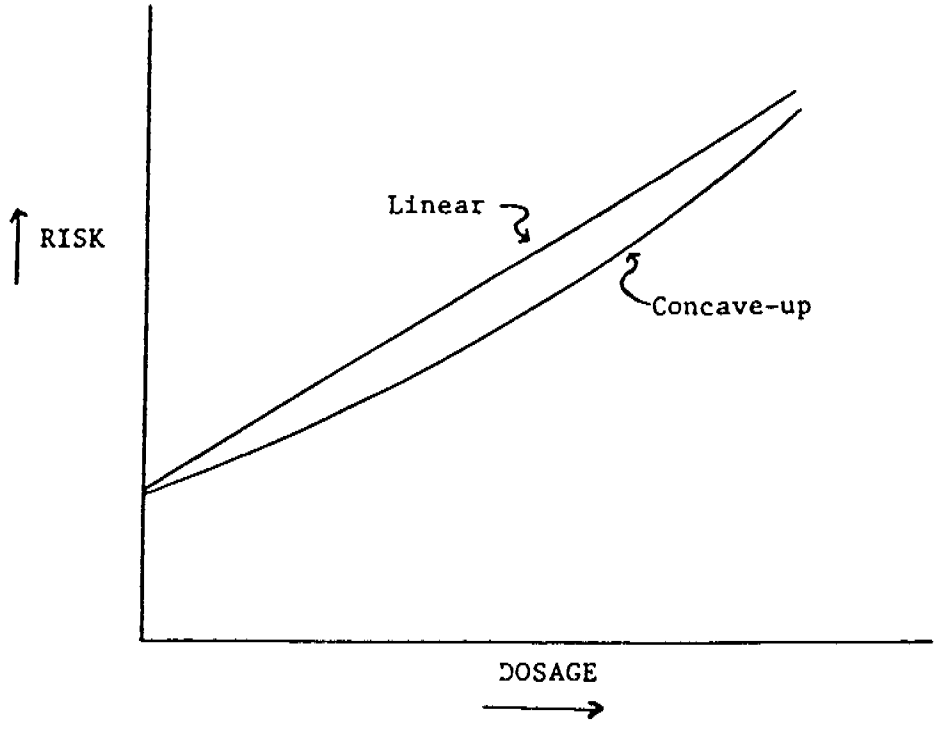
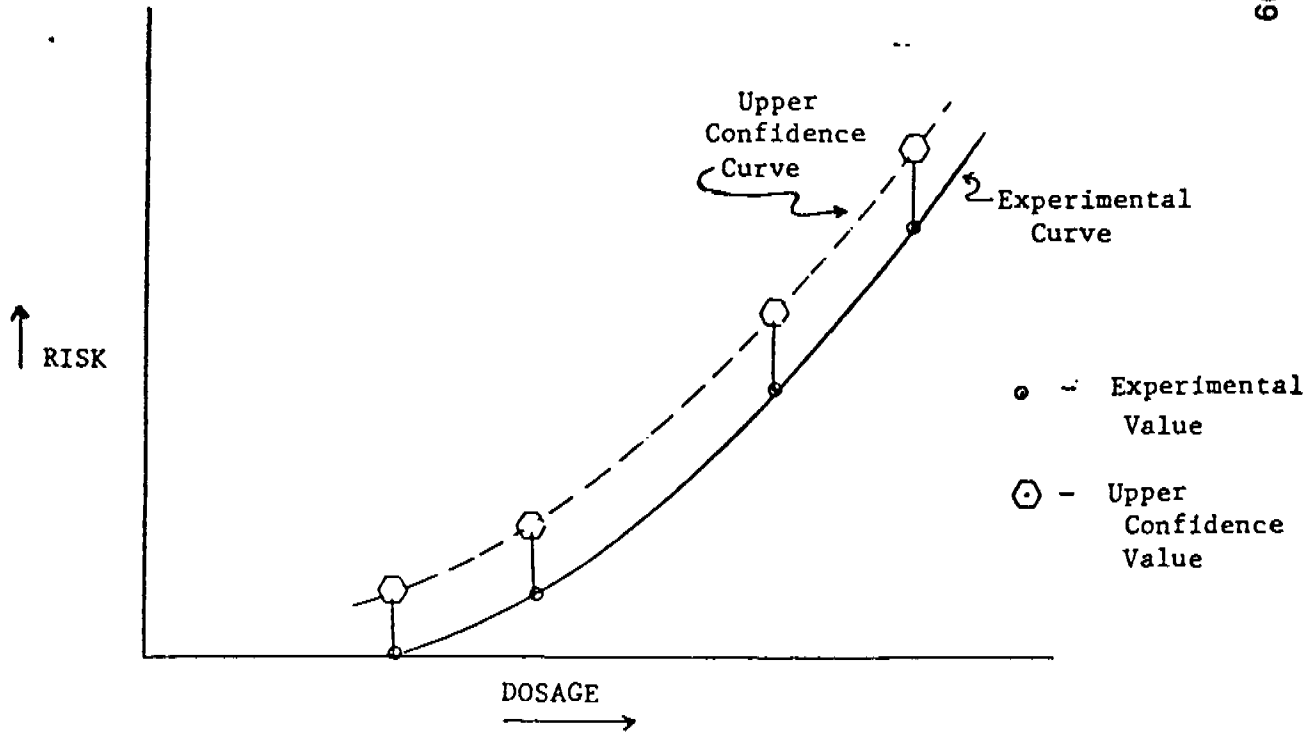


FIGURE X



R&S 029499