Little Sioux River Synthetic Organic Compound Municipal Well Sampling Survey

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ABSTRACT

In May of 1985 the Iowa Department of Water, Air and Waste Management conducted a sampling survey of public water supplies along the Little Sioux River in northwestern Iowa. Twenty-five wells serving twelve public drinking water supplies were sampled. The samples were analyzed for the presence of 64 synthetic organic compounds including 35 commonly used pesticides. Nine of the 25 wells sampled were found to have one or more contaminant(s) present. These nine wells served six public water supplies. Pesticides were the most frequently detected contaminants and there was an inverse relationship between well depth and the appearance of contaminants. Wells finished to the Little Sioux alluvial system appeared to be the most susceptible to contamination. The findings of this survey strongly support previous work by the Department and the Iowa Geological Survey.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support and assistance of the people who have contributed to this project. A number of staff from the Department of Water, Air and Waste Management assisted in the survey. Particularly noteworthy were the efforts of Jim Humeston, who initiated the project; Bob Drustrup, who stood in the rain for three days to collect samples; and, Mike Geringer and John Metcalfe, who have conducted all of the follow-up activities.

In addition, the authors would like to thank Paul Van Dorpe and George Hallberg, Iowa Geological Survey, and Lauren Johnson, University Hygienic Laboratory, for their assistance and insight.

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INTRODUCTION

In May of 1985 personnel from the Iowa Department of Water, Air and Waste Management collected samples from 25 wells serving 12 public water supplies along the Little Sioux River in northwestern Iowa. The samples collected from the wells represented ground-water quality at the well prior to any treatment. The purposes of the survey were:

1) to identify those systems contaminated by synthetic organic compounds (SOC's) including pesticides;

2) to identify, where possible, any apparent patterns of contamination which could be related to local or regional geologic or geographic conditions; and,

3) to assess the accuracy and validity of previous sampling which suggested that there may be systematic deterioration of alluvial aquifer systems across the state.

In 1984/85 the Department conducted a similar statewide sampling survey which found one or more contaminant(s) in 44 percent of the wells sampled.[1] However, the sites selected for inclusion in the 1984/85 survey were not selected at random, rather, because they were believed to be likely candidates for contamination problems. Further, the 1984/85 survey was conducted over a 12 month period while this survey was conducted over a three day period in May. The municipal public water supplies along the Little Sioux River fairly well typify public water supplies statewide in terms of well construction and sources utilized. It was hoped therefore that the Little Sioux River survey would give the Department a better idea of how accurate a picture of ground water contamination the 1984/85 survey provided.

This survey was conducted in cooperation with the U.S. Environmental Protection Agency, through its contract laboratory Southwest Research Institute in San Antonio, Texas, which provided sampling containers and laboratory analytical services for 25 samples.

METHODOLOGY

Water samples were collected from 25 wells at the well head and before any treatment. Those wells served 12 municipal public water supplies along the Little Sioux River in northwestern Iowa (Figure 1). The Little Sioux River was chosen for the reasons listed below.

1) The 1984/85 SOC study[1] conducted by the Iowa Department of Water, Air and Waste Management found that over one-half of the alluvial wells sampled had contaminants present. However, because the sampling sites were not chosen at random it was not clear how representative the findings were.

2) The availability of analytical services for a limited number of samples (25) was insufficient to provide conclusive findings from a statewide sampling program. The Little Sioux River basin is of such a size that at least one well sample could be obtained from each municipal water supply. Therefore, it was felt that a smaller project would yield more useful information.

3) The recent State Water Plan developed by the Iowa Department of Water, Air and Waste Management estimated that over one-half of the water used by municipal and rural water systems was ground water derived from alluvial aquifers. Alluvial aquifers are widely used for municipal water supplies in northwest Iowa, including the Little Sioux River basin.

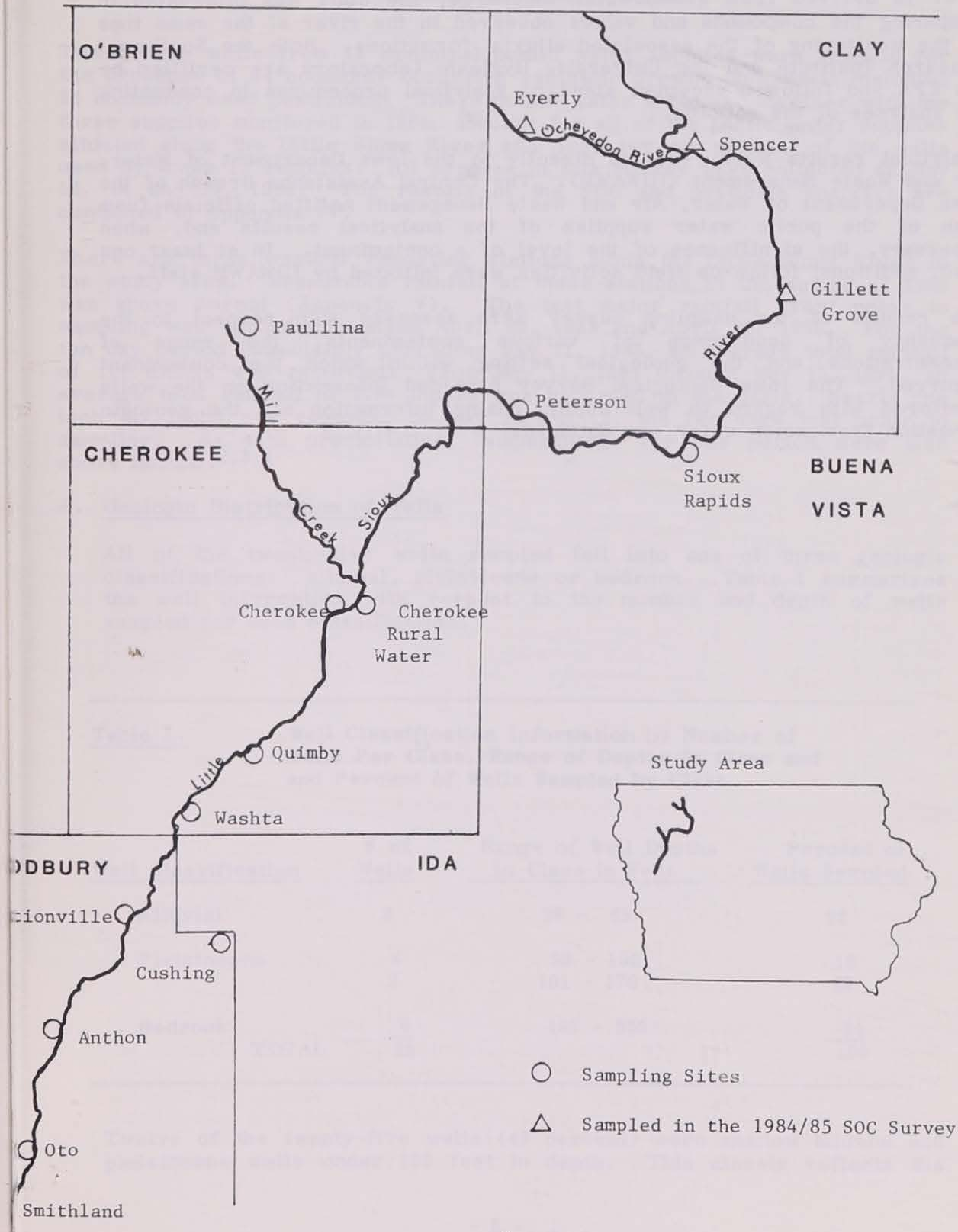
4) Little data on the presence of synthetic organic compounds in ground water was available for northwest Iowa.

There are 15 municipal public water supplies along the Little Sioux River and its major tributaries. Three of these supplies were monitored as part of the 1984/85 SOC survey. The remaining 12 supplies maintain and use 32 wells. Twenty-five of these wells were selected at random to be included in this survey. The random selection of wells could have eliminated one or more supplies from the sampling. In this case it did not and at least one sample was collected from each supply.

Samples were collected by staff from the Program Development Division of the Iowa Department of Water, Air and Waste Management. The samples were collected at the well head prior to treatment. The sampling was conducted over a three day period beginning on May 13, 1985, and ending on May 15, 1985. Samples were collected per instructions from the U.S. Environmental Protection Agency, packed in ice and air freighted over night to the Southwest Research Institute Laboratory, San Antonio, Texas, for analysis.

Three duplicate well samples were submitted to the Southwest Research Institute Laboratory with believable, but false, information as a quality control measure. In addition, two duplicate well samples were collected and sent to the University Hygienic Laboratory (UHL) in Iowa City for analysis. Finally, one surface water sample was collected from the Little Sioux River at Cherokee and sent to the UHL for analysis. Because base flow in the

Figure 1 Sampling Locations



river is derived from groundwater discharge, the staff was interested in comparing the compounds and values observed in the river at the same time as the monitoring of the associated alluvial formations. Both the Southwest Research Institute and the University Hygienic Laboratory are certified by the EPA and followed accepted standard analytical procedures in conducting the analyses of the samples.

Analytical results were reported directly to the Iowa Department of Water, Air and Waste Management (IDWAWM). The Central Assistance Branch of the Iowa Department of Water, Air and Waste Management notified officials from each of the public water supplies of the analytical results and, when necessary, the significance of the level of a contaminant. In at least one case, additional follow-up field activities were initiated by IDWAWM staff.

The results of the sampling survey were assessed with respect to the frequency of occurrence of various contaminants, the range of concentrations and the geological setting within which the contaminant occurred. The Iowa Geological Survey provided information on the wells monitored with regard to well depth, casing information and the geologic formation from which water was obtained.

RESULTS AND DISCUSSION

Twenty-five wells from 12 municipal public water supplies were sampled for the presence of 64 commonly occurring synthetic organic compounds including 35 commonly used pesticides. These public water supplies, together with the three supplies monitored in 1984, account for all of the public water supplies situated along the Little Sioux River and over seventy percent of the wells used by these 15 supplies. All samples in this survey were collected on May 13, 14 and 15, 1985. The results of the SOC and pesticide analyses are contained in Appendix IV.

There are three weather reporting stations along the Little Sioux River in the study area. Measurable rainfall at these stations in the spring of 1985 was above normal (Appendix V). The last major rainfall event prior to sampling was recorded between April 20, 1985 and April 26, 1985. For the ten day period immediately preceding May 11, 1985, an average total rainfall of .11 inches was recorded. From May 11, 1985 through May 15, 1985, an average total rainfall of 2.64 inches was recorded in the basin. Nearly one inch (.7 inch) was recorded on May 11 and 12, the two days just prior to sampling. As with precipitation, temperatures for this period were also above normal.[2,3,4]

A. Geologic Distribution of Wells

All of the twenty-five wells sampled fell into one of three geologic classifications: alluvial, pleistocene or bedrock. Table 1 summarizes the well information with respect to the number and depth of wells sampled for each classification.

Table 1. **Well Classification Information by Number of Wells Per Class, Range of Depths in Class and and Percent of Wells Sampled by Class**

Well Classification	# of Wells	Range of Well Depths in Class in Feet	Percent of Wells Sampled
Alluvial	8	26 - 65	32
Pleistocene	4	50 - 100	16
	7	101 - 379	28
Bedrock	6	187 - 255	24
TOTAL	25		100

Twelve of the twenty-five wells (48 percent) were shallow alluvial and pleistocene wells under 100 feet in depth. This closely reflects the overall distribution of well depth for all municipal water supplies in northwestern Iowa.

B. **Distribution of Contaminants**

One or more of eleven contaminants were found in measurable concentrations in nine wells serving six of the supplies sampled. The contaminants could be divided into three groups: industrial solvents; aromatic hydrocarbons; and, pesticides.

Only one industrial solvent, 1,2-dichloroethane, was found in measurable concentrations in this survey. This organic compound was present in two wells serving two public water supplies. Table 2 shows the range of values detected in the samples. 1,2-dichloroethane is a frequently found contaminant in ground water.[1] Although the authors cannot offer a suggestion as to the possible source of this compound in these two supplies, it should be noted that aromatic hydrocarbons were present in both samples, pesticides in one. 1,2-dichloroethane has been detected in the past in association with high pesticide concentrations at or near agricultural chemical storage and handling facilities.[5] Its presence may also be associated with the spillage or improper disposal of the chemical.

The aromatic hydrocarbons toluene, benzene and ethylbenzene were the second most frequently detected compounds. Aromatics were found in three wells serving three public water supplies. The presence of aromatic hydrocarbons suggest the leakage or spillage of petroleum products in the vicinity of the well. In one case the concentration of benzene was high enough to be of concern with regard to public health. An investigation of the site is currently underway to identify and eliminate the source of contamination. The frequency and range of values for the aromatics found are shown in Table 2.

Table 2. Frequency and Range of Industrial Solvent and Aromatics

	Industrial Solvent	Aromatics		
	1,2-dichloroethane	benzene	toluene	ethylbenzene
# of Wells Contaminated	2	1	1	2
# of Supplies Effected	2	1	1	2
Low Value (ug/l)	0.3	44.0	0.6	0.7
High Value (ug/l)	3.2	44.0	0.6	0.8

The greatest array of compounds and the most frequently detected compounds were pesticides. One or more of five herbicides and two insecticides were found in measurable concentrations. Ten samples collected from seven wells, serving five public water supplies were found to have measurable residuals of pesticides present. The insecticide terbufos (Counter) and the herbicide atrazine were the most frequently detected compounds in the survey being found in seven (28%) and three (12%) of the wells, respectively. The compounds, frequency of occurrence and the range of concentrations are shown in Table 3.

3. Frequency and Range of Pesticides

	Atrazine	Cyanazine (Bladex)	Metribuzin (Sencor)	Terbufos (Counter)	Metolachlor (Dual)	Alachlor (Lasso)	Sulprofos** (Bolstar)
Wells minated	3	2	2	7	2	1	1
Supplies ted	3	2	2	5	2	1	1
Alluvial (8 possible)	3	2	2	6	2	1	1
Pleistocene (11 possible)	0	0	0	1	0	0	0
/alue (ug/l)	2.0	0.26	0.44	0.3	4.5	0.18	1.3
Value)	4.4	0.67	1.1	12.0	7.3	0.18	1.4*
Sioux er	0.57	0.20	ND	ND	0.25	0.21	ND

licate Sample Value
registered for use in Iowa

ND = Not Detected

Work conducted by the Iowa Geological Survey in northeastern Iowa, and the 1984/85 SOC Survey have both suggested that low concentrations of commonly used pesticides are likely to be found in shallow ground water across the state.[6,7] However, this was the first time that the insecticide terbufos had been detected in ground-water monitoring in Iowa. While terbufos is persistent in soil (up to 23 weeks[8]), it is believed to decay rapidly once in solution in water. The University

Hygienic Laboratory in Iowa City has experienced low recovery rates from spiked samples for terbufos (0% at room temperature, 80% at 4°C after ten days).[9] Thus, the appearance of terbufos in ground water is somewhat surprising in view of its relatively rapid decay rate in water.

Residuals of terbufos in samples collected in this survey may reflect a rather fortuitous combination of climatic conditions and sample collection prior to the passage of a sufficient period of time to allow for decay. Terbufos is one of the most widely used corn rootworm insecticides in Iowa. Rootworm insecticides are commonly applied at the time of planting. According to agricultural statistics for the region, 31 percent of the crops in northwestern Iowa were planted by May 5, 1985. By May 12, 1985, 90 percent of the crops were planted. This substantial increase in planted acreage mirrors the period of dry weather between April 30, 1985 and May 11, 1985.[10]

If the detection of terbufos in the ground water is attributable to the rains of May 11 and 12, as the data suggest, then it appears that shallow ground water response to a climatic event in the region is immediate. The exact means by which such a response may occur is not clear, although macropore flow through the unsaturated zone in the soil is the probable cause. Indeed, observations by the Iowa Geological Survey of tile line flow response in northeastern Iowa suggests that such immediate responses in shallow ground water flow systems are possible.[6,13] Regardless of the means of transport, the detection of terbufos in this survey suggests that any pesticide, regardless of decay rate, can leach to the ground water and thus affect water quality, even if only for a short period of time.

Interestingly, the only discrepancy in the analytical results of the duplicate samples involved the reporting of terbufos in one sample. The analytical results for the other pesticides present in that sample were in close agreement. The discrepancy with terbufos likely relates to its rapid decay rate at room temperature conditions. The sample reporting a residual of terbufos was packed in ice, air freighted over night to the lab where it was refrigerated and extracted for analysis four days later. The duplicate, however, could not be air freighted to the lab. Because of transportation time the sample was not received by the lab for 48 hours. Although the sample was initially iced, the sample spent a considerable amount of time at room temperature before the lab received the sample. The lab refrigerated the sample upon receipt and extracted for analysis 13 days later.

The discrepancy in the reporting of terbufos in the duplicate sampling may suggest another possible reason for the lack of positive analyses for terbufos in past studies. Previous studies in Iowa represent the first attempts to assess pesticide residues in ground water. With the number of samples collected, in relation to limited personnel and lab facilities, it has generally not been possible to handle the samples or make prompt extractions for such unstable compounds. Thus, terbufos with its rapid decay rate, may have gone undetected.[9,13]

The surface water sample collected from the Little Sioux River indicated the presence of four of the pesticides detected in ground water.

Atrazine, cyanazine, metolachlor and alachlor were found in the river in concentrations generally lower than those associated with ground-water samples. The generally lower concentrations may be the result of dilution from high stream flow at the time the sample was collected. However, in both the ground water and the surface water samples it is not possible to determine if concentrations were increasing or decreasing at the time the samples were collected.

There was a direct relationship between the appearance of contaminants and well depth. Seventy-five percent of the alluvial wells sampled had one or more contaminant(s) present, while none of the bedrock wells were found to be contaminated (Table 4). All contaminated wells were less than 110 feet deep.

Table 4. Number and Percent of Contaminated Wells by Geologic Classification

Well Class	# of Wells Sampled	Range of Well Depths in Class (feet)	% of Wells Sampled	# of Contaminated Wells in Class	% of Contaminated Wells in Class
Alluvial	8	26 - 65	32	6	75
Pleistocene	11	50 - 379	44	3	37
Bedrock	6	187 - 255	24	0	0

Work conducted by the Iowa Geological Survey in the Big Spring basin of Clayton county has shown that infiltration of soluble fractions of pesticides through the soils, is the major means of transport to shallow ground water.[6] Ag-chemical storage and handling facilities can also contribute pesticide concentrations to shallow ground water, as was demonstrated in the 1984/85 SOC survey. However, previous investigations of these facilities tend to suggest that contamination is within a small well defined geographic area.

The authors believe that the widespread distribution of the contaminants and the concentrations observed suggest that the major source of pesticides in the shallow ground water of the Little Sioux River basin is the result of routine land application of these compounds, and is associated with modern farming practices.

C. **Combined Study Results**

If the data from this survey is combined with the data from the 1984/85 SOC Survey to include all municipal public water supplies along the Little Sioux River, the following observations can be made.

1) Seventeen of the 33 wells sampled (52%) had one or more contaminant(s) detected.

2) These seventeen wells served nine of the 15 municipal public water supplies (60%) monitored.

3) 1,2-dichloroethane was the one common industrial organic detected. The compound was found in measurable concentrations in six wells serving three public water supplies.

4) Pesticides were the most frequently detected contaminants. These compounds were found in 12 of the 33 wells (36%) serving eight of the 15 supplies (53%) monitored.

5) Terbufos and atrazine were the most commonly detected pesticides. Terbufos was found in seven wells serving five supplies and atrazine was detected in five wells serving five supplies.

6) All wells found to have synthetic organic contaminants present in measurable concentrations were less than 110 feet deep.

7) Fourteen of the 16 alluvial wells sampled (88%) had one or more contaminant(s) present.

CONCLUSIONS

In the 1985 Little Sioux River Survey, nine of the 25 wells sampled (36%) serving six of the 12 public water supplies monitored (50%) were found to have one or more synthetic organic contaminant(s) present. Samples were collected at the well prior to any treatment and thus represented ground-water quality, not finished water. The highest number of contaminants, as well as the most frequently detected compounds, were pesticides. Pesticides appeared in seven of 25 wells (28%) sampled serving five (42%) of the public water supplies surveyed. The insecticide terbufos (Counter) and the herbicide atrazine were the most commonly detected compounds. Terbufos was detected in seven wells (28%) serving five (42%) public water supplies. Atrazine was found in three wells (12%) serving three (25%) public water supplies.

Synthetic organic compounds (SOC's), other than pesticides, affected a smaller number of water supply wells. One industrial solvent and three aromatic hydrocarbons were detected in four wells (16%) serving four (33%) public water supplies. In one instance the concentration of benzene was high enough to be of concern with regard to public health. All concentrations of synthetic organic compounds observed in ground water were below acute toxicity values and pose no immediate threat to human health. However, little is known of the implications to human health from long term exposure to one or more of these compounds or their by-products. Known health effects information has been compiled in Appendix VI.

The results of this survey strongly support the findings of previous studies with regard to the appearance of agricultural chemicals in shallow ground water. There is a relationship between well depth and susceptibility to contamination. Shallow alluvial systems are at highest risk of contamination by agricultural chemicals. Six of the eight alluvial wells sampled (75%), three of the 11 pleistocene wells (27%) and none of the bedrock wells (0%) sampled had one or more contaminants present. All of the contaminated wells were less than 110 feet deep.

The data suggest that shallow ground-water systems may be affected at least for short periods of time, by any pesticide, even those pesticides with rapid decay rates. Terbufos (Counter) is thought to decay rapidly, yet it was the most frequently detected compound in the survey.

The results of the 1985 Little Sioux River Survey closely reflect the percentage of contaminated wells and public water supplies, 45 and 57 percent respectively, found in the 1984/85 SOC Survey. Based on the results of the Little Sioux River Survey, the 1984/85 SOC Survey appears to have been a representative sampling of ground-water quality statewide, despite the fact that the sampling locations for the 1984/85 SOC Survey were not picked at random.

RECOMMENDATIONS

1. a.* All public water supplies using shallow ground water as a source should monitor their raw water for commonly used pesticides in late spring or early summer each year.

   b. Repetitive sampling throughout the year should be conducted for those supplies with contaminated source water. This sampling may be used to assess treatment effectiveness and exposure risk.

2. Public water supplies using shallow ground water as a source, and that are known to be near spill sites or dump sites, should monitor annually for commonly occurring synthetic organic compounds other than pesticides. These supplies should also make contingency plans for alternate sources.

3. Ground-water protection programs should place a high priority on protection of alluvial aquifers.

4.* Ongoing and proposed research to assess environmentally sound and safe agricultural chemical use should be encouraged by both the state and the federal governments.

5. An emphasis should be placed on public education to increase the awareness of the public with regard to environmental issues related to ground water protection.

6.* Ongoing and proposed research to assess the implications to human health from long term exposure to low concentrations of one or more synthetic organic contaminants should be encouraged.

* Recommended in 1984/85 Synthetic Organic Compound Sampling Survey of Public Water Supplies report.

APPENDIX I

SUPPLIES MONITORED

City	# of Wells	Source
Sioux Rapids	2	Alluvial
Peterson	2	Pleistocene
Cherokee Rural Water	2	Pleistocene
Cherokee	4	Bedrock
Quimby	1	Bedrock
Washta	1	Alluvial
	1	Pleistocene
Correctionville	1	Alluvial
	1	Pleistocene
	1	Bedrock
Anthon	1	Pleistocene
Oto	1	Alluvial
Smithland	2	Pleistocene
Cushing	2	Alluvial
Paullina	1	Alluvial
	2	Pleistocene

APPENDIX II

PESTICIDE COMPOUND STUDY ANALYTICAL PARAMETERS

Aldrin (HHDN)
alpha-BHC (A Benzene Hexachloride)
beta-BHC (B Benzene Hexachloride)
delta-BHC (Benzene Hexachloride)
gamma-BHC (Lindane)
Chlordane
DDD (TDE)
DDE
DDT (Dichlorodiphenyltrichloroethane)
Dieldrin (HEOD)
Endosulfan I (Thiodan I)
Endosulfan II (Thiodan II)
Endosulfan sulfate
Endrin (Endrex)
Endrin aldehyde
Heptachlor
Heptachlor epoxide
Toxaphene (polychlorocamphene)
Dyfonate (Fonofos)
Counter (Terbufos)
Lorsban (Chlorpyrifos)
Thimet (Phorate)
MoCap (Ethoprop)
Atrazine (Atrex)
Bladex (Cyanazine)
Lasso (Alachlor)
Treflan (Trifluralin)
Sencor (Metribuzin)
Dual (Metolachlor)
Prowl (Pendimethalin)
Amiben (Chloramben)
Banvel (Dicamba)
Bolstar (Sulprofos)
2,4-D
Silvex

SYNTHETIC ORGANIC COMPOUND STUDY ANALYTICAL PARAMETERS

acrolein
acrylonitrile
benzene
bis(chloromethyl)ether
bromoform
bromodichloromethane
carbon tetrachloride
chlorobenzene
chloroethane
chloroform
dibromochloromethane
dichlorodifluoromethane
1,1-dichloroethane
1,2-dichloroethane
1,1-dichloroethene
1,2-dichloropropane
1,3-dichloropropylene
ethylbenzene
methyl bromide
methyl chloride
methylene chloride
1,1,2,2-tetrachloroethane
tetrachloroethene
toluene
1,2-trans dichloroethene
1,1,1-trichloroethane
1,1,2-trichloroethene
trichlorofluoromethane
vinyl chloride

RESULTS

Water System	Atrazine	Cyanazine (Bladex)	Metribuzine (Sencor)	Terbufos (Counter)	Metolachlor (Dual)	Alachlor (Lasso)	Sulprofos (Bolstar)	Toluene	Benzene	1,2-dichloroethane	ethylbenzene
Sioux Rapids	X	X	X	X			X				
Peterson				X						X	
Washta	X	X	X	X	X	X		X			
Correctionville									X	X	X
Cushing				X							X
Paullina	X			X	X						

APPENDIX IV

POSITIVE ANALYTICAL RESULTS PER WELL IN ug/l FOR SELECTED PARAMETERS

Contaminant: CITY	WELL#	Atrazine	Cyanazine	Metribuzin	Terbufos	Metolachlor	Alachlor	Sulprofos	Methyl Parathion	1,2-di-chloroethane	Ethyl-benzene	Toluene	Benzene
Sioux Rapids													
	1	ND	ND	ND	0.3	ND	ND	ND	ND	ND	ND	ND	ND
	2	4.1	0.69	1.1	12.0	ND	ND	1.3	ND	ND	ND	ND	ND
Duplicate of	2	ND	ND	NA	10.0	ND	ND	1.4	ND	ND	ND	ND	ND
Peterson													
	1	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND	ND	ND	ND	0.3	ND	ND	ND
Cherokee RWA	MC-2	ND	ND	ND	ND	ND	ND	ND	DO	ND	ND	ND	ND
	MC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Duplicate of	MC-3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cherokee													
	N2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	M3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	A7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	A8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Quimby													
	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Duplicate of	1	ND	ND	ND	ND	ND	ND	N	ND	ND	ND	ND	ND
Paullina													
	3	2.0	ND	ND	5.9	5.6	ND	ND	ND	ND	ND	ND	ND
Duplicate of	3	2.9	ND	ND	4.8	6.3	ND	ND	ND	ND	ND	ND	ND
	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

NA=Not Analyzed DO=Detected Only; Not Quantified ND=Not Detected
No positive analyses were made for parameters not included in this table.

APPENDIX IV

POSITIVE ANALYTICAL RESULTS PER WELL IN ug/l FOR SELECTED PARAMETERS
- Continued -

Contaminant: CITY	WELL#	Atrazine	Cyanazine	Metribuzin	Terbufos	Metolachlor	Alachlor	Sulprofos	Methyl Parathion	1,2-di-chloroethane	Ethyl-benzene	Toluene	Benzene
Anthon													
	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Oto													
	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Little Sioux River Sample		0.57	0.20	ND	ND	0.25	0.21	ND	ND	ND	ND	ND	ND
Washta													
	1	4.4	0.26	0.44	11.0	7.3	ND	ND	ND	ND	ND	0.6	ND
Duplicate of	1	2.2	0.34	0.75	ND	4.5	.18	ND	ND	ND	ND	< 1.0	ND
Correctionville													
	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	4	ND	ND	ND	ND	ND	ND	ND	ND	3.2	0.7	ND	44.0
Smithland													
	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cushing													
	1	ND	ND	ND	2.1	ND	ND	ND	ND	ND	ND	ND	ND
	2	ND	ND	ND	1.7	ND	ND	ND	ND	ND	0.8	ND	ND

NA=Not Analyzed   DO=Detected Only; Not Quanitified   ND=Not Detected

No positive analyses were made for parameters not included in this table.

APPENDIX V

DAILY RAINFALL IN INCHES

	1	3	4	5	6	7	11	12	13	14	15	16	19	20	21	22	23	24	25	26	27	28	30	31
MARCH:																								
Cherokee		.87	1.22		.05	.01	.01		.04								.29	.05			.53			.45
Sioux Rapids		1.16	.04				.03	.01	.02								.42	.01		.01	.42	.01	.11	.53
Spencer		2.19	.03				.23	.04								.04	.41			.26	.16		.09	.21
APRIL:																								
Cherokee	.05		.28											.08	.84	1.56	2.02	.05		.89	.33			
Sioux Rapids			.41					.02						.04	.83	.98	.23		.44	.40			.50	
Spencer			.95					.07					.04	.95	.90	1.28	.56		.24	.37				
MAY:																								
Cherokee							.03	.20		1.08	1.53	.01												
Sioux Rapids				.11			.32		.24	1.30														
Spencer				.10			.09		.45	1.09	.03													
AVERAGE:																								
March		1.40	.43				.09	.03	.02							.04	.37	.03		.14	.37	.01	.10	.40
April	.05		.55		.05	.01		.05					.04	.36	.86	1.27	.94	.05	.34	.55	.33		.50	
May				.11			.15	.20	.35	1.16	.78	.01												

Inches Above or Below Average per Month:

March	1.61+
April	2.67+
May	.71+

No daily rainfall was recorded for the following days:

March	2, 8, 9, 10, 17, 18, 29
April	2, 8, 9, 10, 17, 18, 29
May	2, 8, 9, 10, 17, 18, 29

APPENDIX VI

HEALTH EFFECTS[11,12]

Contaminant: BENZENE

Acute Exposure: Benzene is acutely toxic at very high concentrations. One human death has been attributed to an exposure of 20,000 ppm. Exposure to high concentrations may lead to nausea, headache, unconsciousness, convulsions or paralysis. Acute toxicity is generally associated with inhalation of benzene.

Chronic Exposure: Benzene has been reported to produce thrombocylopenia, leukopenia, myelocytic anemia and leukemia. The recommended occupational exposure to benzene is 10 ppm. However, current literature does not provide a clear dose-response relationship to chronic exposure of humans to benzene. Data on the toxic effects of ingestion are not complete.

Acceptable Short-Term Exposure Level ----------------- 230 ug/l

Acceptable Long-Term Exposure Level ----------------- 70 ug/l

	ug/l	Excess Cancers of 1 in
Cancer Risk Assessment -------------	6.8	10^5
	.68	10^6
	.068	10^7

Contaminant: TOLUENE

Acute Exposure: All of the information available on acute human exposure to toluene suggest that it has a narcotic effect. The major metabolites of toluene are relatively innocuous. In fact, one of these metabolites, benzoic acid, has been approved as an antimicrobial food additive in concentrations up to 1,000 ppm.

Chronic Exposure: Reports on long term exposure to toluene suggest that concentrations below 200 ppm have no effect upon humans. Data indicates that some effects of narcosis are evident at around 200 ppm. Exposure is generally associated with inhalation. Data on the toxic effects of ingestion are not complete.

Acceptable Short-Term Exposure Level ----------------- 18,000 ug/l

Acceptable Long-Term Exposure Level ----------------- 280 ug/l

Cancer Risk Assessment ----------------- None

APPENDIX VI

HEALTH EFFECTS[11,12]
- Continued -

Contaminant: ETHYLBENZENE

Acute Exposure: In experiments with human volunteers, inhalation exposure to EB at a concentration of 100 ppm (434 mg/m^3) did not result in adverse health effects. An increase in this level reportedly resulted in sleepiness, fatigue, headache and mild eye and respiratory irritation. Reports of health effects in workers exposed to EB have involved situations with exposures to multiple toxicants. Effects reported include elevation of serum ornithine carbamoultransferase activity and dystrophic changes of the myocardium.

Chronic Exposure: No effects were noted in groups of rats exposed at 13.6 and 136 mg/kg/day. Increases in liver and kidney weights were reported following oral administration of 408 or 680 mg/kg/day. There were also slight histopathological changes at these dose levels. Thse included cloudiness and swelling of hepatocytes and renal tubular epithelium. From these results, a NOAEL of 136 mg/kg/day was identified.

Acceptable Short-Term Exposure Level ---------------- 21,000 mg/l

Acceptable Long-Term Exposure Level ---------------- 34,000 mg/l

Cancer Risk Assessment ---------------- None

Contaminant: PESTICIDES

Not surprisingly, pesticides generally exhibit relatively low acute toxicity characteristics. However, the carcinogenicity of these compounds are often of greater concern. In the past, the National Academy of Sciences has established recommended acceptable daily intake (ADI) values from a number of pesticides. The ADI value was based upon chronic feeding studies with considerations being made for data (or a lack of) on mutagenicity, teratogenicity and information on sex and strain. The aceptable daily intake value reflects the no observed effects level (NOEL) over some factor of uncertainty or safety factor. The safety factor represents the level of confidence that was determined to be justified on the basis of animal and human toxicity data.

APPENDIX VI

HEALTH EFFECTS[11,12]
- Continued -

Standard Safety Factors for Toxicological Effects

Effect	Safety Factor*
cholinesterase inhibition based on two-year rodent or dog studies	10
cholinesterase inhibition based on human NOEL	10
general toxicity based on chronic studies	100
cholinesterase inhibition based on subchronic studies	200
teratogenic effects	at least 100
general toxicity based on subchronic studies	2,000

*These are minimal safety factors and actual margins of safety are likely to be higher.

If the data indicated a NOEL of 25 mg/kg/day and a safety factor of 1,000 was used, the acceptable level would be 25/1,000 or .025 mg/kg. This value is then used to establish a suggested level or concentration of the pollutant in drinking water. In calculating the value for drinking water, it was assumed that the average weight of a human was 70 kg; the average daily intake of water for that human was two liters; and that 20% of those two liters was taken in directly as drinking water. Therefore, from the example above, one could derive the maximum level on the pollutant allowable in drinking water to be considered safe to be .7 mg/l (25/1.=,000 = .025 x 70 x 0.4 = .7 mg/l).

The following is a summary of the toxicity data base for the four remaining pesticides detected in this survey and their associated NOEL.

APPENDIX VI

HEALTH EFFECTS[11,12]
- Continued -

COMPOUND	DATA SUMMARY	BASIS FOR ACCEPTABLE INTAKE CALCULATIONS AND THE NOEL
Atrazine	- Rat teratology, NOEL = 100 mg/kg - Negative mutagenicity (1 study) The other Pivotal data are not adequate (CORE supplementary) to regulate this chemical: - 2-Year dog feeding, NOEL = 150 ppm (LDT) - 2-Generation rat reproduction, NOEL = 100 ppm (HDT) using the 80W formulation	1-Year dog feeding, CORE supplementary:* NOEL = 150 ppm
Metolachlor (Dual)	- 6-month dog feeding, NOEL = 100 ppm - 2-year supplementary (IBT) onco. in rate: weak oncogen, i.e., liver tumors. - 2-year chronic in rat (repeat study): weak oncogen - liver tumors, NOEL = 30 ppm (testicular atrophy) - 2-year oncogen in mouse negative at 3,000 ppm (Highest Dose Tested (HDT) Industrial Dio-Test, validated) - 3-generation rat reproduction - 300 ppm - Teratology rat NOEL = 360 mg/kg (HDT) - Teratology rabbit NOEL = 360 mg/kg - Mutagenicity: negative (2 tests) - Positive skin sensitizer - 2-year oncogen in mouse: negative at 3,000 ppm (HDT)	6-month dog feeding, NOEL = 100 ppm weak
Cyanazine (Bladex)	- Teratology in Fisher rat: a potential weak teratogen, (NOEL for study not yet determined: 10 mg/kg for micro-ophthalia/anophthalmia, and pending additional studies, the NOEL may be lower than 1 mg/kg (LDT) for liver-induced hernia) - Teratology in SD rat: negative at 30 mg/kg (HDT), (however, MTD not tested) - Teratology in rabbit: negative at 4 mg/kg (HDT), NOEL = 1 mg/kg/day - 2-year oncogen in mice: negative at 1,000 ppm (HDT)	2-year rat feeding CORE supplementary: NOEL = 12 ppm

*The CORE classification system was developed by the Office of Pesticide Programs in 1977 to assess the adequacy of toxicology studies.

APPENDIX VI

HEALTH EFFECTS[11,12]
- Continued -

COMPOUND	DATA SUMMARY	BASIS FOR ACCEPTABLE INTAKE CALCULATIONS AND THE NOEL
Metribuzin (Sencor)	- Rabbit teratology; NOEL = 15 mg/kg (HDT) - Mutagenicity: negative (three tests). All the other pivotal data were not CORE classified - 2-year dog feeding, NOEL = 100 ppm - 2-year rat feeding/oncogen, negative for oncogencity; NOEL: = 300 ppm - 2-year mouse oncogen, negative at 3,200 ppm (HDT) - 3-generation reproduction, NOEL = 300 ppm - Rat teratology, NOEL = 100 mg/kg (HDT)	2-year dog feeding, not CORE classified NOEL = 100 ppm
Alachlor (Lasso)	- In the case of alachlor (Lasso)the greatest concern is the carcinogenicity of the pesticides. The EPA has made the following assessment of the risk of increased cancer as a result of ingestion of Lasso in the drinking water:	

Exposure Level (ppb)	Upper Limit Estimate of Lifetime Cancer Risk	
	10 Kg Child	60 Kg Adult
0.15	10^6	10^7 to 10^6
1.5	10^5	10^6 to 10^5
15.0	10^4	10^5 to 10^4

COMPOUND	DATA SUMMARY	BASIS FOR ACCEPTABLE INTAKE CALCULATIONS AND THE NOEL
Terbufos (Counter)	- Health information regarding terbufos is unavailable. Restricted use insecticide.	
Sulprofos (Bolstar)	- Health information regarding sulprofos is unavailable. Not registered for use in Iowa.	

REFERENCES

[1] Kelley, R.D.: Synthetic Organic Compound Sampling Survey of Public Water Supplies: Iowa Department of Water, Air and Waste Management, 1985.

[2] Climatological Data, Iowa, March 1985: National Oceanic and Atmospheric Administration. Vol. 96, No. 3.

[3] Climatological Data, Iowa, April 1985: National Oceanic and Atmospheric Administration. Vol. 96, No. 3.

[4] Climatological Data, Iowa, May 1985: National Oceanic and Atmospheric Administration. Vol. 96, No. 4

[5] Hallberg, G.R.: Nonpoint Source Contamination of Groundwater by Agricultural Chemicals (Technical Comments): Delivered to the United States Senate Committee on Environment and Public Works, Subcommittee on Toxic and Environmental Oversight. December 1985.

[6] Hallberg, G.R., Libra, R.D., Bettis, E.A., III, and Hoyer, B.E.: Hydrogeologic and Water Quality Investigations in the Big Spring Basin, Clayton County, Iowa, 1983 Water-Year: Iowa Geological Survey, Open-File Report 84-4, 1984.

[7] Libra, R.D., Hallberg, G.R., Ressmeyer, G.G., and Hoyer, B.E.: Groundwater Quality and Hydrogeology of Devonian-Carbonate Aquifers in Floyd and Mitchell Counties, Iowa: Iowa Geological Survey, Open-File Report 84-2, 1984.

[8] A Technical Assessment of Nonpoint Pollution in Iowa: Iowa State University, March 1978.

[9] Lauren Johnson: University Hygienic Laboratory, personal correspondence.

[10] Iowa Livestock and Crop Reporting Service, 1985 statistics: personal correspondence.

[11] Alachlor Position Document 1: U.S. EPA Office of Pesticide Programs, U.S. EPA, 1984.

[12] Drinking Water and Health: National Academy of Sciences, 1977.

[13] George Hallberg: Iowa Geological Survey, personal correspondence.

REFERENCES

1. [illegible], R.D., Synthetic Organic Compound Sampling Survey of Public Water Supplies. Iowa Department of Water, Air and Waste Management, 1985.

2. Climatological Data, Iowa, [illegible] 1986. National Oceanic and Atmospheric Administration. Vol. 96, No. [illegible]

3. Climatological Data, Iowa, [illegible] 1986. National Oceanic and Atmospheric Administration. Vol. 96, No. [illegible]

4. Climatological Data, Iowa, May 1986. National Oceanic and Atmospheric Administration. Vol. 96, No. [illegible]

5. Hallberg, G.R., [illegible] Contamination of Groundwater by [illegible] Iowa [illegible] Toxic and Environmental Chemicals, [illegible]

6. Hallberg, G.R., Libra, R.D., Bettis, E.A. III, and Hoyer, B.E., Hydrogeologic and Water Quality Investigations in the Big Spring Basin, Clayton County, Iowa: 1983 Water-Year. Iowa Geological Survey, Open-File Report 84-4, 1984.

7. Libra, R.D., Hallberg, G.R., Ressmeyer, G.G., and Hoyer, B.E., Groundwater Quality and Hydrogeology of Devonian-Carbonate Aquifers in Floyd and Mitchell Counties, Iowa. Iowa Geological Survey, Open-File Report 84-2, 1984.

8. [illegible] Iowa State University, [illegible]

9. [illegible] personal correspondence.

10. Iowa Department of Water, Air and Waste Management, [illegible] personal communication.

11. [illegible] Pesticide Program, [illegible]

12. [illegible] 1977.

13. [illegible] personal correspondence.