SELECTED WATER RESOURCES ABSTRACTS

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W

The Identification and Measurement of Chlorinated Hydrocarbon Pesticides Accumulated from Urban Runoff

Joseph L. Norton

Tulsa City-County Health Department
Tulsa, Oklahoma

B-013-OKLA.

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Oklahoma Water Resources Research Institute

A total of 198 samples of runoff and Arkansas River water were collected in the metropolitan area of Tulsa, Oklahoma, and analyzed for chlorinated hydrocarbon pesticides from March, 1970 through June, 1972. Sampling at fifteen different sites was conducted in three phases: (1) Arkansas River water above and below the metropolitan area, (2) storm drainage basins at maintenance flow, and (3) storm water runoff. The following pesticides have been identified entering the river from drainage basin outfalls at some time during the project: lindane, heptachlor, heptachlor epoxide, aldrin, and dieldrin. A supplementary investigation of heavy metals in storm water runoff was conducted. Lead and chromium were identified entering the Arkansas River from drainage basin outfalls.

17a. Descriptors

chlorinated hydrocarbons - pesticides - heavy metals - urban runoff - lindane - heptachlor - heptachlor epoxide - aldrin - dieldrin - lead - chromium

17b. Identifiers

Tulsa, Oklahoma - Arkansas River

V-A

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NOTE

Project B-013-OKLA. was initially proposed by Dr. Edwin Klehr and Mr. Walter E. Engelken as a joint research project between the University of Oklahoma and the Tulsa City-County Health Department. Shortly after the proposal was funded, Mr. Engelken terminated his employment with the Tulsa City-County Health Department and was replaced by Mr. Joseph L. Norton (M.S., Limnology, Oklahoma State University). Dr. Klehr was active in the project for about one year until his sabbatical departure from the University. He was replaced as principal investigator by Dr. Jimmie Harp, also of the University of Oklahoma. As Dr. Harp's participation was somewhat limited by other commitments, the research reported herein is primarily the effort of Mr. Norton and the staff of the Tulsa City-County Health Department. The guidance of Dr. Klehr and Dr. Harp, and the additional technical assistance provided by OWRRI's personnel at the Oklahoma State University materially aided the project to its successful conclusion.

Marvin T. Edmison, Chairman
Coordinating Committee, OWRRI

THE IDENTIFICATION AND MEASUREMENT OF CHLORINATED HYDROCARBON PESTICIDES ACCUMULATED FROM URBAN RUNOFF

by

Joseph L. Norton

ABSTRACT

A total of 198 samples of runoff and Arkansas River water were collected in the metropolitan area of Tulsa, Oklahoma, and analyzed for chlorinated hydrocarbon pesticides from March, 1970 through June, 1972. Sampling at fifteen different sites was conducted in three phases: (1) Arkansas River water above and below the metropolitan area, (2) storm drainage basins at maintenance flow, and (3) storm water runoff. The following pesticides have been identified entering the river from drainage basin outfalls at some time during the project: lindane, heptachlor, heptachlor epoxide, aldrin, and dieldrin. A supplementary investigation of heavy metals in storm water runoff was conducted. Lead and chromium were identified entering the Arkansas River from drainage basin outfalls.

This report is submitted in fulfillment of a grant from the Oklahoma Water Resources Research Institute, Project No. B-013-OKLA.

LIST OF FIGURES

LIST OF TABLES

SECTION I

CONCLUSIONS

1. Measurable quantities of chlorinated hydrocarbon pesticides are being added to the Arkansas River by the Tulsa metropolitan area. Tributaries found to be contributing chlorinated hydrocarbon pesticides are the Joe Creek drainage basin and the 21st Street drainage basin.

2. Chlorinated hydrocarbon pesticides were found in runoff water most often in the late winter, spring, and early summer. This period of time coincides with the periods of heaviest use of pesticides, highest rainfall, and most runoff.

3. Chlorinated hydrocarbon pesticides were not found in any samples of water being released from Keystone Dam. It must be concluded, therefore, that any pesticide load being borne by the Arkansas and Cimarron Rivers is either being retained in Keystone Reservoir or being diluted below detectable limits.

4. Grab sampling of natural waters for chlorinated hydrocarbon pesticide analysis is not a satisfactory method for monitoring pesticide pollution. Temporal and spatial variability inherent in this type of pollutant precludes description of long term trends in pesticide levels.

5. Lead and chromium were the only heavy metals found during the Phase III sampling period. This should not rule out the occurrence

of other heavy metals. As evidenced by one sample with a high concentration of lead, heavy metal introduction to the river from storm water runoff is probably occurring in high concentration for a relatively short period of time.

SECTION II

RECOMMENDATIONS

1. A method of monitoring long-term changes in pesticide levels in the Arkansas River should be investigated. Such a program would probably be based on routine analysis of tissue from some resident biological organism.

2. Future studies should include consideration of polychlorinated biphenyl compounds and organophosphate pesticides.

3. A monitoring system should be instituted for the detection of heavy metal discharges. This type of monitoring program should provide information on the shock pollutional load of metals imposed on the receiving stream.

4. With the advent of Federal Revenue Sharing Funds, the Tulsa River Lakes Park plan is being revived. This, in view of the observations made on apparent retention of chlorinated hydrocarbon pesticides by Keystone Reservoir, dictates that careful consideration be given a permanent monitoring program for toxic substances entering the Arkansas River from the Tulsa metropolitan area.

SECTION III

INTRODUCTION

The use of chlorinated hydrocarbon pesticides has been widespread in agricultural practices since they became readily available in the middle 1940s. Chlorinated hydrocarbon pesticides have been used extensively in world-wide control of insect pests of all types. In many instances, the long-term residual effect of chlorinated hydrocarbons was considered desirable.

Since 1960, however, the concept of persistence has become the major issue in the justification of chlorinated hydrocarbon pesticide use. While persistence is economically good, it is ecologically detrimental. Effects of the long-term toxic residuals of chlorinated hydrocarbon pesticides has been both reported (Butler, 1969) and dramatized (Carson, 1962). Recently, public awareness and ecological pressure groups have been forcing legislation which will remove the persistent pesticides from household and agricultural use.

While pesticide pollution is a very basic problem, a second, more nebulous problem is facing the ecologist. Large concentrations of population in urban areas have had considerable effect in modifying the surrounding aquatic environment. Much time and effort has been expended to characterize the impact of urbanization of the aquatic environment (American Public Works Association, 1969; AVCO Economic Systems Corporation, 1970). These studies relate the overall problem caused by urbanization and demonstrate the effect of storm water runoff in producing shock pollution loads from accumulated debris.

It is the purpose of this study to incorporate these two areas of interest, chlorinated hydrocarbon pesticide pollution and storm water runoff from urban areas, and characterize the pollution potential from pesticides added to the Arkansas River by runoff from the Tulsa metropolitan area.

SECTION IV

METHODS

PHASE I

The primary objective of the project is to evaluate the chlorinated hydrocarbon pesticide load introduced into the Arkansas River by runoff from the Tulsa area. Primary sampling sites, therefore, were selected at Keystone Dam and the Bixby bridge (Figure 1). These sites provide a background sample of water as it enters Tulsa County from Keystone Reservoir and a measure of added pesticides as the water leaves the Tulsa metropolitan area. A third sample site, at a low water bridge on Joe Creek just above its confluence with the Arkansas River, was chosen to provide insight into possible pesticide contribution from that drainage basin. During Phase I, fifteen sets of samples, a total of 54 samples, were collected and analyzed.

The samples from the Keystone Dam sampling site during Phase I, as were all samples collected there, were void of measurable chlorinated hydrocarbon pesticides residues. This would indicate that pesticides which may be found in the Cimarron or Arkansas Rivers are being retained by the reservoir or are being diluted below detectable limits.

The Bixby samples revealed that certain chlorinated hydrocarbons are being added to the river. During Phase I, which spanned the crop-growing months of the year (March through September, 1970), lindane, heptachlor, heptachlor epoxide, and aldrin were found. Lindane was found at significant levels on two separate occasions, once in April (9.5 ng/l) and once in June (8.3 ng/l). Aldrin was found in May, June,

FIGURE 1

SAMPLING STATIONS

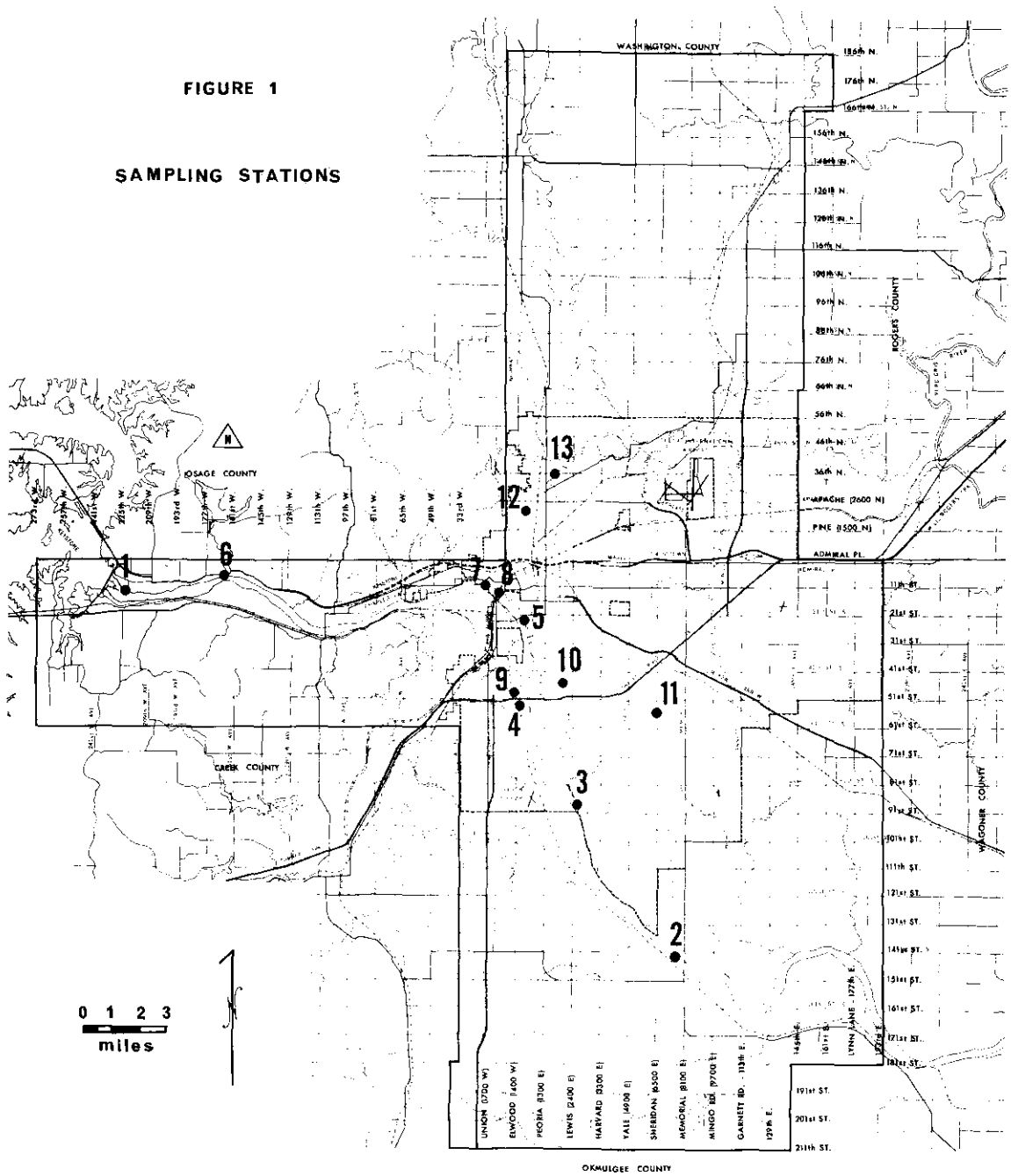

FIGURE 1. Sampling Stations used in the project:
1) Keystone Dam, 2) Bixby Bridge, 3) Joe Creek, 4) 51st Street Bridge, 5) 21st Street Drain, 6) Shell Creek, 7) Indian Avenue Drain, 8) 11th Street Drain, 9) Cherry Creek, 10) Bolewood Acres, 11) Sungate, 12) Greenwood Drain, 13) Dirty Butter Creek.

and August in concentrations from 2.7 ng/l to 7.1 ng/l. Heptachlor and heptachlor epoxide were each found once at concentrations of 8.9 ng/l and 1.3 ng/l, respectively. Attempts were made to correlate the occurrence of these pesticides to rainfall and river flow. The low frequency of occurrence prevents meaningful statistics.

Persistent chlorinated hydrocarbons were also recovered from the Joe Creek sampling site. Both aldrin and heptachlor were found during Phase I. On May 12, 1970, aldrin was found in both the Joe Creek (10.4 ng/l) and Bixby (4.2 ng/l) samples. It would be foolhardy, however, to infer that these two samples represented a single source of aldrin. It is most probable that this occurrence is coincidental.

PHASE II

During Phase II, a total of 126 samples were collected from nine sampling sites with five tributary sites and one river site being added to the Phase I sites. Each tributary received runoff from a well defined drainage basin (AVCO, 1970). The basins sampled, in addition to the new river sampling site at the 51st Street bridge were the 11th Street storm drainage basin, the 21st Street storm drainage basin, Dirty Butter Creek drainage basin, the Shell Creek drainage basin, and the Indian Avenue storm drainage basin.

Pesticides were recovered from only one of the six additional Phase II sampling sites in samples collected between October, 1970, and March, 1972. Dieldrin and aldrin were both recovered from the 21st Street basin; however, the occurrences were so sporadic it is difficult to draw conclusions.

During Phase II, lindane and aldrin were recovered from the Bixby sampling site while the Joe Creek samples were found to contain lindane

on four occasions, aldrin on three occasions and heptachlor and heptachlor epoxide were each recovered once.

The pesticides recovered from all three stations during Phase II were found during the growing season. The only exception to this is the dieldrin recovered during the winter months at the 21st Street storm drain.

PHASE III

The third phase of the project was designed to sample some new drainage basins and to concentrate sampling effort to the initial runoff following significant rainfall. The six basins selected for Phase III (Figure 2) were the Greenwood basin, the 21st Street basin, the 11th Street basin, the Cherry Creek basin, the Bolewood Acres basin, and the Sungate basin (Appendix I). During the sampling period which extended from April to July, 1972, samples were collected on five occasions following rainfall. A total of only eighteen samples were collected, however, because of patchiness of rainfall, or failure of personnel to catch the initial runoff. Only one of the samples was found to have measurable pesticide residue. In April, a small amount of aldrin was found (<1 ng/1) in the 21st Street drain.

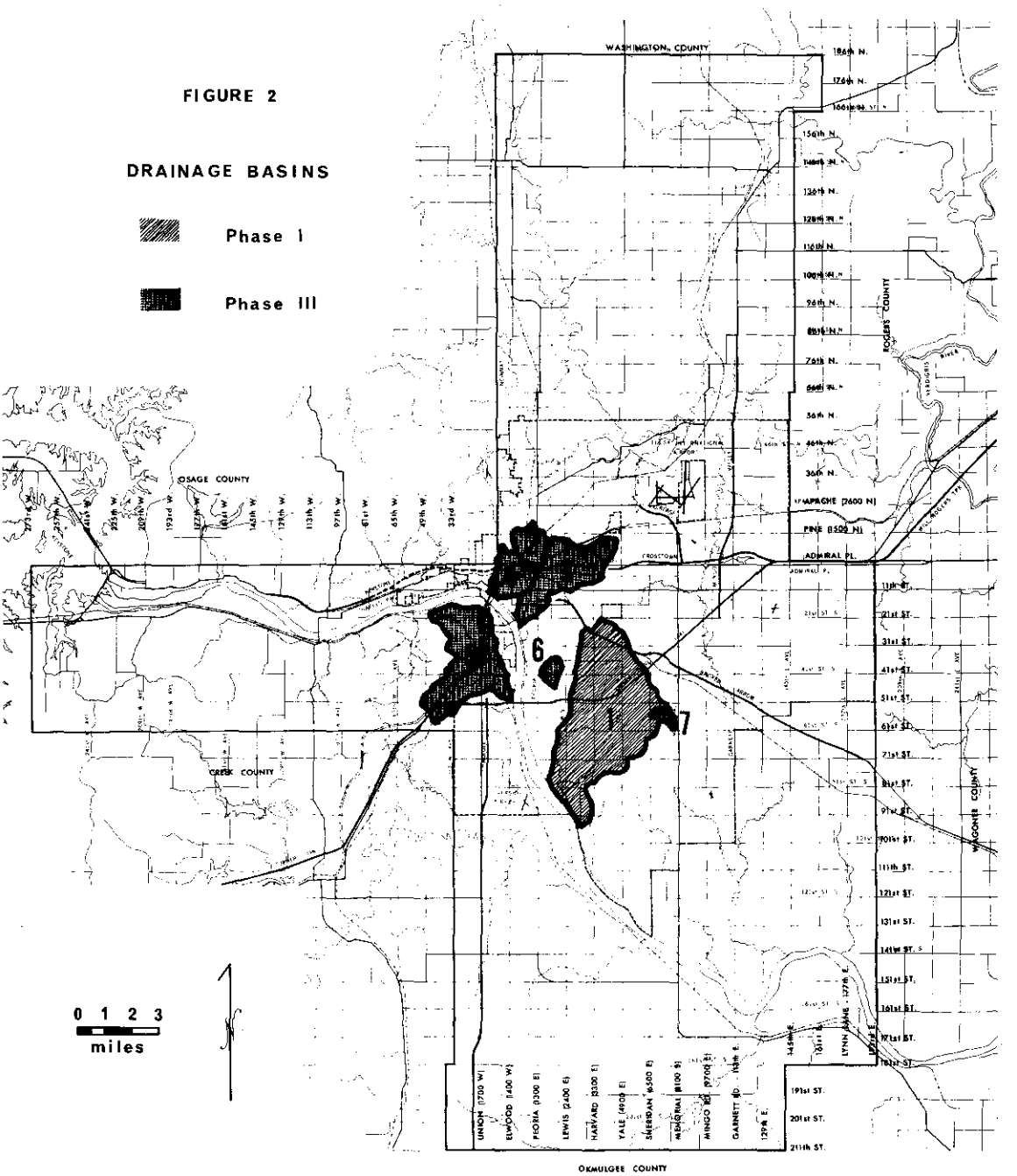

FIGURE 2. Drainage Basins used in Phase I and Phase III:
1) Joe Creek, 2) Greenwood, 3) 21st Street, 4) 11th Street, 5) Cherry Creek, 6) Bolewood Acres, 7) Sungate.

SECTION V

SUPPLEMENTAL INVESTIGATION

Samples were also collected during Phase III to be used in a heavy metals study. Metals selected for the screening study were lead, chromium, manganese, cadmium and zinc. Only two metals, lead and chromium, were found and only one sample contained a significant amount. The 29 ng/l of lead reported from the 11th Street drainage basin may reflect accumulation of the metal from automobile exhausts in the high traffic density area of downtown Tulsa. Small amounts of lead were found in other 11th Street drain samples. The chromium found in two samples probably represents residuals from metal plating wastes which are at times inadvertently introduced into the storm drains.

SECTION VI

ACKNOWLEDGMENTS

This study has been completed through the cooperation of a great many people including Dr. E. H. Klehr and Mr. W. E. Engelken who developed the proposal, and Dr. J. F. Harp who served as advisor for a period of time. I would like to thank Dr. G. W. Prothro, Director; Mr. H. L. Spencer, Laboratory Chief; and the Laboratory Staff of the Tulsa City-County Health Department for the use of equipment and space for the analytical portion of the project. Lastly, I would like to thank Mr. H. R. Jarrell, Oklahoma Water Resources Research Institute, whose assistance and patience throughout this project have been greatly appreciated.

SECTION VII

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APPENDIX I

DESCRIPTION OF MAJOR BASINS SAMPLED

1. Joe Creek Basin - Joe Creek drainage basin totals about 14.7 square miles and consists largely of residential and commercial developments. Housing is mostly of the upper-middle to upper socioeconomic level. About 10% of the total area is used for agricultural purposes. There is a high percentage of impervious cover. The lower portion of the drainage network is largely unimproved and receives a large amount of illegally dumped trash.

2. Greenwood Basin - This drainage area encompasses roughly one square mile of mostly residential use with some commercial land activities. Area structures are old, lying directly north of downtown Tulsa, with extensive railroad holdings in the upper portions of the watershed. The area can be classified as lower socioeconomic, containing the Tulsa Model City's area with at least one-third of the residential structures in poor or dilapidated condition. This is the only basin studied which drains to the Verdigris River.

3. 21st Street Basin - This area is the most heterogeneous test area in terms of land use activities containing a small percentage of older, upper class residences, approximately 80% lower and lower-middle class residences, considerable commercial activities along major traffic arteries and scattered industry, both light and heavy.

Area structures are for the most part, pre-1930. The basin drains into the Arkansas River through the largest underground drainage network in Tulsa County.

4. 11th Street Basin - The 11th Street basin is roughly one and one-third square miles of approximately two-thirds downtown commercial and office zoning and roughly one-third lower and lower-middle socioeconomic class residential with scattered light industrial, warehousing and railroad activities. There is a considerable amount of urban renewal demolition, new construction and highway construction occurring in the area. A very high percentage of the area is covered by impervious material.

5. Cherry Creek Basin - The Cherry Creek basin is the second largest basin studied, covering about six square miles with considerable amounts of open land in the upper reaches. Developed areas are characterized by lower and lower middle class housing and aggregates of commercial and light and heavy industrial activities. Much of the area drainage is accomplished by open drainage channels into Cherry Creek.

6. Bolewood Acres - This study area is characterized by large tracts, expensive four to five bedroom, three bathroom homes, and private swimming pools. Houses in the lower portion of the watershed are on individual septic systems for sewage disposal. The area is unusual in the respect that it is completely devoid of all land activities other than upper-middle and lower-upper class residential. Most of the area is served by an underground storm drainage system. The basin size is roughly 320 acres.

7. Sungate Basin - Land use in this basin is almost entirely upper-middle class residential of brick masonry constructed within the past ten years. Houses range from 1,800 to 3,000 square feet in floor area and are surrounded by well-kept lawns. Drainage is carried by an underground concrete storm sewer system which empties into an open drainage channel. The basin is approximately two-thirds of a square mile in area.

APPENDIX II

PROCEDURES

CHLORINATED HYDROCARBON PESTICIDES

Sample Collection

All samples were collected in one liter glass stoppered glass bottles. The bottles were pre-rinsed with concentrated sulfuric acid and distilled demineralized water. The final rinse was with pesticide grade acetone. Samples were obtained using a grab sample technique without rinsing with the sample water. The samples were then transported to the laboratory and refrigerated until extractions could be made. The samples were usually extracted within twenty-four hours.

Sample Extraction

All glassware used in extraction was rinsed with concentrated sulfuric acid, rinsed three times with distilled demineralized water and finally with pesticide grade acetone. Small pieces of glassware were heated at 400° C. for thirty minutes in a muffle furnace.

The liter sample was placed in a two liter separatory funnel with teflon stopcock and extracted two times with 80 ml of 25% ethyl ether in hexane and one with 80 ml of ethyl ether. The sample container was rinsed with the extraction solvent prior to placing the solvent in the separatory funnel. The combined solvent extracts were passed through a short column of anhydrous sodium sulfate, then reduced to about 10 ml on a boiling-water bath with a Kuderna-Danish evaporator. The concentrated sample was then transferred quantitatively to a 15 ml centrifuge tube with a teflon-lined cap.

Sample Cleanup

All glassware used in sample cleanup was rinsed once with concentrated sulfuric acid, three times with distilled demineralized water and finally with acetone.

Fifteen to twenty grams of activated florisil (activated at 600° C. for 3 1/2 hours) was placed in a 20 x 400 cm glass column with a fritted disc over a one-inch layer of anhydrous sodium sulfate. A second layer of anhydrous sodium sulfate was placed over the florisil.

The column was pre-eluted with 100 ml of hexane and the wash discarded. Just prior to the exposure of the top of the column packing, the sample was added. The column was then successively eluted with 200 ml of 6% ethyl ether in hexane and 200 ml of 15% ethyl ether in hexane. These elutions become separate fractions of the sample. The first elution will contain lindane, aldrin, heptachlor, heptachlor epoxide, DDT, methoxychlor, and chlordane. Separated into the 15% fraction is dieldrin, endrin, and possibly some lindane. The volume of each fraction is reduced to about 10 ml on a water bath and then further reduced to 1/2 ml with a stream of dry filtered air. The sample is then made up to a volume of 1 ml with hexane and refrigerated until analysis.

Sample Analysis

Reasonable positive identification of chlorinated hydrocarbon pesticides can be obtained by corroboration of results from gas chromatographic analysis of the sample on two different types of columns. The packings employed in this project were the relatively non-polar 5% OV-17 on Gas Chrom Q, 60-80 mesh and the more polar 5% QF-1/3%DC-200 on Gas Chrom Q, 60-80 mesh.

In each case, the column used is a six foot, 1/4 inch O.D. glass coil. The columns were cured for two hours at 270° C. with no carrier flow then the temperature was lowered to 225° C. for twelve hours. The carrier gas flow was then regulated to 45 ml/minute, the temperature was raised to 250° C. and conditioned for twenty-four hours. The column was then cooled and connected to the detector.

The instrument used for analysis is a Hewlett Packard Model 5750 gas chromatograph. The detector is a parallel plate electron capture detector with a Ni_{63} source. The column oven was operated at 230° C., the injection port at 250° C. and the detector at 260° C. Quantitation was achieved by absolute calibration methods using both commercial and laboratory prepared standards. Relative retention times (relative to aldrin) were used for identification (Table 1). The carrier and purge gas were 5% methane in Argon. The volume of sample extract injected was approximately 3 microliters.

A P P E N D I X I I

TABLE 1. Relative Retention Times achieved on relatively polar and relatively non-polar columns (relative to aldrin).

Pesticide	OV-17	QF-1/DC-200
Lindane	0.61	0.52
Heptachlor	0.79	0.81
Aldrin	1.00	1.00
Heptachlor epoxide	1.43	1.46
p,p´ DDT	4.00	3.38
Methoxychlor	7.06	5.30
Aldrin (Minutes Absolute)	3.32	3.92

APPENDIX II

TABLE 2. Concentrations (nanograms per liter) of Pesticides Found during Phase I at Bixby.

Sampling Date:	Lindane	Heptachlor	Aldrin	Heptachlor Epoxide	Endrin	Dieldrin	DDT	Methoxychor
3-25-70	--[1]	--	--	--	--	--	--	--
4-10-70	9.5[2]	--	--	--	--	--	--	--
4-23-70	--	--	--	--	--	--	--	--
5-12-70	--	--	4.2	--	--	--	--	--
5-22-70	--	--	--	--	--	--	--	--
6--9-70	8.3	--	2.7	--	--	--	--	--
6-25-70	--	8.9	--	--	--	--	--	--
7--7-70	--	--	--	--	--	--	--	--
7-21-70	--	--	--	--	--	--	--	--
8--7-70	--	--	--	--	--	--	--	--
8-20-70	--	--	7.1	--	--	--	--	--
9--4-70	--	--	--	--	--	--	--	--
9-11-70	--	--	--	--	--	--	--	--
9-21-70	--	--	--	--	--	--	--	--

1 None found
2 Average of two samples

APPENDIX II

TABLE 3. Concentrations (nanograms per liter) of Pesticides Found during Phase I at Joe Creek.

Sampling Date:	Lindane	Heptachlor	Aldrin	Heptachlor Epoxide	Endrin	Dieldrin	DDT	Methoxychor
3-25-70	--[1]	--	--	--	--	--	--	--
4-10-70	--	--	--	--	--	--	--	--
4-23-70	--	--	--	--	--	--	--	--
5-12-70	--	--	10.4	--	--	--	--	--
5-22-70	--	--	--	--	--	--	--	--
6--9-70	--	--	--	--	--	--	--	--
6-25-70	--	--	11.2	--	--	--	--	--
7--7-70	--	--	--	--	--	--	--	--
7-21-70	--	--	--	--	--	--	--	--
8--7-70	--	--	--	--	--	--	--	--
8-20-70	--	--	--	--	--	--	--	--
9--4-70	--	11.0	--	--	--	--	--	--
9-11-70	--	--	--	--	--	--	--	--
9-21-70	--	--	--	--	--	--	--	--

1 None found

APPENDIX II

TABLE 4. Concentrations (nanograms per liter) of Pesticides Found during Phase II at Bixby.

Sampling Date:	Lindane	Heptachlor	Aldrin	Heptachlor Epoxide	Endrin	Dieldrin	Methoxychlor	DDT
10--8-70	--[1]	--	--	--	--	--	--	--
11--5-70	--	--	--	--	--	--	--	--
11-30-70	--	--	--	--	--	--	--	--
12-14-70	--	--	--	--	--	--	--	--
12-21-70	--	--	--	--	--	--	--	--
1--7-71	--	--	--	--	--	--	--	--
1-25-71	--	--	3.1	--	--	--	--	--
2--4-71	--	--	--	--	--	--	--	--
2-16-71	--	--	--	--	--	--	--	--
2-25-71	--	--	--	--	--	--	--	--
3-11-71	--	--	--	--	--	--	--	--
3-17-71	--	--	--	--	--	--	--	--
3-26-71	--	--	--	--	--	--	--	--
4--6-71	--	--	--	--	--	--	--	--
4-20-71	--	--	--	--	--	--	--	--
5--4-71	--	--	--	--	--	--	--	--
5-14-71	--	--	--	--	--	--	--	--
6--1-71	--	--	--	--	--	--	--	--
6-15-71	--	--	--	--	--	--	--	--
6-23-71	--	--	--	--	--	--	--	--
7--9-71	7.9	--	--	--	--	--	--	--
7-23-71	--	--	--	--	--	--	--	--
7-27-71	--	--	--	--	--	--	--	--
8-17-71	--	--	--	--	--	--	--	--
9--7-71	--	--	--	--	--	--	--	--
9-16-71	--	--	--	--	--	--	--	--
9-23-71	--	--	--	--	--	--	--	--
9-30-71	--	--	--	--	--	--	--	--
10-11-71	--	--	--	--	--	--	--	--
11--8-71	--	--	--	--	--	--	--	--
11-12-71	--	--	--	--	--	--	--	--
11-19-71	--	--	--	--	--	--	--	--
11-29-71	--	--	--	--	--	--	--	--
12--8-71	--	--	--	--	--	--	--	--
12-16-71	--	--	--	--	--	--	--	--
12-30-71	--	--	--	--	--	--	--	--
1-17-72	--	--	--	--	--	--	--	--
2--1-72	--	--	--	--	--	--	--	--
2-29-72	--	--	--	--	--	--	--	--
3-13-72	--	--	--	--	--	--	--	--
3-22-72	--	--	--	--	--	--	--	--

1 None found

APPENDIX II

TABLE 5. Concentrations (nanograms per liter) of Pesticides Found during Phase II at Joe Creek.

Sampling Date:	Lindane	Heptachlor	Aldrin	Heptachlor Epoxide	Endrin	Dieldrin	Methoxychlor	DDT
10--8-70	--[1]	--	--	--	--	--	--	--
11--5-70	--	--	--	--	--	--	--	--
11-30-70	--	--	--	--	--	--	--	--
12-14-70	--	1.7	9.2	--	--	--	--	--
12-21-70	--	--	--	--	--	--	--	--
1--7-71	1.7	--	1.4	--	--	--	--	--
1-25-71	--	--	--	--	--	--	--	--
2--4-71	--	--	--	--	--	--	--	--
2-16-71	--	--	--	--	--	--	--	--
2-25-71	--	--	--	--	--	--	--	--
3-11-71	--	--	--	--	--	--	--	--
3-17-71	--	--	--	--	--	--	--	--
3-26-71	--	--	--	--	--	--	--	--
4--6-71	--	--	--	--	--	--	--	--
4-20-71	--	--	--	--	--	--	--	--
5--4-71	--	--	--	--	--	--	--	--
5-14-71	--	--	--	--	--	--	--	--
6--1-71	--	--	--	1.9	--	--	--	--
6-15-71	--	--	--	--	--	--	--	--
6-23-71	3.9	--	--	--	--	--	--	--
7--9-71	--	--	--	--	--	--	--	--
7-23-71	--	--	--	--	--	--	--	--
7-27-71	--	--	--	--	--	--	--	--
8-17-71	--	--	--	--	--	--	--	--
9--7-71	--	--	--	--	--	--	--	--
9-16-71	--	--	--	--	--	--	--	--
9-23-71	--	--	--	--	--	--	--	--
9-30-71	--	--	--	--	--	--	--	--
10-11-71	--	--	--	--	--	--	--	--
11--8-71	--	--	--	--	--	--	--	--
11-12-71	--	--	--	--	--	--	--	--
11-19-71	--	--	--	--	--	--	--	--
11-29-71	7.0	--	--	--	--	--	--	--
12--8-71	--	--	--	--	--	--	--	--
12-16-71	--	--	--	--	--	--	--	--
12-30-71	--	--	--	--	--	--	--	--
1-17-72	--	--	--	--	--	--	--	--
2--1-72	0.1	--	0.4	--	--	--	--	--
2-29-72	--	--	--	--	--	--	--	--
3-13-72	--	--	--	--	--	--	--	--
3-22-72	--	--	--	--	--	--	--	--

[1] None found

APPENDIX II

TABLE 5. Concentrations (nanograms per liter) of Pesticides Found during Phase II at Joe Creek.

Sampling Date:	Lindane	Heptachlor	Aldrin	Heptachlor Epoxide	Endrin	Dieldrin	Methoxychlor	DDT
10--8-70	--[1]	--	--	--	--	--	--	--
11--5-70	--	--	--	--	--	--	--	--
11-30-70	--	--	--	--	--	--	--	--
12-14-70	--	1.7	9.2	--	--	--	--	--
12-21-70	--	--	--	--	--	--	--	--
1--7-71	1.7	--	1.4	--	--	--	--	--
1-25-71	--	--	--	--	--	--	--	--
2--4-71	--	--	--	--	--	--	--	--
2-16-71	--	--	--	--	--	--	--	--
2-25-71	--	--	--	--	--	--	--	--
3-11-71	--	--	--	--	--	--	--	--
3-17-71	--	--	--	--	--	--	--	--
3-26-71	--	--	--	--	--	--	--	--
4--6-71	--	--	--	--	--	--	--	--
4-20-71	--	--	--	--	--	--	--	--
5--4-71	--	--	--	--	--	--	--	--
5-14-71	--	--	--	--	--	--	--	--
6--1-71	--	--	--	1.9	--	--	--	--
6-15-71	--	--	--	--	--	--	--	--
6-23-71	3.9	--	--	--	--	--	--	--
7--9-71	--	--	--	--	--	--	--	--
7-23-71	--	--	--	--	--	--	--	--
7-27-71	--	--	--	--	--	--	--	--
8-17-71	--	--	--	--	--	--	--	--
9--7-71	--	--	--	--	--	--	--	--
9-16-71	--	--	--	--	--	--	--	--
9-23-71	--	--	--	--	--	--	--	--
9-30-71	--	--	--	--	--	--	--	--
10-11-71	--	--	--	--	--	--	--	--
11--8-71	--	--	--	--	--	--	--	--
11-12-71	--	--	--	--	--	--	--	--
11-19-71	--	--	--	--	--	--	--	--
11-29-71	7.0	--	--	--	--	--	--	--
12--8-71	--	--	--	--	--	--	--	--
12-16-71	--	--	--	--	--	--	--	--
12-30-71	--	--	--	--	--	--	--	--
1-17-72	--	--	--	--	--	--	--	--
2--1-72	0.1	--	0.4	--	--	--	--	--
2-29-72	--	--	--	--	--	--	--	--
3-13-72	--	--	--	--	--	--	--	--
3-22-72	--	--	--	--	--	--	--	--

1 None found

APPENDIX II

TABLE 6. Concentrations (nanograms per liter) of Pesticides Found during Phase II at the 21st Street drain.

	SAMPLE DATE					
	5-4-71	9-23-71	11-12-71	1-17-72	2-29-72	3-22-72
Lindane	--[1]	--	--	--	--	--
Heptachlor	--	--	--	--	--	--
Aldrin	3.7	--	--	--	--	--
Heptachlor Epoxide	--	--	--	--	--	--
Endrin	--	--	--	--	--	--
Dieldrin	--	--	2.1	1.9	--	--
Methoxychlor	--	--	--	--	--	--
DDT	--	--	--	--	--	--

1 None found (--)

APPENDIX II

TABLE 7. Concentrations (nanograms per liter) of Pesticides Found during Phase III at the 21st Street drain.

	SAMPLE DATE				
	4-12-72	4-19-72	4-27-72	5-7-72	6-19-72
Lindane	--[1]	--	--	--	--
Heptachlor	--	--	--	--	--
Aldrin	--	--	0.9	--	--
Heptachlor Epoxide	--	--	--	--	--
Endrin	--	--	--	--	--
Dieldrin	--	--	--	--	--
Methoxychlor	--	--	--	--	--
DDT	--	--	--	--	--

1 None found (--)

APPENDIX III

PROCEDURES

HEAVY METALS

Sample Collection

Polypropylene bottles (500 ml) were used for the collection of samples to be analyzed for heavy metals. The bottles were washed with chromic acid and rinsed three times with distilled, demineralized water. Grab sampling techniques were used to obtain the sample and 5 ml of concentrated hydrochloric acid was used to preserve the sample until analyses. Blanks were prepared for each sample set from distilled, demineralized water. The samples were stored and analyzed collectively at the end of the Phase III sampling period.

Sample Analysis

Analysis was performed on a Corning Model 240 atomic absorption spectrophotometer. Standard procedures were followed for the analysis of each element. Laboratory prepared standards were used to construct the calibration curves.

A P P E N D I X III

TABLE 1. Concentrations (ng/l) of Lead Found in Runoff Samples

	SAMPLE DATE				
Station	4-12-72	4-16-72	4-27-72	5-7-72	6-19-72
Greenwood	--[1]	*[2]	*	--	--
21st Street	--	--	--	*	--
11th Street	29	*	*	7.4	1.8
Cherry Creek	--	*	*	*	*
Joe Creek	--	*	*	*	--
Bolewood Acres	--	--	--	*	*
Sungate	--	--	*	--	--

1 None found (--)

2 No sample collected or sample unsatisfactory (*)

APPENDIX III

TABLE 2. Concentrations (ng/l) of Chromium Found in Runoff Samples

	SAMPLE DATE				
Station	4-12-72	4-16-72	4-27-72	5-7-72	6-19-72
Greenwood	--[1]	*[2]	*	--	--
21st Street	0.08	--	--	*	--
11th Street	0.17	*	*	--	--
Cherry Creek	--	*	*	*	*
Joe Creek	--	*	*	*	--
Bolewood Acres	--	--	--	*	*
Sungate	--	--	*	--	--

1 None found (--)

2 No sample collected or sample unsatisfactory (*)