HE 18/30.2/D63/1995
c. 1

COLORADO STATE PUBLICATIONS LIBRARY
HE18/30.2/D63/1995 local
/The Rocky Mountain Arsenal pilot exposu
3 1799 00034 0257

DRAFT FOR PUBLIC COMMENT

PUBLIC COMMENT PERIOD ENDS NOVEMBER 25, 1995

THE ROCKY MOUNTAIN ARSENAL PILOT EXPOSURE STUDY PART II: ANALYSIS OF EXPOSURE TO DIISOPROPYLMETHYLPHOSPHONATE, ALDRIN, DIELDRIN, ENDRIN, ISODRIN AND CHLOROPHENYLMETHYLSULFONE

Colorado Department
of Public Health
and Environment

DISEASE CONTROL AND ENVIRONMENTAL EPIDEMIOLOGY DIVISION
DENVER, COLORADO

in collaboration with

DEPARTMENT OF ENVIRONMENTAL HEALTH
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO

and

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY
ATLANTA, GEORGIA

SEPTEMBER 1995

This study and final report were supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund under Grant Number H75/ATH890033.

DISCLAIMER

Mention of the name of any company or product does not constitute endorsement by the Agency for Toxic Substances and Disease Registry, the Public Health Service, the U.S. Department of Public Health and Environment and Human Services, the Colorado Department of Public Health and Environment, or Colorado State University.

TABLE OF CONTENTS

ABSTRACT

A pilot exposure study was undertaken in communities surrounding Rocky Mountain Arsenal (RMA) in order to determine whether exposures to several chemicals were greater among persons who resided there than among residents of a comparison area. Areas 1 and 2 were adjacent to RMA and considered potentially exposed; area 3 was 12 to 15 miles from RMA and served as the comparison area. Following a census and selection of a stratified random sample, 472 persons were interviewed. Urine samples were obtained from 469 persons and serum samples from 444 persons.

In Part II of the exposure study, participants were screened for four organochlorine pesticides (dieldrin, endrin, aldrin, and isodrin); and diisopropylmethylphosphonate (DIMP), a byproduct of nerve agent manufacture, which was produced at RMA by the United States Army. Urine samples were also screened for chlorophenylmethylsulfone ($CPMSO_2$), an oxidation product of chlorophenylmethylsulfide (CPMS). CPMS is an intermediate in the synthesis of nitralin, a herbicide once manufactured at the RMA.

The laboratory method used for DIMP analysis is thought to be useful under some matrix conditions. The components of urine, however, may have produced interferences reducing sensitivity for the target analyte. These potential interferences introduced unresolvable uncertainties about the laboratory results; therefore, further analysis of these data were not conducted.

The initial protocol for the analysis of the cyclodiene pesticides called for a cross check of 12.5% of the samples by a second laboratory. Because of the methodological differences between laboratories and the uncertainties associated with analyte concentrations near the detection limit, only positive results which were reported by both laboratories were used in the cyclodiene analysis.

Dieldrin was initially reported to be present in the serum of 123/402 (30.6%) study participants. Dieldrin was subsequently found in the serum of 6/102 dieldrin positive study participants and in none of 34 dieldrin negative persons by the second laboratory performing quality control analysis. Based on the frequency of confirmed positive results for dieldrin, the overall prevalence of serum dieldrin is estimated to be approximately 2.3%. There was no evidence found in this study that the presence of dieldrin in serum was related to the RMA. Persons with dieldrin in serum were more likely to live in the more rural portions of area 3, to have been involved in farm or ranch work, or to have had a home garden. The qualitative analysis suggested that exposure to dieldrin contaminated soil might have been responsible for dieldrin detected in serum from study participants.

No acute health effects would be anticipated from a body burden of dieldrin at the levels found in this study.

Aldrin was not detected in any of the 444 samples analyzed by the Colorado Department of Public Health and Environment Laboratory at a detection limit of 1 ppb. "Trace" values of aldrin were detected in 2 of 136 samples at Colorado State University during the quality control laboratory cross checking procedure. Since these values were well below the detection limit and neither value could be confirmed, they most likely do not represent true aldrin values.

No confirmed evidence of isodrin or its metabolite endrin was found in the serum from study participants.

A total of 274 participants were evaluated for urine chlorophenylmethylsulfone ($CPMSO_2$). Urine from 121 persons in area 1, 117 persons in area 2, and 36 persons in area 3 was tested in the CSU laboratory in April, 1992. Six of the 238 tested persons from areas 1 and 2 (2.5%) and none of 36 control subjects had detectable concentrations of $CPMSO_2$ in their urine. The method for $CPMSO_2$ had a detection limit of 10 ppb and a quantification limit of 20 ppb. One person had a quantifiable value for $CPMSO_2$ of 20 ppb; five had detectable, but not quantifiable values of the analyte in urine.

Three of 121 persons who resided in area 1, 3 of 117 persons in area 2 and none of 36 persons tested from area 3 had evidence of $CPMSO_2$ in urine when initially tested in 1992. The difference in distribution of $CPMSO_2$ in urine between the exposed and comparison areas was not statistically significant.

The six positive samples were retested in April, 1994; two samples were reported positive for $CPMSO_2$ with concentrations of 10 to 20 ppb. Further analyses were performed at the Centers for Disease Control and Prevention in May, 1994 using capillary gas chromatography coupled to tandem mass spectroscopy. One of the 2 samples reported positive in both 1992 and 1994 was found to contain 0.5 ppb $CPMSO_2$; the remainder were negative at a detection limit of 0.2 ppb. The findings are difficult to interpret due to the low rate of detection, the small number of comparison subjects, the elapsed time between collection of urine and the laboratory analyses and uncertainty regarding background concentrations of $CPMSO_2$ in the general population.

THE ROCKY MOUNTAIN ARSENAL PILOT EXPOSURE STUDY PART II: ANALYSIS OF EXPOSURE TO DIISOPROPYLMETHYLPHOSPHONATE, ALDRIN, DIELDRIN, ENDRIN, ISODRIN AND CHLOROPHENYLMETHYLSULFONE

INTRODUCTION

Rocky Mountain Arsenal (RMA) near Denver, Colorado, is a CERCLA (Superfund) site on the National Priorities List (NPL). It is unique in terms of its large size, levels of contaminants, and the complex mixture of chemicals documented in various media onsite. Contaminants have been measured in soil, water, and air in adjacent communities (ESE, 1989). Human exposure to volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), organochlorine pesticides, heavy metals, and products associated with the manufacture of chemical warfare agents is believed to have occurred via air, water, and soil exposure pathways (Colorado Department of Public Health and Environment, 1989).

In response to evidence of chemical concentrations offsite, known pathways of exposure, presumed exposed populations, a substantial amount of subjective information indicating that acute adverse health outcomes have taken place, and risk estimates predicting an increased risk of cancer if exposure has occurred, an exposure study was conducted in communities surrounding RMA.

The analytes chosen for screening included arsenic and mercury; four organochlorine (cyclodiene) pesticides (dieldrin, endrin, aldrin, and isodrin); and diisopropylmethylphosphonate (DIMP), a byproduct of nerve agent manufacture produced at RMA by the United States Army. As described below, chlorophenylmethylsulfone ($CPMSO_2$) was added to the list of analytes at a later date.

The results of analyses for arsenic and mercury have been published previously as Part I of this report (ATSDR, 1993). This report (Part II) presents the results of the analyses for DIMP, aldrin, dieldrin, endrin, isodrin and $CPMSO_2$. Information regarding contamination at RMA, potential exposure pathways and methods employed in this cross-sectional exposure study have been presented in detail in Part I of the report. Therefore, Part II contains only those aspects of the study relevant specifically to the analytes under consideration here. The report is organized into three major sections corresponding to each of the major classes of chemicals evaluated: DIMP, the cyclodiene pesticides (aldrin, dieldrin, endrin and isodrin) and $CPMSO_2$.

The investigation was conducted collaboratively by the Colorado Department of Public Health and Environment (CDPHE) and the Department of Environmental Health at Colorado State University (CSU). Laboratory analyses for DIMP were conducted by the CDPHE Laboratory. Analyses for the cyclodiene pesticides (aldrin,

dieldrin, endrin and isodrin) were conducted initially by the CDPHE Laboratory. A subset of the analyses for the cyclodiene pesticides was repeated at the CSU Environmental Health Analytical Laboratory for confirmation. Analyses for $CPMSO_2$ were conducted by the CSU Environmental Health Analytical Laboratory. Confirmatory analyses for $CPMSO_2$ were performed by the Centers for Disease Control, Emergency Response Laboratory.

The study objectives were:

1. To determine whether levels of DIMP or its metabolite IMPA in urine were greater among residents of communities adjacent to RMA than among residents of comparison communities located 12 to 15 miles from RMA and presumed to be unexposed;

2. To determine whether levels of aldrin, dieldrin, endrin, or isodrin in serum were greater among residents of communities adjacent to RMA than among residents of comparison communities located 12 to 15 miles from RMA and presumed to be unexposed;

3. To determine whether $CPMSO_2$ was detectable in urine more frequently among residents of communities adjacent to RMA than among residents of comparison communities located 12 to 15 miles from RMA and presumed to be unexposed;

4. To test <u>a priori</u> hypotheses regarding specific pathways of exposure for these chemicals.

DIISOPROPYLMETHYLPHOSPHONATE (DIMP)

a. Background

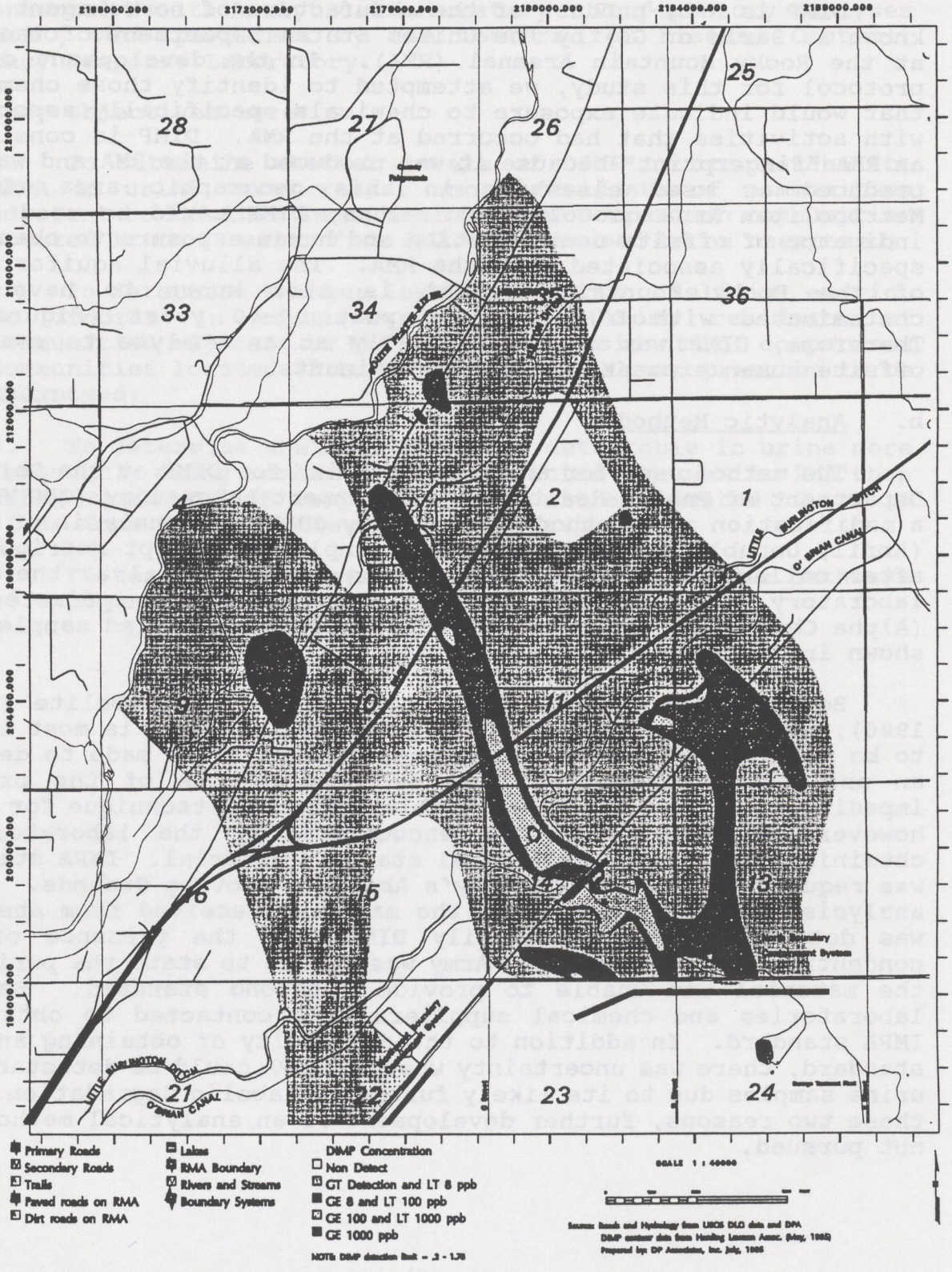
DIMP is a by-product of the manufacture of nerve agent (also known as Sarin or GB) by the United States Department of the Army at the Rocky Mountain Arsenal (RMA). In the development of the protocol for this study, we attempted to identify those chemicals that would indicate exposure to chemicals specifically associated with activities that had occurred at the RMA. DIMP is considered an RMA "fingerprint" because it was produced at the RMA and was not produced or used elsewhere in this geographic area (Denver Metropolitan Area or Colorado). Thus, DIMP could be used as an indicator of offsite contamination and human exposure to chemicals specifically associated with the RMA. The alluvial aquifer north of the Rocky Mountain Arsenal is also known to have been contaminated with DIMP for the past 30-40 years (Figure 1). Therefore, DIMP was chosen initially as an analyte to evaluate offsite human exposure to RMA contaminants.

b. Analytic Methods

The method used for analysis of urine for DIMP at the Colorado Department of Public Health and Environment Laboratory (CDPHE) was a modification of a method developed by CDPHE for analysis of water (Abril, Unpublished). Human urine samples were kept refrigerated after collection and were frozen soon after arrival at the CDPHE laboratory. A DIMP standard was obtained from a private firm (Alpha Chemical). Percent recovery for DIMP in spiked samples are shown in Appendix A.

Because DIMP was found to have one major metabolite (Hart, 1980), isopropylmethylphosphonic acid (IMPA), which is most likely to be at detectable levels in urine, attempts were made to develop an analytical method for this substance. One of the primary impediments to developing verifiable analytical technique for IMPA, however, was the difficulty encountered by the laboratory in obtaining appropriate analytical standard material. IMPA standard was requested from the U.S Army's Aberdeen Proving Grounds. After analysis by H1NMR and C13NMR, the material received from Aberdeen was determined to be primarily DIMP with the presence of low concentrations of IMPA. The Army was unable to state the purity of the material and unable to provide a second standard. Several laboratories and chemical suppliers were contacted to obtain an IMPA standard. In addition to the difficulty of obtaining an IMPA standard, there was uncertainty whether IMPA could be detectable in urine samples due to its likely further metabolic degradation. For these two reasons, further development of an analytical method was not pursued.

Figure 1. Map showing Contamination in South Adams County around Rocky Mountain Arsenal: Source: Roads and Hydrology from USGS DLG data and DPA DIMP contour data from Harding Lawson Assoc., May, 1995.



c. Results and Discussion

The laboratory results for DIMP were unreliable due to possible matrix interferences, the inability to confirm results, and the experimental status of the method, and are therefore not reported. Enzymatic degradation during transit from the field to the laboratory or during frozen storage could have further compromised the samples before analysis. Given these observations the laboratory results could not be used to make any determination of exposure to DIMP. No further analyses of these data were conducted.

ALDRIN, DIELDRIN. ENDRIN, ISODRIN

a. Background

Aldrin, dieldrin, endrin, and isodrin are cyclodiene pesticides that were manufactured at the RMA and have been detected in environmental media both onpost and offpost. These compounds were commonly used from the 1950's to the early 1970's primarily as soil insecticides for the control of termites and other soil-borne insects. Aldrin and dieldrin were used in the past for control of corn pests and in the citrus industry. In 1970 the registrations of aldrin and dieldrin were canceled by the U.S. Department of Agriculture and in 1974 the EPA imposed a near total ban on use and production (ATSDR, 1991). The use of aldrin and dieldrin as termiticides was canceled by EPA in 1987. These compounds are no longer manufactured in or imported into the United States (ATSDR, 1989). The use of endrin in the United States was voluntarily canceled by its manufacturer in 1986 (ATSDR, 1990). Isodrin is a byproduct of the manufacture of endrin. It was produced and used as a pesticide to a lesser extent than the above cyclodienes. In general, the chemical and toxicological properties of isodrin are similar to those of endrin and dieldrin.

The cyclodienes as a group are relatively insoluble in water and are persistent in soils. These properties, which contribute to their effectiveness as pesticides, also increase their potential for bioaccumulation in plants, animals, and humans. Aldrin is readily converted in the environment and in humans to its epoxide, dieldrin (ATSDR, 1989).

b. Environmental Prevalence at Rocky Mountain Arsenal

Aldrin, dieldrin, endrin and isodrin were detected in offpost environmental samples collected in 1987 as part of the Remedial Investigation (RI) of the Offpost Operable Unit (ESE, 1989; U.S. Army, 1991). Dieldrin contamination was identified primarily in alluvial aquifer samples located north and northwest of the RMA. The maximum detected dieldrin concentration in these samples was 1.62 ug/l (ESE, 1989). These results were confirmed by alluvial aquifer groundwater sampling and analysis that was performed as a follow-up to the Offpost RI (RI Addendum) in newly installed offpost monitoring wells (sampled between September, 1989 and March, 1990) as well as in domestic use groundwater wells (sampled between January and April, 1989) located north and northwest of the RMA (U.S. Army, 1991). The highest concentrations of dieldrin reported for this sampling event (maximum detected concentration: 0.89 ug/l) were identified along First Creek directly north of the North Boundary Containment System (NBCS) and the RMA boundary (U.S. Army, 1991). Concentrations of dieldrin northwest of the RMA boundary ranged from below detection (less than 0.05 ug/l) to approximately 0.10 ug/l (U.S. Army, 1991). There is currently no drinking water standard for dieldrin but the EPA has issued a

drinking water health advisory for dieldrin (and aldrin) of 0.2 ug/l. This level is based on a cancer risk of one additional case per 10,000 exposed persons (EPA, 1992).

The distributions of aldrin, endrin and isodrin in offpost alluvial aquifer groundwater samples were similar to that of dieldrin although these compounds tended to be less frequently detected. The highest concentrations of these chemicals occurred north of the NBCS and northern RMA boundary near the confluence of First Creek and O'Brian Canal (U.S. Army, 1991). Only isolated occurrences of isodrin and endrin at concentrations marginally above the detection limit (approximately 0.05 ug/l) were reported to the northwest of the RMA boundary (U.S. Army, 1991). Maximum concentrations reported for aldrin, endrin and isodrin in offpost alluvial aquifer samples were 0.35 ug/l, 1.51, and 0.26, respectively (U.S. Army, 1991). The EPA's Maximum Contaminant Level (MCL) for endrin, promulgated under the Safe Drinking Water Act, is 2 ug/l (EPA, 1992). No MCL or drinking water health advisory is currently available for isodrin.

Aldrin, dieldrin, and endrin were detected in a limited number of surface water samples collected as part of the Offpost RI (ESE, 1989) but only dieldrin was detected in surface water samples collected as part of the RI Addendum (U.S. Army, 1991). Contaminants detected in First Creek surface water samples reportedly originate from groundwater discharge into this creek (U.S. Army, 1991). A limited number of sediment samples from the RI contained elevated levels of dieldrin whereas sediment samples reported in the RI Addendum contained elevated levels of dieldrin, aldrin and endrin (U.S. Army, 1991). Dieldrin was detected in 10 of 16 sediment samples taken from First Creek, Burlington Ditch and Barr Lake (U.S. Army, 1991). Concentrations of dieldrin in these samples progressively decrease with distance from the RMA. The highest dieldrin concentration reported in sediment was 370 ug/kg (U.S. Army, 1991). Aldrin and endrin were also detected in sediment samples from First Creek and Burlington Ditch but at a lesser frequency than dieldrin.

Aldrin, dieldrin, endrin and isodrin have been widely detected in surficial soil samples collected offpost. The pattern of detection and concentrations detected are generally consistent with predominant wind patterns, suggesting that these compounds have been dispersed via fugitive dust emissions from the RMA (U.S. Army, 1991). Dieldrin was detected primarily to the north but also northwest, west, and east of the RMA in approximately 90 percent of the surface soil samples analyzed. No soil analysis for dieldrin has taken place south of the RMA. Detected dieldrin concentrations ranged from 2.05 to 250.0 ug/kg (U.S. Army, 1991; Jeff Edson, Personal Communication). Aldrin and endrin were detected in approximately 20 to 30 percent of the samples analyzed at

concentrations ranging from 3.2 to 390 ug/kg (U.S. Army, 1991). Isodrin was detected at a lower frequency and at relatively lower concentrations than the above compounds.

Detectable concentrations of dieldrin have also been reported in tissue from a variety of biota samples collected from locations directly north of the RMA as part of the RI Addendum (U.S. Army, 1991). These samples include bovine fat, chicken tissues, fish, earthworms, deer mice, prairie dogs and pheasants. Aldrin, endrin or isodrin were not identified in any of these samples. These results are similar to those obtained from biota samples collected onpost, with the exception of samples collected in the most highly contaminated areas (U.S. Army, 1991). Dieldrin concentrations in biota samples offpost have been attributed to concentrations identified in environmental media in this area (U.S. Army, 1991).

c. Toxicity Profile

Aldrin/Dieldrin

Because aldrin is readily converted to its epoxide dieldrin following absorption (Hayes, 1982), the primary toxic effects of these chemicals can be considered similar, if not identical (ATSDR, 1989). Aldrin and dieldrin may be absorbed following inhalation, ingestion or dermal contact. Aldrin/dieldrin are distributed to the liver and other tissues and tend to bioaccumulate in adipose tissue (Hayes, 1974). Metabolism occurs primarily in the liver. The primary metabolite is the 9-hydroxy derivative. Dieldrin or 9-hydroxydieldrin are excreted primarily in the feces. In humans and animals, urinary excretion is minimal (ATSDR, 1989). The biological half-life of dieldrin in humans is approximately 266 days (ATSDR, 1989). Human studies on aldrin and dieldrin consist of either case reports of accidental or intentional poisonings or epidemiological studies of workers employed in the manufacture or application of these agents (ATSDR, 1991).

The acute toxicity of dieldrin in animals and humans is primarily associated with the central nervous system. These symptoms range from hyperexcitability, tremors, and depression to convulsions, coma and death. The oral LD_{50} in humans is approximately 5 mg/kg (Hodge et al., 1967; Joy, 1983). The threshold concentration for the neurotoxic effects of dieldrin has been estimated as approximately 150 to 200 ug/l in human blood (Brown et al., 1964). Brown et al. (1964) reported a mean dieldrin blood level of 160 to 170 ug/l in dieldrin-intoxicated workers whereas Van Raalte (1977) reported blood dieldrin concentrations ranging from 280 to 290 ug/l in insecticide workers suffering from convulsions. However, Jager (1970) reported a maximum blood dieldrin level of 430 ug/l in workers without clinical signs.

The liver is the primary target organ in animals following subchronic and chronic exposure to dieldrin. Nonneoplastic histologic changes and increased liver-to-body weight ratios have been reported in rats, dogs, and hamsters (ATSDR, 1989). No teratogenic effects associated with dieldrin exposure have been reported in humans or animals (ATSDR, 1989). Immunosuppression following subchronic ingestion of dieldrin has been reported in mice (Loose et al., 1981; Loose, 1982) but studies concerning such effects in humans have not been identified in the scientific literature.

Dieldrin has been shown to cross the placenta in humans and animals. Reproductive toxicity, including primarily decreased litter size and postnatal mortality, has been demonstrated in experimental animals at doses eliciting toxic maternal effects. The threshold for reproductive toxicity in rats and mice is approximately 2 and 3 ppm in the diet, which is approximately equivalent to 0.10 and 0.45 mg/kg/day for rats and mice, respectively (ATSDR, 1989). However, a LOAEL designation for histopathological lesions (cerebral edema, internal and external hydrocephalis) in the pups is appropriately established at 0.004 mg/kg/day, based on the obsevation of the investigators (Harr et al. 1970).

Significant evidence of genotoxicity associated with aldrin and dieldrin has not been reported (ATSDR 1989). The epidemiological evidence for carcinogenicity in humans is also considered inadequate (ATSDR, 1991). Sufficient evidence for carcinogenicity following the ingestion of aldrin and dieldrin has been reported in mice (ATSDR, 1991). The target organ in these studies was the liver. Several bioassays in rats indicated the induction of liver pathology but did not show evidence of a carcinogenic response. Based on the finding that sufficient evidence for carcinogenicity exists in animals, the EPA has rated aldrin and dieldrin as Class B2 (probable human) carcinogens (ATSDR, 1991).

Endrin/Isodrin

The toxic effects of endrin and isodrin are similar to those for aldrin/dieldrin. Isodrin and endrin may be absorbed via inhalation, ingestion or dermal contact and are distributed to most tissues. As with aldrin/dieldrin, isodrin is rapidly metabolized to endrin via epoxidation, and therefore the toxicity of isodrin is basically that of endrin (Hayes, 1982).

Endrin bioaccumulates to a much lesser degree than dieldrin (Hayes, 1982). Metabolism occurs via initial hydroxylation and subsequent conjugation as glucuronides and sulfates. Excretion in humans occurs via the feces and urine (ATSDR, 1990).

Central nervous stimulation is the primary toxic effect associated with acute exposure to endrin. A lethal dose of endrin in humans has not been identified but a dose of 0.20 to 0.25 mg/kg was reported as sufficient to elicit convulsions (Davies and Lewis, 1956; Hayes, 1963). Blood concentrations ranging from 3 to 254 ug/l have been reported in humans experiencing convulsions following acute oral exposure to endrin (Rowley et al., 1987). In another poisoning incident, patients hospitalized with acute symptoms of endrin ingestion had blood concentrations ranging from 7 to 32 ug/l (Curley et al., 1970).

Limited evidence suggests that children may be more sensitive to endrin than adults. Rowley (et al., 1987) reported that 61 percent of the individuals experiencing convulsions were less than 14 years of age. Treon et al., (1955) reported that 29 to 31-day-old rats were more sensitive to the lethal effects of endrin than 6-month-old rats.

Data concerning the immunological, reproductive, developmental, or genotoxic effects of endrin in humans or animals is inconclusive (ATSDR, 1990). Studies in workers in the endrin manufacturing industry show no association between endrin exposure and the development of cancer (ATSDR, 1990). However, these studies had low statistical power and are therefore not considered conclusive. Limited (inconclusive) evidence also suggests that endrin is not carcinogenic in dogs, rats or mice (ATSDR, 1990). The EPA has not classified endrin with regard to its potential carcinogenicity due to insufficient data.

d. Analytical Methods

Interlaboratory Analysis

Our initial protocol for this study called for a cross check of 12.5% of the samples by the Colorado State University Laboratory. Interlaboratory differences observed as a result of this comparison are addressed in detail under the results and discussion sections for cylcodiene analysis.

Serum Analysis and QA/QC for Cyclodiene Pesticides (CDPHE)

A 3 ml serum sample was used unless only a smaller amount was available. After addition of surrogate (di-butyl chlorendate, DBC), the sample was deproteinized with 3 ml of methanol in a glass culture tube with a teflon lined screw cap. A 5 ml solution of 1:1 ethyl ether and hexane was added along with a glass bead to each tube. Following thorough mixing by vortex, the samples were extracted for 15 minutes on a rotary mixer. After centrifugation, the organic layer was transferred to a clean culture tube with a Pasteur pipette. The extraction was repeated 2 more times, making sure that the protein layer was always dispersed after centrifugation and prior to the next extraction.

The combined extracts were concentrated by evaporation to approximately 5 ml prior to florisil cleanup.

Prior to use, the florisil was washed with 1:1 ethyl ether-hexane solution. It was then activated at 400 degrees, and stored in a 130 degree oven for no more than 4 days. It had been determined in this laboratory during preliminary work that storage of the florisil at 130 degrees for longer time periods could affect its activity. Specifically, it required a 20% ethyl ether in petroleum ether eluant to completely elute the dieldrin and endrin from florisil which had been held for a prolonged period at 130 degrees. Both analytes eluted completely with the 15% eluant when the florisil had been kept at 130 degrees for less than 4 days.

The 5 ml extract was transferred onto the florisil which was held in a chromatographic tube. It was then eluted with 200 ml of 15% ethyl ether in petroleum ether. The eluate was concentrated to 3 ml and analyzed by GC\ECD, using a Hewlett-Packard 5890 series II dual electron capture detector system. Since the chromatographic system would separate DDE from dieldrin, only one elution mixture was used. Two fused silica capillary columns were used, 0.32 mm Rtx-5, and 0.32 mm Rtx-1701. All samples were analyzed on both columns. No results were reported as positive unless the analyte was detected on both columns, in which case the lowest value was reported.

The samples were analyzed in sets consisting of 20 sera and 5 QC samples in each set. QC was as follows:

1 reagent blank (water instead of serum)
1 reagent spike (water instead of serum)
1 serum blank (pooled serum from serology lab)
2 serum spikes (duplicates).

The spike levels were as follows (these are the serum levels):

aldrin	6.05 ppb	DBC (surrogate)	5.0 ppb
isodrin	5.12 ppb		
dieldrin	6.56 ppb		
endrin	5.10 ppb		

The serum spikes were prepared in one large set before beginning analyses on the study sera. The spikes were from the same spiked serum pool used initially to demonstrate capability by analyzing 10 replicate serum spikes. After the large set of pooled serum spike was prepared, appropriate portions were dispensed into glass vials and kept frozen until needed. Prior to spiking the pooled serum, a portion was separated for use as the serum blank.

The internal standard method of calibration was used, with endosulfan I as the internal standard and di-butyl chlorendate as the surrogate compound.

When quality control problems were observed, repeat analyses could not be performed due to inadequate quantities of serum. Standard operating procedure would otherwise be to reanalyze such samples to resolve qualified results.

Serum Analysis and QA/QC for Cyclodiene Pesticides (CSU)

The CSU analytical method for the cyclodiene pesticides followed a previously published method (Burse, 1990a; 1990b) with minor modifications. A 3.0 gram serum sample was deproteinized with 3.0 ml of methanol in a teflon lined culture tube. Five ml of 1:1 ethyl ether:hexane was added and vortexed for 30 seconds. The sample was then mixed on a roto-rack for 15 minutes at 45-50 RPM. The sample was then centrifuged for 5 minutes at 200 RPM. The upper organic layer was removed using a disposable pipet and placed into a 25 ml concentrator tube. This extraction was repeated two more times each time with 5 ml of 1:1 ethyl ether:hexane. The extract was then concentrated to 0.5 ml before cleanup using Florisil column chromatography. Florisil columns chromatography followed the procedure described in the Manual of Analytical Methods for the Analysis of Pesticides in Humans and Environmental Samples (EPA, 1980). Columns were eluted with 200 ml of 6% diethyl ether/hexane (fraction 1) followed with 200 ml of 15% diethyl ether/hexane (fraction 2). Each fraction was reduced to 0.5 ml, the internal standard (heptachlorobiphenyl) was added to both and the final volume was adjusted to 1.0 ml before analysis using gas chromatography. Hewlett-Packard Model 5890 series II gas chromatographs equipped with Ni63 constant current electron capture detectors and packed injection ports were used. Several analytical columns were used for this study; the primary columns were: 1) 1.8-m X 4.0-mm i.d. column packed with 4% SE-30/6% OV-210 on 80-100 mesh Gas Chrom Q, and 2) 1.8-m X 4.0-mm i.d. column packed with 1.5% OV-17/1.95% OV-210 on 100-120 mesh Gas Chrom Q. Other analytical columns used for confirmation purposes were: 1) 30-m X 0.53-mm i.d. X 0.50-um SPB-608 TM fused-silica and 2) 30-m X 0.53-mm i.d. X 0.50-um DB-1701 fused-silica column.

Serum samples were extracted and analyzed in sets. Each set consisted of six serum samples, one control serum and one spiked serum. Control and spiked sera were treated similarly to field samples. The spiked sera solutions contained aldrin, dieldrin, endrin, and isodrin. Spike concentrations of each analyte were 20 ppb (20 ng/ml). Heptachlorobiphenyl (100ng/ml) was added to each sample (0.5 ml) before volume adjustment.

The internal standard method of calibration was used for the analyses. Heptachlorobiphenyl was selected as an internal standard and was added to all standards and samples. This method of calibration corrects for differences in injection volume or instrument sensitivity differences between samples or standards.

The serum samples were analyzed in two groups separated in time by several months; therefore there are two groups of control charts, one for each group of analyses. The recoveries for each group are shown in Appendix B. The mean percent recovery for spiked samples across analytes was 92.1% for group 1 and 95.7% for group 2.

All quality control check samples for sera analyzed at the CSU laboratory were coded numerically without additional identifiers. For each set of analyses, a quality control chart was constructed (see Appendix B). The quality control charts provide graphic assessment of accuracy and precision for the analysis of each substrate and permit early recognition of erroneous data. The charts also allow convenient evaluation of recovery trends for a particular analyte and have long term value for evaluation of laboratory analytical quality.

e. Results

Serum samples were initially analyzed for aldrin, dieldrin, endrin and isodrin in the CDPHE laboratory. Twenty-eight of the 472 persons interviewed declined to provide a serum sample by venipuncture. The age and sex distribution of the 444 persons initially tested for these pesticides is shown in Table 1 by area. Serum was provided by 145 of 150 persons in area 1 (96.7%), 163 of 173 persons in area 2 (94.2%) and 136 of 149 persons in area 3 (91.3%).

Dieldrin

The results of analysis for aldrin, dieldrin, endrin and isodrin were reported by the CDPHE laboratory in sets of 20-22 samples each. All samples of set 6 were reported as positive for dieldrin and the duplicate spike recovery was considered atypical when compared to all other spike recoveries for other sets. Based on these observations, it is unlikely that all positive dieldrin results in set 6 are valid. Only those results which were confirmed in the second laboratory were considered positive. The QC data for set 19 show dieldrin contamination of the set's blanks, thus invalidating these results as well (see Appendix A). In addition to the critical review of the laboratory data, it was also noted the all three exposure areas were sampled simultaneously and each set included samples from each area. Variability in results among sets of sera, therefore, could not be attributed to the source of the samples.

As already noted above, our initial protocol for this study called for a cross check of 12.5% of the samples by the Colorado State University Laboratory. Initially, the CSU laboratory analyzed 56 randomly chosen samples for dieldrin. Of 20 reported positive for dieldrin by the CDPHE laboratory, only two could be confirmed in the CSU laboratory. One sample was reported as trace

(< 1.0 ppb) and one sample as positive at the detection limit of 1.0 ppb. Of 36 samples reported negative for dieldrin in the CDPHE laboratory, all were confirmed to be negative for dieldrin by CSU at the detection limit of 1.0 ppb.

To help resolve some of these interlaboratory differences, an independent national laboratory was consulted (see attached documentation in Appendix C). The Supervisory Research Chemist, Toxicology Branch, Division of Environmental Health, Centers for Disease Control, (Virlyn W. Burse) provided reference materials. The CDC laboratory provided serum quality control pools that had been analyzed and values for dieldrin and endrin determined. The CDPHE and CSU laboratories agreed to analyze three replicates of each of the two pooled reference samples as unknown samples. The analyses were conducted by both laboratories in May, 1991 (approximately one year after the initial reporting of serum dieldrin values by the CDPHE laboratory). The results are shown in Appendix C. The CDC quality control samples contained 0 ppb dieldrin in sample 1 and a mean dieldrin value of 1.1 ppb in sample 2. Both laboratories correctly identified all 3 replicates of sample extract number 1 as negative. The CDPHE laboratory reported sample 2 as a mean of three results of 2.4 ppb; the mean CSU value was 1.5 ppb. Although the CDPHE laboratory results averaged higher than those of CSU, which were also higher than the spiked concentration, the spiked concentration was only slightly higher than the study's detection limit.

To further investigate the interlaboratory differences, the decision was made to screen the remaining positive samples which contained adequate quantities of frozen serum at the CSU laboratory in an attempt to confirm the reported findings. An additional 80 samples were analyzed for aldrin, dieldrin, endrin and isodrin at the CSU laboratory. None of these 80 sera contained aldrin, endrin or isodrin at a detection limit of 1.0 ppb. Four of the 80 samples were found to contain dieldrin; two at "trace" levels (not quantifiable at 1.0 ppb), one at 1.9 ppb and one at 2.5 ppb. The serum containing 2.5 ppb dieldrin had been run twice in the CDPHE laboratory. Initially it was reported to contain 3.3 ppb (set 3); upon re-running (set 22) it contained 3.8 ppb.

The results of the cross checking procedure for dieldrin between the two laboratories are shown in Appendix C for 136 samples examined by both laboratories. Of these 136 samples, 102 had been initially reported as positive by the CDPHE laboratory. Only 6 of the 102 (5.9%) samples reported positive for dieldrin by the CDPHE laboratory were confirmed in the CSU laboratory. The positive samples checked in the second laboratory included samples from sets 6 and 19; the data from these sets were qualified by the CDPHE laboratory. Of 34 samples reported negative for dieldrin in the CDPHE laboratory and checked in the second laboratory, all were confirmed to be negative.

Due to the apparent inconsistencies in the reporting of values for serum pesticides between the two laboratories, further data analysis of serum dieldrin was restricted to the results confirmed by both laboratories. The distribution of persons evaluated for serum dieldrin at the CSU laboratory is shown in Table 2 by area, age and sex. A total of 136 of the total sample of 444 persons tested initially by CDPHE were tested further by the CSU laboratory (30.6%); 41 in area 1, 51 in area 2 and 44 in area 3.

The 6 persons that could be confirmed as positive included 2 of the 56 tested in the initial quality control cross check and 4 of the 80 tested in the subsequent rechecking of samples tested initially at CDPHE. Their characteristics are summarized in Table 3. All confirmed dieldrin positive persons were adults; four were male and two female. Four of the six resided in area 3 and one each in area 1 and area 2 ($p = 0.09$ for residence in area 3 by Fisher's Exact test). Farm or ranch work was reported by three of the six and use of a garden was reported by the remaining three. In addition to farm work, one man had worked on a vegetable farm with corn, alfalfa and grain crops and had been involved with pesticide manufacture and production and reported using pesticides for treatment of grain storage bins in 1974. A second rural male resident also reported working with corn, alfalfa or grain crops. There was no reported use of termiticides in any of the interviews.

The highest value for dieldrin reported by the CDPHE laboratory was 172 ppb. Due to a concern for potential health effects at this level of serum dieldrin, a second sample was obtained from the subject in 1991. At that time, CDPHE reported the sample from this person to be negative for dieldrin. The 1989 and 1991 sera from this subject were also analyzed in the CSU laboratory; both the 1989 and 1991 samples were reported negative for dieldrin at a detection limit of 1.0 ppb by the CSU laboratory. Since dieldrin values in serum should be long-lived, and since confirmation of the initial value was not obtained on cross-checking nor on re-sampling, the initial CDPHE report of a value of 172 ppb is assumed to be incorrect.

Aldrin

Aldrin was not detected in any of the 444 samples analyzed by the CDPHE laboratory at a detection limit of 1 ppb. Trace values of aldrin (less than 1 ppb) were detected in 2 of 136 samples at Colorado State University during the quality control laboratory cross checking procedure. Since these values were well below the detection limit and neither value could be confirmed, they most likely do not represent true aldrin values. In support of this conclusion it is known that aldrin is rapidly converted to dieldrin in the human liver by biotransformation reactions to the corresponding epoxide dieldrin (Jager, 1970). Dieldrin is then concentrated in lipid tissues (Hayes, 1974). Neither of the two samples had any detectable residues of dieldrin.

Endrin

Endrin was detected in 14 of the 444 samples analyzed by the CDPHE laboratory at a detection limit of 1 ppb or above and in 4 additional samples at "trace" values. Twelve of the fourteen quantifiable endrin values and all 4 of the trace values occurred in a single set (set 7). Review of the quality control data for endrin for this set showed that the serum reagent blank was reported positive for endrin, thereby invalidating the reported endrin results for the entire set.

Similarly, quality control checks done by the CDPHE laboratory for a reported sample result of 6.6 ppb endrin (set 12) indicated that the value of the surrogate recovery (di-butyl chlorendate) was outside the range of acceptable reference values, and that the sample was affected by matrix interference which may have been due to hemolysis. Therefore, this result is presumed to be incorrect.

A value of 1.8 ppb for endrin was reported in a subject from area 3 who also had a reported (CDPHE) value of 172 ppb for dieldrin. Due to the potential health consequences associated with a high level of serum dieldrin, a second serum from this person was obtained in 1991. Upon retesting, this individual was negative for serum endrin at the CDPHE laboratory. Serum samples tested at the CSU laboratory were negative for endrin in 1989 and remained negative upon resampling of the individual in 1991.

Since endrin values in serum should be long-lived, and since the initial value was not confirmed by cross-checking in a second laboratory, the initial report of a value of 1.8 ppb is assumed to be unreliable.

During the quality control procedures, a total of 136 samples were analyzed for endrin by the CSU laboratory; all were found to be negative. In summary, no confirmed evidence of endrin in serum from study participants was found.

Isodrin

Isodrin was detected in one of the 444 samples analyzed by the CDPHE laboratory at a detection limit of 1 ppb. The result was reported as "trace" with an estimated range of 0.5 to 1.0 ppb. Although this positive sample was contained in set 7 where the serum reagent blank was reported positive for endrin, no apparent QC problems were observed for isodrin.

During the quality control procedures, a total of 136 samples were analyzed for isodrin by the CSU laboratory; all were found to be negative. The sample found to contain a trace level of isodrin in the CDPHE laboratory was found

to be negative for isodrin at a detection limit of 1.0 ppb in the CSU laboratory. In summary, no confirmed evidence of isodrin in serum from study participants was found.

f. Discussion

Because of differences in the number of detectable values for dieldrin reported by the two laboratories, all of the pertinent data, including chromatograms from both laboratories and quality control data from each, were reviewed. This review did not reveal any evident quality control problems for dieldrin other than those associated with CDPHE sets 6 and 19.

Among other factors which may have produced significant systematic errors are the analytical methods and variations used, such as sample extraction and preparations employed, precision of the analytical methods, and the detection limit of each method. In addition, the closer that the analyte concentration is to the detection limit, the greater the uncertainty of the measured value.

Differences in analytical methods used by the two laboratories have been described above. While differences did exist between the laboratories, data reviewed met the QA/QC requirements for the analytical methods used in both laboratories with the exceptions discussed above. Because of the methodological differences between laboratories and the uncertainties associated with analyte concentrations near the detection limit, only positive results which were reported by both laboratories were used in further cyclodiene analysis.

No confirmed evidence of aldrin, endrin or isodrin in serum from study participants was found. Dieldrin was initially reported to be present in the serum of 123/402 (30.6%) of study participants after exclusion of two sets of sera (6 and 19) where technical problems occurred in the analysis. Dieldrin was found in the serum of 6 of 102 dieldrin positive study participants by the laboratory performing confirmatory analysis for these analytes. Of the samples initially reported to contain dieldrin by the CDPHE laboratory, 102 were retested in the CSU laboratory. For the remaining 62 samples, no confirmatory analyses were run, primarily due to inadequate sample volume. If the confirmation rate for the additional 62 samples was the same as that for the 102 initially run by CSU, then 6% of these, or 4 additional samples might be expected to contain dieldrin. Thus, the overall prevalence of serum dieldrin might be expected to be on the order of 6+4/444 or 2.3%. The assumption was made that there were no false negatives at the detection limit of 1.0 ppb, based on the quality control testing conducted in both laboratories and the results of analyses on check samples obtained from the Centers for Disease Control Laboratory.

There was no evidence found in this study that serum levels of these pesticides were related to the RMA. Persons with dieldrin in serum were likely to live in the more rural portions of area 3, to have been involved in farm or ranch work, or to have had a home garden. The qualitative analysis suggested that exposure to pesticide contaminated soil might have been responsible for some of the positive findings for dieldrin. There was no association between consumption of water from private wells and any of the cyclodiene pesticides.

Finally, to allay concerns that the decision to use only those results reported as positive by both laboratories may have "masked" an association between potential dieldrin exposure and residence near RMA, an analysis of the CDPHE reported dieldrin data by area was conducted. The results are shown in Table 4. After elimination of sets 6 and 19 due to technical problems in the analysis, dieldrin was detected in 123 of 402 sera examined (30.6%). Dieldrin was found in sera from 33/135 persons residing in area 1 (24.4%), 42/146 in area 2 (28.8%) and 48/121 (39.7%) in area 3. This distribution of dieldrin in serum by area was unlikely to have occurred by chance ($p = 0.03$ by chi square analysis). However, there was no evidence of an association between serum dieldrin and residence in area 1 or area 2. The odds ratio for dieldrin in serum in area 3 (compared to areas 1 and 2 as referents) was 1.8, 95% CI 1.1-2.9.

The comparison area is a relatively rural region which had been selected to match the previously agricultural use of much of area 1 and thus might have contained residual soil dieldrin. Therefore, a portion of the results obtained for dieldrin in the large sample (N=402) may represent real exposure to the pesticide. This hypothesis is borne out by the fact that 4 of the 6 persons with confirmed dieldrin in serum resided in area 3 and that agricultural occupations or exposure to soil through gardening may account for at least a portion of the exposures documented.

Table 1. Age and Sex Distribution of Persons Tested for Aldrin, Dieldrin, Endrin and Isodrin in Serum by Area. (N=444), Colorado Department of Public Health and Environment Laboratory.
RMA Exposure Study 1989-1990.

	Area 1		Area 2		Area 3	
Agegroup	Male	Female	Male	Female	Male	Female
< 10	10	6	6	8	7	3
10 - 19	11	9	13	8	5	13
20 - 29	8	7	7	13	10	9
30 - 39	12	8	11	15	8	11
40 - 49	10	13	16	12	6	10
50 - 59	8	11	6	7	10	9
60 - 69	12	9	15	12	12	9
≥ 70	4	7	8	6	7	7
Total	75	70	82	81	65	71
Area Total	145		163		136	

Table 2. Age and Sex Distribution of Persons Tested for Aldrin, Dieldrin, Endrin and Isodrin in Serum by Area. (N=136), Colorado State University Laboratory. RMA Exposure Study 1989-1990.

	Area 1		Area 2		Area 3	
Agegroup	Male	Female	Male	Female	Male	Female
< 10	2	1	0	1	1	0
10 - 19	3	2	2	2	1	2
20 - 29	1	3	3	7	2	4
30 - 39	2	3	8	7	4	6
40 - 49	3	7	4	3	1	6
50 - 59	1	5	2	3	1	3
60 - 69	3	2	3	4	0	7
≥ 70	1	2	2	0	4	2
Total	16	25	24	27	14	30
Area Total	41		51		44	

Table 3. Characteristics of Persons with Dieldrin in Serum. RMA Exposure Study, 1989-1990.

Individual	CDPHE Dieldrin	CSU Dieldrin	Area	Age	Sex	Farm or Ranch Work	Water Supply	Garden
1	1.30	<1.00	2	38	Male	No	Public	Yes
2	3.40	1.87	3	39	Male	No	Bottled	Yes
3	1.00	<1.00	3	33	Male	Yes	Well	No
4	3.30	2.51	3	79	Female	No	Public	Yes
5	1.80	1.00	1	45	Female	Yes	Public	No
6	1.80	<1.00	3	31	Male	Yes	Public	No

Table 4. Distribution of Sera Reported Positive for Dieldrin by Area, Colorado Department of Public Health and Environment Laboratory.
RMA Exposure Study 1989-1990.

Area	Number TestedP	Number Positive	Percent Positive
1	135	33	24.4
2	146	42	28.8
3	121	48	39.7
Total	402	123	30.6

CHLOROPHENYLMETHYLSULFONE ($CPMSO_2$)

a. Background

Chlorophenylmethylsulfone ($CPMSO_2$) was selected as an additional contaminant for study. Chlorophenylmethylsulfone is a member of a group of organosulfur compounds. This group is comprised by chlorophenyl-methyl sulfide (CPMS), chlorophenylmethyl sulfoxide (CPMSO) and chlorophenylmethyl sulfone ($CPMSO_2$). The compounds 4-chlorophenyl-methyl sulfide, the sulfoxide and the sulfone analogs are intermediates in the manufacture of the herbicide Planavin (Nitralin), 4-(methyl-sulfonyl)-2,6-dinitro-N, N-dipropyl-benzeneamine (Miller et al, 1976). These compounds were stored in the unlined waste ponds at the Rocky Mountain Arsenal (RMA). Both CPMS and $CPMSO_2$ were subsequently found to be groundwater contaminants in the area.

CPMS and its sulfone analog are absorbed through the gastro-intestinal tract. CPMS is rapidly oxidized to the sulfone $CPMSO_2$ which is resistant to further metabolism and excreted predominantly through the kidneys. Therefore, assay of urine for $CPMSO_2$ should provide an estimate of the exposure to this class of compounds and could indicate exposure to RMA contaminants. CPMSO is an intermediate in the oxidation of CPMS to $CPMSO_2$.

b. Environmental Prevalence at RMA

The organosulfur compounds have been directly associated with RMA onsite activities and have been observed onsite and offsite within the documented contamination plume (ESE, 1989). The organosulfur compounds have been detected offpost at RMA. CPMSO was detected in 6 of 6 water samples from test wells north of the arsenal at an average concentration of 54 ug/l with a maximum concentration of 380 ug/l (ESE, 1989). It was also detected along First Creek pathway at lower concentrations in 2 of 5 test well samples. Like DIMP, the organosulfur compounds are a component of the groundwater contamination which has resulted from onsite activities at the Rocky Mountain Arsenal.

Other environmental sources of $CPMSO_2$ may be encountered; pesticides in particular. Planavin (Nitralin) was also disposed of at Sand Creek, a second Superfund site several miles from RMA, by dumping the herbicide into waste pits. $CPMSO_2$ is an obligatory metabolite of chlorobenzene, and may be a metabolite of several pesticides including carbophenothion (trithion), its methyl analogue (methyl trithion), the insecticide chlorfenson (Ovex), and perhaps tetradifon and tetrasul. The presence of $CPMSO_2$ in urine of persons residing near the RMA may indicate exposure to these compounds or their residues. Therefore, exposure of persons to $CPMSO_2$ may not be related to the RMA.

c. Toxicity Profile

The toxicology of $CPMSO_2$ is reviewed briefly here, since this compound is not widely discussed in the literature. Although no data on the toxicity of CPMSO for humans are available in the literature (ESE, 1989), CPMSO is known to cause depression, anorexia, hypothermia and weakness in laboratory animals (Thake et al., 1979). No data on carcinogenicity are available in the literature (ESE, 1989). CPMSO is non-mutagenic in the Ames assay (Thake et al., 1979).

Toxicologic testing of this class of chemicals has been conducted, albeit on a limited basis. In acute toxicity assays, rats are equally sensitive to the three related compounds, i.e., sulfide, sulfoxide, sulfone. The LD50 for the sulfoxide was 611 mg/kg bw for male rats and 463 mg/kg bw for female rats (Thake et al., 1979). The mouse is more sensitive to the sulfoxide (328 mg/kg bw for the male mouse and 440 mg/kg bw for the female) than to the sulfide or the sulfone.

Rats exposed to CPMSO for 91 days at or above the maximum tolerated dose (750 ppm) experienced reduced red blood cell counts, reduced levels of serum enzymes (SGOT) in males, and mortality in the highest dose groups. Compound related hepatic lesions were found in all dose groups (Thake et al., 1979).

Subacute doses (14 days) of CPMSO (at 5, 10 and 20 mg/kg) to Rhesus monkeys resulted in depression, anorexia, emesis, hypothermia, weakness and mortality at the highest dose, with clinical signs also observed at 5 mg/kg. Decreased red blood cell counts, increased levels of BUN, SGOT, SGPT, serum alkaline phosphatase and calcium and increased liver and kidney weights were observed at 10 and 20 mg/kg. Liver lesions consisting of vacuolization of hepatocytes and necrosis were observed at low dosages. At higher dosages, vacuolization of proximal renal tubular epithelium was observed. Lymphoid tissue hyperplasia was observed at all dosages. (Thake et al, 1979).

Toxicity testing has also been performed for the sulfone in the same series of rodent and primate experiments described above (Thake et al, 1979). In general, the results were similar to those described for the sulfoxide. Clinical signs of disease with histologic evidence of liver lesions were observed in rats subchronically exposed to $CPMSO_2$ in the diet at concentrations of 750 ppm. Subacute oral toxicity studies in rhesus monkeys at doses ranging from 2.5 to 30 mg/kg demonstrated toxicity consisting of mortality at 20 and 30 mg/kg. Clinical signs of anorexia, vomiting and diarrhea were observed at lower doses. Increased levels of BUN, SGOT and sodium and decreased serum glucose and inorganic phosphorous were observed at all dose levels. Hepatic lesions and lymphoid hyperplasia were seen at

doses of 10 mg/kg and higher (Thake et al., 1979). The studies of Thake et al. clearly show that monkeys (and perhaps humans) are much more sensitive to the adverse effects of these chemicals than rats or mice.

CPMS and $CPMSO_2$ are absorbed through the gastrointestinal tract in cattle with CPMS rapidly oxidized to $CPMSO_2$ (Oehler and Ivie, 1983). The sulfone is slowly excreted through the kidneys in its unmetabolized state. $CPMSO_2$ remains in the body for up to two weeks after ingestion and is distributed in blood and a wide variety of tissues (Oehler and Ivie, 1983). Administration of radiolabelled $CPMSO_2$ at low doses to sheep resulted in excretion of 80% of the dose within 10 days. Although the data on excretion cited above were from ruminant animals, and the kinetics of urinary excretion of the sulfone in humans have not been studied, these data suggest that urine concentrations of $CPMSO_2$ in humans represent relatively recent exposure; i.e., within the past two weeks. The animal studies suggest that testing of human urine for $CMPSO_2$ should be a useful method for biomonitoring.

d. Analytic Methods for $CPMSO_2$

A total of 274 urine samples were analyzed for $CPMSO_2$. The samples were selected randomly from those collected originally for the analysis of DIMP between December, 1989 and February, 1990. They were stored at -20 degrees C at the CDPHE laboratory, and transferred to the CSU laboratory in a frozen state. Laboratory analyses for $CPMSO_2$ were conducted at CSU between April and August, 1992.

$CPMSO_2$ was isolated and concentrated from human urine samples by Solid Phase Extraction (SPE). Preliminary experiments showed that SPE satisfied the specific analytical requirements for the determination of $CPMSO_2$ in urine. The following method was developed and subsequently used:

A SPE column (C18 BondElut, 6.0 cc) was prepared by rinsing with 2 ml of a 50:50 mixture of acetone:hexane, followed with 2 ml of a 50:50 mixture of acetone:methanol, followed with 3 ml of D.I. water. Two ml of urine sample was mixed with 2 ml of D.I. water was applied to the SPE column. The column was then rinsed with 2 ml of D.I. water followed by 2 ml of 10% methanol/water. The column was then aspirated and dried for 10 minutes. $CPMSO_2$ was eluted from the column with 2 ml of acetone followed with 2 ml of a 50:50 mixture of acetone:hexane. The eluate volume was reduced to 0.2 ml using a nitrogen evaporator and then adjusted to a final volume of 4.0 ml with n-hexane. Extracted samples were analyzed by a Hewlett-Packard Model 5890 series II gas chromatograph equipped with a Ni 63 constant current electron capture detector. Good resolution was obtained with either packed columns or wide-bore capillary columns. The analytic

quantification limit for $CPMSO_2$ was 20 ppb. Concentrations of the analyte which were detectable but not quantifiable between 10 and 20 ppb were reported as <20 ppb.

e. Laboratory Quality Control for $CPMSO_2$

Urine samples to be analyzed for $CPMSO_2$ were extracted and analyzed in 26 sets; each set consisted of between 7-14 samples and 1 quality control urine spiked sample. A positive control urine spiked sample was prepared from a pooled urine sample by adding 300 ng of $CPMSO_2$ to 10 ml of urine to give a 30 ppb concentration. The analytical recoveries of the spiked $CPMSO_2$ for the 26 sets of samples ranged between 71-116%. Reagent blanks were analyzed together with the urine samples; no interference was noted.

f. Confirmatory Laboratory Analyses for $CPMSO_2$

In February, 1994, 16 urine samples were sent to the Centers for Disease Control and Prevention for confirmatory analysis of $CPMSO_2$. These samples included 6 urine samples obtained from persons residing near RMA which were reported to contain $CPMSO_2$ in 1992, 6 negative urine samples from these residents, 3 urine samples spiked at 10 ppb, 20 ppb and 30 ppb, and one control urine. The Centers for Disease Control Laboratory developed a confirmation method using capillary gas chromatography coupled with tandem mass spectroscopy (GC/MS/MS). The laboratory analyzed for the two daughter ions (m/z 111 and 113) that resulted from the two parent ions (m/z 191 and 193, respectively) of $CPMSO_2$. Internal standard solution was added to each extract, the samples were concentrated to approximately 150 *u*L, and 2 *u*L aliquots were injected into the GC/MS/MS.

g. Results

Initial Findings

A total of 274 participants were evaluated for urine $CPMSO_2$. Urine from 121 persons in area 1, 117 persons in area 2, and 36 persons in area 3 was tested in the CSU laboratory in April, 1992. Six of the 238 tested persons from areas 1 and 2 (2.5%) and none of 36 control subjects had detectable concentrations of $CPMSO_2$ in their urine. The method for $CPMSO_2$ had a detection limit of 10 ppb and a quantification limit of 20 ppb. One person had a quantifiable value for $CPMSO_2$ of 20 ppb; five had detectable, but not quantifiable values of the analyte in urine.

Three of 121 persons who resided in area 1, 3 of 117 persons in area 2 and none of 36 persons tested from area 3 had evidence of $CPMSO_2$ in urine when initially tested in 1992. The difference in distribution of $CPMSO_2$ in urine between the exposed and

comparison areas was not statistically significant ($p = 0.43$ by Fisher's exact test).

Demographic information for the 6 persons with initial evidence of $CPMSO_2$ in urine is shown in Table 5. Four of these 6 persons were children less than 15 years of age and two were adults ($p = 0.02$ by Fisher's exact test). The occupations of the potentially exposed adults and parents of the potentially exposed children were examined. No plausible source of current occupational exposure to $CPMSO_2$ was found.

Additional lifestyle variables were examined qualitatively for a possible association with $CPMSO_2$. Two of the 6 persons with initial evidence of $CPMSO_2$ in urine consumed water from private wells, three from municipal supplies and one drank bottled water. Use of a vegetable garden was reported in 3 of the six homes with a potentially $CPMSO_2$ exposed resident. CPMS0 has a half life in soil of 6 months to one year (Cogley and Foy, 1978). Uptake in selected plants has been reported (Guenzi et al., 1979). However, urine samples for $CPMSO_2$ were collected during the winter, minimizing the likelihood that a soil or fresh food pathway was responsible for the exposure. We do not know whether residents canned or froze their summer garden produce.

The likelihood of finding a second exposed person in the same home as a person with initial evidence of $CPMSO_2$ exposure was examined. A total of 8 other persons (spouses, siblings) who resided in 5 of 6 the homes of persons with $CPMSO_2$ in urine had been tested; $CPMSO_2$ was not detected in urine from any of these individuals. Twenty-four other residents of blocks where $CPMSO_2$ was found were tested; none were positive.

The six positive samples were retested in the CSU laboratory in April, 1994 prior to sending them to a second laboratory for confirmatory analyses; two samples were reported positive for $CPMSO_2$ with detectable, non quantifiable concentrations of 10 to 20 ppb (Table 6). The remaining 4 samples were reported as negative. All 6 samples originally reported negative were reported negative on re-analysis. Freshly prepared urine samples spiked at 10, 20 and 30 ppb $CPMSO_2$ were reported positive at 9.3, 18.3 and 27.9 ppb respectively (Table 6).

Confirmatory Analyses

Confirmatory analyses were conducted by the Centers for Disease Control and Prevention Emergency Response Laboratory on the urine extracts prepared in April, 1994 at the CSU laboratory. The analyses were carried out during the week of May 23, 1994, using capillary gas chromatography coupled to tandem mass spectroscopy. This re-analysis took place approximately 51 months since the samples had been collected and 25 months since they had

been initially analyzed in the CSU laboratory. In the interim, the samples had been stored at -20 degrees C at the Colorado Department of Public Health and Environment and -10 degrees C at Colorado State University. The CDC laboratory re-analyzed extracts the 6 urine samples reported positive in 1992, 6 urine samples reported negative for $CPMSO_2$, 3 urine samples spiked at 10 ppb, 20 ppb, and 30 ppb, and one negative control.

The detection limit for the CDC GC/MS/MS analysis was estimated at 0.2 ppb. All three spiked urine samples were positive, showing large signals; the response of the three spiked samples was linear (9.6, 18, 26 ppb). The CDC laboratory confirmed the presence of $CPMSO_2$ at 0.5 ppb in one of the original six positive samples; $CPMSO_2$ was not detected in the other five samples. The positive response was based on the detection of two peaks at m/z 111 (daughter 191) and m/z 113 (daughter 193) at the correct retention time (Table 6).

The single sample reported positive by CDC was a 41 year old male (individual 3 in Table 5) whose urine was reported to contain < 20 ppb when tested in 1992 and when the sample was retested in 1994. He had a private well on his property. Water from the well was used for cooking; he reports not drinking well water.

h. Discussion

The significance of these finding in the persons tested living in the vicinity of the Rocky Mountain Arsenal is unclear for the following reasons:

(1) Although the frequency of detection of $CPMSO_2$ in urine was low, it was found only in persons residing near the RMA (areas 1 and 2). However, only 36 persons in the comparison area were tested for $CPMSO_2$, reducing the power of the finding. Given the low frequency of positive findings for areas 1 and 2, a sample size of 153 persons testing negative in area 3 would have been required for statistical significance at $p<0.05$.

(2) Confirmatory analyses conducted at the Centers for Disease Control, Emergency Response Laboratory provided partial confirmation of the original results. One of 6 samples reported positive by CSU in 1992 was reported to contain 0.5 ppb $CPMSO_2$. Four of the six positive samples contained no detectable $CPMSO_2$ when retested at CSU in 1994. The reasons for the discrepancies may include (a) non-specific positivity and interference on the electron capture gas chromatography; (b) degradation of the analyte over time. The first laboratory analysis was conducted 25 months after initial collection of urine and the second (CDC) 51 months after collection. The samples were stored at -20 degrees C at CDPHE and -10 degrees C at CSU; (c) individual urine samples

were stored in a single container, rather than as multiple aliquots. Therefore, the urine samples were subjected to multiple freeze-thaw cycles prior to analysis at CDC. Despite the partially discrepant results on the positive samples there was complete agreement on the 6 negative samples submitted for confirmation. Further, the quantitation of freshly prepared spiked samples between laboratories was in close agreement.

(3) The source of exposure for the person or persons whose urine was reported to contain $CPMSO_2$ is unknown. As described above, Nitralin was disposed of at RMA and at Sand Creek, a second Superfund site several miles from RMA. Further, $CPMSO_2$ is an obligatory metabolite of chlorobenzene, and may be a metabolite of several pesticides including carbophenothion (trithion), its methyl analogue (methyl trithion), the insecticide chlorfenson (Ovex), and perhaps tetradifon and tetrasul. The presence of $CPMSO_2$ in urine of persons residing near the RMA may indicate exposure to these compounds or may represent exposure to $CPMSO_2$ from the RMA. The prevalence of residues of $CPMSO_2$ in the general population is unknown.

Table 5. Selected Demographic and Environmental Characteristics of Persons with $CPMSO_2$ in Urine. RMA Exposure Study 1989-1990.

Individual	Age	Sex	Race	Area	Water Supply	Garden	House Hold
1	13	Male	White	1	Bottled	No	0/3
2	39	Male	White	1	Municipal	No	None
3	41	Male	Am Ind/ Hisp	1	Well	Yes	0/1
4	14	Female	White	2	Municipal	No	0/2
5	5	Female	Am Ind/ Anglo	2	Well	Yes	0/2
6	9	Female	White	2	Municipal	Yes	0/1

Table 6. Results of Re-analysis and Confirmatory Testing for $CPMSO_2$ in Urine (ppb). RMA Exposure Study 1989-1990.

Sample #	Colorado State University 1992	Colorado State University 1994	Centers for Disease Control 1994
012	< 20	< 20	0.5
024	20.4	< 20	ND
123	< 20	ND	ND
125	< 20	ND	ND
140	< 20	ND	ND
145	< 20	ND	ND
025	ND	ND	ND
026	ND	ND	ND
031	ND	ND	ND
127	ND	ND	ND
304	ND	ND	ND
417	ND	ND	ND
Control	ND	ND	ND
Spike 10 ppb		9.3	9.6
Spike 20 ppb		18.3	18.
Spike 30 ppb		27.9	26.

ND = None Detected

CONCLUSIONS

1. The laboratory method used for DIMP analysis is useful under some matrix conditions, however, the components of urine may have produced interferences reducing specificity or sensitivity for the target analyte. These potential interferences introduced unresolvable uncertainties about the laboratory results and therefore it is concluded that further analyses of these data are not appropriate.

2. Dieldrin was initially reported to be present in the serum of 123/402 (30.6%) of study participants. Dieldrin was subsequently found in the serum of 6 of 102 dieldrin positive study participants and in none of 34 dieldrin negative persons by the laboratory performing quality control analysis for these analytes. Based on the frequency of confirmed positive results for dieldrin, the overall prevalence of serum dieldrin is estimated to be approximately 2.3%. No acute health effects would be anticipated from a body burden of dieldrin at the levels found in this study.

3. There was no evidence found in this study that the presence of dieldrin in serum was related to residence near RMA. Persons with dieldrin in serum were likely to live in the more rural portions of area 3 (OR = 1.8, 95% CI 1.1-2.9), to have been involved in farm or ranch work, or to have had a home garden. The qualitative analysis suggested that exposure to dieldrin contaminated soil might have been responsible for dieldrin detected in serum from study participants.

4. Aldrin was not detected in any of the 444 samples analyzed by the Colorado Department of Public Health and Environment Laboratory at a detection limit of 1 ppb. "Trace" values of aldrin were detected in 2 of 136 samples at Colorado State University during the quality control laboratory cross checking procedure. Since these values were well below the detection limit and neither value could be confirmed, they most likely do not represent true aldrin values.

5. No confirmed evidence of endrin or isodrin in serum from study participants was found.

6. Chlorophenylmethylsulfone was initially detected in urine from 6 of 238 persons residing near the RMA (2.5%) and in none of 36 persons residing in the comparison area. This difference was not statistically significant. Twenty parts per billion $CPMSO_2$, the quantification limit, was initially measured in one sample; five were below the quantification limit. The small number of persons initially positive for $CPMSO_2$ limited the ability to draw conclusions from this study.

7. Four of the 6 samples originally reported positive for $CPMSO_2$ at a detection limit of 10 ppb in 1992 by the CSU laboratory were reported negative when retested in 1994. Two were reported positive below the quantification limit of 20 ppb.

8. Confirmatory analyses for $CPMSO_2$ were conducted at the Centers for Disease Control and Prevention Emergency Response Laboratory on blind coded samples that included the 6 positive samples and 6 negative samples. Their results showed that one of the original 6 positive samples was positive at 0.5 ppb., while all other samples were negative at a detection limit of 0.2 ppb.

9. The reasons for the discrepancies among the two initial and confirmatory analyses are unclear but may include (a) non-specific positivity and interference on the electron capture gas chromatography; (b) degradation of the analyte in urine stored at -10 to - 20 C over 26 months between analyses and multiple freeze-thaw cycles.

10. The analyte $CPMSO_2$ was confirmed in the urine of one person residing near the RMA; the analyte may also have been present in the urine of 5 other persons initially reported positive. The source of any reported $CPMSO_2$ exposure is unknown. The prevalence of residues of $CMPSO_2$ in the general population is also unknown.

RECOMMENDATIONS

The recommendations which appear below are made to ATSDR for their consideration and potential follow up.

1. Urine obtained from persons residing near the RMA during the course of future studies should be tested for $CPMSO_2$ in order to further evaluate the findings of this study. Multiple aliquots of urine should be stored at -70 degrees C until tested.

2. Wells used for domestic consumption at homes where $CPMSO_2$ has been detected in household residents should be tested for CPMS and $CPMSO_2$ to assure that they are free from contamination with these chemicals.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR) 1989. Toxicological Profile for Aldrin/Dieldrin. ATSDR/TP-88/01, May, 1989.

Agency for Toxic Substances and Disease Registry (ATSDR) 1991. Draft Toxicological Profile for Aldrin/Dieldrin. October, 1991.

Agency for Toxic Substances and Disease Registry (ATSDR) 1990. Toxicological Profile for Endrin/Endrin Aldehyde. ATSDR/TP-90/14. December 1990.

Agency for Toxic Substances and Diseases Registry, U.S.P.H.S. and Colorado Department of Public Health and Environment. Final Report: The Rocky Mountain Arsenal Pilot Exposure Study. Part I: Analysis of Exposure to Arsenic and Mercury. ATSDR, Atlanta,GA. September, 1993.

Brown V.K., Hunter, C.G., Richardson, A. 1964. A blood test diagnostic of exposure to aldrin and dieldrin. Br. J. Ind. Med. 21:283-286.

Burse, V.W., Head, S.L., Korver, M.P., McClure, P.C., Donahaue, J.F., and Needham, L.L. Determination of Selected Organochlorine Pesticides and Polychlorinated Biphenyls in Human Serum. J. Anal. Toxicol.14:137-142 (1990).

Burse, V.W., L.L. Needham, C.R. Lapeza, Jr., M.P. Korver, J.A. Liddle, and D.D. Bayse. Evaluation of potential analytical approach for determination of polychlorinated biphenyls in serum; interlaboratory study. J. Assoc. off. Anal. Chem. 66: 956-68 (1983)

Cogley DR and Foy W. Readily available data on 169 compounds associated with operations at Rocky Mountain and Pine Bluff Arsenals. United States Army Medical Research and Development Command, Fort Detrick, Frederick, MD, 1978, AD AO74214.

Colorado Department of Public Health and Environment. Colorado Disease Bulletin. The Rocky Mountain Arsenal Site History and Update. February 24, 1989; 17:4

Curley, A., Jennings, R.W., Mann, H.T., et al., 1970. Measurement of endrin following epidemics of poisoning. Bull. Envir. Contam. Toxicol. 5:24-29.

Davies, D.M., Lewis, I. 1956. Outbreak of food poisoning from bread made of chemically contaminated four. Br. Med. J. 11:393-398.

Environmental Protection Agency (EPA) 1992. Drinking Water Regulations and Health Advisories. Office of Water. Wash., DC. April, 1992.

ESE (Environmental Science and Engineering Inc.). Offpost Operable Unit Endangerment Assessment/Feasibility Study with Applicable or Relevant and Appropriate Requirements. Prepared for the Office of the Program Manager Rocky Mountain Arsenal Contamination Cleanup. March 1989. Draft Final Report Version 2.1, vol I, March, 1989.

ESE (Environmental Science and Engineering). Rocky Mountain Arsenal -Data assessment and analysis for the Offpost Feasibility study with applicable or relevant and appropriate requirements. Denver, CO, Contract # DAAK11-84-DO016 Task 39, 1988.

Guenzi WD, Beard WE, Bowman RA, Olsen SR. Plant Toxicity and Soil Transformation of Soil Incorporated Sulfur Compounds. Final Report. USDA/SEA/ARS Western Region, Colorado-Wyoming Area. Fort Collins, 1979.

Harr JR, Claeys RR, Bone JF, et al. 1970. Dieldrin toxicosis: Rat reproduction. Am. J. Vet. Res. 31:181-189.

Hart, ER. Mammalian toxicological evaluation of DIMP and DPCD (phase 2). Final Report. Litton Bionetics, Inc., Kensington, MD. Contract No. DAMD 17-75-C-5086, 1980.

Hayes, W.J. Jr. 1963. Clinical Handbook on Economic Poisons: Emergency information for treating poisoning. U.S. Dept. of Health, Education, and Welfare, Public Health Service, Communicable Disease Center, Toxicology Section. Atlanta, GA.

Hayes, W.J. Jr. 1982. Pesticides Studied in Man. Williams and Wilkins, Baltimore, MD. p. 228.

Hayes, W.J. 1974. Distribution of dieldrin following a single oral dose. Toxicol. Appl. Pharmacol. 28:485-492.

Hodge, H.C., Boyce, A.M., Deichman, W.B., Kraybill, H.F., 1967. Toxicology and no-effect levels of aldrin and dieldrin. Toxicol. Appl. Pharmacol. 10:613-675.

Jager, K.W. 1970. Aldrin, Dieldrin, Endrin and Telodrin: An Epidemiological and Toxicological Study of Long-Term Occupational Exposure. Elsevier Press. New York City, NY. pp. 121-131.

Joy, R.M. 1983. The chlorinated hydrocarbon insecticides; in Pesticides and Neurologic Diseases. Ecobichon D.J., Joy, R.M., eds. CRC Press. Boca Raton, FL. pp. 91-159.

Loose, L.D., Silkworth, J.B., Charbonneau, T., Blumenstock, F. 1981. Environmental chemical induced macrophage dysfunction. Environ. Health Perspectives. 39:79-91.

Loose, L.D. 1982. Macrophage induction of T-suppressor cells in pesticide-exposed and protozoan-infected mice. Environ. Health Perspectives. 43:89-97.

Manual of Analytical methods for the Analysis of Pesticide Residues in Human and Environmental Samples. R. R. Watts, Ed., U.S. Environmental Protection Agency, Research Triangle Park, NC, 1980, Section 5, A,(1),(a).

Miller TA, Rosenblatt DH, Dacre JC, Cogley DR, Welch JL (eds). Problem definition studies on potential environmental pollutants. III. Toxicology and ecological hazards of benzene, toluene, xylene, and p-chlorophenyl methyl sulfide, sulfoxide, and sulfone at Rocky Mountain Arsenal, Technical Report No. 7604. U.S. Army Bioengineering Research and Development Laboratory, Fort Detrick, MD, 1976.

Oehler DD, Ivie GW. Metabolism of 4-chlorophenyl methyl sulfide and its sulfone analog in cattle and sheep. Arch Environ Contam Toxicol 12:227-233, 1983.

Rowley, D.L., Rab, M.A., Hardjotanojo, W., et al. 1987. Convulsions caused by endrin poisoning in Pakistan. Pediatrics. 79:728-734.

Thake DC, Mays D, Leber D, et al. Mammalian toxicologic evaluation of chlorophenyl methyl sulfide, chlorophenyl methyl sulfoxide and chlorophenyl methyl sulfone. Final report. Contract # DAMD 17-77-C-7038. Battelle Columbus Laboratories, Columbus, OH. 1979.

Treon, J.F., Cleveland, F.P., Cappel, J. 1955. Toxicity of endrin for laboratory animals. Agricultural and Food Chemistry. 3:842-848.

United States (U.S.) Army 1991. Offpost Operable Unit Remedial Investigation. Draft Addendum. Prepared for the Office of the Program Manager Rocky Mountain Arsenal Contamination Cleanup. November 1991.

Van Raalte, H.G.S. 1977. Human experience with dieldrin in perspective. Ecotoxicol. Envir. Safety. 1:203.

AUTHORS AND ACKNOWLEDGEMENTS

Authors

Theodora A. Tsongas, Ph.D.[1] (Principal Investigator)
John S. Reif, D.V.M.[2]
Jane Mitchell, B.S.[1,2]
Thomas J. Keefe, Ph.D.[2]
John D. Tessari, Ph.D.[2]
Linda Metzger, M.S.[1]
Michael P. Wilson, Ph.D.[1]

ATSDR Representation and Coordination

Dr. Robert Amler[3]
Dr. Michael Straight[3]
Debbie M. Monis[3]
Terry Maricle[3]
Susan Baburich[3]
Marcie Edwards[3]

ATSDR Regional Representation

Glenn Tucker, Ph.D.[4]

Scientific Reviewers

Philip J. Landrigan, M.D., M.Sc.[5]
Rafael Moure-Eraso, Ph.D.[6]
Thomas Burke, Ph.D., M.P.H.[7]
David Savitz, Ph.D.[8]

Funding

This study and final report were partially supported by funds from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) trust fund.

Affiliations

1. Disease Control and Environmental Epidemiology Division, Colorado Department of Public Health and Environment, Denver, Colorado.

2. Department of Environmental Health, Colorado State University, Fort Collins, Colorado.

3. Agency for Toxic Substances and Disease Registry, Atlanta, Georgia

4. Agency for Toxic Substances and Disease Registry, Denver Regional Office, Denver Colorado.

5. Mt. Sinai Medical Center, New York, New York.

6. University of Massachusetts, Lowell, Massachusetts.

7. John Hopkins University, Baltimore, Maryland.

8. University of North Carolina, Chapel Hill, North Carolina.

Acknowledgements

The authors would like to express their appreciation to the people whose help, guidance, patience and cooperation made this study possible.

We would especially like to thank Dr. Ellen Mangione, Lane Cook, Susan Miller, Claudia Carmody, Char Butler, Rosemary Novakovich, Yvonne Herman, Dr. Ruben Abril, Clarence Lott, Alan Dunhill, Lee Koleski, Dr. Robert McCurdy, Lee Theilen, Thomas Haddon, and Jeff Edson of the Colorado Department of Public Health and Environment;

Donna Winn and Denise May of the Department of Environmental Health at Colorado State University;

For the use of facilities at Rosemary Street Building we would like to thank the staff of Adams County School District #14 and Commerce City Community Health Services, especially Ronnie Rosenblum and Betty Peppin who made room for us and welcomed us through the winter of 1989-90;

To the people of Commerce City, Brighton, Lochbuie, Irondale, and Henderson without whose participation and great patience we could not have done this study;

To the Mayor and City Manager of Commerce City, the Mayor and Town Council of Lochbuie, the Mayor and City Manager of Brighton, the Adams County Commissioners, the Weld County Commissioners, the Commerce City Police Department, and the Adams County Sheriff's Department for help in getting the field study started;

To Beth Gallegos for her help in arranging public meetings;

To Norm from the Commerce City Beacon and Susan of the Commerce City Sentinel for their continued interest in the study;

Finally, we would like to extend our great thanks and respect for the stalwart and cheerful members of our field staff, census takers, interviewers, and phlebotomists, who braved the weather, long hours, and our stringent specifications to gather the data upon which we depended for this report.

APPENDIX A

Quality Control Data

Colorado Department of Public Health and Environment Laboratory

TABLE A1. Percent recovery for diisopropylmethylphosphonate (DIMP) in spiked samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Set #	Recovery 1	Recovery 2	Replicate Average
1	82.9	81	81.95
2	86.4	81.3	83.85
3	67.1	55.8	61.45
4	87.4	75.8	81.6
5	55.3	59.7	57.5
6	101.5	100	100.75
7	111.2	96.8	104
8	88	98.3	93.15
9	91.8	85.2	88.5
10	77.3	55.3	66.3
11	70.1	73.4	71.75
12	76	86.7	81.35
13	78.4	78.1	78.25
14	70.8	78	74.4
15	82	78.7	80.35
16	---	---	---
17	---	66.6	66.6
18	135.3	92	113.65
19	122.7	90	106.35
20	54.7	38.7	46.7
21	65.3	96.2	80.75
22	76.2	74.9	75.55
N	20	21	
Average	84.02	78.21428	80.70238
Std Dev	20.20006	15.61562	16.24293

Blanks = No Data

Total Number of Samples = 471	---------->	100%
Total Number of Positives = 5	---------->	1.06%
Total Number of Traces = 28	---------->	5.94%
Total Number of BDL'S = 438	---------->	92.99%

FIGURE A1. Percent Recovery for Diisopropylmethylphosphonate (DIMP) in Spiked Samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

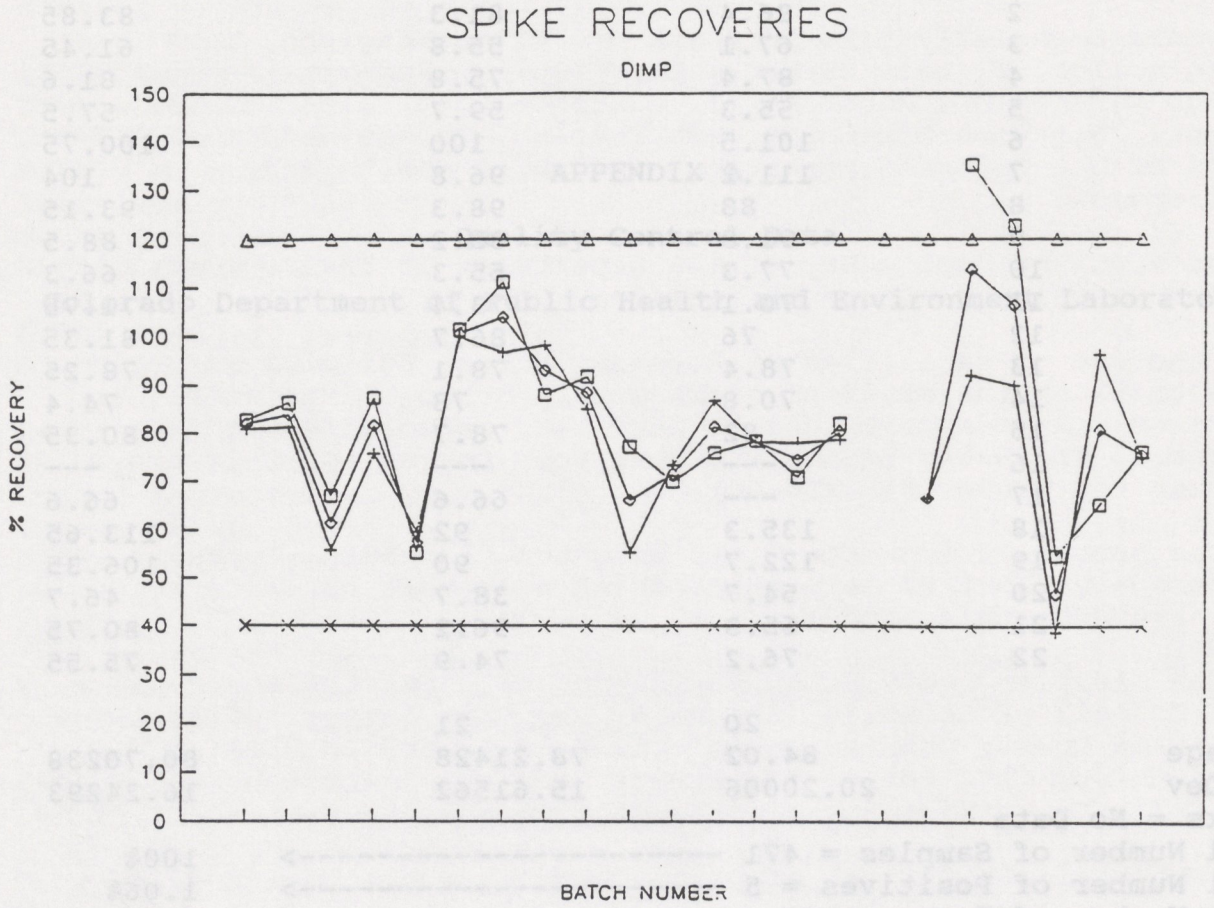


TABLE A2. Aldrin spike recovery data from two pooled serum spikes ("initial" and "duplicate"), the average recovery, and the reagent spike (laboratory fortified blank) recovery. The overall average recovery (22 analytical batches), standard deviations, and control limits are also shown. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

>Batch #	Aldrin Initial	Aldrin Duplicate	Aldrin Average	Aldrin Reagent
1	98.510	79.690	89.100	87.440
2	103.640	72.230	87.935	72.560
3	77.690	91.240	84.465	79.830
4	91.740	87.770	89.755	75.370
5	76.860	84.630	80.745	49.090
6	57.690	52.400	55.045	50.960
7	58.350	66.610	62.480	56.030
8	60.830	60.660	60.745	55.870
9	64.630	57.520	61.075	58.180
10	56.530	61.980	59.255	54.050
11	53.390	55.700	54.545	59.670
12	62.810	50.910	56.860	80.830
13	64.300	67.600	65.950	61.320
14	62.310	47.600	54.955	72.560
15	68.600	70.080	69.340	78.020
16	63.800	55.210	59.505	72.560
17	54.210	52.560	53.385	62.640
18	52.230	51.240	51.735	56.360
19	62.810	49.920	56.365	50.080
20	49.920	52.070	50.995	52.730
21	58.680	60.830	59.755	54.050
22	55.870	54.050	54.960	54.710
DATA AS IS				
Average	66.155	62.841	64.498	63.405
Minimum	49.920	47.600	50.995	49.090
Maximum	103.640	91.240	89.755	87.440
Std.Dev.	14.779	13.084	13.000	11.687
%RSD	22.340	20.820	20.160	18.430
OUTLIERS OUT				
AVERAGE	66.155	62.841	64.498	63.405
STD.DEV.	14.779	13.084	13.000	11.687
%RSD	22.340	20.820	20.160	18.430
AVERAGE		64.498		63.405
STD.DEV.		13.896		11.687
%RSD		21.540		18.430
2X STD. DEV.		27.792		23.374
LWL		36.706		40.031
UWL		92.290		86.779

FIGURE A2. Graphic display of percent recovery of aldrin in Spiked Samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

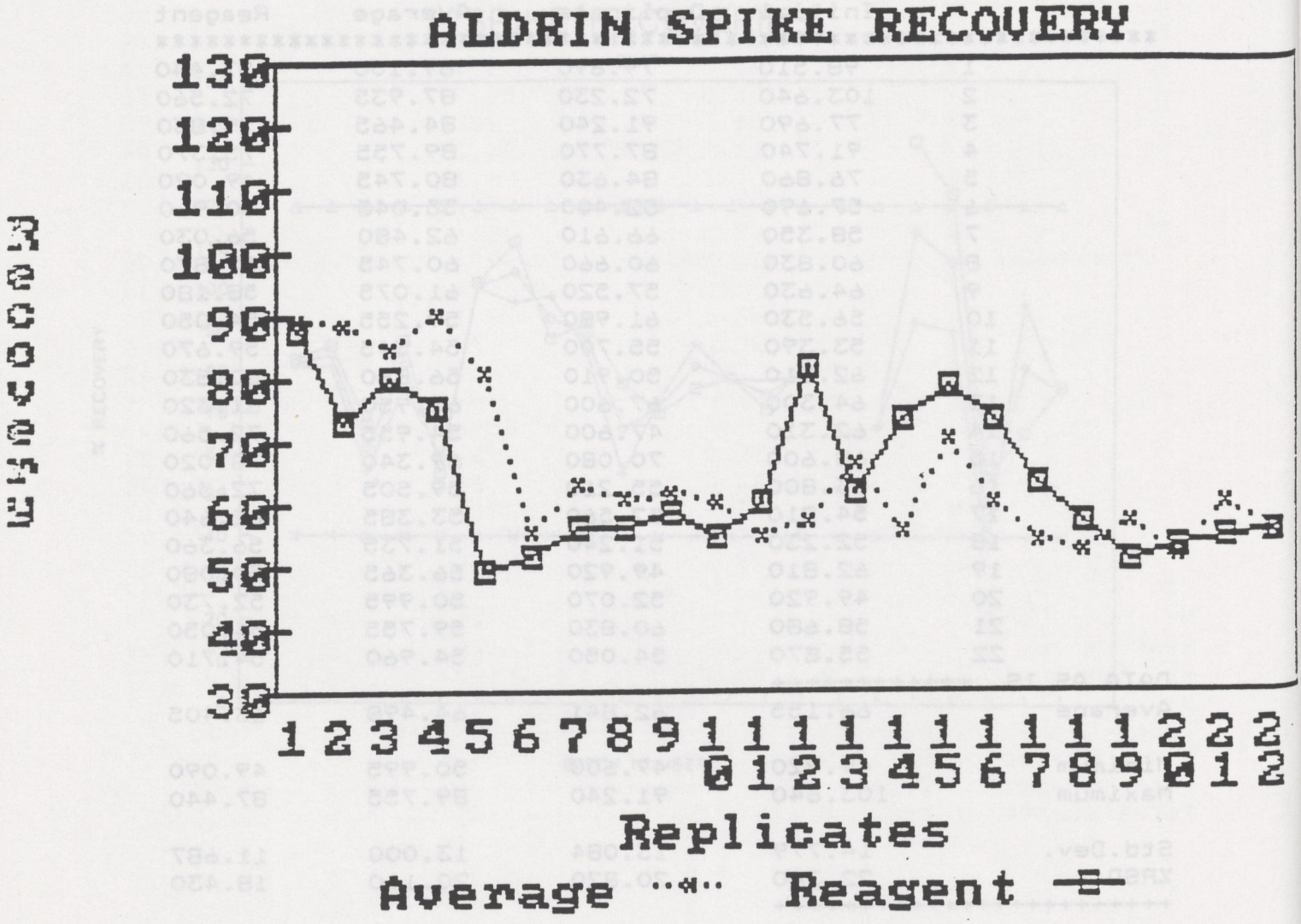


TABLE A3. Endrin spike recovery data from two pooled serum spikes ("initial" and "duplicate"), the average recovery, and the reagent spike (laboratory fortified blank) recovery. The overall average recovery (22 analytical batches), standard deviations, and control limits are also shown. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Batch #	Endrin Initial	Endrin Duplicate	Endrin Average	Endrin Reagent
1	169.410	137.840	153.625	107.450
2	153.920	158.040	155.980	110.000
3	137.650	110.590	124.120	107.450
4	148.430	172.750	160.590	110.000
5	115.690	121.370	118.530	116.200
6	101.370	121.180	111.275	94.120
7	119.610	162.350	140.980	103.140
8	85.490	91.760	88.625	100.000
9	103.530	87.060	95.295	101.760
10	113.920	101.370	107.645	104.510
11	138.820	139.220	139.020	108.820
12	158.240	102.160	130.200	117.450
13	136.860	128.630	132.745	124.710
14	125.690	120.780	123.235	122.550
15	59.220	71.370	65.295	100.590
16	112.550	112.160	112.355	111.570
17	120.000	120.590	120.295	139.610
18	194.120	177.250	185.685	138.430
19	21.180	78.630	49.905	114.120
20	136.270	122.350	129.310	64.120
21	150.000	158.820	154.410	154.900
22	183.140	200.000	191.570	153.730
DATA AS IS **********				
Average	126.596	127.103	126.850	113.874
Minimum	21.180	71.370	49.905	64.120
Maximum	194.120	200.000	191.570	154.900
Std.Dev.	38.983	33.554	34.240	34.250
%RSD	30.790	26.400	27.000	17.640
**********				
OUTLIERS OUT				
AVERAGE	135.240	127.100	130.500	113.870
STD.DEV.	27.879	33.554	30.328	20.090
%RSD	20.620	26.700	23.240	17.640
AVERAGE		130.975		113.874
STD.DEV.		30.882		20.090
%RSD		23.580		17.640
2X STD.DEV.2		61.760		40.180
LWL		69.215		73.694
UWL		192.735		154.054

FIGURE A3. Graphic display of percent recovery of endrin in spiked samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

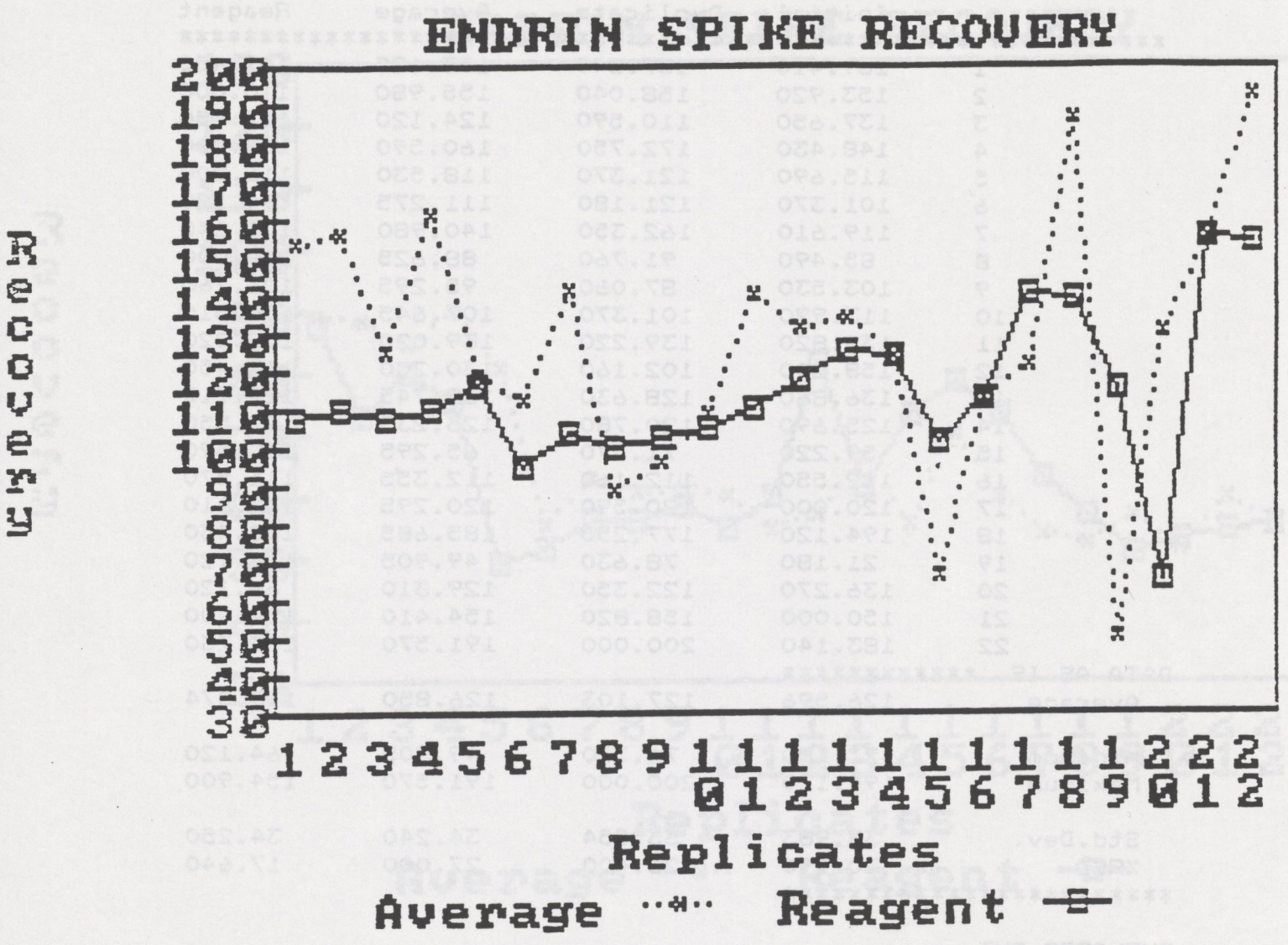


TABLE A4. Isodrin spike recovery data from two pooled serum spikes ("initial" and "duplicate"), the average recovery, and the reagent spike (laboratory fortified blank) recovery. The overall average recovery (22 analytical batches), standard deviations, and control limits are also shown. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Batch #	Isodrin Initial	Isodrin Duplicate	Isodrin Average	Isodrin Reagent
1	108.400	102.730	105.565	79.490
2	104.880	96.880	100.880	72.660
3	81.050	109.370	95.210	83.590
4	113.870	116.020	114.945	75.590
5	88.870	108.200	98.535	62.890
6	89.650	84.380	87.015	68.950
7	71.680	100.590	86.135	78.320
8	87.890	85.940	86.915	76.370
9	89.060	82.620	68.033	79.490
10	80.470	90.430	85.450	72.660
11	79.100	82.810	80.955	66.990
12	100.780	84.770	92.775	67.190
13	81.840	78.710	80.275	68.160
14	81.250	75.200	78.225	71.290
15	80.860	85.350	83.105	89.840
16	82.030	83.790	82.910	84.180
17	75.980	74.020	75.000	71.680
18	77.540	75.590	76.565	52.340
19	70.510	72.070	71.290	62.110
20	69.530	73.630	71.580	73.440
21	82.620	80.660	81.640	77.340
22	89.060	86.720	87.890	76.370
DATA AS IS ++++++++++++				
Average	85.769	87.749	85.950	73.225
Minimum	69.530	72.070	68.033	52.340
Maximum	113.870	116.020	114.945	89.840
Std.Dev.	11.913	12.597	10.999	8.289
%RSD	13.890	14.360	12.710	11.320
**********				
OUTLIERS OUT				
AVERAGE	85.769	87.749	86.555	73.225
STD.DEV.	11.913	12.597	10.999	8.289
%RSD	13.890	14.360	12.710	11.320
AVERAGE		86.759		73.225
STD.DEV.		12.158		8.289
%RSD		13.860		11.320
2X STD.DEV.2		24.316		16.578
LWL		62.443		56.647
UWL		111.075		89.803

FIGURE A4. Graphic display of percent recovery of isodrin in spiked samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

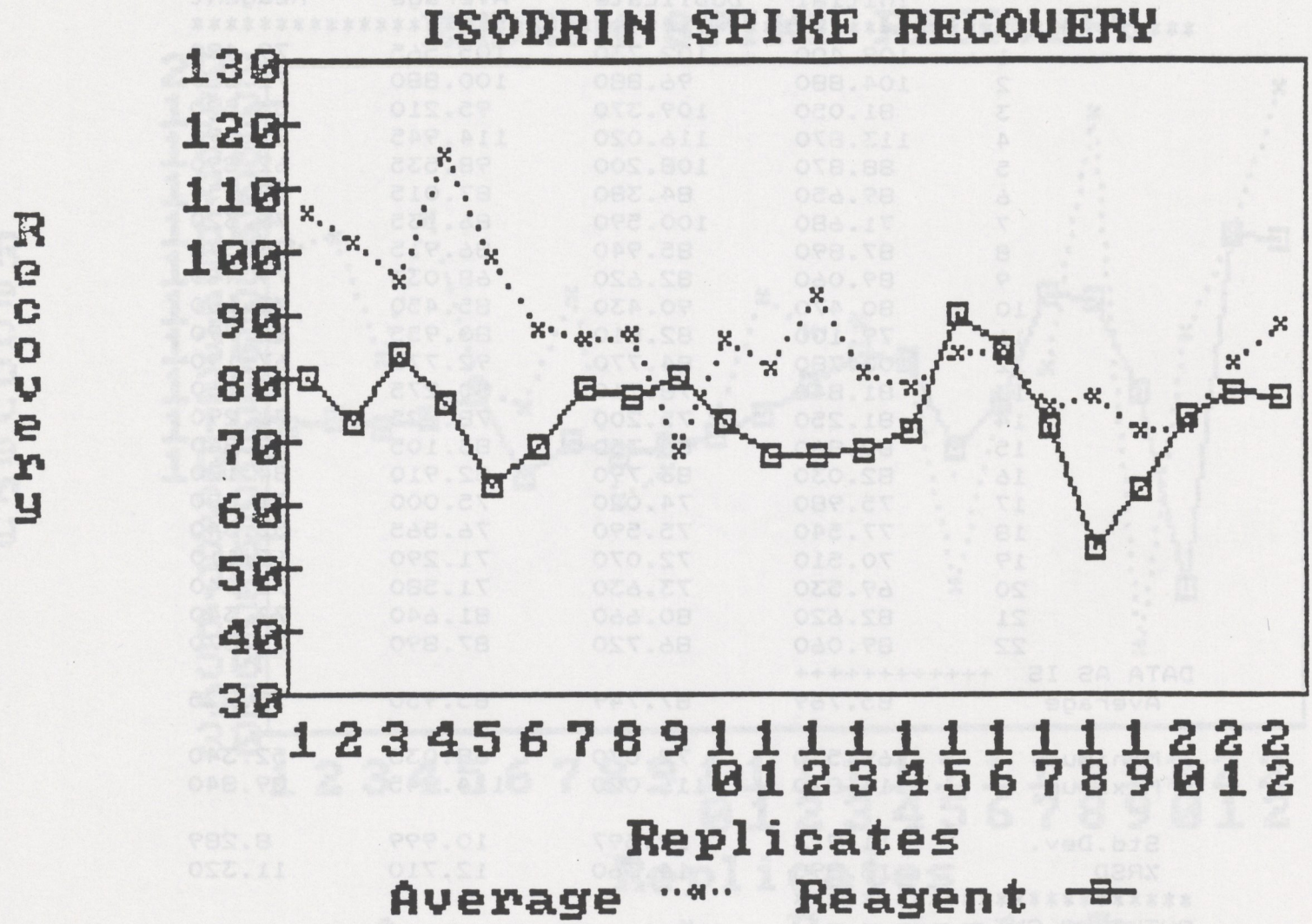


TABLE A5. Dibutyl chlorendate (DBC) spike recovery data from two pooled serum spikes ("initial" and "duplicate"), the average recovery, and the reagent spike (laboratory fortified blank) recovery. The overall average recovery (22 analytical batches), standard deviations, and control limits are also shown. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Batch #	DBC Initial	DBC Duplicate	DBC Average	DBC Reagent
1	108.400	90.000	99.200	97.200
2	97.000	88.400	92.700	122.400
3	75.600	72.600	74.100	89.400
4	89.800	109.800	99.800	107.600
5	94.400	105.600	100.000	79.400
6	86.600	100.400	93.500	85.000
7	91.000	102.200	96.600	92.600
8	86.600	84.800	85.700	102.200
9	105.400	94.000	99.700	96.200
10	94.200	104.800	99.500	100.400
11	91.000	93.000	92.000	87.200
12	94.200	115.600	104.900	102.000
13	96.600	90.000	93.300	89.400
14	102.400	90.200	96.300	97.400
15	81.800	98.600	90.200	99.000
16	83.200	92.400	87.800	87.400
17	89.400	91.000	90.200	91.000
18	86.000	81.600	83.800	77.400
19	85.600	92.800	89.200	110.800
20	86.000	90.600	88.300	77.400
21	65.000	58.000	61.500	97.400
22	99.400	99.400	99.400	95.600
DATA AS IS				
Average	90.436	92.991	91.714	94.745
Minimum	65.000	58.000	61.500	77.400
Maximum	108.400	115.600	104.900	122.400
Std.Dev.	20.090	9.719	12.343	9.658
%RSD	10.750	13.270	10.530	11.490
OUTLIERS OUT				
AVERAGE	90.440	92.991	91.714	94.745
STD.DEV.	9.719	12.343	9.658	10.884
%RSD	10.750	13.270	10.530	11.490
AVERAGE		91.704		94.745
STD.DEV.		11.040		10.884
%RSD		12.040		11.490
2X STD.DEV.2		22.080		21.768
LWL		69.624		72.977
UWL		113.784		116.513

FIGURE A5. Graphic display of percent recovery of dibutyl chlorendate (DBC) in spiked samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

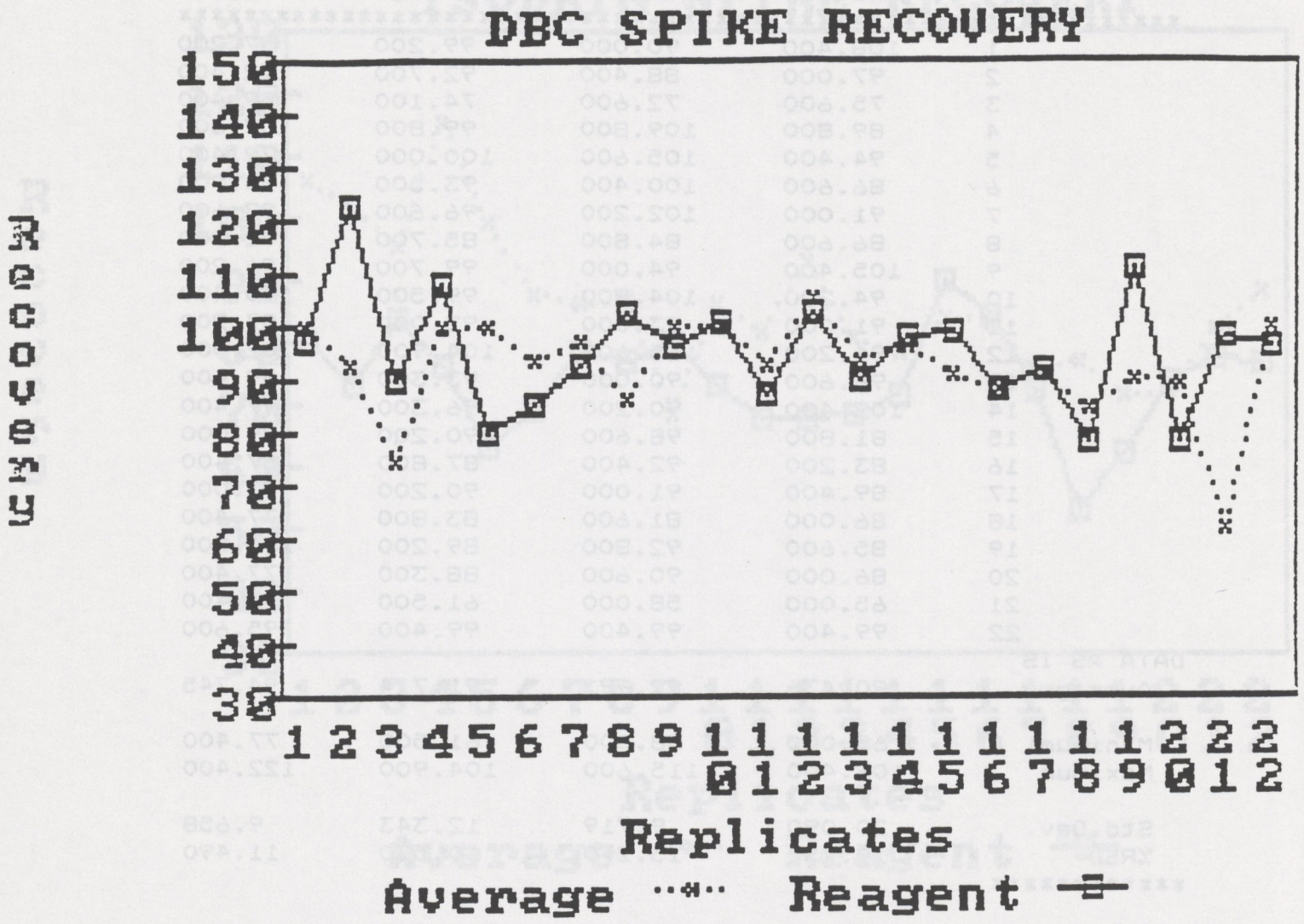


TABLE A6. Dieldrin spike recovery data from two pooled serum spikes ("initial" and "duplicate"), the average recovery, and the reagent spike (laboratory fortified blank) recovery. The overall average recovery (22 analytical batches), standard deviations, and control limits are also shown. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Batch #	Dieldrin Initial	Dieldrin Duplicate	Dieldrin Average	Dieldrin Reagent
**********	**********	**********	**********	**********
1	107.770	76.830	92.300	88.870
2	114.020	143.410	128.715	89.480
3	102.290	105.340	103.815	89.790
4	92.380	99.390	95.885	105.180
5	105.790	108.200	106.995	76.060
6	107.930	286.590	197.260	86.280
7	105.030	104.270	104.650	85.980
8	105.640	85.520	95.580	82.770
9	99.540	91.620	95.580	86.280
10	100.610	106.860	103.735	90.400
11	91.920	99.390	95.655	83.080
12	112.960	102.290	107.625	93.600
13	86.590	82.320	84.455	87.650
14	83.080	85.210	84.145	83.990
15	94.970	93.140	94.055	107.320
16	97.560	100.150	98.855	87.650
17	96.490	94.050	95.270	95.430
18	90.240	89.180	89.710	89.790
19	150.460	147.260	148.860	149.090
20	121.950	83.230	102.590	17.230
21	85.210	79.120	82.165	80.490
22	93.450	90.240	91.845	89.330
DATA AS IS **********				
Average	102.085	106.982	104.534	88.443
Minimum	83.080	76.830	82.165	17.230
Maximum	150.460	286.590	197.260	149.090
Std.Dev.	14.649	43.855	25.411	21.586
%RSD	14.350	40.990	24.310	24.410
**********				
OUTLIERS OUT				
AVERAGE	102.085	98.430	100.120	91.830
STD.DEV.	14.649	18.157	15.087	14.950
%RSD	14.350	18.450	15.070	16.280
AVERAGE		100.300		91.830
STD.DEV.		16.361		14.950
%RSD		16.310		16.280
2X STD.DEV.2		32.722		29.900
LWL		67.578		61.930
UWL		133.022		121.730

FIGURE A6. Graphic display of percent recovery of dieldrin in spiked samples. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

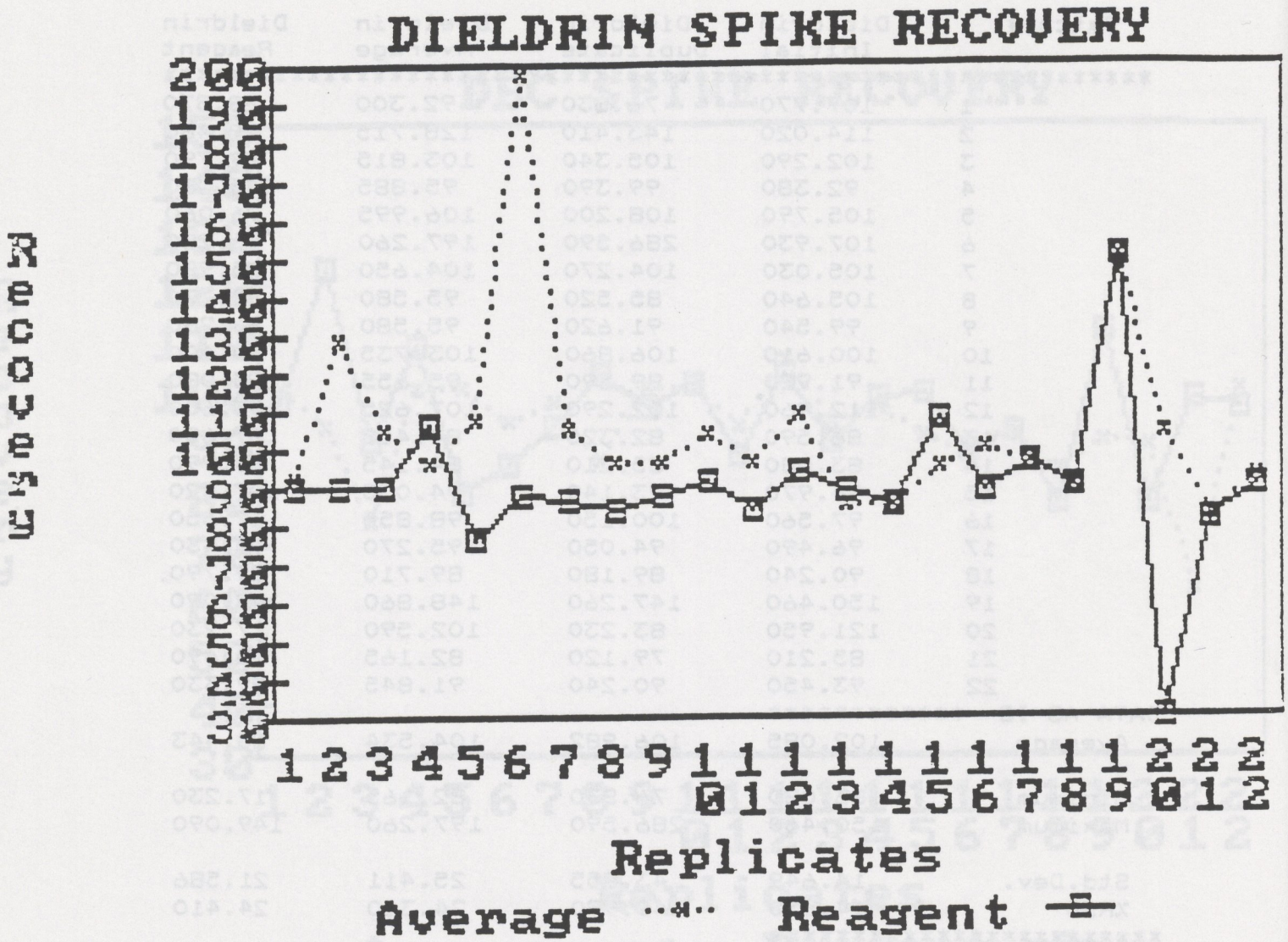


TABLE A7. Results of analysis for dieldrin by set. Colorado Department of Public Health and Environment Laboratory. RMA Exposure Study, 1989-1990.

Set Number	Reporting Date	Number of Samples	Number Quantifiable	Number Trace
1	5/15/90	20	0	2
2	6/5/90	20	1	1
3	7/8/90	20	8	8
4	7/9/90	20	9	0
5	7/11/90	20	11	2
6	9/7/90	20	20	0
7	9/7/90	20	9	7
8	9/10/90	20	5	5
9	9/11/90	20	1	9
10	9/11/90	20	4	11
11	9/26/90	20	2	9
12	9/27/90	20	1	0
13	10/1/90	20	0	1
14	10/1/90	20	1	2
15	10/9/90	20	0	0
16	10/15/90	20	2	0
17	10/22/90	20	9	0
18	10/29/90	20	1	0
19*	10/29/90	20	20	0
20	10/29/90	20	1	0
21**	10/29/90	22	0	0
22**	10/29/90	22	0	0
Total		444	105	57

* Laboratory reported values were qualified due to co-interference in the reagent blank.

** Samples in these sets were noted to contain less than 3.0 ml of serum.

APPENDIX B

Quality Control Data

Colorado State University Laboratory

TABLE B1. Aldrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are tabulated. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

ARSENAL STUDY 1989 CSU
SERUM ~~URINE~~ SPIKE PESTICIDES
SPIKING LEVEL 20 PPB
DL = 1 PPB

ALDRIN

REPLICATE NUMBER	CSU'S (PPB)	MEAN	UCL	UWL	LWL	LCL
1	16.85	17.5526	21.379	20.104	15.0014	13.7258
2	15.86	17.5526	21.379	20.104	15.0014	13.7258
3	17.36	17.5526	21.379	20.104	15.0014	13.7258
4	17.27	17.5526	21.379	20.104	15.0014	13.7258
5	14.71	17.5526	21.379	20.104	15.0014	13.7258
6	17.29	17.5526	21.379	20.104	15.0014	13.7258
7	18.46	17.5526	21.379	20.104	15.0014	13.7258
8	16.81	17.5526	21.379	20.104	15.0014	13.7258
9	18.29	17.5526	21.379	20.104	15.0014	13.7258
10	17.76	17.5526	21.379	20.104	15.0014	13.7258
11	15.95	17.5526	21.379	20.104	15.0014	13.7258
12	17.53	17.5526	21.379	20.104	15.0014	13.7258
13	18.3	17.5526	21.379	20.104	15.0014	13.7258
14	18.96	17.5526	21.379	20.104	15.0014	13.7258
15	18.68	17.5526	21.379	20.104	15.0014	13.7258
16	19.76	17.5526	21.379	20.104	15.0014	13.7258
17	18.88	17.5526	21.379	20.104	15.0014	13.7258
18	15.93	17.5526	21.379	20.104	15.0014	13.7258
19	18.85	17.5526	21.379	20.104	15.0014	13.7258

19 AVG = 17.55263

S = 1.275609

UWL = 20.10385 UCL = 21.37946

LWL= 15.00141 LCL = 13.72581

FIGURE B1. Aldrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are plotted. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

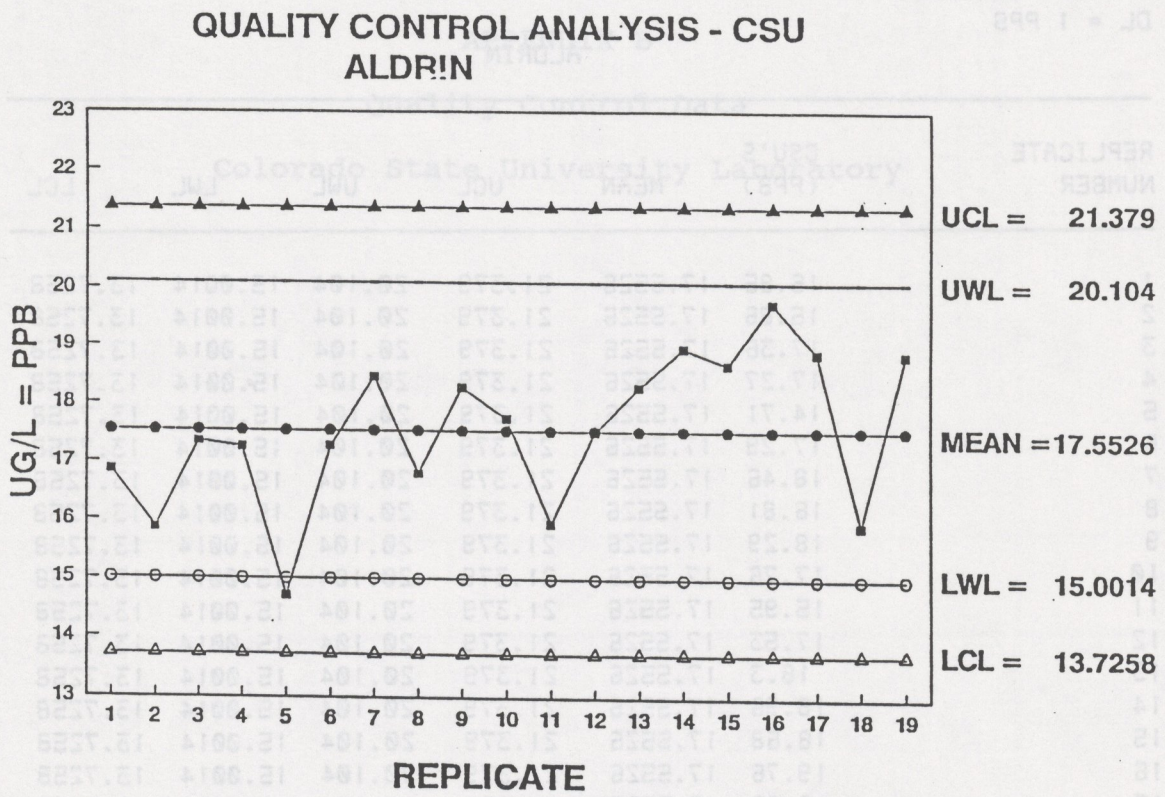


FIGURE B3. Endrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are plotted. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

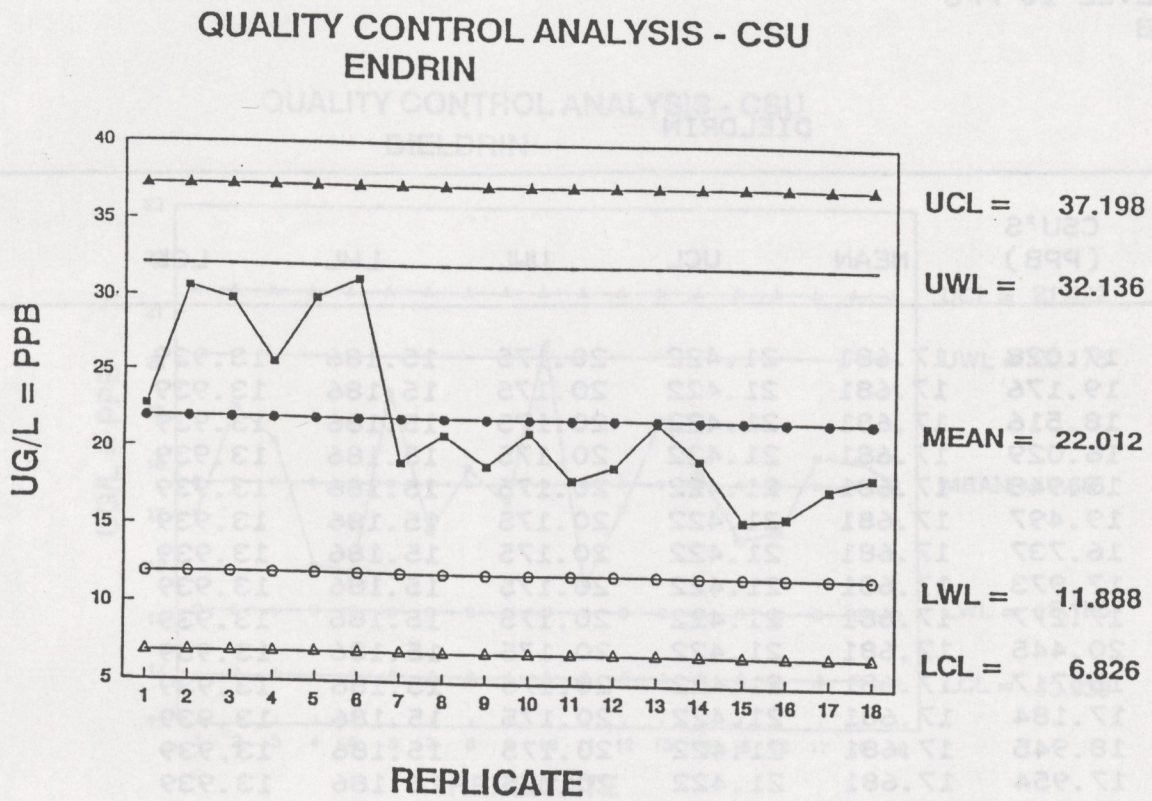


TABLE B2. Dieldrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are tabulated. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

ARSENAL STUDY 1989 CSU
SERUM SPIKE PESTICIDES
SPIKING LEVEL 20 PPB
DL = 1 PPB

DIELDRIN

REPLICATE NUMBER	CSU'S (PPB)	MEAN	UCL	UWL	LWL	LCL
1	17.028	17.681	21.422	20.175	15.186	13.939
2	19.176	17.681	21.422	20.175	15.186	13.939
3	18.516	17.681	21.422	20.175	15.186	13.939
4	16.029	17.681	21.422	20.175	15.186	13.939
5	15.948	17.681	21.422	20.175	15.186	13.939
6	19.497	17.681	21.422	20.175	15.186	13.939
7	16.737	17.681	21.422	20.175	15.186	13.939
8	17.973	17.681	21.422	20.175	15.186	13.939
9	17.277	17.681	21.422	20.175	15.186	13.939
10	20.445	17.681	21.422	20.175	15.186	13.939
11	15.717	17.681	21.422	20.175	15.186	13.939
12	17.184	17.681	21.422	20.175	15.186	13.939
13	18.945	17.681	21.422	20.175	15.186	13.939
14	17.954	17.681	21.422	20.175	15.186	13.939
15	16.596	17.681	21.422	20.175	15.186	13.939
16	16.739	17.681	21.422	20.175	15.186	13.939
17	18.24	17.681	21.422	20.175	15.186	13.939
18	18.158	17.681	21.422	20.175	15.186	13.939
19	17.773	17.681	21.422	20.175	15.186	13.939

19
AVG = 17.68063

S = 1.247267

UWL = 20.17516 UCL = 21.42243

LWL = 15.1861 LCL = 13.93883

FIGURE B2. Dieldrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are plotted. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

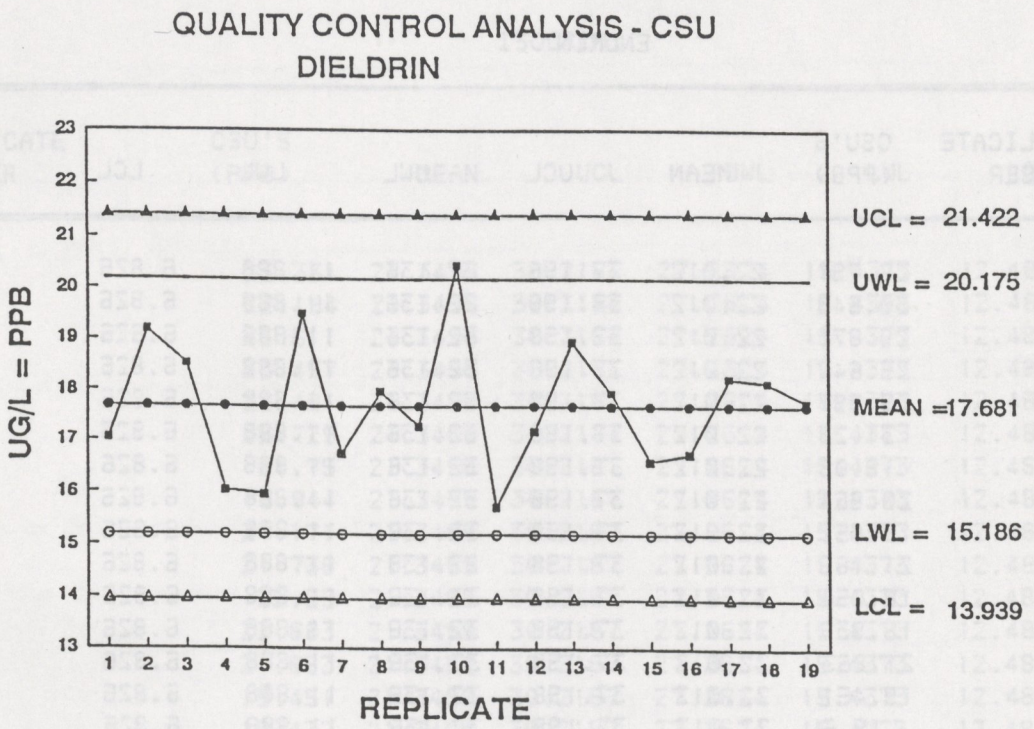


TABLE B3. Endrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are tabulated. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

ARSENAL STUDY 1989 CSU
SERUM SPIKE PESTICIDES
SPIKING LEVEL 20 PPB
DL = 1 PPB

ENDRIN

REPLICATE NUMBER	CSU'S (PPB)	MEAN	UCL	UWL	LWL	LCL
1	22.791	22.012	37.198	32.136	11.888	6.826
2	30.648	22.012	37.198	32.136	11.888	6.826
3	29.871	22.012	37.198	32.136	11.888	6.826
4	25.647	22.012	37.198	32.136	11.888	6.826
5	29.997	22.012	37.198	32.136	11.888	6.826
6	31.23	22.012	37.198	32.136	11.888	6.826
7	19.08	22.012	37.198	32.136	11.888	6.826
8	20.964	22.012	37.198	32.136	11.888	6.826
9	18.951	22.012	37.198	32.136	11.888	6.826
10	21.189	22.012	37.198	32.136	11.888	6.826
11	18.054	22.012	37.198	32.136	11.888	6.826
12	18.939	22.012	37.198	32.136	11.888	6.826
13	21.863	22.012	37.198	32.136	11.888	6.826
14	19.451	22.012	37.198	32.136	11.888	6.826
15	15.6	22.012	37.198	32.136	11.888	6.826
16	15.839	22.012	37.198	32.136	11.888	6.826
17	17.635	22.012	37.198	32.136	11.888	6.826
18	18.471	22.012	37.198	32.136	11.888	6.826

Add sets #4 #5 #6

18

AVG = 22.01222

S = 5.062085

UWL = 32.13639 UCL = 37.19848

LWL = 11.88805 LCL = 6.825967

TABLE B4. Isodrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are tabulated. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

ARSENAL STUDY 1989 CSU
SERUM SPIKE PESTICIDES
SPIKING LEVEL 20 PPB
DL = 1 PPB

ISODRIN

REPLICATE NUMBER	CSU'S (PPB)	MEAN	UCL	UWL	LWL	LCL
1	23.331	21.3499	30.2187	27.2624	15.4373	12.481
2	22.194	21.3499	30.2187	27.2624	15.4373	12.481
3	26.511	21.3499	30.2187	27.2624	15.4373	12.481
4	23.457	21.3499	30.2187	27.2624	15.4373	12.481
5	25.401	21.3499	30.2187	27.2624	15.4373	12.481
6	25.725	21.3499	30.2187	27.2624	15.4373	12.481
7	21.75	21.3499	30.2187	27.2624	15.4373	12.481
8	19.944	21.3499	30.2187	27.2624	15.4373	12.481
9	24.171	21.3499	30.2187	27.2624	15.4373	12.481
10	21.738	21.3499	30.2187	27.2624	15.4373	12.481
11	22.58	21.3499	30.2187	27.2624	15.4373	12.481
12	22.683	21.3499	30.2187	27.2624	15.4373	12.481
13	21.863	21.3499	30.2187	27.2624	15.4373	12.481
14	19.451	21.3499	30.2187	27.2624	15.4373	12.481
15	18.432	21.3499	30.2187	27.2624	15.4373	12.481
16	17.734	21.3499	30.2187	27.2624	15.4373	12.481
17	18.99	21.3499	30.2187	27.2624	15.4373	12.481
18	18.211	21.3499	30.2187	27.2624	15.4373	12.481
19	16.03	21.3499	30.2187	27.2624	15.4373	12.481
20	16.791	21.3499	30.2187	27.2624	15.4373	12.481

20 AVG = 21.34985

S = 2.956286

UWL = 27.26242 UCL = 30.21871

LWL = 15.43729 LCL = 12.48099

FIGURE B4. Isodrin serum quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are plotted. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

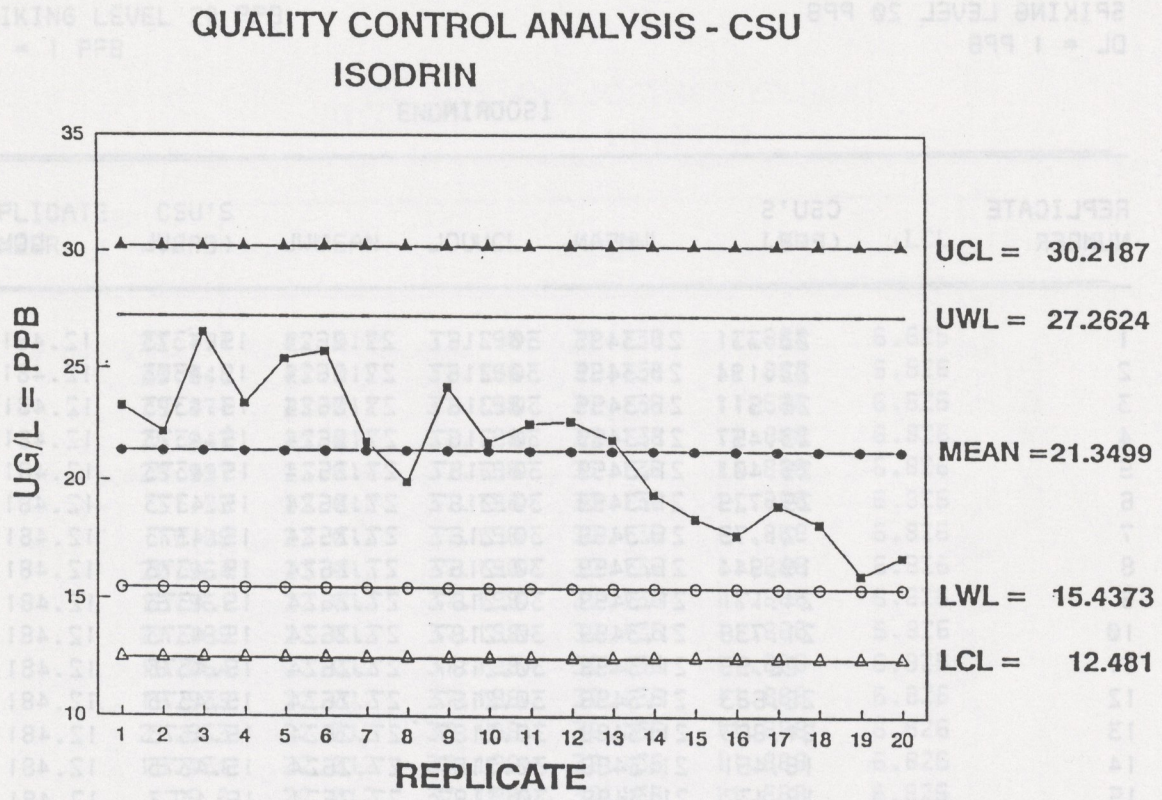


TABLE B5. Mean Percent Recovery for Organochlorine Pesticides in Spiked Samples. Each if the four compounds were spiked at 20 ppb. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

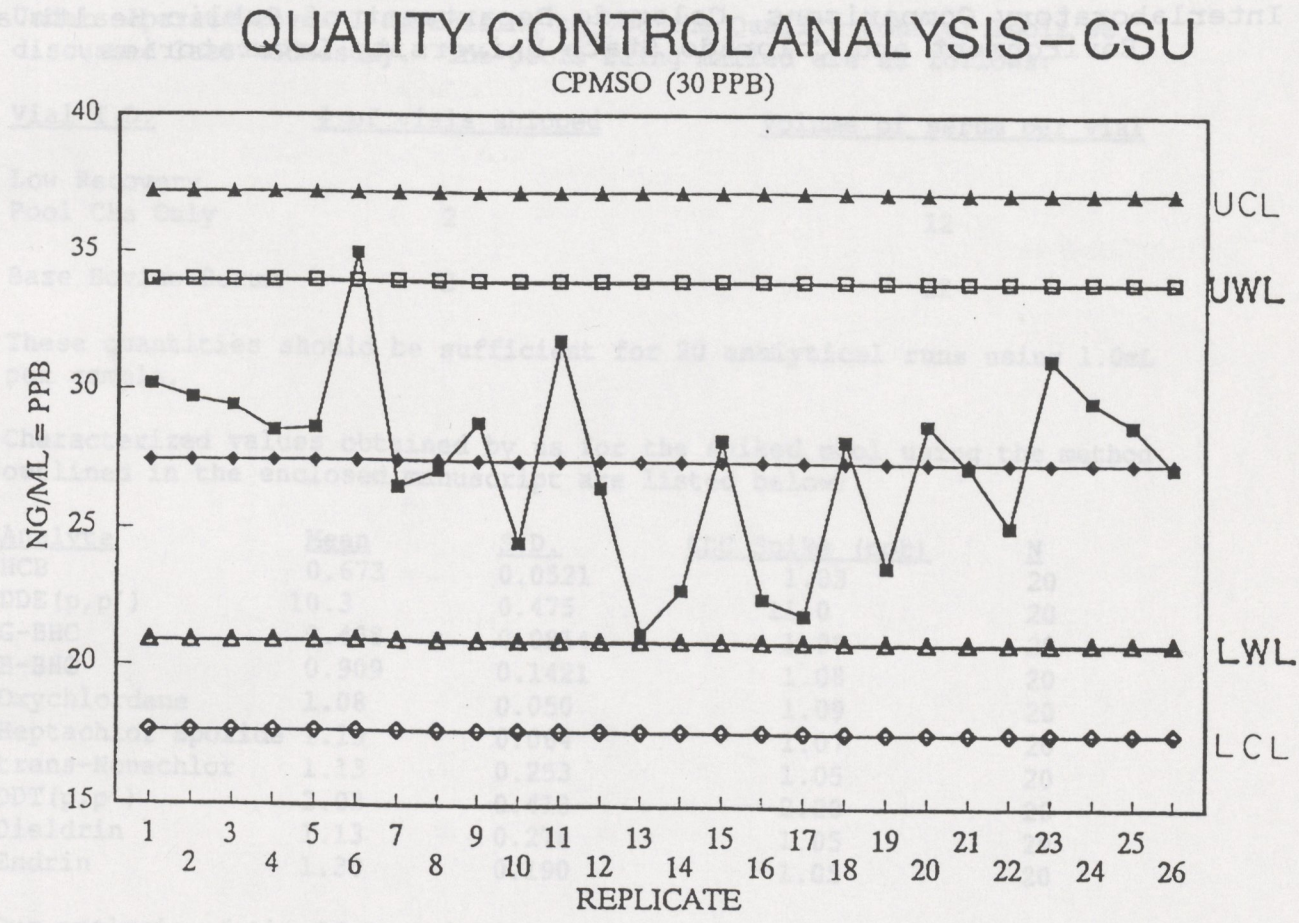
Compound	Percent Recovery Group 1	Group 2
Aldrin	88	97
Isodrin	106	98
Dieldrin	88	102
Endrin	110	89

TABLE B6. Chlorphenylmethylsulfone ($CPMSO_2$) quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are tabulated. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

Replicate #	Replicate ppb	MEAN	UCL	UWL	LCL	LWL
1	30.2	27.438462	37.229343	33.965716	17.64758	20.911207
2	29.7	27.438462	37.229343	33.965716	17.64758	20.911207
3	29.4	27.438462	37.229343	33.965716	17.64758	20.911207
4	28.5	27.438462	37.229343	33.965716	17.64758	20.911207
5	28.6	27.438462	37.229343	33.965716	17.64758	20.911207
6	35	27.438462	37.229343	33.965716	17.64758	20.911207
7	26.5	27.438462	37.229343	33.965716	17.64758	20.911207
8	27.1	27.438462	37.229343	33.965716	17.64758	20.911207
9	28.8	27.438462	37.229343	33.965716	17.64758	20.911207
10	24.5	27.438462	37.229343	33.965716	17.64758	20.911207
11	31.8	27.438462	37.229343	33.965716	17.64758	20.911207
12	26.5	27.438462	37.229343	33.965716	17.64758	20.911207
13	21.2	27.438462	37.229343	33.965716	17.64758	20.911207
14	22.8	27.438462	37.229343	33.965716	17.64758	20.911207
15	28.2	27.438462	37.229343	33.965716	17.64758	20.911207
16	22.5	27.438462	37.229343	33.965716	17.64758	20.911207
17	21.9	27.438462	37.229343	33.965716	17.64758	20.911207
18	28.2	27.438462	37.229343	33.965716	17.64758	20.911207
19	23.7	27.438462	37.229343	33.965716	17.64758	20.911207
20	28.8	27.438462	37.229343	33.965716	17.64758	20.911207
21	27.3	27.438462	37.229343	33.965716	17.64758	20.911207
22	25.2	27.438462	37.229343	33.965716	17.64758	20.911207
23	31.2	27.438462	37.229343	33.965716	17.64758	20.911207
24	29.7	27.438462	37.229343	33.965716	17.64758	20.911207
25	28.8	27.438462	37.229343	33.965716	17.64758	20.911207
26	27.3	27.438462	37.229343	33.965716	17.64758	20.911207

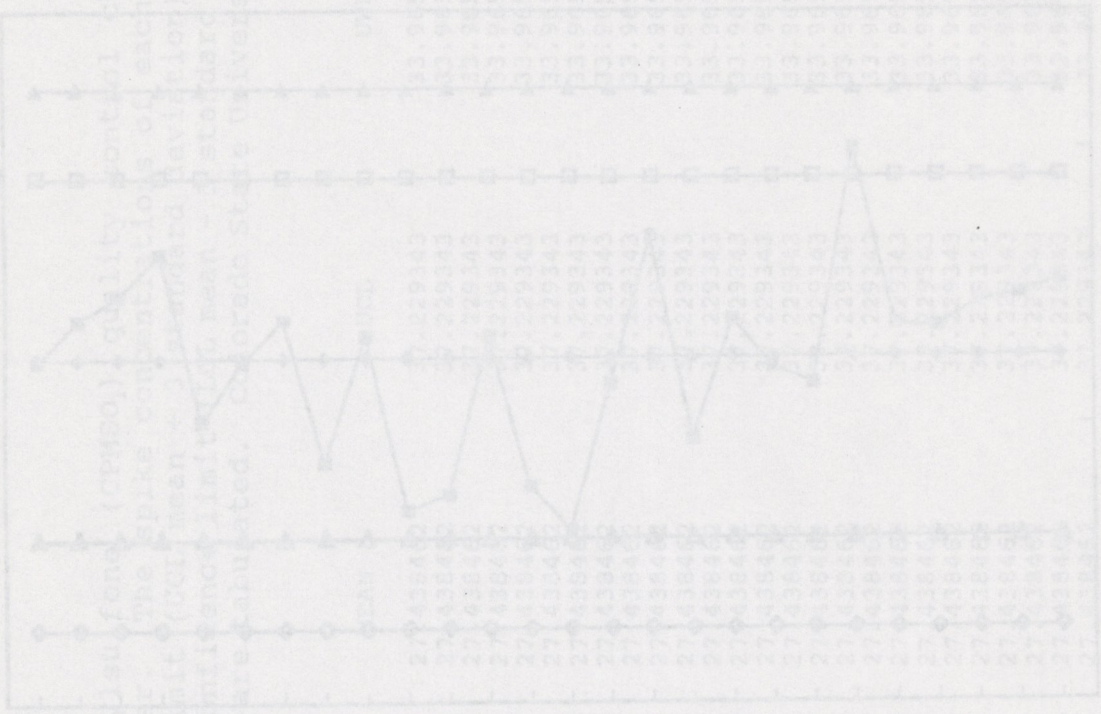
Mean	27.438462	UWL	33.965716	UCL	37.229343
Std. Dev.	3.2636271	LWL	20.911207	LCL	17.64758

FIGURE B6. Chlorphenylmethylsulfone ($CPMSO_2$) quality control check samples, coded numerically as indicated by replicate number. The spike concentrations of each replicate is reported in ppb. The mean and upper confidence limit (UCL mean + 3 standard deviation), upper warning limit (UWL mean + 2 standard deviation), lower confidence limit (LCL mean - 3 standard deviation), lower warning limit (LWL mean - 2 standard deviation) are plotted. Colorado State University Laboratory. RMA Exposure Study, 1989-1990.



APPENDIX C

Interlaboratory Comparisons, Colorado Department of Public Health and Environment and Colorado State University Laboratories



DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
Atlanta GA 30333

Mailstop F17
(404) 488-4176
September 24, 1990

Dr. John Tessari
Colorado Pesticide Center
Colorado State University
Physiology Building Room 127
Fort Collins, Colorado 80523

Dear John:

Under separate cover I am mailing to you the Quality Control Pools we discussed last Wednesday. The pools being mailed are as follows:

Vial I.D.	# of vials shipped	Volume of serum per vial
Low Recovery Pool CHs Only	2	12
Base Bovine Serum	2	12

These quantities should be sufficient for 20 analytical runs using 1.0mL per sample.

Characterized values obtained by us for the spiked pool using the method outlined in the enclosed manuscript are listed below:

Analyte	Mean	S.D.	CDC Spike (ppb)	N
HCB	0.673	0.0521	1.03	20
DDE(p,p')	10.3	0.475	11.0	20
G-BHC	0.488	0.0814	1.08	20
B-BHC	0.909	0.1421	1.08	20
Oxychlordane	1.08	0.050	1.09	20
Heptachlor Epoxide	1.19	0.064	1.07	20
trans-Nonachlor	1.13	0.253	1.05	20
DDT(p,p')	2.03	0.413	2.20	20
Dieldrin	1.13	0.278	1.05	20
Endrin	1.30	0.190	1.05	20

Our analysis of the QC Pool labeled Base Bovine Serum did not detect measureable amounts of the above analytes.

Although the pool does not contain all of the analytes with which your study is concerned, hopefully the ones that it does contain are at a

sufficient concentration to provide you the type of data you will need inorder to make some decisions regarding future analysis of your remaining specimens.

Sincerely yours,

Virlyn W. Burse

Virlyn W. Burse
Supervisory Research Chemist
Toxicology Branch
Division of Environmental Health
Laboratory Sciences
Center for Environmental Health
and Injury Control

2 enclosures

TABLE C1. Results of quality control analyses for dieldrin and endrin by the Colorado Department of Public Health and Environment Laboratory and the Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

Sample Number	CDC*		CDPHE		CSU	
	Dieldrin	Endrin	Dieldrin	Endrin	Dieldrin	Endrin
1	Neg	Neg	Neg	Neg	Neg	Neg
2	Neg	Neg	Neg	Neg	Neg	Neg
3	Neg	Neg	Neg	Neg	Neg	Neg
4	1.13	1.30	2.32	2.01	1.51	1.37
5	1.13	1.30	2.11	1.80	1.51	1.45
6	1.13	1.30	2.69	2.05	1.43	1.45

* Centers for Disease Control Reference Sera

TABLE C2. Results of analysis for dieldrin by Colorado Department of Public Health and Environment Laboratory and Colorado State University Laboratory. RMA Exposure Study, 1989-1990.

Colorado Department of Public Health and Environment Laboratory

Colorado State University Laboratory	Positive*	Negative	Total
Pos	6	0	6
Neg	96	34	130
Total	102	34	136

* Includes values reported as "trace".

RECEIVED
OCT 13 2004
STATE PUBLICATIONS
Colorado State Library