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PESTICIDE AND NITRATE MONITORING RESULTS FOR CRAIGHEAD, MISSISSIPPI, AND POINSETT COUNTIES, ARKANSAS PHASE II

1993

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APPENDIX A

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ABSTRACT

Because of the concern for potential contamination of ground water by agricultural chemicals, 38 wells drilled in the Mississippi River Valley alluvial aquifer in Mississippi County and the eastern parts of Craighead and Poinsett Counties, Arkansas were analyzed for pesticides and nitrate. The pesticide, fluometuron, was detected in one sample at a concentration of 0.5 mg/L. Bentazon was detected in three samples at concentrations of 2.5, 0.3, and 0.3 mg/L. The occurrences of the pesticides appear to represent isolated incidents rather than a widespread aquifer contamination. All detections were below health and safety standards. Nitrate is present in several wells at concentrations above 0.15 mg/L, one of which exceeded the EPA established maximum contaminant level for drinking water of 10 milligrams per liter as nitrogen. Except for two wells nitrate and iron are not present together at concentrations above 0.15 mg/L. This is probably due to microbially mediated reactions. Nitrate concentrations above 0.15 mg/L is only present in wells that are less than 60 feet deep and near permeable soils. Iron is present in wells that are not near permeable soils or wells that are greater than 40 feet deep, and may exceed 1 mg/L in some cases.

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INTRODUCTION

Mississippi, Craighead and Poinsett counties in northeastern Arkansas are important agricultural areas where it is economically beneficial to use pesticides and fertilizers. In order to determine if agricultural practices are contaminating the ground water, water was collected from shallow wells and analyzed. This investigation is part of a monitoring program designed to determine pesticide contamination of shallow ground water in the most vulnerable areas of Arkansas. The study area includes all of Mississippi County and parts of Craighead and Poinsett counties east of Crowley's Ridge. The study area is bounded on the east by the Mississippi River, on the south by Crittenden and Cross counties, and on the north by Greene County and the state of Missouri (Figure 1).

PURPOSE AND SCOPE

This report describes and discusses the occurrence of pesticides, nitrate, iron and lead in water from the alluvial aquifer in the study area in northeastern Arkansas. The description and occurrence includes the discussion of parameter relationships to each other and to the soils near the wells that were sampled. Information on other major and minor water quality parameters is provided by Clayton (1995).

BACKGROUND

According to the U.S. Environmental Protection Agency (EPA) nationwide evidence has shown that agricultural pesticides can contaminate ground water (U.S. EPA, 1990). Because of this, the EPA has encouraged each state to develop a management plan for dealing with possible pesticide contamination of ground water.

The responsibility for developing a pesticide management plan for Arkansas has been given to the Arkansas State Plant Board (ASPB). The Arkansas Soil and Water Conservation Commission (ASWCC) coordinated development of a vulnerability model (Fugitt, 1992) to determine potential problem areas for pesticide contamination of ground water with ASPB. ASWCC also has been involved in some monitoring (especially of deeper wells). The plan developed by the Arkansas State Plant Board in collaboration with the Arkansas Water Resource Center (AWRC) includes an education program designed to prevent contamination, and a monitoring program to determine if contamination has occurred. The monitoring program uses the vulnerability model to determine potential problem areas (Arkansas State Plant Board, 1992). The areas chosen for monitoring were those considered to be most vulnerable to contamination by pesticides. The vulnerability assessment was based, in part, on the pesticide version of the

1

36° —

35° —

34° —

BENTON   CARROLL   BOONE   BAXTER   FULTON   RANDOLPH   CLAY

MARION   IZARD   SHARP   LAWRENCE   GREENE

WASHINGTON   MADISON   NEWTON   SEARCY   STONE   INDEPENDENCE   CRAIGHEAD   MISSISSIPPI

CRAWFORD   FRANKLIN   JOHNSON   VAN BUREN   CLEBURNE   JACKSON   POINSETT

POPE   CONWAY   WHITE   CROSS   CRITTENDEN

SEBASTIAN   LOGAN   FAULKNER   WOODRUFF

YELL   PERRY   PRAIRIE   ST. FRANCIS

SCOTT   PULASKI   LONOKE   LEE

SALINE   MONROE   PHILLIPS

POLK   MONTGOMERY   GARLAND

HOWARD   HOT SPRING   GRANT   JEFFERSON   ARKANSAS

PIKE   CLARK

SEVIER   DALLAS   CLEVELAND   LINCOLN

LITTLE RIVER   HEMPSTEAD   NEVADA   OUACHITA   BRADLEY   DREW   DESHA

MILLER   CALHOUN   CHICOT

LAFAYETTE   COLUMBIA   UNION   ASHLEY

0   20   40 MILES

0   20   40 KILOMETERS

Figure 1. Location of the study area.

DRASTIC method for determining areas sensitive to ground water contamination (Aller et al., 1987).

DRASTIC determines sensitivity based on seven factors:

- **D**epth to the water table,
- net **R**echarge,
- **A**quifer media,
- **S**oil media,
- **T**opography,
- **I**mpact of the vadose zone, and
- hydraulic **C**onductivity

In the study area, depth to the water table, aquifer media, topography, and hydraulic conductivity are nearly uniform (Ryling, 1960). The three remaining factors, net recharge, soil media, and impact of the vadose zone are all indicators of how easily water can move from the surface to the aquifer.

The vulnerability in a county also considers the amount of pesticides used in the county. Pesticide use was based on information about crop production by county, and an estimate of the type and amount of pesticides used for specific crops. The most vulnerable areas in the state were determined by considering pesticide use and DRASTIC sensitivity (Nichols and Wilkes, 1992).

Sample collection and analyses were performed by the Arkansas Water Resource Center (AWRC) Water Quality Laboratory. Monitoring in Ashley County, previously determined to be the most vulnerable area, has been completed (Nichols et al., 1993). Metolachlor was detected at 0.71 μg/L in only one of 23 wells. The well was later re-sampled for verification of the detection; the re-sample did not contain detectable levels of pesticide. This present study, involves the second most vulnerable area (Mississippi County and the eastern parts of Craighead and Poinsett counties).

LAND USE AND CLIMATE

The study area is predominantly farm land, but forest remains in some areas, especially in the floodway adjacent to the St. Francis River, and areas near the Mississippi River that are not protected from flooding. Soybeans, cotton, and rice are the main crops grown. Some areas are also used for wheat, corn, grain sorghum, and cattle grazing (Arkansas Agricultural Experiment Station, 1995). Crop statistics for each of the three counties in the study area are given in Table 1 (Arkansas Agricultural Experiment Station, 1995). Note that Table 1 gives totals for all of Craighead and Poinsett counties, i.e., it includes the parts of these counties not in the study area.

Table1. Agricultural statistics for Craighead, Mississippi and Poinsett Counties.
Values given are in acres.

	Craighead County	Mississippi County	Poinsett County
Total land area	454,913	574,922	484,987
Land in farms	350,402	484,751	404,585
Soybean	104,000	223,000	143,000
Cotton	84,000	200,000	55,000
Rice	78,000	20,000	111,000
Wheat	14,500	58,000	12,000
Sorghum	6,500	16,500	7,000
Corn	5,600	3,700	1,700

Source: Arkansas Agricultural Experiment Station, 1995.

The climate of the study area is characterized by typically hot, humid summers and cool winters. Cold winter storms occur but are of short duration. Average precipitation is nearly 50 inches per year. January is the wettest month, but the heaviest rainfall events occur during the spring (Ferguson and Gray, 1971; Ferguson, 1979; and Gray and Ferguson, 1977).

HYDROGEOLOGY AND GEOLOGY

The uppermost aquifer in the area is the Mississippi River Valley alluvial aquifer. It is composed of Mississippi River alluvial deposits. These deposits grade upward from coarse sand and gravel to silt and clay (Plafcan and Fugitt, 1985).

The lower half to two thirds of the aquifer is composed of braided-stream deposits laid down during glaciation. The upper part of the aquifer was deposited by the Mississippi River after it became a meandering stream. These deposits consist of point-bar sands and some gravel (Saucier, 1964; Saucier and Snead, 1989).

In most of the study area the depth to ground water is less than 20 feet. The base of the aquifer is 100-200 feet below the land surface (Ryling, 1960). Wells in the alluvial aquifer yield 1000-3000 gallons per minute (gpm). The direction of ground-water flow is generally to the southwest. The Mississippi River acts as a source of recharge, but this may change seasonally with changes in river level, resulting in changes in the direction of flow near the river (Plafcan and Fugitt, 1985). Ryling (1960) reports ground-water velocities of 0.2 to 0.3 feet per day (fpd) in northwestern Mississippi County, and velocities of 0.1 to 0.8 fpd near the Mississippi River. Velocities near the river are greatly affected by the level of the river. Hydraulic conductivity values for the aquifer range from 120-390 fpd (Mahon and Ludwig, 1990).

Overlying the alluvial aquifer are finer-grained sands, silts and clays that were deposited by the Mississippi River and smaller streams as backswamp, meander-belt and braided-stream deposits. These units form the overlying confining layer for the alluvial aquifer (Ackerman, 1989).

The Memphis aquifer underlies the alluvial aquifer. This aquifer is mainly sand with some interbedded clay and comprises the lower part of the Claiborne Group. The boundary between the two aquifers is an erosional surface, an angular unconformity. In the northeastern part of the study area the two aquifers are connected. In the southwestern part they are separated by the Jackson-Claiborne clay, which includes the upper part of the Claiborne Group and the Jackson Group (Broom and Lyford, 1982).

SOILS

Soils in Mississippi County are related to the past and present deposits of the Mississippi River in which they have developed. Near the Mississippi River, loamy to sandy soils are

developed on the natural levees of the river. Clayey soils occur throughout much of the central part of the county and are developed in backswamp deposits. Sandy or loamy soils occur in some areas of the central part of Mississippi County. Northwest of the Left Hand Chute of the Little River the soils become more loamy with some sandy soils. Locally, sandy soils exist as a result of sand blows that occurred during the 1811-1812 New Madrid earthquakes (Ferguson and Gray, 1971).

Soils in the part of Craighead County included in the study area are generally loamy to fine sandy loam; however, in the St. Francis River basin, which crosses the county from north to south, the soils are clayey. These soils were developed in clays deposited by the St. Francis River (Ferguson, 1979). In the selected portion of Poinsett County soils are generally clayey, although there are some sandy soils. These grade to loamy soils in the western part of the study area (Gray and Ferguson, 1977).

PARAMETERS AND METHODS

A total of 38 wells were sampled for this study. Samples for pesticide, nitrate, iron, lead, and other analyses were collected on seven trips to the study area from November 1993 to October 1994. See Clayton (1995) for details of collection and analysis of other cations and anions, and field parameters. Sample locations are shown in Figure 2. Locations and depths of wells are given in Table 2. The appropriate U.S. Geological Survey 7 1/2.-minute quadrangles for each well, and well use are also listed in this table.

For all of these wells pH, temperature and specific conductance were measured at the time of sampling. Well depth was obtained from the owner. Wells that contained detectable levels of pesticides were resampled at a later date, except for one well, M4, that was no longer in use. Before water was collected, the wells were purged until temperature, conductance and pH became stable. This was done to ensure that the collected water represented ambient aquifer conditions.

The project involved monitoring for the following 13 herbicides.

metolachlor;	norflurazon;
fluometuron;	alachlor;
atrazine;	cyanazine;
bentazon;	2,4-D;
metribuzin;	acifluorfen;
molinate;	diuron;
linuron.	

These pesticides were chosen because of their extensive use in the area, their high leaching potential and their long half-life in soil. Solubility, half-life, adsorption coefficient (K_{oc}), and leaching potential are given in Table 3. Data are taken from Nichols and Wilkes (1992) which is based on data from the Cooperative Extension Service.
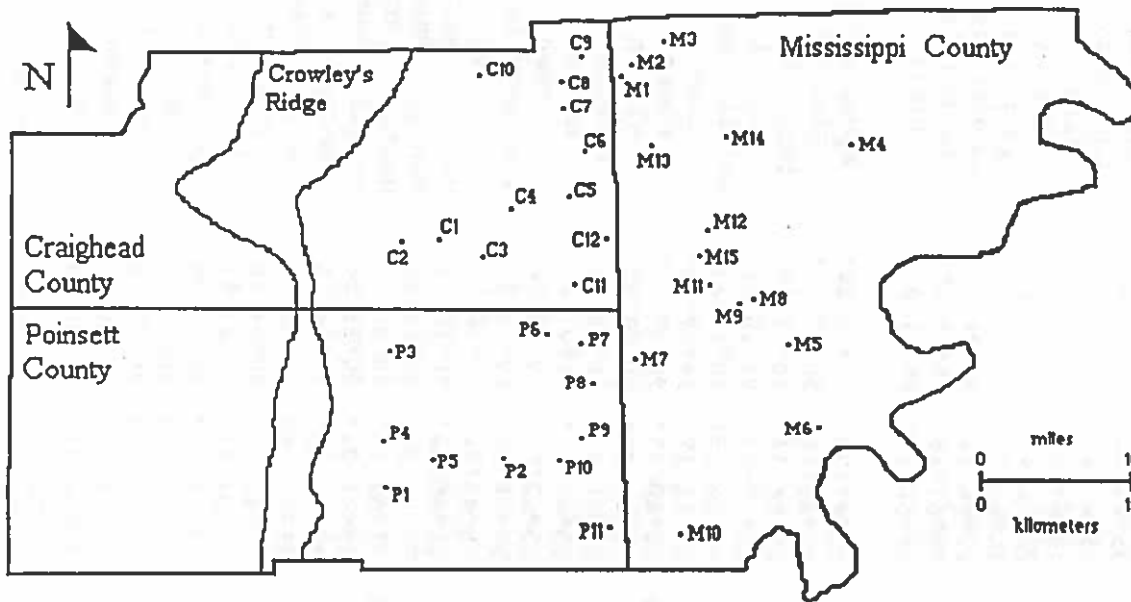
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Figure 2. Locations of wells sampled.

Table 2. Location, depth and use of wells.

Well	Depth in feet	Latitude	Longitude	USGS quadrangle	Well use
C1	25	35°46'22"	90°29'27"	Lake City	Domestic
C2	30	35°46'25"	90°33'09"	Needham	Domestic
C3	20	35°45'26"	90°27'42"	Lake City	Agriculture
C4	20	35°47'27"	90°25'30"	Lake City	Agriculture
C5	25	35°48'12"	90°21'01"	Caraway	Agriculture
C6	20	35°51'46"	90°18'53"	Caraway	Agriculture
C7	50	35°53'31"	90°20'30"	Leachville	Agriculture
C8	50	35°56'31"	90°20'32"	Leachville	Agriculture
C9	35	35°57'38"	90°19'08"	Leachville	Agriculture
C10	18	35°56'36"	90°27'02"	Dixie	Domestic and agriculture
C11	30	35°43'55"	90°20'24"	Rivervale	Agriculture
C12	50-60	35°46'19"	90°17'58"	Caraway	Agriculture
M1	100+	35°56'34"	90°17'00"	Leachville	Agriculture
M2	100+	35°57'23"	90°16'02"	Leachville	Agriculture
M3	100+	35°58'15"	90°13'33"	Manilla North	Agriculture
M4	50	35°52'19"	89°59'24"	Luxora	Agriculture
M5	30-50	35°40'33"	90°05'00"	Kieser	Agriculture
M6	125	35°34'29"	90°02'32"	Wilson	Pond
M7	25	35°38'43"	90°16'07"	Rivervale	Domestic
M8	50	35°43'12"	90°07'30"	Etowah	Agriculture
M9	45	35°42'54"	90°08'38"	Etowah	Agriculture
M10	55	35°28'09"	90°13'02"	Frenchmans Bayou	Domestic
M11	65	35°43'36"	90°10'30"	Etowah	Agriculture
M12	27	35°46'42"	90°10'39"	Manilla South	Domestic
M13	30	35°51'52"	90°14'52"	Manilla South	Agriculture
M14	20-40	35°52'19"	90°08'52"	Manilla South	Agriculture
M15	30	35°45'24"	90°11'16"	Manilla South	Domestic
P1	100+	35°31'29"	90°34'14"	McCormick	Agriculture
P2	100	35°33'16"	90°25'48"	Marked Tree	Agriculture
P3	14	35°40'33"	90°34'18"	Trumann	Domestic
P4	40	35°34'31"	90°34'53"	McCormick	Agriculture
P5	14	35°36'15"	90°31'09"	McCormick	Agriculture
P6	30	35°41'10"	90°22'34"	Hatchie Coon	Agriculture
P7	60	35°40'21"	90°20'29"	Rivervale	Agriculture
P8	15	35°38'04"	90°19'23"	Rivervale	Agriculture
P9	20	35°34'10"	90°20'01"	Lepanto	Hand pump
P10	50	35°32'54"	90°21'39"	Lepanto	Domestic
P11	65	35°29'10"	90°18'01"	Tyronza	Domestic

Table 3. Pesticide characteristics and uses.

Pesticide	Solubility mg/L	Half Life days	Soil Sorption K_{oc}	Leaching Potential	Trade Name	Crops Used on
2,4-D	890	10	20	medium	Amine	corn, rice, wheat
Acifluorfen	250,000	14	113	medium	Blazer	soybean
Alachlor	240	15	170	medium	Lasso	corn, cotton, soybean
Atrazine	33	60	100	large	Aatrex	corn
Bentazon	230,000	20	34	medium	Basagram	soybean, corn, rice
Cyanazine	170	14	190	medium	Bladex	corn, cotton, wheat
Diuron	42	90	480	medium	Bladex	corn, cotton, wheat
Fluometuron	110	85	100	medium	Cotoran	cotton
Linuron	75	60	400	medium	Lorox	corn, cotton, winter wheat
Metolachlor	530	90	200	medium	Dual	corn, cotton, soybean
Metribuzin	1220	40	60	large	Sencore/Lexone	soybean, corn, wheat
Molinate	970	21	190	medium	Odram	rice
Norflurazon	28	90	600	medium	Zorial	cotton

From Wauchope and Goss, 1988

Three different methods were used for pesticide analysis. EPA method 507 (U.S. Environmental Protection Agency, 1991a), and EPA method 515.2 (U.S. Environmental Protection Agency, 1992) use gas chromatography for analysis, but use different detectors and different extraction processes. The third method is National Pesticide Survey method 4 which uses high performance liquid chromatography (HPLC) (Table 4). Iron and lead were analyzed using inductively coupled plasma emission spectrometry (EPA, 1991b). Nitrate-N was analyzed by ion chromatography (Plafcan et al, 1989). See Clayton (1995) for details of inorganic methods and analytical data.

Laboratory analyses were performed at the AWRC Water Quality Laboratory. All analyses were conducted in accordance with EPA accepted methodology. Estimated detection limits for all analytes for which a method is approved are published with the method. Method detection limits are specific to the laboratory conducting the analyses and are computed from results obtained in that laboratory. Both of these limits are reported in Table 4. A quality control report for the pesticide data by Nichols et al. (1994) is given in Appendix A. See Clayton (1995) for quality control information for the inorganic analyses.

Table 4. EPA analytical methods, and detection limits.

Group	Units	Parameter	Method Detection Limit	Estimated Detection Limit
EPA 200.7	mg/L	Fe	0.001	0.003
		Pb	0.003	0.003
EPA 300.0	mg/L	NO_3-N	0.005	0.01
EPA 507	µg/L	molinate	0.085	0.15
		atrazine	0.032	0.13
		metribuzin	0.09	0.15
		alachlor	0.103	0.38
		metolachlor	0.141	0.75
		norflurazon	0.122	0.5
NPS4	µg/L	cyanazine	0.236	0.15
		fluometuron	0.056	0.13
		diuron	0.083	0.15
		linuron	0.085	0.085
EPA 515.2	µg/L	2,4-D	0.069	0.28
		bentazon	0.676	0.63
		acifluorfen	0.208	0.25

RESULTS AND DISCUSSION

Pesticide Data

With the exception of well P8, all 38 wells were analyzed for the 13 pesticides. The extracts of the water from well P8 contained an oily residue and was not analyzed to

prevent contamination of the equipment. Pesticides were detected in samples taken from four wells. Bentazon was detected in wells M4, M5 and P1 with concentrations of 2.5, 0.3 and 0.2 micrograms per liter (mg/L), respectively. Well C4 had a 0.5 mg/L fluometuron detection (Table 5). The locations of these wells are shown in Figure 3.

Table 5. Wells With Pesticides Detections

Well	Pesticide	Pesticide ug/L	NO_3-N mg/L	Depth feet	Soil Association
M4	bentazon	2.5	0.05	50	Sharkey-Steele complex
M5	bentazaon	0.3	0.02	30-50	Sharkey-Steele clay
P1	bentazon	0.2	0.02	100+	Sharkey clay
C4	fluometuron	0.5	4.62	20	Sharkey clay

The detections for wells M4 and P1 were confirmed by the Arkansas State Plant Board using a gas chromatograph with a mass spectrometer detector. There was no additional sample from well M5 available for confirmation. The fluometuron detection from well C4 was confirmed by using an alternate column on the HPLC. Three of these wells were later resampled for verification of the contamination. Well M4 could not be resampled, even though two separate attempts were made, because the pump was no longer working. Of these samples collected for verification none contained detectable levels of pesticides.

The bentazon detections from wells M5 and P1 are below the method detection limit of 0.676 µg/L. They are reported as detections because they produced an identifiable peak on the chromatogram. The quantitative concentrations of these detections may not be reproducible or accurate but the presence of a trace amount of pesticide is indicated.

The EPA has tentatively set a maximum contaminant level goal (MCLG) of 200 µg/L (0.02 mg/L) for bentazon. The maximum contaminant level goal is a non-enforceable concentration for drinking water set to protect against adverse human health effects. The EPA has not set an enforceable maximum contaminant level (MCL) for bentazon. An MCL is enforceable only for public water supply, not for domestic wells. The EPA has not set an MCLG or an MCL for fluometuron. None of the detections for bentazon are above the MCLG. The EPA has set health advisories for bentazon and fluometuron. Health advisories are concerned with only non-carcinogenic health effects. These advisories are levels of a contaminant in drinking water that are not expected to cause any non-carcinogenic health problems (EPA, 1994). None of these levels have been exceeded. Wells C4, M4 and M5 are reported to have depths of 20, 50, and 30-50 ft, respectively. These well depths are in distinct contrast to well P1, which is reported as being greater than 100 ft.
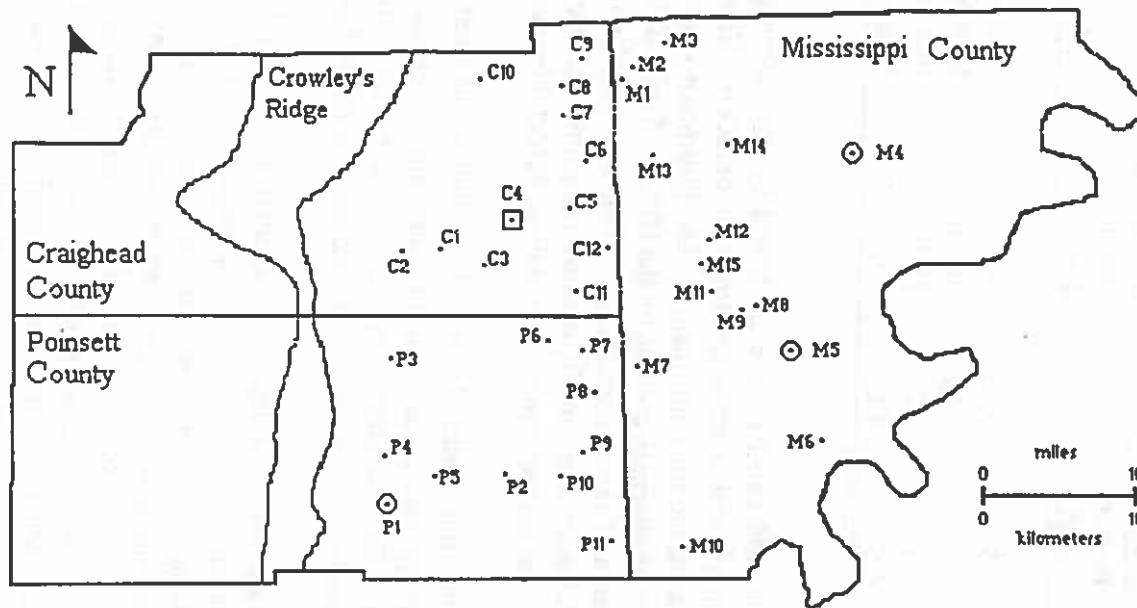
Figure 3. Locations of wells that contain pesticides. Bentazaon detections are circled and the floumetron detection is in a square.

Pesticide Contamination

A pesticide must travel through the soil and through the unsaturated or vadose zone in order to reach the water table. Then the pesticide must travel through the aquifer to a well if it is to be detected. There are several factors which can affect the movement of pesticides. Pesticides will move with water (Cheng and Koskinen, 1986); therefore, where there is more recharge to the aquifer it is more likely for a pesticide to be carried to the ground water. In most cases the pesticide will not move through the soil at the same rate as the water. This is due to the adsorption of some of the pesticide onto soil particles. The amount of the chemical that is adsorbed depends on the chemical properties of the pesticide as well as properties of the soil. Important soil properties are organic carbon content, clay content, field moisture capacity, pH and cation exchange capacity. Of these, the organic carbon content is the most important (Helling and Dragun, 1980). Unfortunately, there are only incomplete and indefinite data on organic carbon content available for the study area. Because a pesticide will only move appreciable distances through permeable materials with moving water, pesticides should only be able to contaminate the aquifer through soils that allow recharge to the aquifer.

Pesticides may also reach the ground water by movement along the annulus of an improperly cased well, or by direct contamination of the well. These are situations that are the result of negligence or mishandling of pesticides.

The permeability of soils in the study area is described in the soil surveys for the counties in the study area (Ferguson and Gray, 1971; Gray and Ferguson, 1977; Ferguson, 1979). In these reports, permeability is described by how rapidly water moves through the soil. The categories used are very slow, slow, moderately slow, moderate, moderately rapid and rapid.

One would expect a relationship between pesticide detections and the sensitivity of the site. An investigation of this relationship using geographical information systems was not possible because the necessary detail for soils and other factors determining sensitivity were not available in a magnetic useable format. Because soils are one of the most critical factors determining sensitivity and detailed soils maps were available for the area, the relationship between permeability of soils and pesticide detections was investigated. In order to limit the number of soils considered for each well, only those soils within one mile were used. It is reasonable to impose such a limit because at some point all soil types would be encountered. Maps showing the soils within one mile of each well are included in Appendix B. Soils through which water movement is moderately rapid or rapid will be considered permeable in this report. Wells C4 and M4 are within one mile of at least one permeable soil, but wells M5 and P1 are not. This indicates that bentazon and fluometuron detections may not be related to nearby soils. This could be because pesticides may travel more than one mile in the aquifer, or they could leach through less permeable soils, or the detections could be the result of well contamination.

The occurrence of bentazon in three wells does not represent widespread aquifer contamination. The bentazon detections were separated by at least 14 miles (23 kilometers). None of the wells in between, or closer to the contaminated wells contained detectable levels of pesticides. Therefore, it is thought that the detections are separate incidents.

All of the contaminated wells are used in agriculture or gardening. It is possible that the wells were contaminated by back-siphoning during the mixing or application of the pesticides. It is also possible that the pesticide could have been carried down along macropores, e.g., the zone between the well casing and the surrounding material. If either of these cases occurred, the pesticide detections may represent a contaminated well as opposed to a contaminated aquifer. It is not possible to determine which potential pathway of contamination was taken by the pesticides. In either case, re-sampling indicates that the pesticide detections were temporary, localized occurrences that do not represent a long-term or widespread aquifer contamination.

Inorganic Data

The results of the cation, anion, and other parameter analyses are given in Clayton (1995). Ryling (1960) reported that water from the alluvial aquifer is typically of calcium bicarbonate type water. The results of analyses of the wells in this study support this statement (Clayton, 1995).

Only three of the inorganic parameters will be discussed in this report. Nitrate is included because of its agricultural importance, associated use with pesticides, and its potential health hazard. Iron is included because of its staining properties and potential interaction with nitrate. Because of its potential health hazard lead is also included (Table 6).

High iron concentrations are a common problem with water from the alluvial aquifer. Ryling (1960) reported iron concentrations as high as 26 mg/L from the alluvial aquifer. Because he does not report whether or not his samples were filtered, it is assumed that his analyses were for raw water, i.e., unfiltered samples. Iron concentrations over 0.3 mg/L are generally considered undesirable and can stain plumbing fixtures and clothing. Iron concentrations from this study, based on filtered samples, are listed in Table 6. Values range from less than the detection limit of 0.003 to 15.3 mg/L, with an average value of 3.5 mg/L.

The EPA has set an MCLG for lead at zero (EPA, 1994). Eighteen of the 31 wells for which lead was determined contained lead at or above the detection limit of 0.003 mg/L. One sample, taken from well P6, contained a lead concentration of 0.026 mg/L. This is above the action level of 0.015 mg/L which has been set by the EPA for public supply wells. The wells sampled were purged before sample water was collected. If the wells or the pumping equipment contain lead, persons drinking from the wells without purging above the action level of 0.015 mg/L which has been set by the EPA for public supply

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Table 6. Nitrate, lead, and iron concentrations for individual wells.

Well	NO_3^-	Fe	Pb
C1	14.35	0.605	0.002
C2	0.04	NA	NA
C3	<0.01	NA	NA
C4	4.62	<0.003	<0.003
C5	2.20	0.004	0.007
C6	<0.01	0.009	<0.003
C7	7.70	0.027	<0.003
C8	<0.01	1.751	<0.003
C9	7.46	0.096	<0.003
C10	6.52	0.014	<0.003
C11	0.77	0.908	<0.003
C12	0.80	0.111	<0.003
M1	0.04	0.008	<0.003
M2	0.03	0.008	0.004
M3	0.05	1.943	<0.003
M4	0.05	NA	NA
M5	0.02	10.360	<0.003
M6	<0.01	2.442	0.003
M7	<0.01	NA	NA
M8	0.02	9.820	<0.003
M9	<0.01	4.774	<0.003
M10	<0.01	11.175	0.003
M11	0.01	9.945	0.003
M12	2.00	0.129	<0.003
M13	6.49	<0.003	<0.003
M14	0.02	0.105	<0.003
M15	8.04	<0.003	0.003
P1	0.02	5.170	<0.003
P2	0.11	1.578	0.004
P3	0.41	NA	NA
P4	<0.01	NA	NA
P5	<0.01	NA	NA
P6	0.01	3.083	0.026
P7	0.04	13.710	0.003
P8	0.02	6.140	0.005
P9	0.07	3.173	0.003
P10	0.07	5.740	0.003
P11	0.04	15.320	0.005

NA = not analyzed

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them first could be ingesting significantly more lead than indicated by the analyses in this report.

Relationships with Depth

To investigate the relationship of well depth and nitrate concentrations, wells were separated into two groups--shallow wells and deep wells. Wells 40 feet deep or less were considered shallow, and wells deeper than 40 feet were considered deep. Forty feet was chosen as the depth for demarcation because it is approximately the median depth for wells in this study. Iron has higher concentrations in deep wells. Nitrate has higher concentrations in shallow wells. Statistical significance was determined by using the Student t-test for sample means (Wine, 1964). T-test values that exceed the critical value indicate that within a 95% confidence limit, the deep and shallow samples were taken from different populations. Averages and standard deviations for deep and shallow wells, as well as t-test and critical values, are given in Table 7. Other parameter and well depth relationships are discussed in Clayton (1995).

Table 7. Averages and standard deviations for 17 deep and 21 shallow wells.

Parameter	Wells ≤ 40 ft	Wells > 40 ft	T-test value	Critical t value at $\alpha = 0.05$
Depth ft				0
Average	25.6	71.8		
Std. dev.	7.7	25.9		
			2.22	2.06
Fe mg/L				
Average	1.82	5.22		
Std. dev.	3.16	5.19		
			2.07	2.04
Nitrate-N mg/L				
Average	2.53	0.53		
Std. dev.	3.92	1.86		

Oxidation, Reduction and Denitrification

Nitrate contaminated ground water can cause the sometimes fatal condition methemoglobinemia in infants (Korom, 1992). Several wells contained detectable levels of nitrate. Concentrations below 0.40 mg/L as nitrogen are considered trace amounts in this study based on background concentrations for another aquifer (Steele and McCalister, 1996). Twelve wells contained nitrate above 0.40 mg/L. The locations of these 12 wells are shown in Figure 4. Well C1 exceeded the MCL of 10 mg/L (reported as N). This well contained 14.35 mg/L nitrate-N.
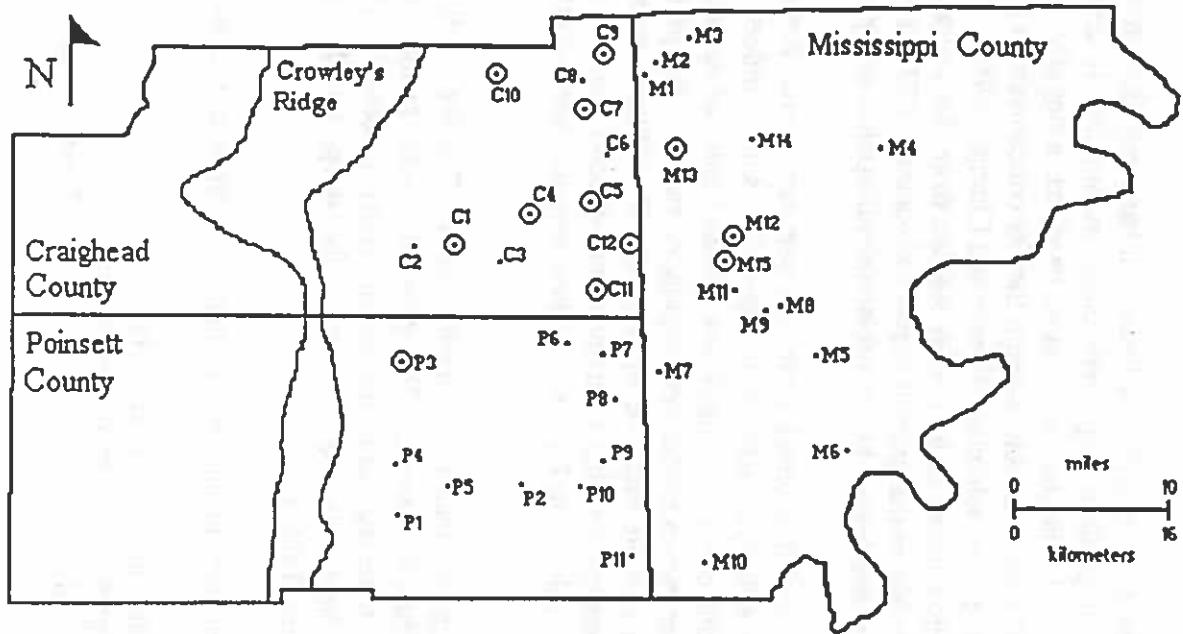
Figure 4. Locations of wells with nitrate. Wells with anomalously high nitrate concentrations are circled.

usually as ammonium nitrate (NH_4NO_3) or urea [$CO(NH_2)_2$], is applied to the land surface as fertilizer. The nitrogen in urea will be hydrolyzed by urease to ammonium (NH_4^+). This can occur over a period of several days (Alexander, 1977). The ammonium nitrate will disassociate to ammonium and nitrate (NO_3^-). The ammonium can then be converted to nitrate by microorganisms in a process known as nitrification. This process requires oxygen and typically occurs above the water table, in the soil zone. This also can occur over a period of several days (Alexander, 1977; Freeze and Cherry, 1979). Septic tanks are another source of nitrogen that could be oxidized to nitrate.

The mobility of the ammonium ion is limited because it has a positive charge, which allows it to be adsorbed onto soil particles, especially clays; its mobility is controlled by cation exchange capacity of the soil. Nitrate, on the other hand, has a negative charge, and is not significantly adsorbed. Nitrate is soluble enough that its concentration in ground water is limited by availability rather than solubility (Freeze and Cherry, 1979). The high solubility and lack of adsorption allow nitrate to be readily leached from the soil zone to the ground water, and to be very mobile in the ground water (Alexander, 1977; Freeze and Cherry, 1979). Nitrate mobility is also limited by microbial immobilization and plant uptake.

Because nitrate can be readily leached from the soil zone, one would expect nitrate contamination to be more likely in areas with permeable soils. Indeed, all twelve wells with nitrate concentrations above 0.15 mg/L are within 1 mile of at least one permeable soil, through which water moves moderately rapidly or rapidly. Maps showing the soils within one mile of each well are included in Appendix B. Nitrate occurrences are also related to depth. The deepest well that contains nitrate greater than 0.15 mg/L is 55 feet deep. This relationship is shown in Figure 5. There are nine wells in this study that are deeper than 55 feet.

Twenty-four wells within one mile of permeable soils. Twelve of these wells do not contain nitrate greater than 0.15 mg/L. The permeable soils around these wells could conceivably allow nitrate to be leached to the ground water if excessive fertilizer is applied at the surface. Five of these wells are 60 or more feet deep, which might protect them from nitrate contamination (Table 8).

Table 8. Nitrate and well depth means with respect to distance to permeable soils.

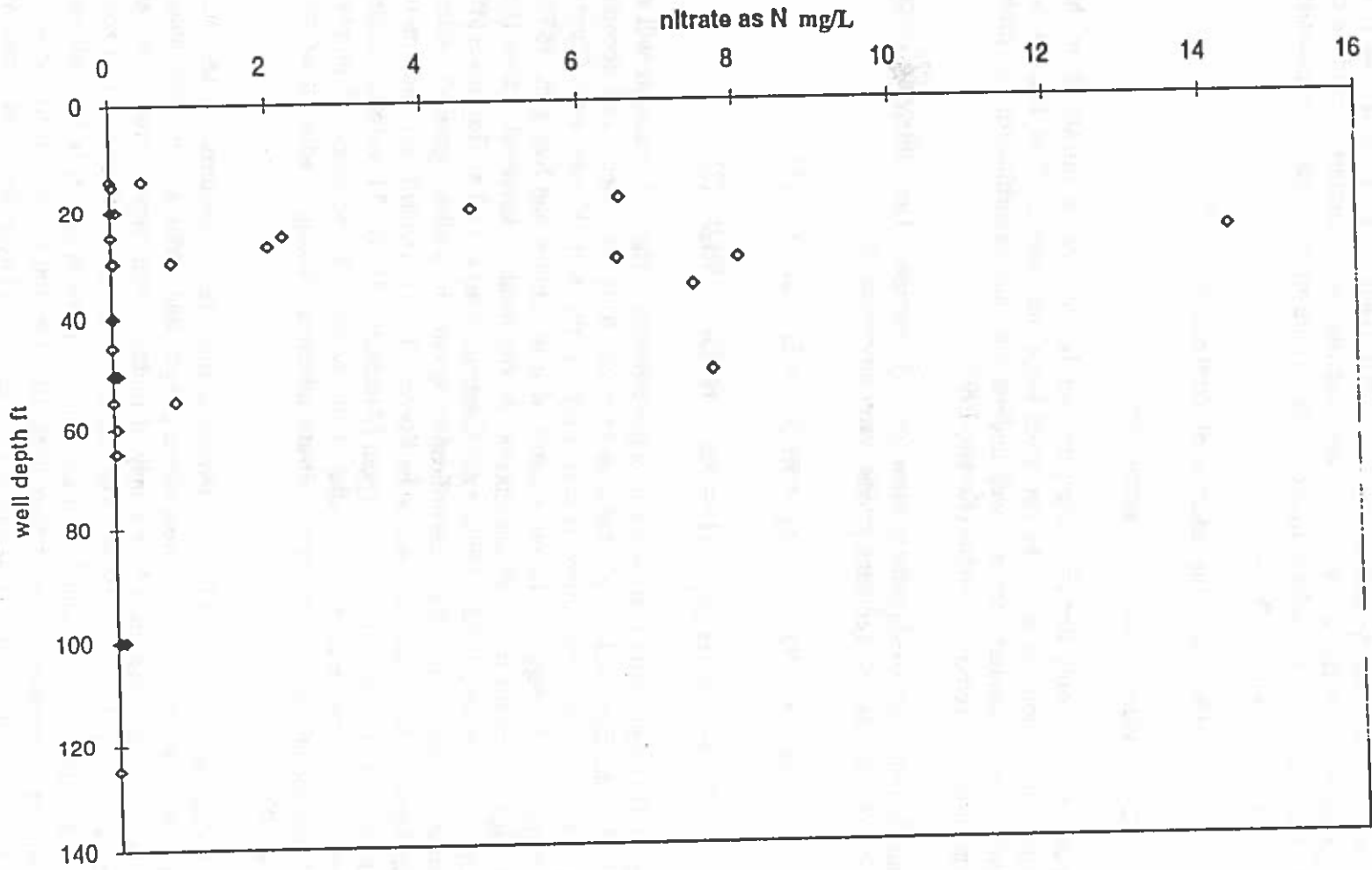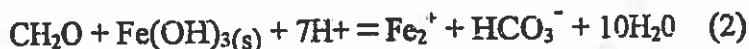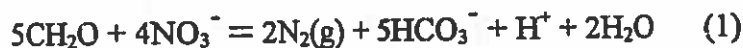| Parameter	Wells ≤ mile from permeable soil	Wells > 1 mile from permeable soil	T-test value	Critical t-value at $\alpha = 0.05$
Depth ft				
Average	47.8	45.4		
Std. dev.	27.3	31.0	0.24	2.03
Nitrate-N mg/L				
Average	0.03	2.56		
Std. dev.	0.03	3.9	3.21	2.07

Figure 5. Nitrate versus well depth.

Because nitrate concentrations greater than 0.15 mg/L are only present in shallow wells with some of the nearby soils having moderately rapid or rapid permeability, nitrate is being removed from the water. If this were not the case the nitrate would be carried to wells near less permeable soils or to deep wells. There are two possible explanations for the removal of nitrate. They are:

(1) denitrification -- the reduction of nitrate to N_2O or N_2, or

(2) reduction of nitrate to ammonium.

Of these methods only denitrification permanently removes the nitrate from the aquifer because the ammonium could be converted back into nitrate. The factors controlling reduction to ammonium are not well understood, but denitrification is probably the dominant process removing nitrate (Korom, 1992).

Denitrification is an oxidation-reduction (redox) reaction. The following reactions can occur in a progressively reducing ground water environment.

$$5CH_2O + 4NO_3^- = 2N_2(g) + 5HCO_3^- + H^+ + 2H_2O \quad (1)$$

$$CH_2O + Fe(OH)_{3(s)} + 7H+ = Fe_2^+ + HCO_3^- + 10H_2O \quad (2)$$

where CH_2O represents metabolizable organic matter. The first reaction will not occur until all of the dissolved oxygen has been removed from the water. The second reaction will not occur until the nitrate is consumed by the first (Freeze and Cherry, 1979). $Fe(OH)_{3(s)}$ may be replaced by other forms of iron (Stumm and Morgan, 1970). These processes only occur in significant amounts as the result of bacterial action (Freeze and Cherry, 1979;Korom, 1992). Gillham and Cherry (1978) as well as Edmunds (1973) have described situations in which denitrification occurs in shallow ground water. Other denitrification studies are summarized by Korom (1992). Denitrifying bacteria use nitrate as an electron acceptor in place of oxygen (Alexander, 1977). Therefore, nitrate can give an indication of the oxidation potential of the water. The presence of nitrate indicates oxidizing conditions. The absence of nitrate indicates reducing conditions or the lack of a source of nitrate.

The reduction of iron from ferric to ferrous is mediated by bacteria. These bacteria use iron as an electron acceptor in areas where oxygen and nitrate are not available. For this process to occur there must be a supply of metabolizable organic matter to serve as an electron donor (Alexander, 1977). The iron could be leached from the soil zone or from the aquifer material. The supply of organic matter is much greater in the soil zone than in the aquifer. Therefore, it seems more likely that the iron is reduced in the soil zone and then leached to the aquifer. Chapelle and Lovely (1992) have described a case where iron is known to be reduced in a confined aquifer.

Iron was only considered important if it was above 0.15 mg/L (the mean value for all wells). Eighteen of the 31 wells that were analyzed for cations contained iron concentrations greater than 0.15 mg/L. Because soluble iron occurs under reducing conditions, iron occurrences should be related to local soils. Impermeable soils typically become saturated after rain. Saturated conditions prevent oxygen from being replenished to the soil so that oxygen used by microorganisms is not replaced. Certain types of bacteria are then able to use iron (or nitrate, if present) in place of oxygen. The iron is reduced to the soluble Fe^{2+} ion and can be leached to the ground water.

Eleven of the 18 wells with iron concentration exceeding 0.15 mg/L are not within one mile of a permeable soil. Four of these wells are 40 feet deep or less. The other seven wells, including two that also had nitrate, are associated with permeable soils; however, only one of these wells is less than 40 feet deep.

Stumm and Morgan (1970) state that nitrate is not compatible with iron in waters with neutral pH. It is commonly observed that ground water does not contain both iron and nitrate (Korom, 1992), as is the case for this study. With only two exceptions, no well has more than 0.15 mg/L of both iron (Fe) and nitrate (NO_3^-, reported as N). This relationship is shown in Figure 6. One of the exceptions is well C1. As previously mentioned, this well contains 14.35 mg/L nitrate-N as well as 0.61 mg/L Fe. The other exception is well C11, which contains 0.77 mg/L nitrate and 0.91 mg/L Fe.

Although it is possible that the mutual exclusion of iron and nitrate could be due to the progressive reduction of ground water by reactions (1) and (2) stated above, this is not likely because these reactions require a sufficient supply of organic substrate. It is much more likely that the of iron reduction is occurring in the soil zone, due to the availability of organic carbon.

Denitrification can also proceed as the reaction between iron and nitrate. The reaction between NO_3^- and Fe^{2+} is:

$$3Fe^{2+} + NO_3^- + 4H+ = NO(g) + 2H_2O + 3Fe^{3+} \qquad E^o = -0.19$$
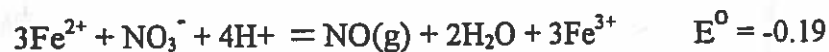
Where E^o is the standard potential of the reaction. A negative standard potential indicates that the reaction will occur spontaneously (Krauskopf, 1979). Any iron converted to Fe^{3+} would quickly be precipitated, most likely as $Fe(OH)_3$ (Stumm and Morgan, 1970). The fact that there are two wells that contain iron and nitrate above 0.15 mg/L, as well as other wells that contain smaller amounts, indicates that the reactions do not happen instantaneously. Supporting this conclusion, Freeze and Cherry (1979) state that many oxidation-reduction reactions occur slowly. Korom (1992) reports that this reaction does not happen at significant rates without microbial activity. Certain bacteria can use iron as an electron donor in place of organic carbon. The nitrate serves as the electron acceptor (Korom, 1992). This explains why iron and nitrate are not usually present together. It also helps to explain why there is more iron in deeper parts of the aquifer. Oxygen and

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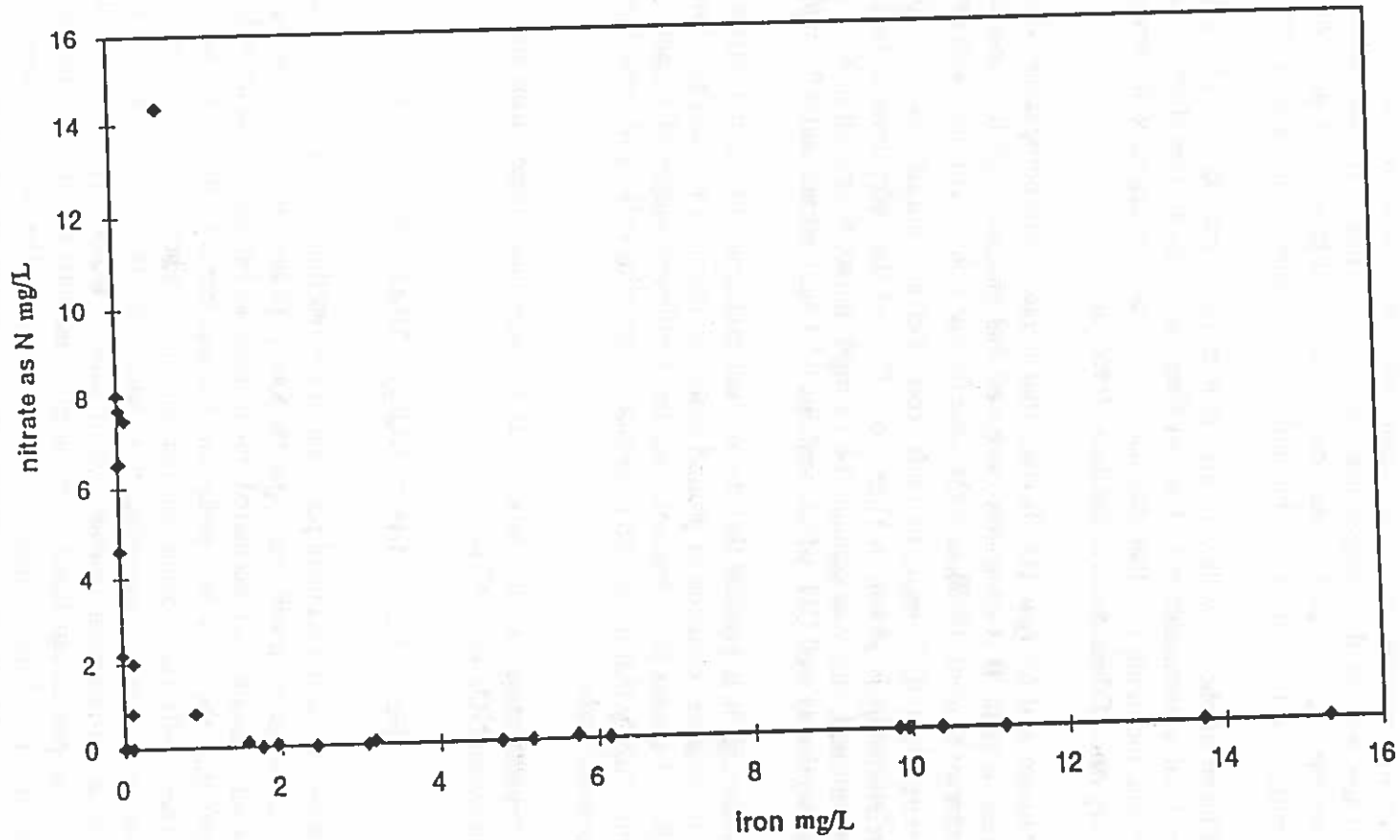
Figure 6. Nitrate versus iron.

nitrate which could oxidize the iron are likely consumed in shallow parts of the aquifer. In fact, denitrification may be occurring in the soil zone where carbon substrate is available.

A generalized conceptual model is shown in Figure 7. The general direction of ground-water flow is indicated by the arrow. Water in well A is likely to contain nitrate because the well is shallow and is surrounded by permeable soils. Water from wells B and C would not likely contain nitrate because well B is too deep and well C is surrounded by impermeable soils. Ground water that moves to deep parts of the aquifer or under impermeable soils will become reducing and denitrification will occur. Wells B and C would also contain iron. The iron could be reduced in the soils during saturated conditions and leached to the aquifer, or the iron could come from the aquifer material. Well A would not have iron because the ground water would be oxidizing and iron would exists in the insoluble ferric state. Wells B and C would have higher total dissolved solids than well A.

Nitrate and Pesticide Relationships

Pesticides and nitrate enter the ground water after being applied to the land surface. One would expect nitrate to be present in the wells containing pesticides. However, of the four wells that contained pesticide, only well C4 had significant amounts of nitrate. There are two reasons for the lack of a relationship between nitrate and pesticide contamination. One reason is that nitrate is more mobile. Pesticides are readily adsorbed to clay and organic matter. It is likely that the pesticides are held in the soil zone. In the soil zone, the pesticide can be degraded by microorganisms. Nitrate, on the other hand, is not significantly adsorbed to clay or organic matter and is extremely soluble. This explains the reason that nitrate is more common in ground water. The other difference between nitrate and pesticides is that nitrate can be removed by denitrification and would not be stable in reducing ground-water conditions. If a pesticides reaches the aquifer it can persist because it may not be readily degraded below the soil zone.

CONCLUSION

The data show that there is no major pesticide contamination in this area of northeastern Arkansas. Although the possibility of future contamination is not ruled out, current pesticide management practices appear to be adequately protecting the ground water from contamination.

Nitrate, on the other hand, is reaching the ground water. In one case the nitrate exceeded the maximum contaminant level for drinking water. Nitrate contamination was noted only in wells within one mile of permeable soils. This indicates that the nitrogen management practices for permeable soils should address this problem. Because nitrate is not present in deep wells or wells that are not near permeable soils, it is assumed that denitrification is occurring in the soil and perhaps the aquifer where ground water becomes reducing with
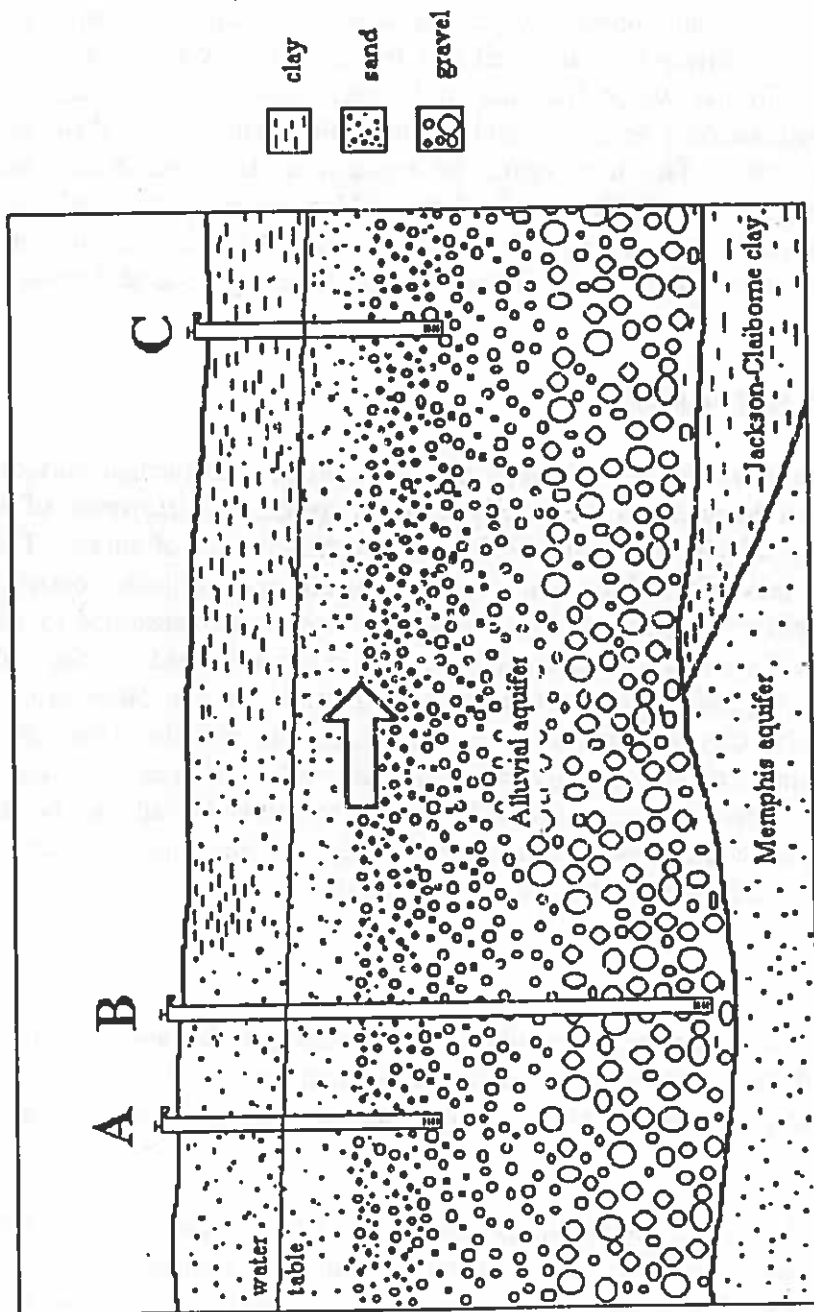
Figure 7. Conceptual model of the alluvial aquifer.

increased distance from the recharge areas. Microorganisms are using nitrate to oxidize ferrous iron or organic matter if it is available. The iron is probably being reduced in impermeable soils and then leached to the ground water or may be dissolved from the aquifer material.

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APPENDIX A

Quality Assurance Report

August 1, 1993 - October 19, 1994

Arkansas State Pesticides in Ground Water

Monitoring Project

PHASE II:

Mississippi, Craighead, and Pointsett Counties.

QUALITY ASSURANCE REPORT: ARKANSAS STATE
PESTICIDES IN GROUND WATER MONITORING PROJECT
PHASE II
MISSISSIPPI, CRAIGHEAD AND POINSETT COUNTIES

T. Nichols, P. Vendrell, K. Steele[1]

I. Introduction

Between November 1, 1993 and October 19, 1994, forty water
samples were drawn from 37 wells in Mississippi, Craighead and
Poinsett Counties. Ten liters of water were collected from each
well, providing enough water to have a sample and a field
fortified sample for each of the three methods, as well as extra
water for duplicate analysis. Table 1 shows a list of the
pesticides analyzed in these samples and the methods used.

Table 1. Phase II Analytes.

Compound	Source/Method	Matrix	Units	EDL
Metolachlor	EPA/507.1	groundwater	ug/L	0.75
Alachlor	EPA/507.1	groundwater	ug/L	0.38
Molinate	EPA/507.1	groundwater	ug/L	0.15
Atrazine	EPA/507.1	groundwater	ug/L	0.13
Metribuzin	EPA/507.1	groundwater	ug/L	0.15
Norflurazon	EPA/507.1	groundwater	ug/L	0.50
Linuron	NPS/4	groundwater	ug/L	0.25
Flumeturon	NPS/4	groundwater	ug/L	0.10
Cyanazine	NPS/4	groundwater	ug/L	0.58
Diuron	NPS/4	groundwater	ug/L	0.070
2,4-D	EPA/515.2	groundwater	ug/L	0.20
Bentazon	EPA/515.2	groundwater	ug/L	0.20
Acifluorfen	EPA/515.2	groundwater	ug/L	0.096

Of the 37 wells tested, four showed trace levels of
pesticides. Bentazon was found in three wells at 2.5, 0.3 and
0.2 ug/L. Fluometuron at 0.5 ug/L was found in one well. The
well with 2.5 ug/L of Bentazon was unavailable for retesting
despite two return trips to the well. The other three wells were
resampled but no trace of pesticide was found again.

II. Interpretation of QC data.

During the project, seven trips were made to collect water.
The samples collected on each trip were extracted and analyzed as
a batch, with each batch being subdivided into the three methods
of analysis indicated in Table 1. The tabulated quality control
data follow this format. Thus, for each sampling trip the

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reported analysis results are accompanied by three QC sheets, one for each method. The following paragraphs are intended as an aid in interpreting the QC data.

The major QA/QC concern of this study is to demonstrate an ongoing ability to detect small amounts of pesticides in various ground waters. Primary to this purpose are the three (one for each method) field fortified samples collected from each well and spiked with low levels of the appropriate pesticides. Table 2 shows the concentrations of these pesticides in the "field spikes." Extraction and analysis of these field spikes were done for every well and for every method, far exceeding EPA's recommendation that one in ten samples be field fortified. A consistent, high recovery of the pesticides spiked into the various ground waters is good indication that sample extraction and analysis are acceptable, that nothing in the ground waters is preventing the detection of pesticides in the non-fortified samples and that sample handling procedures are adequate to avoid pesticide degradation.

As a further check that small amounts of pesticide will not go unnoticed, 2X standards (containing pesticide concentrations at about two times the estimated detection limit for the pesticide) were analyzed with each batch. Concentrations for the 2X standards are also included in Table 2. For each batch and each method, peak areas for a 2X standard are reported to demonstrate instrument capability to detect very small amounts of pesticides. EPA holding times for samples and extracts were met without exception and samples and extracts were held at or below 4°C at all times.

Table 2. Spiking Levels.

METHOD	PESTICIDE	CONCENTRATION (ug/L)	
		FIELD SPIKE	2X STANDARD
507	Molinate	2.00	0.40
	Atrazine	2.06	0.41
	Metribuzin	2.10	0.42
	Alachlor	4.08	0.81
	Metolachlor	13.72	2.74
	Norflurazon	5.90	1.18
515.2	2,4-D	3.00	0.60
	Bentazon	7.21	1.44
	Aciflurofen	3.15	0.63
NPS4	Cyanazine	6.42	1.28
	Fluometuron	1.10	0.22
	Diuron	0.99	0.20
	Linuron	3.03	0.60

Recovery of a spiked pesticide from any field spike should be within the normal range of recovery for the laboratory doing the work. For EPA method 507 (EPA507) and National Pesticide Survey method 4 (NPS4), this laboratory has a history of successful analyses from which to determine a "normal" range of recovery for each analyte. Table 3 shows the mean recoveries and associated standard deviations for ten of the pesticides in this study. These were derived from 29 field spikes collected previously in a study of ground water in Ashley County.

Table 3. Summary of Recoveries for EPA Method 507 and National Pesticide Survey Method 4 - Mean, Standard Deviation and Range.

Chemical	N	Mean(M) %	Std. Dev.(s) %	Range(M±3s) %
Molinate	29	82.2	7.8	58.8 - 105.6
Atrazine	29	97.0	13.5	56.4 - 137.6
Metribuzin	29	103.3	17.5	50.8 - 155.8
Alachlor	29	97.3	14.7	53.3 - 141.2
Metolachlor	29	95.1	13.0	56.0 - 134.2
Norflurazon	29	99.0	20.5	37.4 - 160.5
EPA507 surrogate	84	100.0	17.0	49.0 - 151.0
Cyanazine	29	88.9	13.3	49.0 - 128.8
Fluometuron	29	83.8	16.8	33.3 - 134.3
Diuron	29	87.3	16.1	39.1 - 135.5
Linuron	29	84.0	13.9	42.1 - 125.8
NPS4 surrogate	80	79.5	7.7	56.5 - 102.4

The normal range of recovery is defined as the mean plus or minus 3 standard deviations. For example the mean recovery for molinate was 82.2% with a standard deviation of 7.8% yielding a range of 58.8 - 105.6% (the mean plus/minus 3 standard deviations). If the recovery of a particular analyte from a field spike is outside the normal range then the result for that analyte for that well is reported as suspect. In addition, surrogate recovery for the non-fortified samples must also fall in the normal range of surrogate recoveries which are defined in the same way. A surrogate is a pure compound not expected to be in the sample. A known amount of surrogate is added to the sample before extraction as a check on the sample preparation procedure. The normal range for surrogate recoveries for EPA507 and NPS4 are also given in Table 3.

EPA method 515.2(EPA515), used to analyze for bentazon, aciflurofen and 2,4-D, did not have a history in this laboratory prior to this study. Lacking such a history, EPA suggests 60% to 140% as the appropriate range for "start-up" work when analyzing

spiked reagent water. Experience suggests that recoveries from ground water will be more variable thus the range for this study was expanded to 55% to 145%. In future studies, the recoveries from this study will be used to develop an acceptable range of recoveries. Results for EPA515 are reported as suspect due to matrix effects if the spike recovery or the surrogate recovery was not in the specified range. In actuality, none of the recoveries in this study were so low as to cause suspicion of false negatives.

As specified in the Quality Assurance Project Plan (QAPP), QC data for nitrate consist of percent relative standard deviation (%RSD) between duplicate measurements of one sample and percent recovery (%REC) from a sample spiked with a known amount of nitrate-nitrogen. The maximum allowable %RSD is 10% and the allowable range for %REC is 80-120%. QC measurements are made on one sample from each sampling trip.

III. QA/QC Summary.

For the forty wells-including three resamples-there were a total of 520 data points (40 times 13 pesticides) of which 36, or 6.9%, have been reported as suspect. Thirty-three of these points are reported as suspect due to omission of the surrogate during analysis. Spike recoveries for all 33 points were within acceptable limits (as specified above), and there is no positive reason to doubt the validity of these results. But EPA requires that the data be reported as suspect because of the lack of surrogate information.

Spike recoveries for the three EPA515 analytes in Miss #10 were all below the minimum acceptable level, 55%. As the three points are from the same method and the same well, it is quite possible that the addition of the spike into the sample bottle was performed inaccurately. Alternatively, a problem in the extraction procedure may have caused these low recoveries. In this case, there is no positive proof of ability to recover the analytes from this particular matrix and the results are considered to be suspect due to matrix effects.

Suspect results have been highlighted with grey shading on the analysis reports and the three results associated with low spike recoveries are outlined as well as shaded. Being able to recover the minimum acceptable amount, or more, of the pesticides in the field spikes-except for the three results just mentioned-assures the researchers that no significant amounts of pesticide have gone undetected. The authors feel the pesticide QC data for these analysis results are adequate for the stated purposes of the study.

The nitrate data reported here are all acceptable. All the spike recoveries were very close to 100%. No %RSD was calculated for two of the trips as both of the duplicate measurements were at or below the detection limit. These duplicates are acceptable

even though the %RSD could not be computed. The %RSD associated with the second trip to Poinsett County is 24%. This was computed from duplicate measurements both of which were right at the detection limit (0.01 mg/L). The first measurement was 0.014 and the second .011. Realistically, these measurements are very close to each other and indicate that the measurement process is working properly. The %RSD is not a good measure when the reported concentrations are so close to the detection limit. Alternatives to using the %RSD to evaluate duplicate mesurements are now being considered.

ANALYSIS RESULTS

AND

QUALITY CONTROL DATA

RESULTS OF PESTICIDE MONITORING : TRIP #1 TO MISSISSIPPI COUNTY-NOVEMBER, 1993.

(unk = unknown, NC = not collected, ND = not detected)   (= suspect, see text)

	1	2	3	4	5	6
WELL ID:	MISS #1	MISS #2	MISS #3	MISS#4	MISS #5	MISS #6
DATE SAMPLED:	NOV 1,1993	NOV 1,1993	NOV 1,1993	NOV 2,1993	NOV 2,1993	NOV 2,1993
LATITUDE:	35° 56' 34"	35° 57' 23"	35° 58' 15"	35° 52' 19"	35° 40' 33"	35° 34' 29"
LONGITUDE:	90° 17' 00"	90° 16' 02"	90° 13' 33"	89° 59' 24"	90° 05' 00"	90° 02' 32"
DEPTH OF WELL, ft:	100+	100+	100+	50	30-50	125
pH, standard units:	7.5	7.4	7.5	6.7	6.7	7.1
CONDUCTIVITY AT 25° C , umhos/cm:	543	462	483	611	653	486
TEMPERATURE, ° C :	16	16	16	16	17	17
NITRATE, mg/L:	0.04	0.03	0.04	0.05	0.07	<0.01
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	2.5*	0.30	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND	ND

* CONFORMATION POSITIVE, UNABLE TO COLLECT SAMPLE FOR VERIFICATION

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO MISSISSIPPI COUNTY-NOVEMBER, 1993.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
FIELD FORTIFIED SAMPLES							
MISS #1	87	102	105	102	95	115	114
MISS #2	91	99	110	107	99	121	123
MISS #3	97	106	113	114	101	124	121
MISS #4	103	105	107	104	97	119	116
MISS #5	93	99	86	97	98	110	105
MISS #6	83	110	114	120	105	129	127
NON-FORTIFIED SAMPLES							
MISS #1	96						
MISS #2	70						
MISS #3	77						
MISS #4	71						
MISS #5	69						
MISS #6	86						
LAB BLANKS							
P266	78						
P267	76						

CONCENTRATIONS FOR LAB BLANKS

		MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P266		0	0	0	0	0	0
P267		0	0	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
2X STANDARD	13211	43630	9039	12527	33287	27611

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P202	P204	%RSD
89889	81591	9.68

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
113799	109910	3.48

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO MISISSIPPI COUNTY - NOVEMBER, 1993

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES				
MISS #1	122	104	104	113
MISS #2	102	87	97	96
MISS #3	88	74	83	82
MISS #4	98	85	129	94
MISS #5	113	91	116	110
MISS #6	81	74	87	85
NON-FORTIFIED SAMPLES				
MISS #1	129			
MISS #2	122			
MISS #3	OMITTED			
MISS #4	OMITTED			
MISS #5	OMITTED			
MISS #6	OMITTED			
LAB BLANKS				
P264	95			
P265	OMITTED			

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
P264	0	0		0
P265	0	0		0

PEAK AREAS FOR A 2X* STANDARD

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
2X STANDARD	38266	35068	22657	106688

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P214	P215	%RSD
48794	51104	8.81

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
49909	49776	0.27

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO MISISSIPPI COUNTY - NOVEMBER, 1993

NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
FIELD FORTIFIED SAMPLES					
MISS #1	99	105	98	90	74
MISS #2	94	103	90	80	73
MISS #3	100	101	96	90	82
MISS #4	102	103	97	90	80
MISS #5	90	88	91	81	79
MISS #6	92	94	87	81	81
NON-FORTIFIED SAMPLES					
MISS #1					85
MISS #2					78
MISS #3					87
MISS #4					77
MISS #5					78
MISS #6					87
LAB BLANKS					
P268					74
P270					76

CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P268	0	0	0	0
P270	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
2X STANDARD	2968	922	2178	8545	210614

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P219	P220	%RSD
165203	184481	11.03

* ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO MISISSIPPI COUNTY - NOVEMBER, 1993

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
MISS 6	102%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
0.07 mg/L	0.07 mg/L	1.00%

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RESULTS OF PESTICIDE MONITORING : TRIP #1 TO CRAIGHEAD COUNTY-NOVEMBER, 1993.

(unk = unknown, NC = not collected, ND = not detected)   (▒▒▒▒▒▒▒ = suspect, see text)

	1	2	3	4	5	6
WELL ID:	CH#1	CH#2	CH#3	CH#4	CH#5	CH#6
DATE SAMPLED:	NOV 22,1993	NOV 22,1993	NOV 22,1993	NOV 22,1993	NOV 22,1993	NOV 22,1993
LATITUDE:	35° 46' 22"	35° 46' 25"	35° 45' 26"	35° 47' 27"	35° 48' 12"	35° 51' 46"
LONGITUDE:	90° 29' 27"	90° 33' 09"	90° 27' 42"	90° 25' 30"	90° 21' 01"	90° 18' 53"
DEPTH OF WELL, ft:	25	30	20	20	25	20
pH, standard units:	6.5	7.5	7.9	6.9	7.4	7.6
CONDUCTIVITY AT 25° C , umhos/cm:	314	684	262	170	404	274
TEMPERATURE, ° C :	16	16	17	18	16	17
NITRATE, mg/L:	14.35	0.04	<0.01	5.5	2.2	<0.01
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	0.5@	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND	ND

@CONFIRMATION POSITIVE, VERIFICATION NEGATIVE

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO CRAIGHEAD COUNTY - NOVEMBER, 1993.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
FIELD FORTIFIED SAMPLES							
CH#1	90	81	96	90	98	97	99
CH#2	94	80	92	84	93	94	94
CH#3	97	82	91	86	96	95	94
CH#4	103	84	93	86	99	96	93
CH#5	121	91	97	91	101	101	99
CH#6	115	86	96	92	101	101	99
NON-FORTIFIED SAMPLES							
CH#1	112						
CH#2	88						
CH#3	100						
CH#4	98						
CH#5	91						
CH#6	112						
LAB BLANKS							
P366	80						
P367	120						

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CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P366	0	0	0	0	0	0	0
P367	0	0	0	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
2X STANDARD	12676	28087	7999	8630	30392	22191

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P303	P305	%RSD
122476	113663	7.46

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
106949	109954	2.77

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO CRAIGHEAD COUNTY - NOVEMBER, 1993.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES				
CH#1	85	85	90	82
CH#2	115	101	104	104
CH#3	93	85	74	72
CH#4	112	95	98	95
CH#5	115	97	104	100
CH#8	123	104	108	104
NON-FORTIFIED SAMPLES				
CH#1	113			
CH#2	135			
CH#3	122			
CH#4	129			
CH#5	138			
CH#6	106			
LAB BLANKS				
P361	128			
P362	103			

CONCENTRATIONS FOR LAB BLANKS

	2,4-D	BENTAZON	ACIFLUROFEN
P361	0	0	0
P362	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
2X STANDARD	49469	12270	36110	136383

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P329	P330	%RSD
39274	37819	3.77

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
36034	36311	0.77

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO CRAIGHEAD COUNTY - NOVEMBER, 1993

NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
FIELD FORTIFIED SAMPLES					
CH#1	119	98	99	97	75
CH#2	114	76	70	94	80
CH#3	110	76	71	95	82
CH#4	119	92	75	99	82
CH#5	115	76	74	97	85
CH#6	121	81	61	89	83
NON-FORTIFIED SAMPLES					
CH#1					75
CH#2					78
CH#3					72
CH#4					65
CH#5					66
CH#6					73
LAB BLANKS					
P369B					75
P370B					81

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CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P369B	0	0	0	0
P370B	0	0	0	0

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P314	P315	%RSD
164729	149542	9.66

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

* ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
CH#2	96%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
14.35 mg/L	14.41mg/L	0.40%

RESULTS OF PESTICIDE MONITORING : TRIP #1 TO POINSETT COUNTY - DECEMBER, 1993.

(unk = unknown, NC = not collected, ND = not detected)   (▓▓▓▓▓▓▓ = suspect, see text)

	1	2	3	4	5	6
WELL ID:	POIN #1	POIN #2	POIN #3	POIN #4	POIN #5	MISS #7
DATE SAMPLED:	DEC 6,1993	DEC 6,1993	DEC 6,1993	DEC 6,1993	DEC 6,1993	DEC 7,1993
LATITUDE:	35° 31' 29"	35° 33' 16"	35° 40' 33"	35° 34' 31 '	35° 38' 15"	35° 38' 43"
LONGITUDE:	90° 34' 14"	90° 25' 48"	90° 34' 18"	90° 34' 53"	90° 31' 09"	90° 16' 07"
DEPTH OF WELL, ft:	100+	100	14	40	14	25
pH, standard units:	7.4	7.3	7.3	7.3	7.6	7
CONDUCTIVITY AT 25° C , umhos/cm:	548	554	487	286	199	597
TEMPERATURE, ° C :	15	16	17	16	16	16
NITRATE, mg/L:	<0.01	0.11	0.41	0.01	<0.01	<0.01
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND	ND
BENTAZON, ug/L	0.2@	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND	ND

@CONFIRMATION POSITIVE, VERIFICATION NEGATIVE

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO POINSETT COUNTY - DECEMBER, 1993.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
FIELD FORTIFIED SAMPLES							
POIN #1	117	104	121	112	118	120	127
POIN #2	115	92	111	103	108	110	115
POIN #3	120	95	110	101	108	111	114
POIN #4	96	91	105	95	101	104	106
POIN #5	108	87	107	96	103	105	107
MISS #7	96	78	83	69	85	95	95
NON-FORTIFIED SAMPLES							
POIN #1	109						
POIN #2	100						
POIN #3	89						
POIN #4	80						
POIN #5	79						
MISS #7	82						
LAB BLANKS							
P470	118						
P471	101						
P472	81						

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P470		0	0	0	0	0	0
P471		0	0	0	0	0	0
P472		0	0	0	0	0	0

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P410	P418	%RSD
84088	90406	7.24

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

* ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO POINSETT COUNTY - DECEMBER, 1993.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES				
POIN #1	78	77	80	70
POIN #2	54	66	67	61
POIN #3	71	68	74	71
POIN #4	63	72	70	69
POIN #5	73	78	74	75
MISS #7	58	60	62	58
NON-FORTIFIED SAMPLES				
POIN #1	87			
POIN #2	90			
POIN #3	85			
POIN #4	110			
POIN #5	84			
MISS #7	93			
LAB BLANKS				
P476	101			
P477	116			
P478	88			

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
P476	0	0	0	0
P477	0	0	0	0
P478	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
44507	5283	20528	85859

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P414	P415	%RSD
31409	40898	26.25

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO POINSETT COUNTY - DECEMBER, 1993

NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
FIELD FORTIFIED SAMPLES					
POIN #1	97	112	112	100	73
POIN #2	118	130	115	104	86
POIN #3	105	132	112	99	80
POIN #4	120	103	108	93	67
POIN #5	130	115	116	102	86
MISS #7	119	109	110	98	84
NON-FORTIFIED SAMPLES					
POIN #1					62
POIN #2					82
POIN #3					89
POIN #4					74
POIN #5					90
MISS #7					82
LAB BLANKS					
P474					87
P475					82

CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P474	0	0	0	0
P475	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

CYANAZINE	FLUOMETURON	DIURON	LINURON
1278	1262	1766	6671

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P420	P429	%RSD
189393	182481	3.72

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #1 TO POINSETT COUNTY - DECEMBER, 1993

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
POIN 1	100%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
<0.01mg/L	0.01mg/L	NC

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RESULTS OF PESTICIDE MONITORING : TRIP #2 TO MISSISSIPPI COUNTY - MARCH, 1994.

(unk = unknown, NC = not collected, ND = not detected)　　　　(░░░░░░ = suspect, see text)

	1	2	3	4	5
WELL ID:	MISS#5R	MISS#8	MISS#9	CH#4R	POIN #1R
DATE SAMPLED:	MAR 28,1994	MAR 28,1994	MAR 28,1994	MAR 29,1994	MAR 29,1994
LATITUDE:	35° 40' 33"	35° 43' 12"	35° 42' 54"	35° 47' 27"	35° 31' 29"
LONGITUDE:	90° 05' 00"	90° 07' 30"	90° 08' 38"	90° 25' 30"	90° 34' 14"
DEPTH OF WELL, ft:	30-50	50	45	20	100+
pH, standard units:	6.7	7.2	7.1	7.2	7.4
CONDUCTIVITY AT 25° C , umhos/cm:	476	766	515	159	476
TEMPERATURE, ° C :	17	17	16	17	17
NITRATE, mg/L:	0.02	0.02	<0.01	4.62	0.02
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND
ATRAZINE, ug/L:	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO MISSISSIPPI COUNTY, MARCH 1994.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
FIELD FORTIFIED SAMPLES							
MISS #5R	77	81	98	93	92	96	95
MISS #8	75	82	98	93	93	98	97
MISS #9	83	90	102	93	96	101	98
CH #4R	110	100	107	101	106	107	100
POIN #1R	96	98	105	100	100	106	101
NON-FORTIFIED SAMPLES							
MISS #5R	omitted						
MISS #8	68						
MISS #9	72						
CH #4R	99						
POIN #1R	61						
LAB BLANKS							
P561	82						
P563	71						

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P561		0	0	0	0	0	0
P563		0	0	0	0	0	0

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P410	P418	%RSD
84088	90408	7.24

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO MISSISSIPPI COUNTY, MARCH 1994.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES				
MISS #5R	50	57	83	59
MISS #8	66	79	87	67
MISS #9	75	92	79	82
CH #4R	64	138	79	75
POIN #1R	84	107	106	104
NON-FORTIFIED SAMPLES				
MISS #5R	omitted			
MISS #8	omitted			
MISS #9	omitted			
CH #4R	omitted			
POIN #1R	omitted			
LAB BLANKS				
P580	63			
P569	74			

CONCENTRATIONS FOR LAB BLANKS

	2,4-D	BENTAZON	ACIFLUROFEN
P580	0	0	0
P569	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	2,4-D	BENTAZON	ACIFLUROFEN
2xSTANDARD	7	47322	29491	152952

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P539	P530	%RSD
omitted	38834	none

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
33156	30151	9.49

* ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO MISSISSIPPI COUNTY, MARCH 1994.

NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
FIELD FORTIFIED SAMPLES					
MISS #5R	87	86	91	81	OMITTED
MISS #8	85	85	91	79	OMITTED
MISS #9	89	86	92	85	OMITTED
CH #4R	85	84	88	78	OMITTED
POIN #1R	89	80	88	75	OMITTED
NON-FORTIFIED SAMPLES					
MISS #5R					102
MISS #8					84
MISS #9					84
CH #4R					88
POIN #1R					94
LAB BLANKS					
P566					102
P567					98

CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P566	0	0	0	0
P567	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

CYANAZINE	FLUOMETURON	DIURON	LINURON
5507	2899	7252	17983

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P544	P546	%RSD
349302	357098	2.21

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO MISSISSIPPI COUNTY, MARCH 1994.

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
MISS 5R	100%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
<0.01 mg/L	<0.01 mg/L	0.00%

RESULTS OF PESTICIDE MONITORING : TRIP #3 TO MISSISSIPPI COUNTY - JUNE, 1994.

(unk = unknown, NC = not collected, ND = not detected)   ([   ] = suspect, see text)

	1	2	3	4	5	6
WELL ID:	MISS#10	MISS #11	MISS#12	MISS#13	MISS #14	MISS#15
DATE SAMPLED:	JUNE 13,1994	JUNE 13,1994	JUN 13,1994	14-Jun-94	JUN 14,1994	JUN 14,1994
LATITUDE:	35° 28' 09"	35° 43' 36"	35° 46' 42"	35° 51' 52"	35° 52' 19"	35° 45' 24"
LONGITUDE:	90° 13' 02"	90° 10' 30"	90° 10' 39"	90° 14' 52"	90° 08' 52"	90° 11' 18"
DEPTH OF WELL, ft:	55	65	277	30	20-40	30
pH, standard units:	7.2	7.1	6.7	7.2	6.7	6.1
CONDUCTIVITY AT 25° C , umhos/cm:	454	560	513	557	184	262
TEMPERATURE, ° C :	17.5	17.5	19	19	17	18
NITRATE, mg/L:	<0.01	0.01	2	6.49	0.02	8.04
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND	ND

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #3 TO MISSISSIPPI COUNTY - JUNE 1994.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
FIELD FORTIFIED SAMPLES							
MISS#10	67	112	79	71	77	79	84
MISS #11	73	111	80	74	80	81	87
MISS#12	80	108	77	88	74	80	84
MISS#13	70	88	98	95	94	95	105
MISS #14	63	107	79	73	78	79	85
MISS#15	65	69	80	69	75	77	81
NON-FORTIFIED SAMPLES							
MISS#10	80						
MISS #11	77						
MISS#12	84						
MISS#13	53						
MISS #14	77						
MISS#15	67						
LAB BLANKS							
P881	99						
P882	78						

CONCENTRATIONS FOR LAB BLANKS

		MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P881		0	0	0	0	0	0
P882		0	0	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
2X STANDARD	98519	17004	7646	8012	25403	23966

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P833	P835	%RSD
205925	148691	32.28

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

* ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #3 TO MISSISSIPPI COUNTY - JUNE 1994.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES				
MISS#10	51	48	36	43
MISS #11	94	75	75	85
MISS#12	74	58	57	62
MISS#13	85	69	75	80
MISS #14	92	71	77	88
MISS#15	101	69	79	81
NON-FORTIFIED SAMPLES				
MISS#10	omitted			
MISS #11	105			
MISS#12	84			
MISS#13	95			
MISS #14	83			
MISS#15	84			
LAB BLANKS				
P878	80			
P879	81			

CONCENTRATIONS FOR LAB BLANKS

	2,4-D	BENTAZON	ACIFLUROFEN
P878	0	0	0
P879	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	SURROGATE	2,4-D	BENTAZON	ACIFLUROFEN
2X STANDARD	64868	70727	26088	130838

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P820	P829	%RSD
63465	67714	6.48

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #3 TO MISSISSIPPI COUNTY - JUNE 1994.

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE
FIELD FORTIFIED SAMPLES					
MISS#10	75	100	83	72	91
MISS #11	90	73	77	66	59
MISS#12	117	75	93	82	77
MISS#13	118	71	68	72	85
MISS #14	108	79	92	81	76
MISS#15	121	81	61	89	83
NON-FORTIFIED SAMPLES					
MISS#10					91
MISS #11					72
MISS#12					80
MISS#13					68
MISS #14					77
MISS#15					94
LAB BLANKS					
P875					70
P876					77

CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P875	0	0	0	0
P876	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

CYANAZINE	FLUOMETURON	DIURON	LINURON
4640	4604	5403	15995

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P814	P815	%RSD
387340	389431	0.54

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
319460	325181	1.77

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #3 TO MISSISSIPPI COUNTY - JUNE 1994.

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
MISS 14	100%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
6.49 mg/L	6.51mg/L	0.22%

RESULTS OF PESTICIDE MONITORING : TRIP #2 TO CRAIGHEAD COUNTY - SEPTEMBER, 1994

(unk = unknown, NC = not collected, ND = not detected)　　　　(▓▓▓▓▓▓▓ = suspect, see text)

	1	2	3	4	5	6
WELL ID:	CH #7	CH #8	CH #9	CH #10	CH #11	CH #12
DATE SAMPLED:	AUG. 31, 1994	AUG. 31, 1994	AUG. 31, 1994	AUG. 31, 1994	AUG. 31, 1994	AUG. 31, 1994
LATITUDE:	35° 53' 31"	35° 56' 31"	35° 57' 38"	35° 56' 36"	35° 43' 55"	35° 46' 19"
LONGITUDE:	90° 20' 30"	90° 20' 32"	90° 19' 08"	90° 27' 02"	90° 20' 24"	90° 17' 58"
DEPTH OF WELL, ft:	50	50?	35	18	30	50-60
pH, standard units:	6.8	7.4	6.7	7.1	6.1	6.3
CONDUCTIVITY AT 25° C , umhos/cm:	385	476	492	534	202	445
TEMPERATURE, ° C :	21	17.5	16	16.5	17	17.5
NITRATE, mg/L:	7.70	<0.01	7.46	6.52	0.77	0.80
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND	ND
LINURON, ug/L:	ND ·	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND	ND

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO CRAIGHEAD COUNTY - SEPTEMBER, 1994.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON	INT. STD.
FIELD FORTIFIED SAMPLES								
CH #7	110	87	68	74	88	93	65	75
CH #8	104	78	69	70	78	81	80	80
CH #9	131	126	102	108	111	109	104	78
CH #10	127	115	113	113	120	120	112	89
CH #11	106	112	106	107	113	117	103	112
CH #12	111	111	111	110	115	116	107	94
NON-FORTIFIED SAMPLES								
CH #7	90							107
CH #8	90							118
CH #9	81							108
CH #10	96							130
CH #11	92							111
CH #12	85							118
LAB BLANKS								
P1170	122							103
P1172	97							117

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P1170		0	0	0	0	0	0
P1172		0	0	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
2X STANDARD	3830	6331	3437	3694	10158	7800

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1203	P1205	%RSD
64523	70970	9.52

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
89907	72962	20.81

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO CRAIGHEAD COUNTY - SEPTEMBER, 1994.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	INT. STD.	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES					
CH #7	87	81	93	89	76
CH #8	78	73	82	87	66
CH #9	86	87	87	100	78
CH #10	70	75	78	75	65
CH #11	84	93	84	95	86
CH #12	92	81	86	77	68
NON-FORTIFIED SAMPLES					
CH #7	65		76		
CH #8	78		77		
CH #9	70		92		
CH #10	71		76		
CH #11	60		79		
CH #12	61		90		
FORTIFIED REAGENT WATER					
P1180	92	68	79	69	62
P1182	85	66	100	67	60
LAB BLANKS					
P1179	74		67		
P1181	68		69		

CONCENTRATIONS FOR LAB BLANKS

		2,4-D		BENTAZON	ACIFLUROFEN
P1179		0		0	0
P1181		0		0	0

PEAK AREAS FOR A 2X* STANDARD

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1220	P1229	%RSD
175981	151807	14.74

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
177159	178699	0.87

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

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NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE	INT. STD.
FIELD FORTIFIED SAMPLES						
CH #7	89	74	80	65	77	99
CH #8	76	70	84	70	82	95
CH #9	70	67	82	70	78	107
CH #10	77	74	90	78	93	89
CH #11	75	79	84	70	79	99
CH #12	75	59	87	65	71	97
NON-FORTIFIED SAMPLES						
CH #7					71	98
CH #8					71	104
CH #9					71	104
CH #10					91	103
CH #11					68	93
CH #12					79	105
FORTIFIED REAGENT WATER						
P1175	74	68	88	75	71	110
LAB BLANKS						
P1174					71	97
P1176					72	105

CONCENTRATIONS FOR LAB BLANKS

	CYANAZINE	FLUOMETURON	DIURON	LINURON
P1174	0	0	0	0
P1176	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

CYANAZINE	FLUOMETURON	DIURON	LINURON
667	2732	6126	14123

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1214	P1215	%RSD
296357	290616	1.96

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
406653	418761	2.93

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO CRAIGHEAD COUNTY - SEPTEMBER, 1994.

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
CH #8	106%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
7.70mg/L	7.78 mg/L	0.84%

RESULTS OF PESTICIDE MONITORING : TRIP #2 TO POINSETT COUNTY - OCTOBER, 1994.

(unk = unknown, NC = not collected, ND = not detected)   (▓▓▓▓▓▓▓▓▓ = suspect, see text)

	1	2	3	4	5
WELL ID:	POIN #6	POIN #7	POIN #9	POIN #10	POIN #11
DATE SAMPLED:	Oct. 19, 1994	OCT 19, 1994	19-Oct-94	OCT 19, 1994	19-Oct-94
LATITUDE:	35° 41' 10"	35° 40' 21"	35° 34' 10"	35° 32' 54"	35° 29' 10"
LONGITUDE:	90° 22' 34"	90° 20' 29"	90° 20' 01"	90° 21' 39"	90° 18' 01"
DEPTH OF WELL, ft:	30	60	20	50	65
pH, standard units:	7.4	7.1	6.8	7.1	7
CONDUCTIVITY AT 25° C , umhos/cm:	725	453	604	830	534
TEMPERATURE, ° C :	18	18	18	18	17.5
NITRATE, mg/L:	0.01	0.04	0.13	0.07	0.04
ACIFLUORFEN, ug/L	ND	ND	ND	ND	ND
ALACHLOR, ug/L:	ND	ND	ND	ND	ND
ATRAZINE,ug/L:	ND	ND	ND	ND	ND
BENTAZON, ug/L	ND	ND	ND	ND	ND
CYANAZINE, ug/L:	ND	ND	ND	ND	ND
DIURON, ug/L:	ND	ND	ND	ND	ND
FLUOMETURON, ug/L:	ND	ND	ND	ND	ND
LINURON, ug/L:	ND	ND	ND	ND	ND
METOLACHLOR, ug/L:	ND	ND	ND	ND	ND
METRIBUZIN, ug/L:	ND	ND	ND	ND	ND
MOLINATE, ug/L:	ND	ND	ND	ND	ND
NORFLURAZON, ug/L	ND	ND	ND	ND	ND
2,4-D, ug/L	ND	ND	ND	ND	ND

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QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO POINSETT COUNTY - OCTOBER, 1994.

EPA METHOD 507

PERCENT RECOVERIES

	SURROGATE	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON	INT. STD.
FIELD FORTIFIED SAMPLES								
POIN #6	163	124	100	104	113	113	111	80
POIN #7	112	92	86	71	82	92	95	85
POIN #9	122	90	78	74	84	99	101	86
POIN #10	116	91	96	90	84	94	98	95
POIN #11	98	108	100	90	90	92	95	101
NON-FORTIFIED SAMPLES								
POIN #6	89							100
POIN #7	56							111
POIN #9	95							115
POIN #10	87							116
POIN #11	84							114
FORTIFIED REAGENT WATER								
P1468	72	73	77	61	68	86	92	96
LAB BLANKS								
P1467	87							94
P1469	79							125

CONCENTRATIONS FOR LAB BLANKS

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
P1467	0	0	0	0	0	0
P1469	0	0	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	MOLINATE	ATRAZINE	METRIBUZIN	ALACHLOR	METOLACHLOR	NORFLURAZON
2X STANDARD	2899	5158	2689	2882	7870	6891

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1503	P1505	%RSD
65591	90162	31.55

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
80659	72098	11.21

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

QUALITY CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO POINSETT COUNTY - OCTOBER, 1994.

EPA METHOD 515

PERCENT RECOVERIES

	SURROGATE	2,4-D	INT. STD.	BENTAZON	ACIFLUROFEN
FIELD FORTIFIED SAMPLES					
POIN #6	94	111	73	91	118
POIN #7	112	100	79	112	93
POIN #9	123	108	81	61	103
POIN #10	89	99	77	96	86
POIN #11	91	133	78	77	135
NON-FORTIFIED SAMPLES					
POIN #6	90		71		
POIN #7	87		72		
POIN #9	76		68		
POIN #10	98		73		
POIN #11	86		73		
FORTIFIED REAGENT WATER					
P1463	78	72	88	62	61
LAB BLANKS					
P1466	65		74		

CONCENTRATIONS FOR LAB BLANKS

	SURROGATE	2,4-D	INT. STD.	BENTAZON	ACIFLUROFEN
P1466		0		0	0

PEAK AREAS FOR A 2X* STANDARD

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1530	P1539	%RSD
271382	145341	60.49

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
192766	200756	4.06

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

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NPS METHOD 4

PERCENT RECOVERIES

	CYANAZINE	FLUOMETURON	DIURON	LINURON	SURROGATE	INT. STD.
FIELD FORTIFIED SAMPLES						
POIN #6	80	87	85	90	88	124
POIN #7	79	87	84	91	84	125
POIN #9	88	97	96	101	106	117
POIN #10	84	92	90	93	88	119
POIN #11	82	92	89	93	99	119
NON-FORTIFIED SAMPLES						
POIN #6					96	113
POIN #7					92	109
POIN #9					80	141
POIN #10					105	104
POIN #11					73	157
FORTIFIED REAGENT WATER						
P1470	82	87	90	94	88	126
LAB BLANKS						
P1471					91	123

CONCENTRATIONS FOR LAB BLANKS

P1471	0	0	0	0

PEAK AREAS FOR A 2X* STANDARD

	CYANAZINE	FLUOMETURON	DIURON	LINURON
2X STANDARD	5617	3239	7137	15782

DUPLICATE ANALYSIS

FIELD DUPLICATE - SURROGATE AREA COMPARISON

P1514	P1515	%RSD
122510	141898	14.67

MACHINE DUPLICATE - SURROGATE AREA COMPARISON

1ST RUN	2ND RUN	%RSD
459833	459551	0.06

*ANALYTE CONCENTRATIONS ARE ABOUT 2 TIMES THE EPA ESTIMATED DETECTION LIMIT

CONTROL DATA FOR PESTICIDE MONITORING: TRIP #2 TO POINSETT COUNTY - OCTOBER, 1994.

NITRATE

SPIKE RECOVERY

WELL NUMBER	% RECOVERY
POIN 7	98%

DUPLICATE ANALYSIS

1ST MEASUREMENT	2ND MEASUREMENT	% RSD
0.014 mg/L	0.011mg/L	24.00%

APPENDIX B

Tables B1 - B3 explain the symbols used to identify each soil. Table B4 lists the family, subgroup and order for each of the soil series. Table B5 lists the soil surrounding each well. Figures B1-B38 show the soils within one mile of each well as presented in the soil surveys for each county (Ferguson and Gray, 1971; Gray and Ferguson, 1977; Ferguson, 1979). On these maps, cross lines have been drawn to indicate permeable soils, those through which water movement is rapid or moderately rapid.

Table B1. Key to soil symbols used in Craighead County.

Symbol	Name
1	Amagon fine sandy loam
2	Amagon silt loam
3	Beulah fine sandy loam, 0 to 1 percent slopes
4	Beulah fine sandy loam, gently undulating
7	Bruno loamy sand
12	Commerce very fine sandy loam
14	Convent fine sandy loam
15	Dubbs fine sandy loam, 0 to 1 percent slopes
16	Dubbs fine sandy loam, gently undulating
18	Dundee fine sandy loam
19	Dundee silt loam
20	Dundee-Bruno-Commerce complex
22	Foley silt loam
23	Fountain silt loam
34	Mhoon fine sandy loam
35	Mhoon soils, frequently flooded
36	Roellen silty clay loam
37	Sharkey clay

Table B2. Key to soil symbols used in Mississippi County.

Symbol	Name
Aa	Alligator clay
An	Amagon sandy loam
Bp	Borrow pits
Br	Bowdre silty clay loam
Bv	Bruno-Crevasse complex
Cm	Commerce silt loam
Cn	Convent fine sandy loam
Cr	Crevasse loamy sand
Du	Dundee silt loam
Dv	Dundee-Dubbs-Crevasse complex
Ec	Earle clay
Fe	Forestdale silt loam
Fo	Forestdale silty clay loam
Fr	Forestdale-Routon complex
Ha	Hayti fine sandy loam
Ib	Iberia clay
Je	Jeanerette silt loam
Mo	Morganfield fine sandy loam
Rd	Routon-Dundee-Crevasse complex
Sc	Sharkey silty clay loam
Sh	Sharkey silty clay
Sk	Sharkey-Crevasse complex
Sm	Sharkey-Steele complex
Sn	Sharkey and Steele soils
So	Steele loamy sand
Sr	Steele silty clay loam
Ss	Steele and Crevasse soils
St	Steele and Tunica soils
Td	Tiptonville and Dubbs silt loams
Tu	Tunica silty clay

Table B3. Key to soil symbols used in Poinsett County.

Symbol	Name
Aa	Alligator clay
An	Amagon silt loam
BeU	Beulah fine sandy loam, undulating
BoU	Bowdre silty clay loam, undulating
Cu	Convent silt loam
DbU	Dubbs silt loam, undulating
DdA	Dundee silt loam, 0 to 2 percent slopes
Ec	Earle silty clay loam
Fo	Foley-Calhoun complex
Ha	Hayti soils
Mo	Mhoon silt loam
Sc	Sharkey clay
Sm	Sharkey-Steele complex
SN	Sharkey soils, frequently flooded
TnA	Tunica clay, 0 to 1 percent slopes
TnU	Tunica clay, undulating

Table B4. Classifications of soil series.

Series	Family	Subgroup	Order
Alligator	Very-fine, montmorillonitic, acid, thermic	Vertic Haplaquepts	Inceptisols
Amagon	Fine-silty, mixed, thermic	Typic Ochraqualfs	Alfisols
Beulah	Coarse-loamy, mixed, thermic	Typic Dystrochrepts	Inceptisols
Bowdre	Clayey over loamy, mixed, thermic	Fluvaquentic Hapludolls	Mollisols
Bruno	Sandy, mixed, thermic	Typic Udifluvents	Entisols
Calhoun	Fine-silty, mixed, thermic	Typic Glossudalfs	Alfisols
Commerce	Fine-silty, mixed, nonacid, thermic	Aeric Fluvaquents	Entisols
Convent	Coarse-silty, mixed, nonacid, thermic	Aeric Fluvaquents	Entisols
Crevasse	Mixed, thermic	Typic Udipsamments	Entisols
Dubbs	Fine-silty, mixed, thermic	Typic Hapludalfs	Alfisols
Dundee	Fine-silty, mixed, thermic	Aeric Ochraqualfs	Alfisols
Earle	Clayey over loamy, montmorillonitic, acid, thermic	Vertic Haplaquepts	Inceptisols
Foley	Fine-silty, mixed, thermic	Albic Glossic Natraqualfs	Alfisols
Forestdale	Fine, montmorillonitic, thermic	Typic Ochraqualfs	Alfisols
Fountain	Fine-silty, mixed, thermic	Typic Glossaqualfs	Alfisols
Hayti	Fine-silty, mixed, nonacid, thermic	Typic Fluvaquents	Entisols
Iberia	Fine, montmorillonitic, noncalcareous, thermic	Vertic Haplaquolls	Mollisols
Jeanerette	Fine-silty, mixed, noncalcareous, thermic	Typic Argiaquolls	Mollisols
Mhoon	Fine-silty, mixed, nonacid, thermic	Typic Fluvaquents	Entisols
Morganfield	Coarse-silty, mixed, nonacid, thermic	Typic Udifluvents	Entisols
Roellen	Fine, montmorillonitic, thermic	Vertic Haplaquolls	Mollisols
Routon	Fine-silty, mixed, thermic	Typic Ochraqualfs	Alfisols
Sharkey	Very-fine, montmorillonitic, nonacid, thermic	Vertic Haplaquepts	Inceptisols
Steele	Sandy over clayey, mixed, nonacid, thermic	Aquic Udifluvents	Entisols
Tiptonville	Fine-silty, mixed, thermic	Typic Argiudolls	Mollisols
Tunica	Clayey over loamy, montmorillonitic, nonacid, thermic	Vertic Haplaquepts	Inceptisols

Table B5. Soil that immediately surrounds each well.

Well	Soil
C1	Dubbs fine sandy loam, gently undulating
C2	Fountain silt loam
C3	Mhoon fine sandy loam
C4	Sharkey clay
C5	Commerce very fine sandy loam
C6	Dundee fine sandy loam
C7	Dubbs fine sandy loam, 0 to 1 percent slopes
C8	Dundee fine sandy loam
C9	Dundee fine sandy loam
C10	Dubbs fine sandy loam, gently undulating
C11	Convent fine sandy loam
C12	Commerce very fine sandy loam
M1	Dundee silt loam
M2	Routon-Dundee-Crevasse complex
M3	Routon-Dundee-Crevasse complex
M4	Sharkey-Steele complex
M5	Sharkey silty clay
M6	Bowdre silty clay loam
M7	Dundee silt loam
M8	Tunica silty clay
M9	Tunica silty clay
M10	Alligator clay
M11	Steele and Crevasse soils
M12	Routon-Dundee-Crevasse complex
M13	Routon-Dundee-Crevasse complex
M14	Routon-Dundee-Crevasse complex
M15	Amagon sandy loam
P1	Sharkey clay
P2	Sharkey clay
P3	Dundee silt loam, 0 to 2 percent slopes
P4	Dundee silt loam, 0 to 2 percent slopes
P5	Mhoon silt loam
P6	Hayti soils
P7	Hayti soils
P8	Hayti soils
P9	Sharkey-Steele complex
P10	Sharkey-Steele complex
P11	Sharkey clay
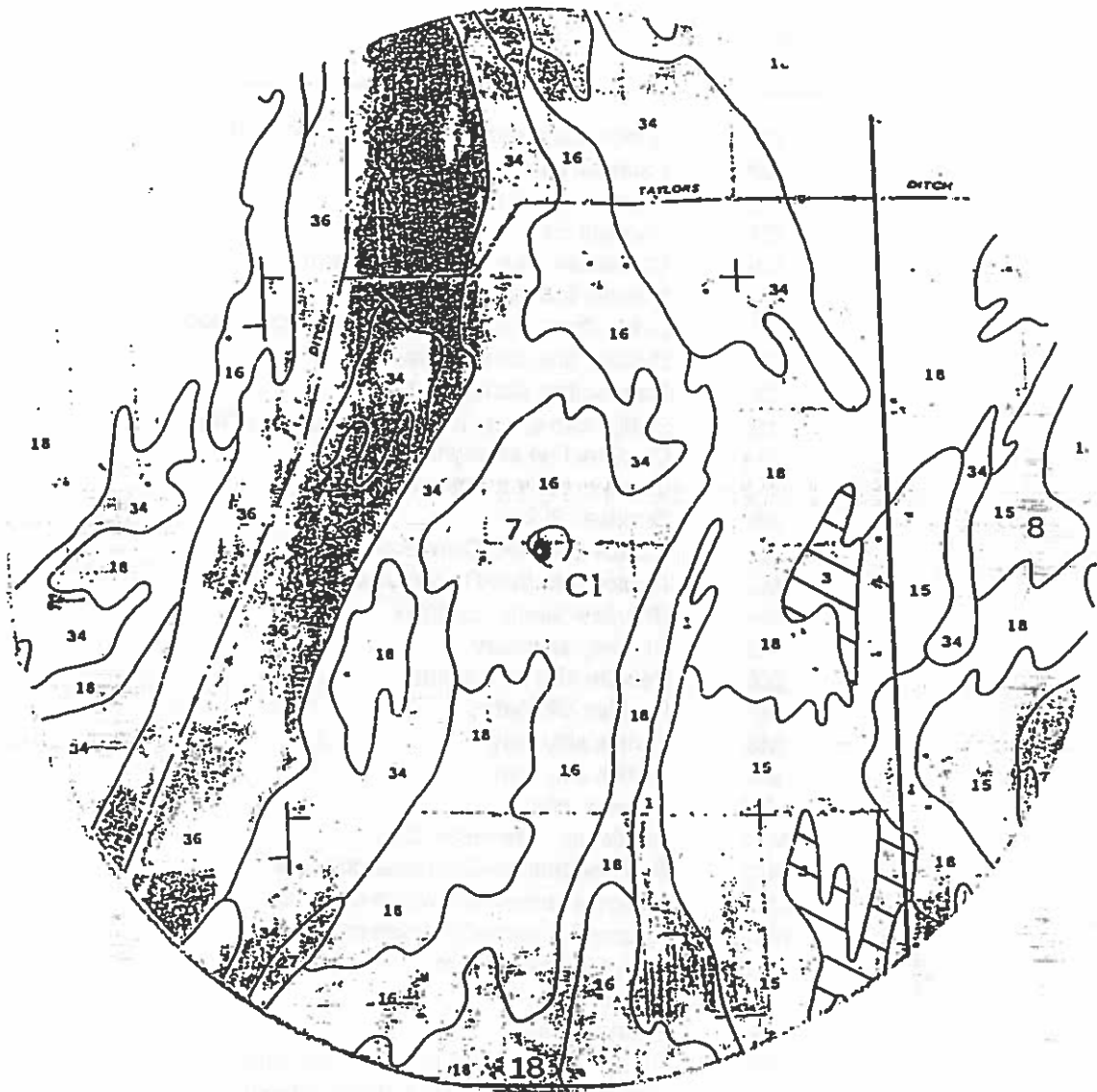
Figure B1. Soils within one mile of well C1. Permeable soils are indicated by cross lines.
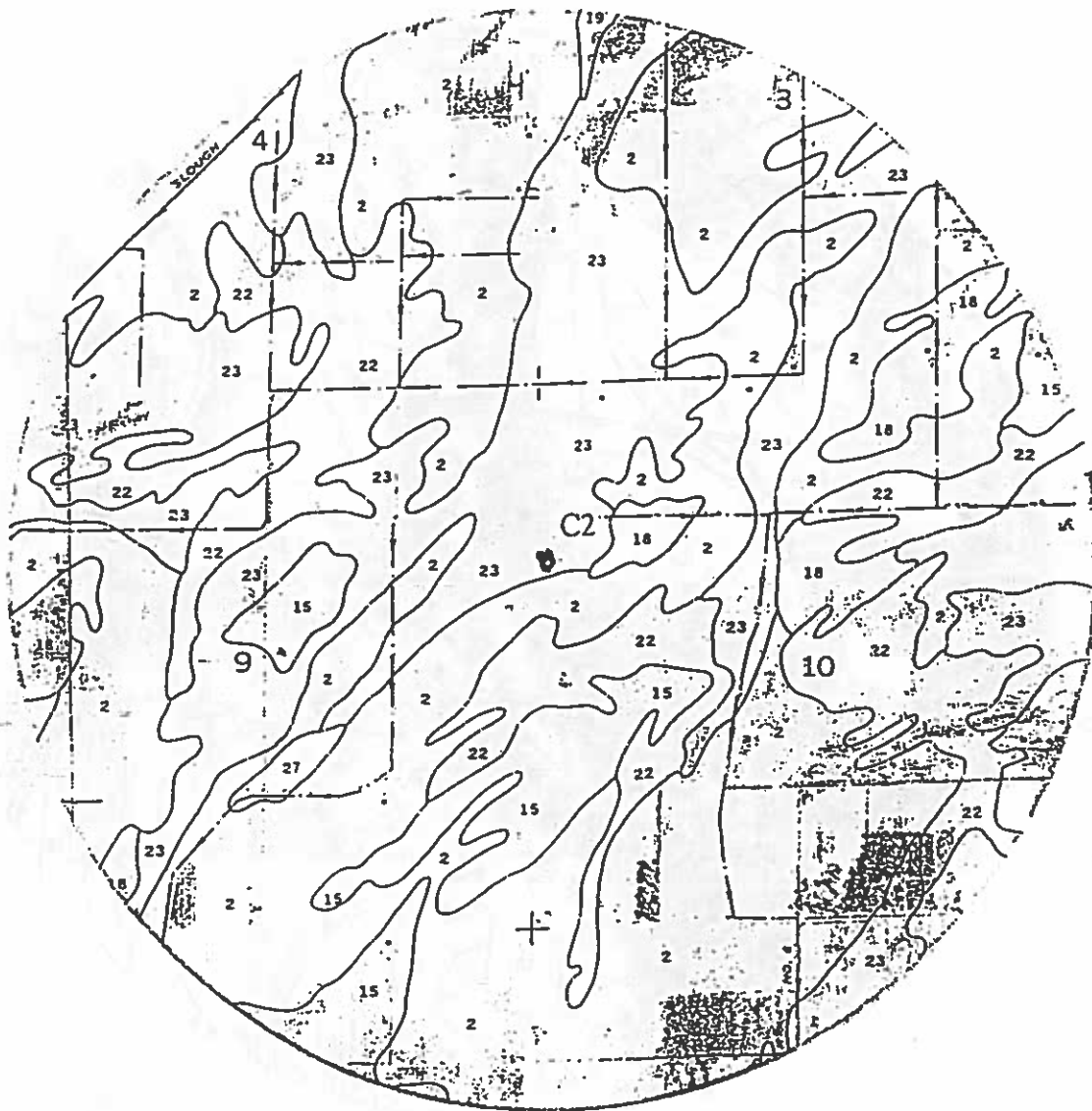
N↑

Figure B2. Soils within one mile of well C2. Permeable soils are indicated by cross lines.
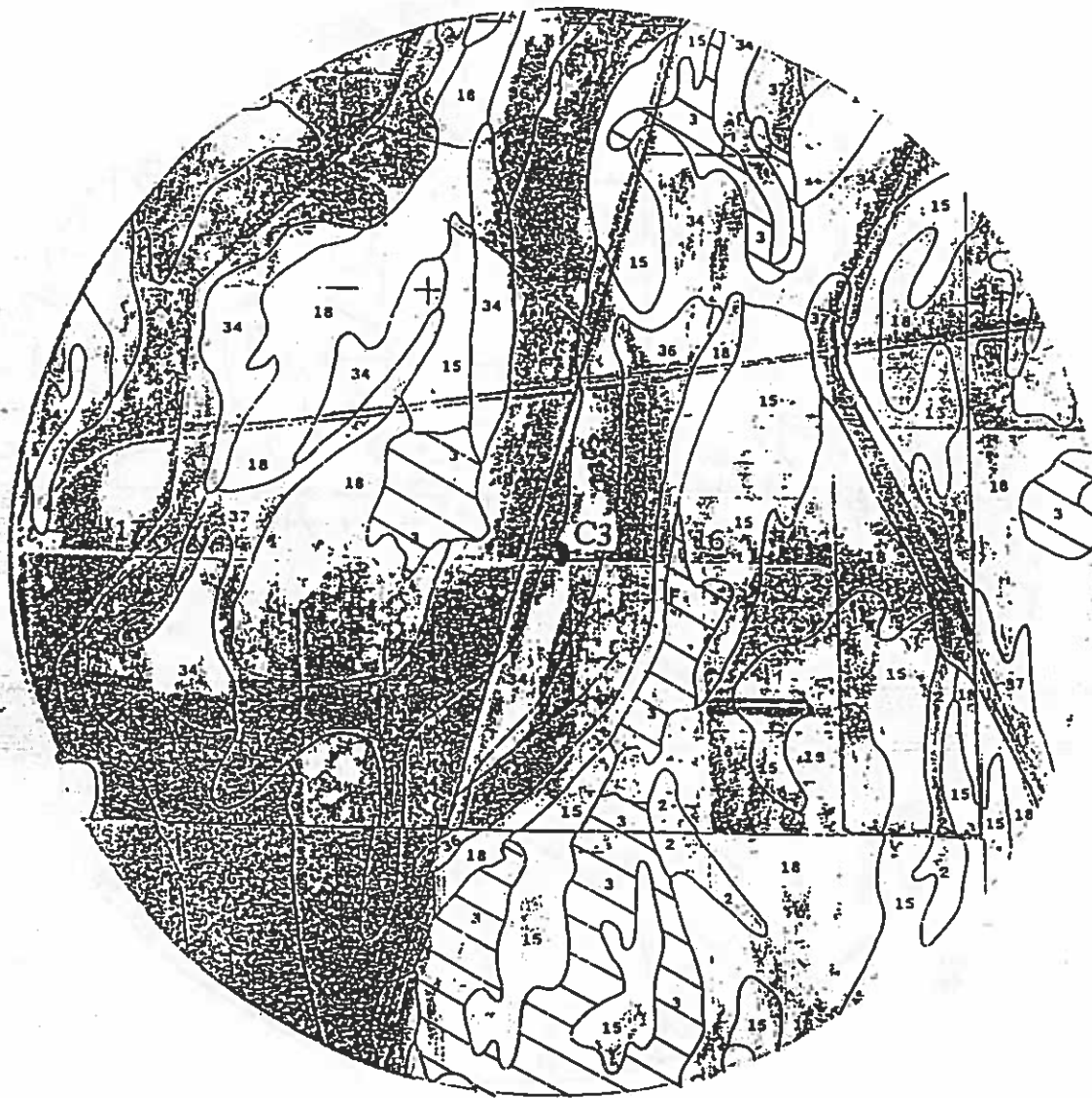
N↑

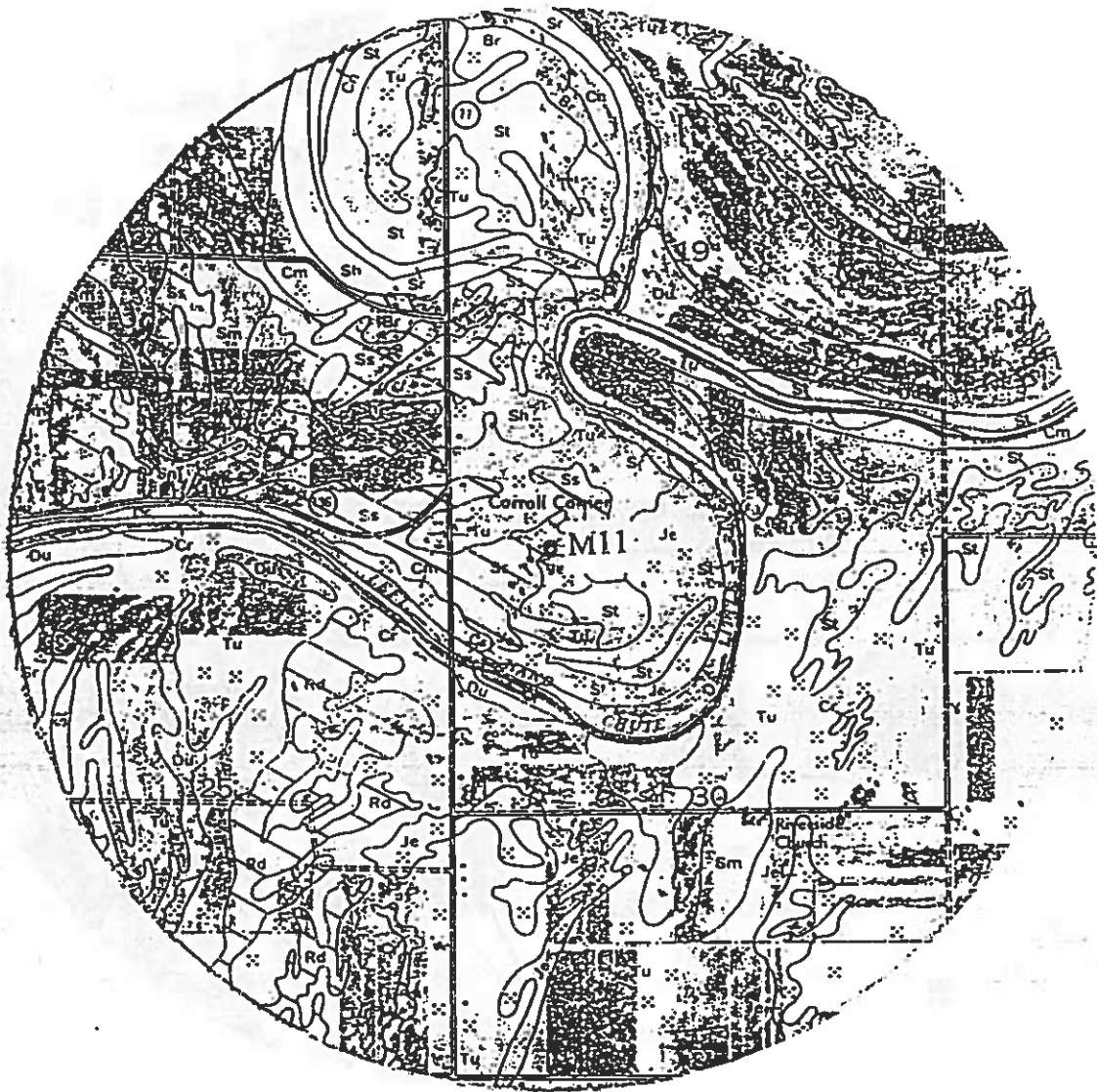**Figure B3.** Soils within one mile of well C3. Permeable soils are indicated by cross lines.
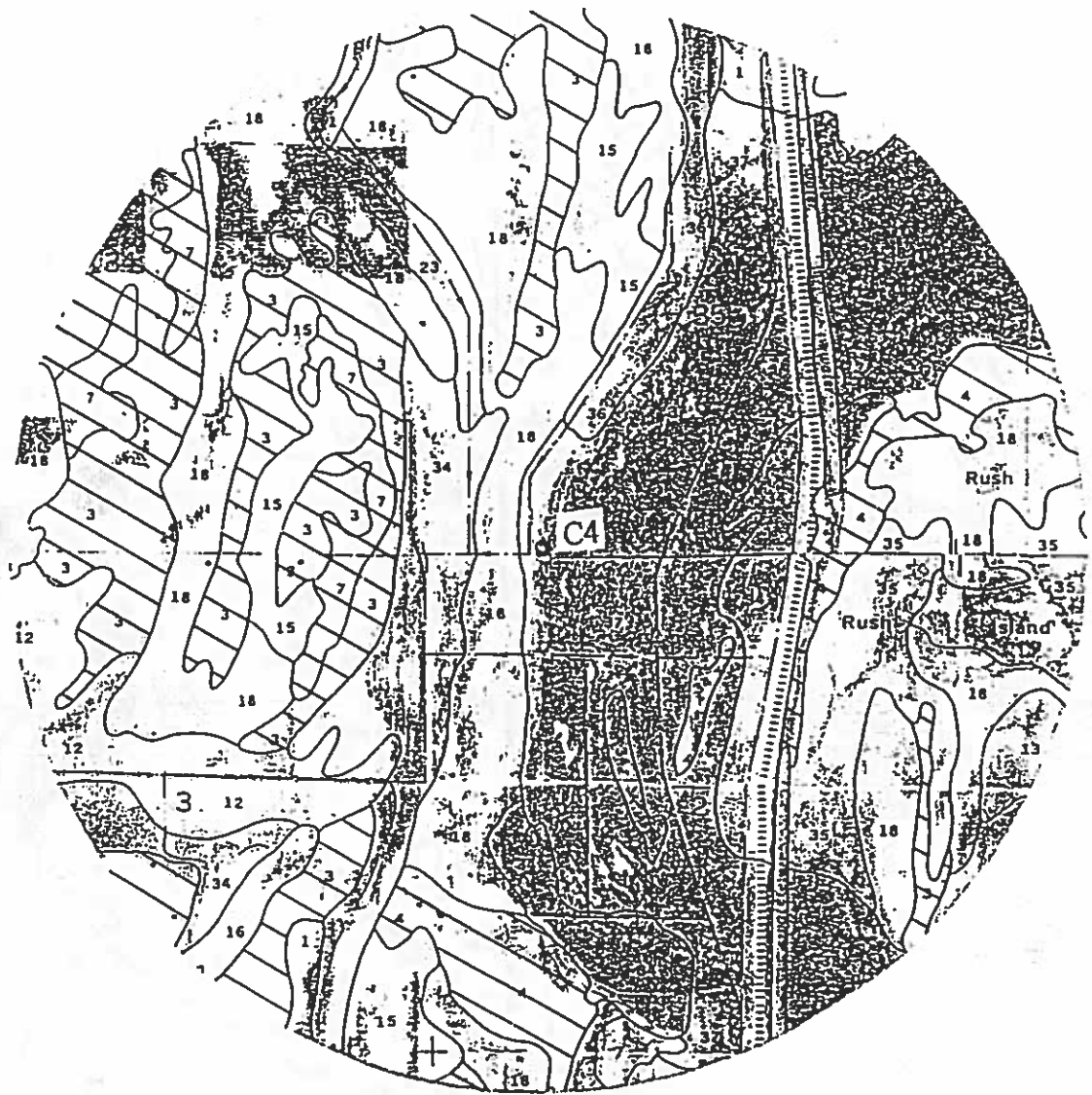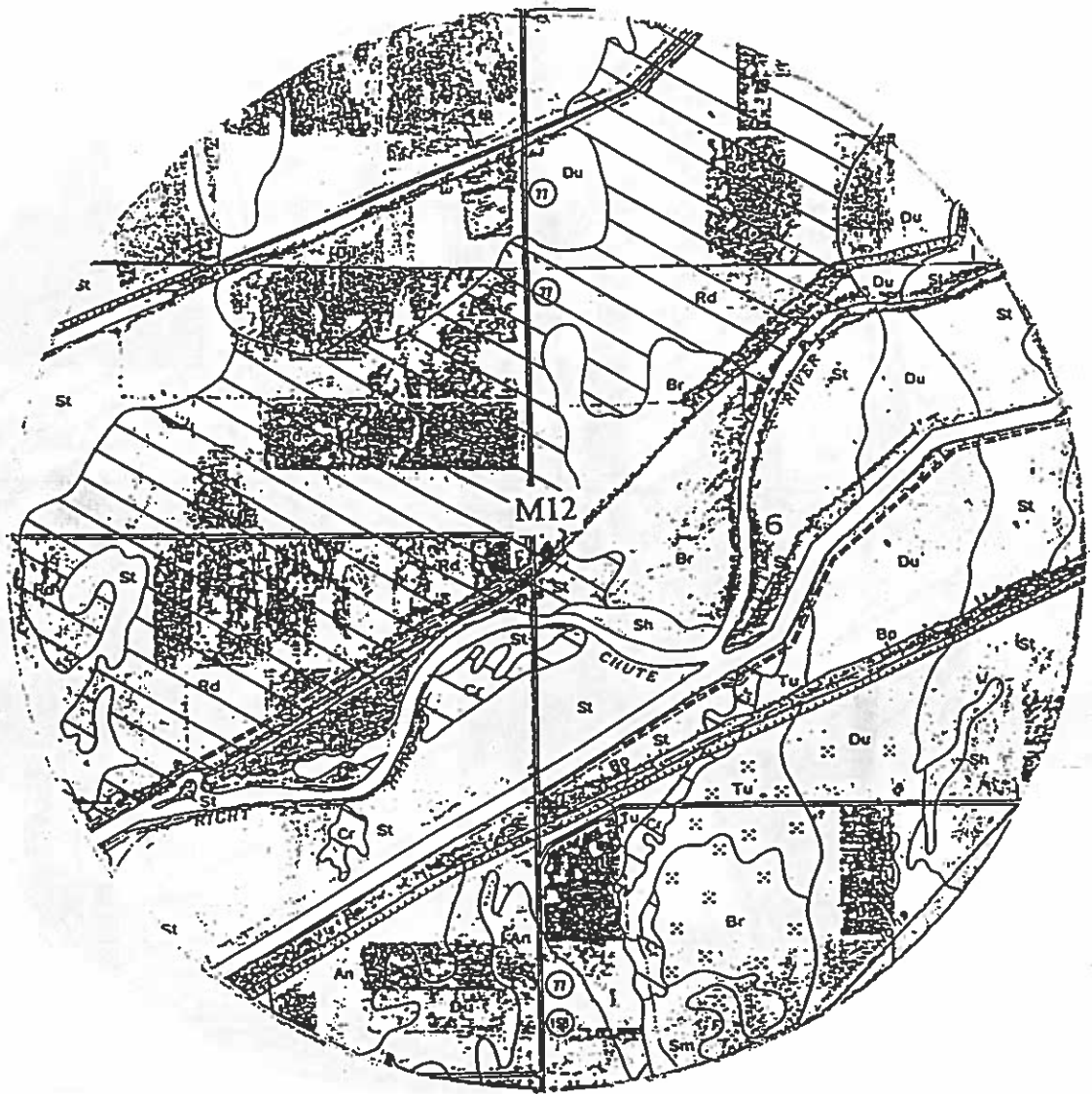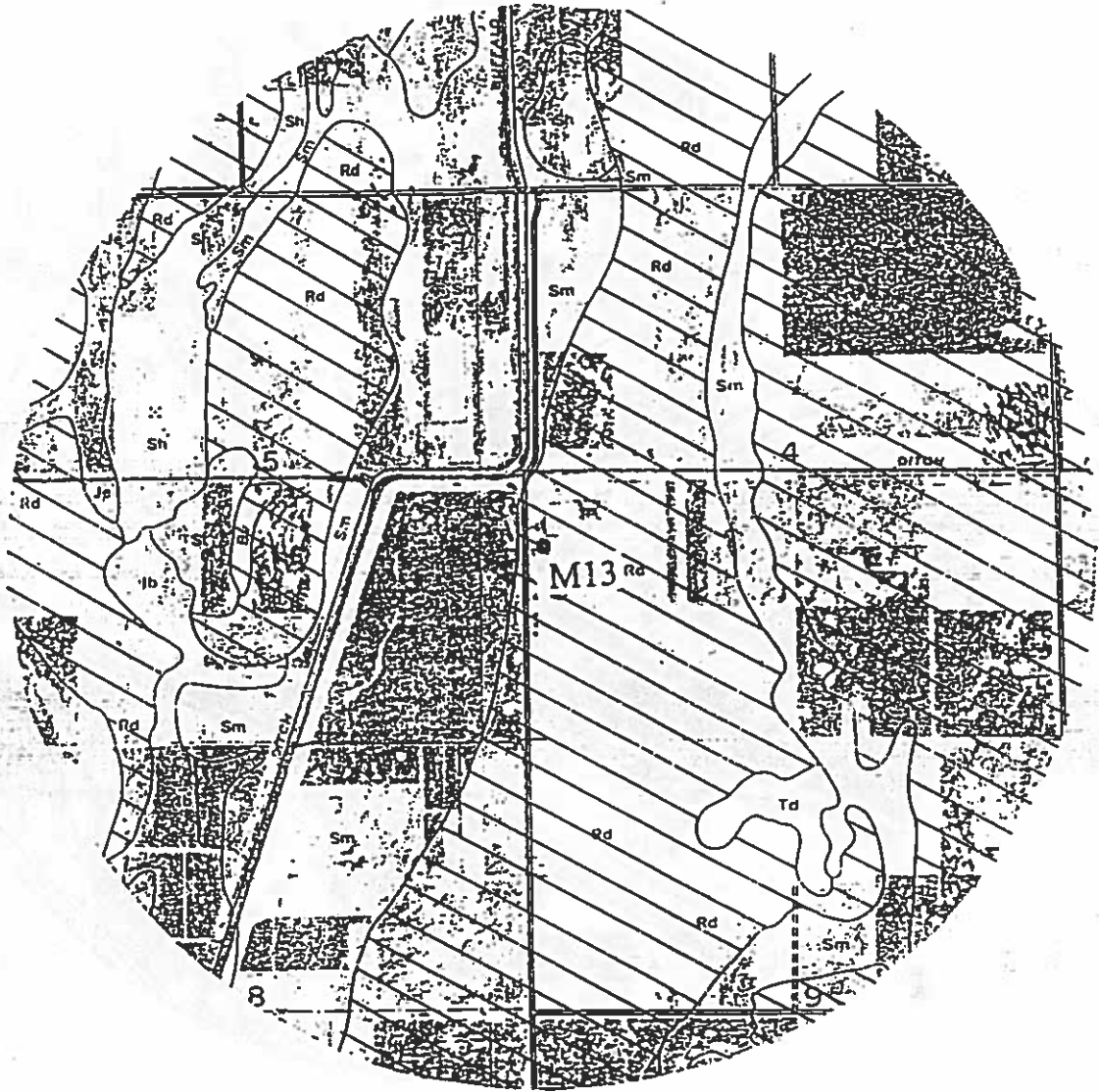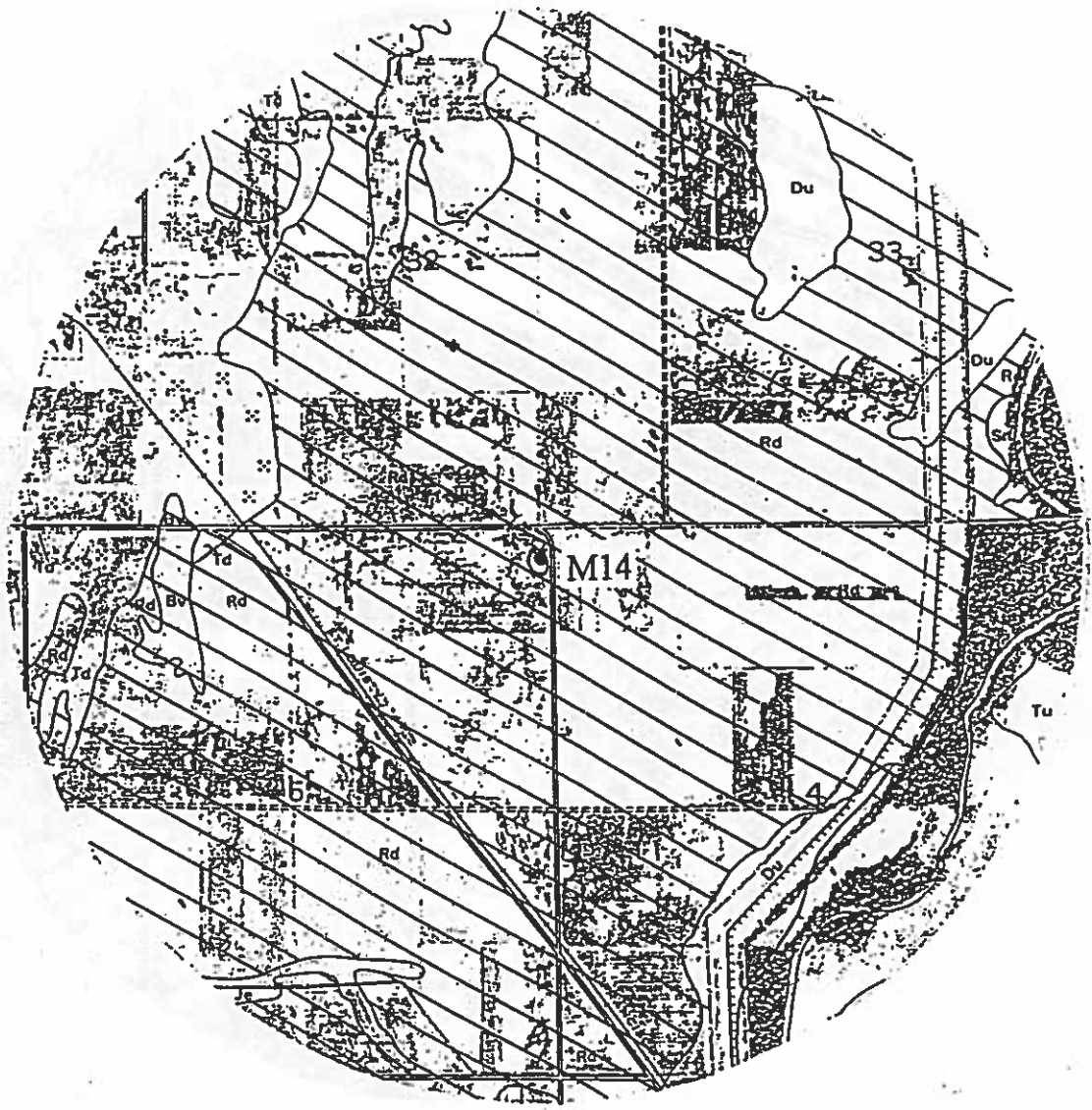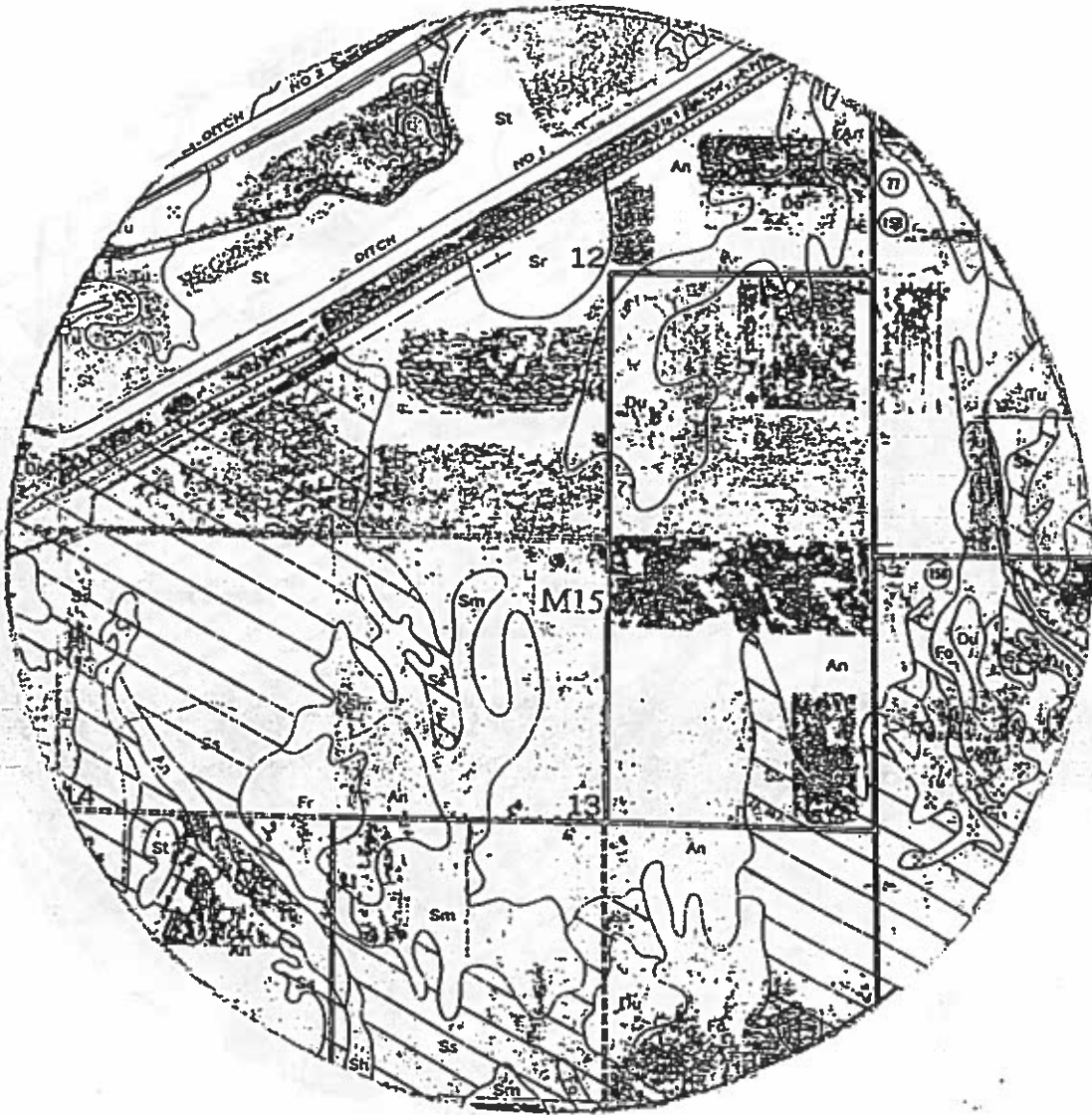
N↑

Figure B4. Soils within one mile of well C4. Permeable soils are indicated by cross lines.
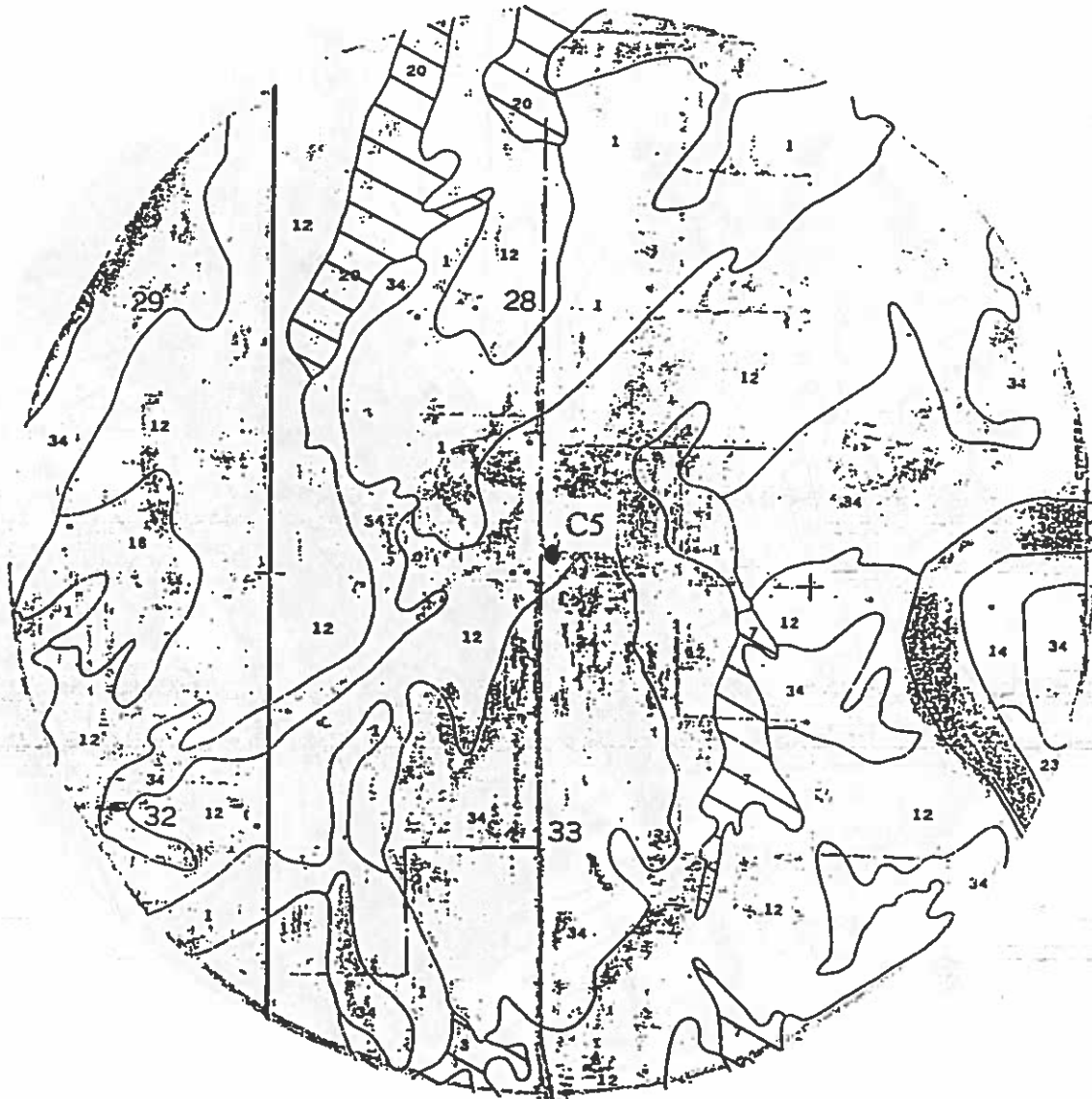
N↑

Figure B5. Soils within one mile of well C5. Permeable soils are indicated by cross lines.
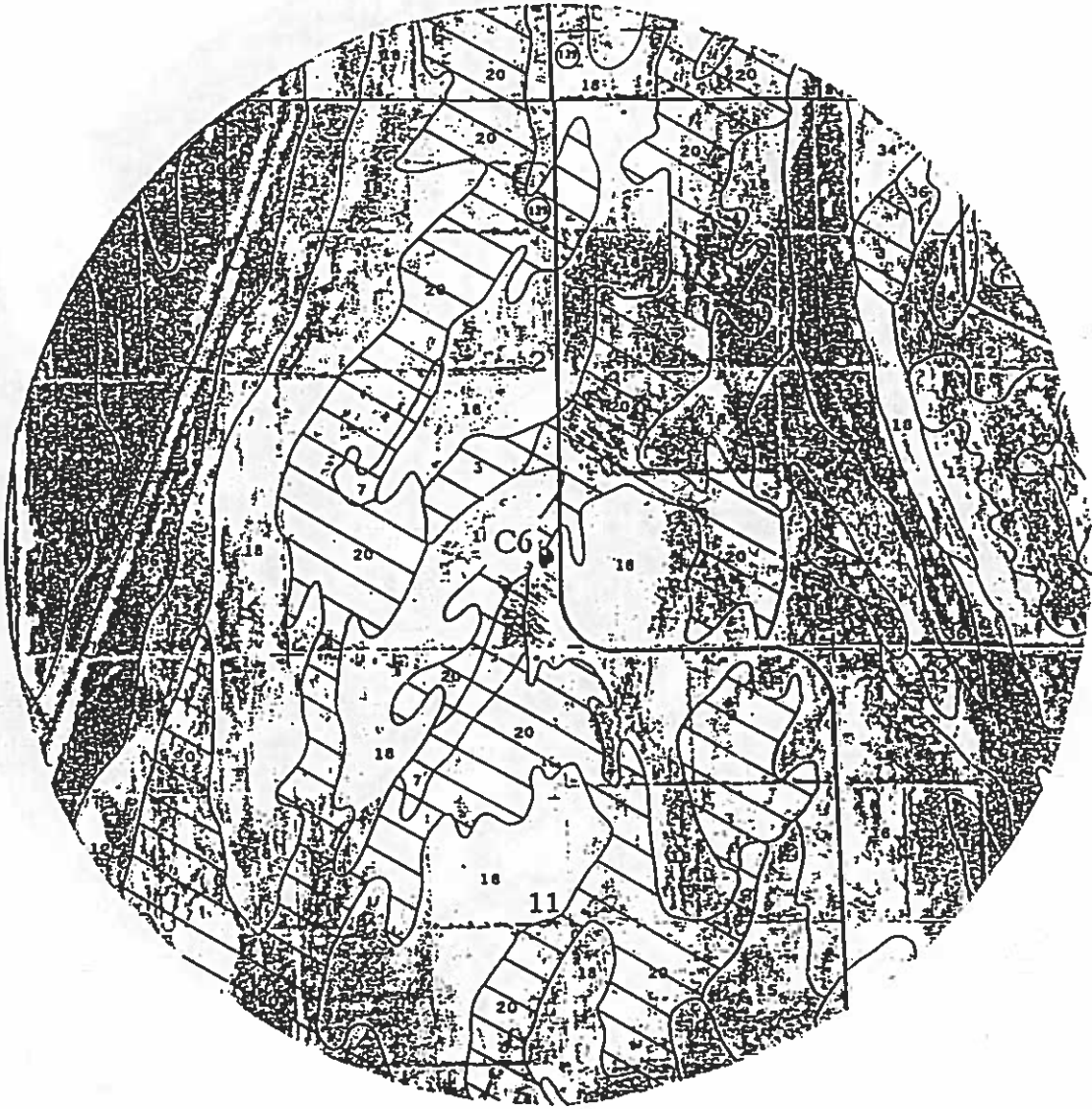
N↑

Figure B6. Soils within one mile of well C6. Permeable soils are indicated by cross lines.
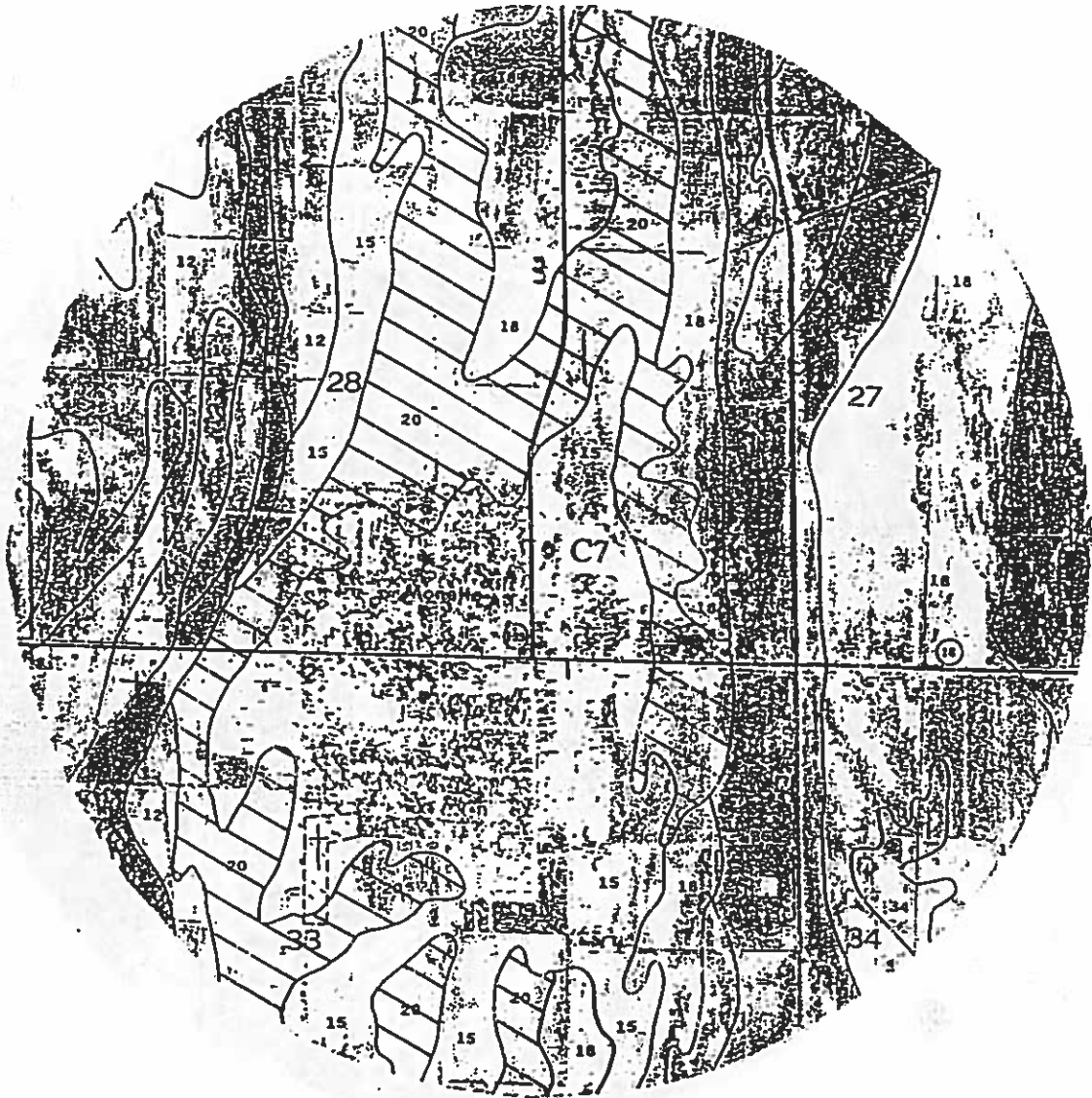
N↑

Figure B7. Soils within one mile of well C7. Permeable soils are indicated by cross lines.
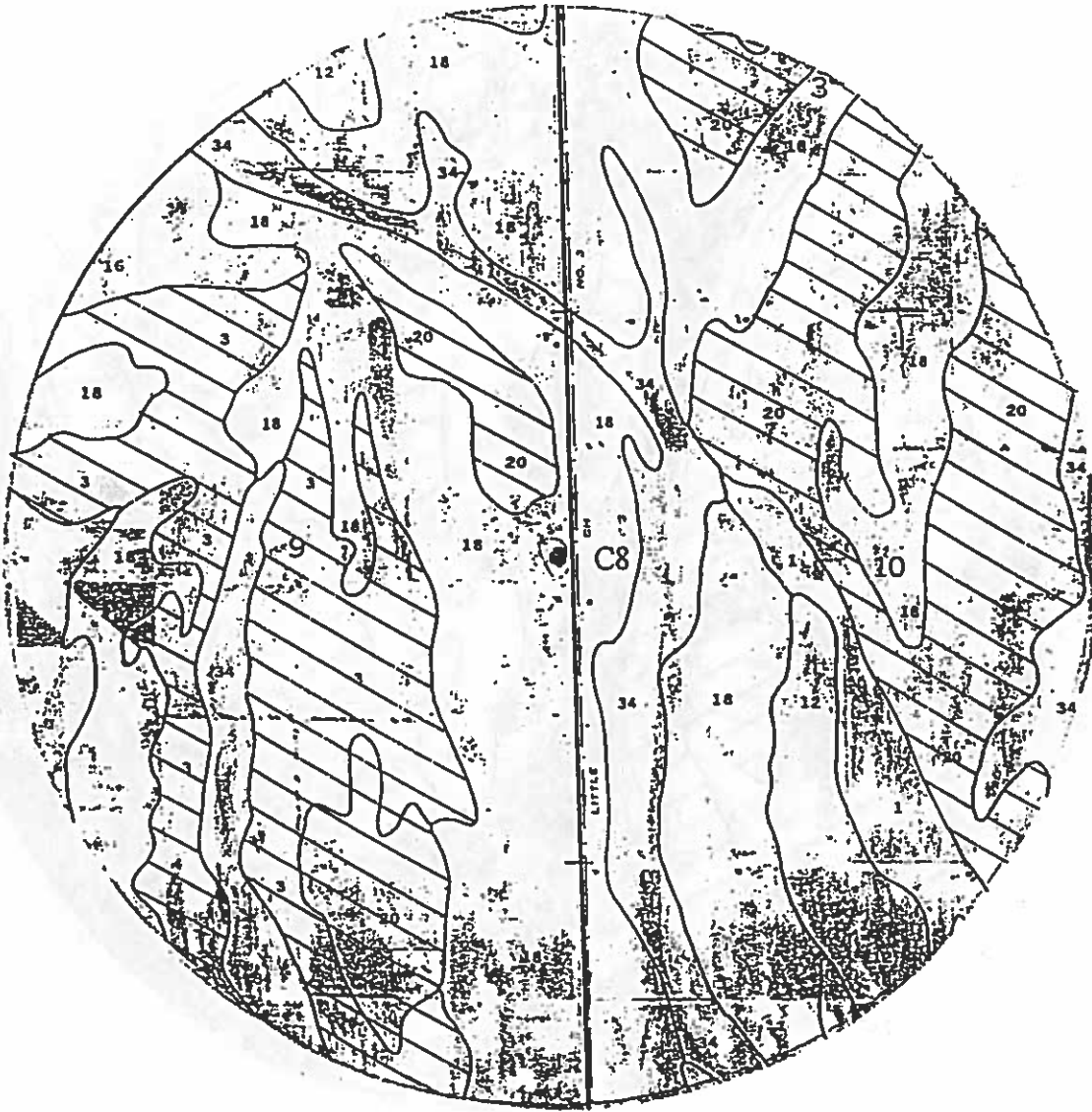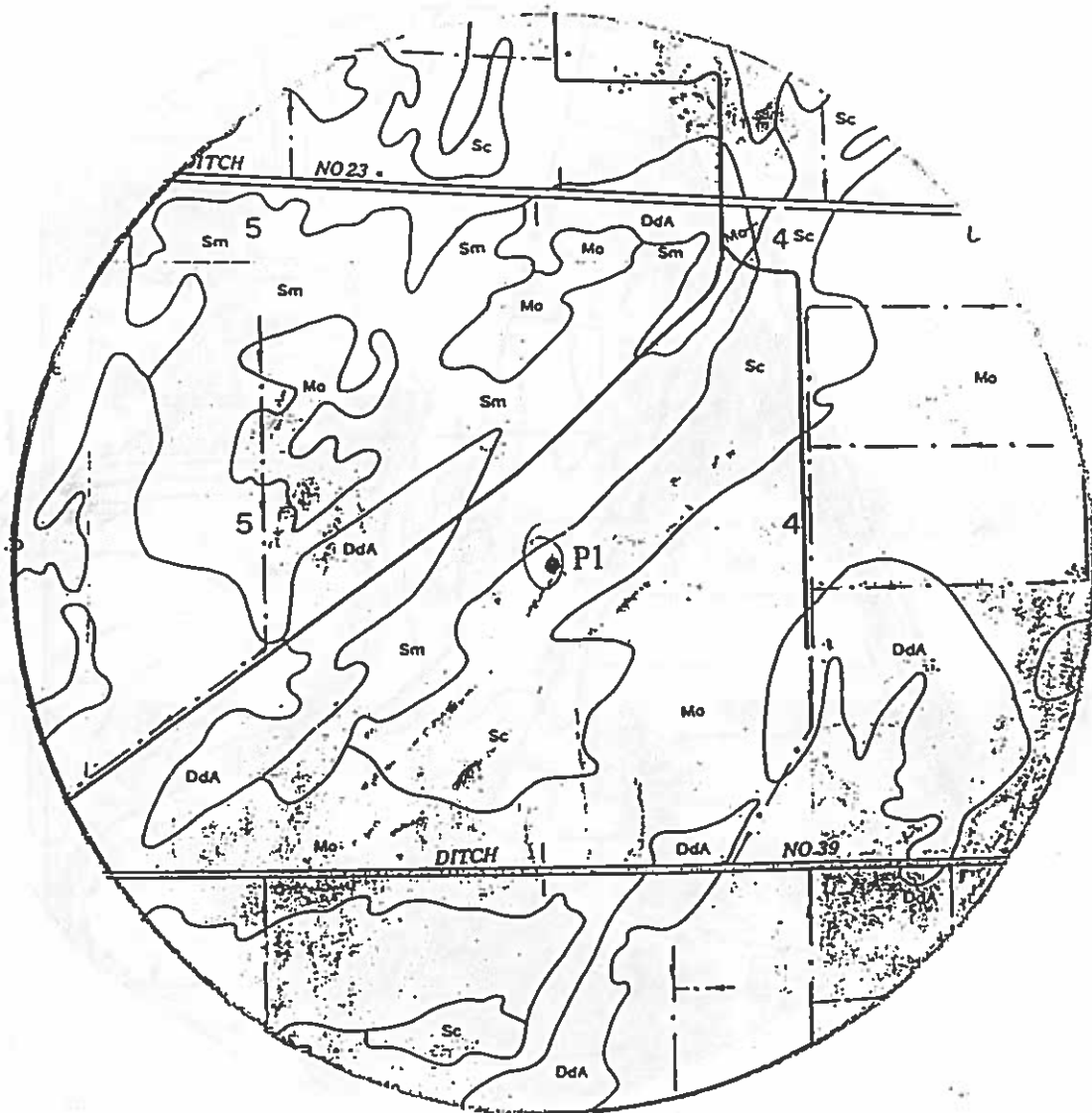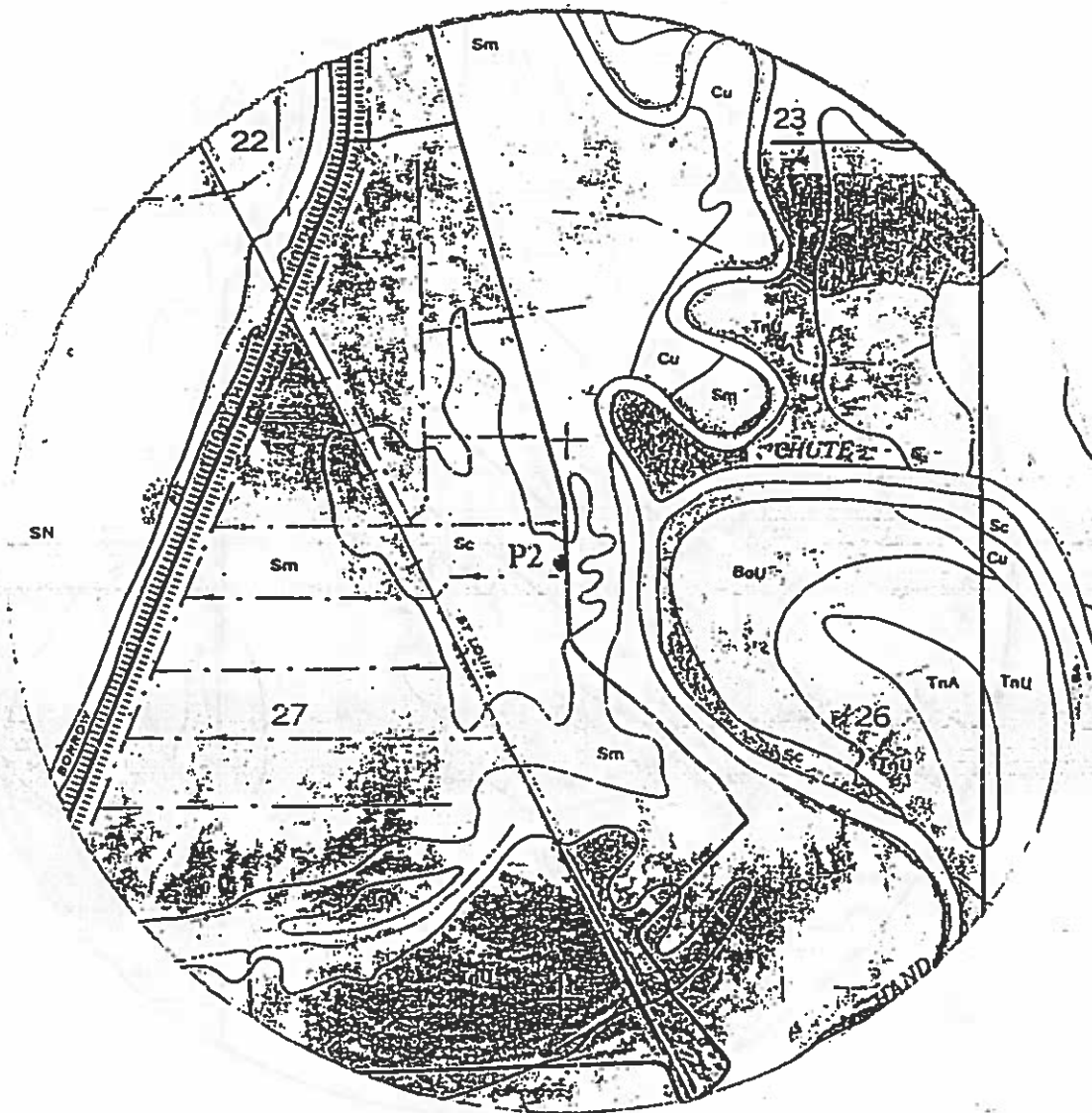
N↑

Figure B8. Soils within one mile of well C8. Permeable soils are indicated by cross lines.
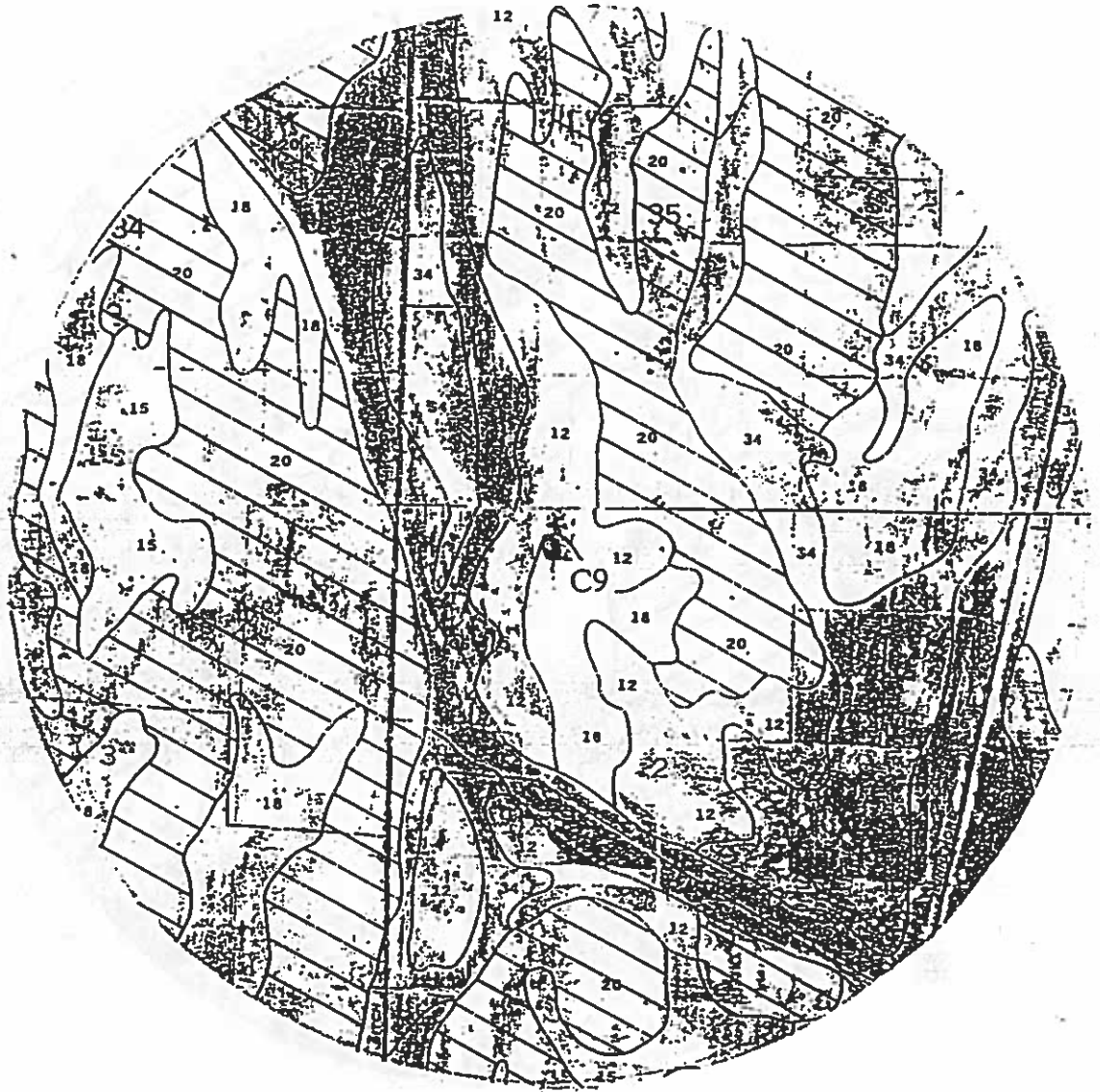
N↑

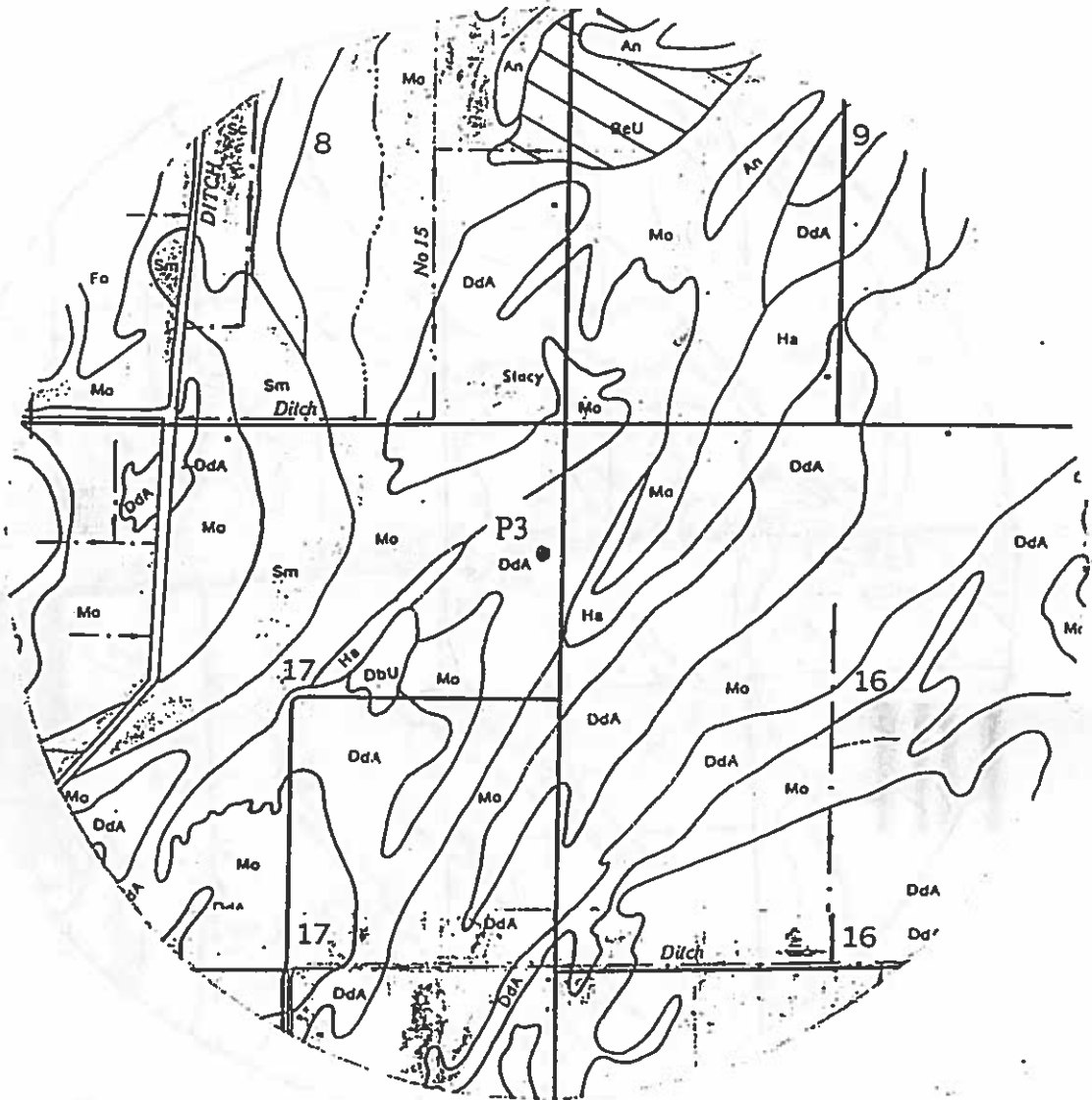Figure B9. Soils within one mile of well C9. Permeable soils are indicated by cross lines.
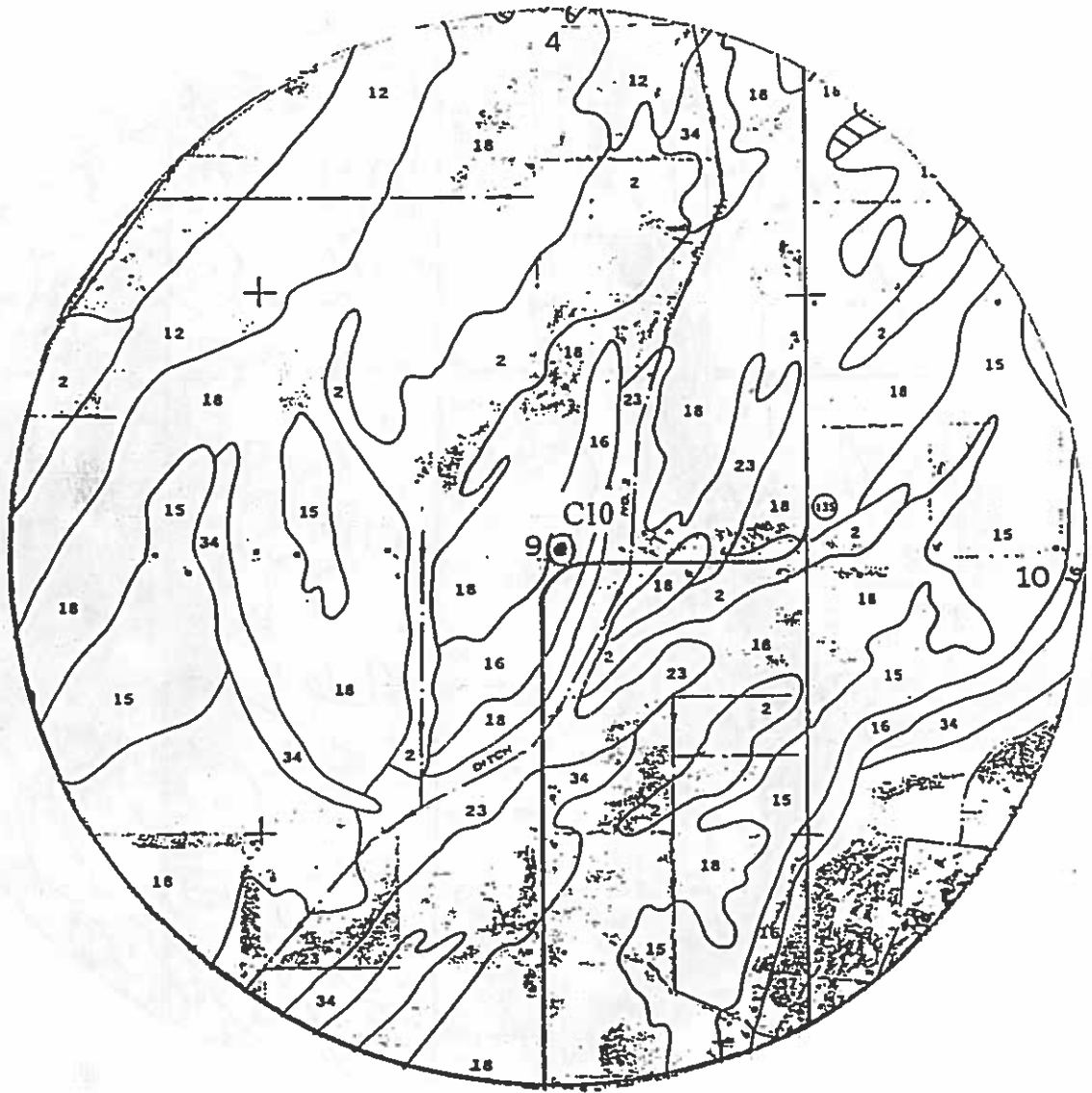
N↑

Figure B10. Soils within one mile of well C10. Permeable soils are indicated by cross lines.
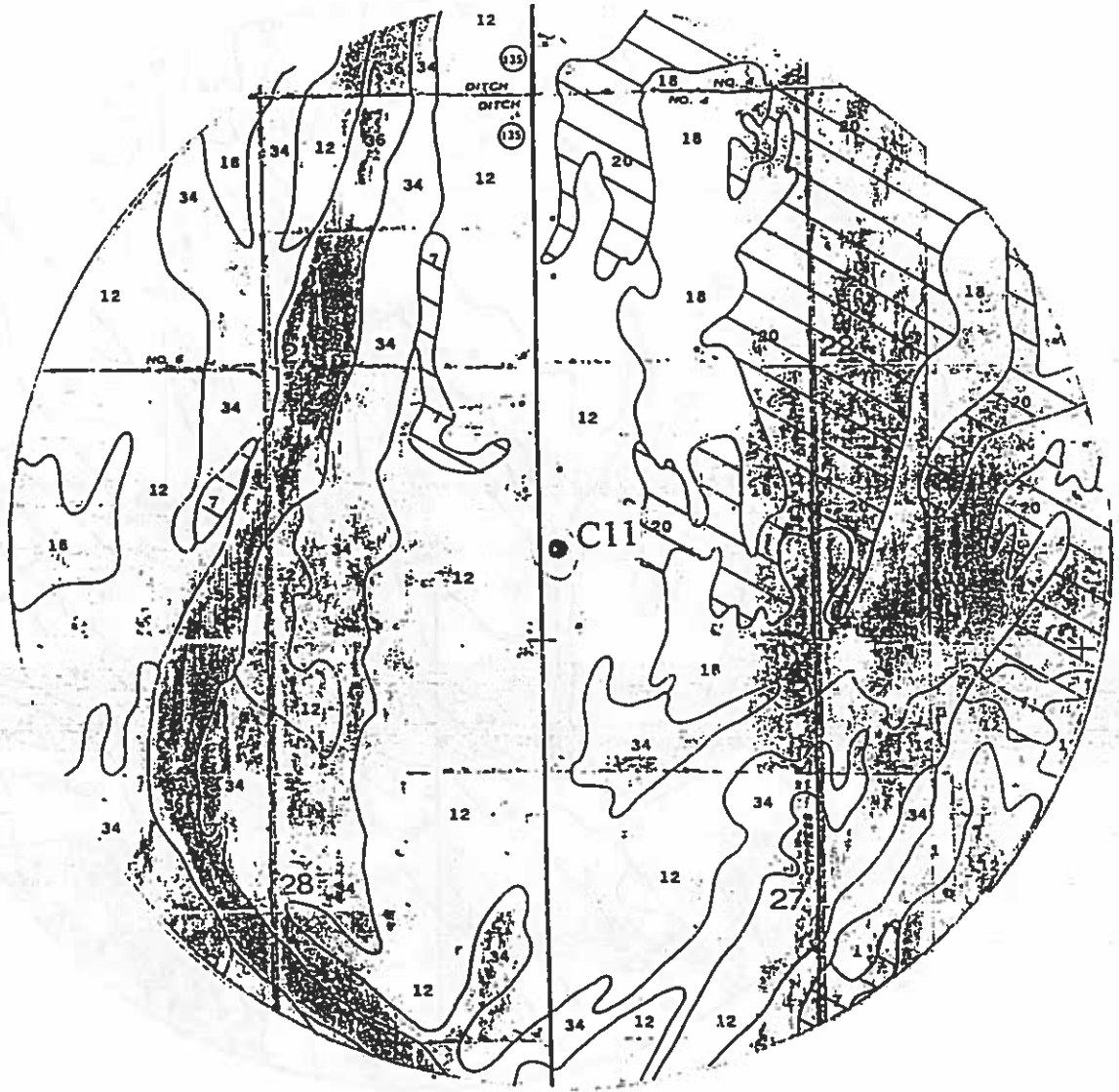
N↑

Figure B11. Soils within one mile of well C11. Permeable soils are indicated by cross lines.
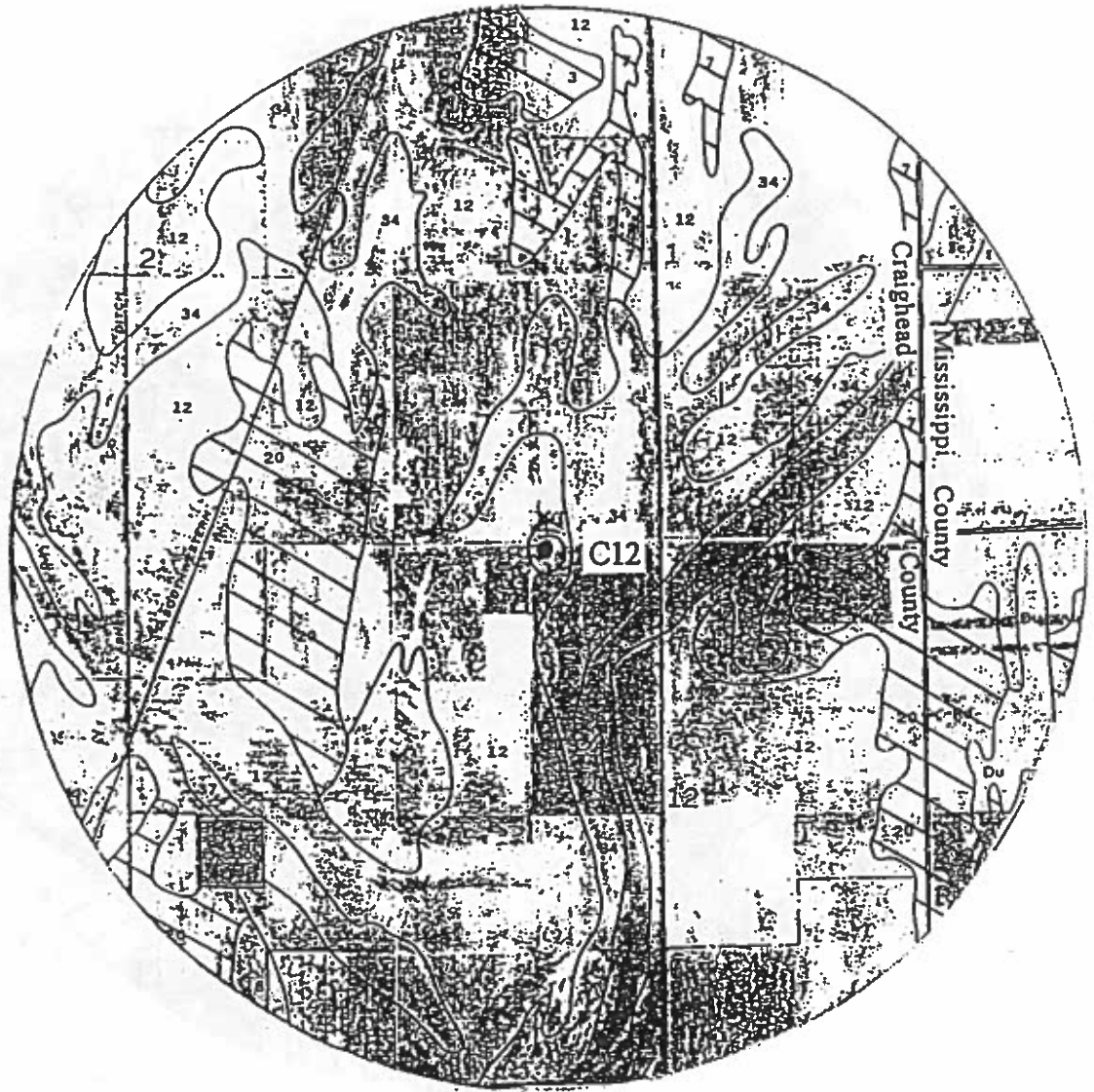
N↑

Figure B12. Soils within one mile of well C12. Permeable soils are indicated by cross lines.
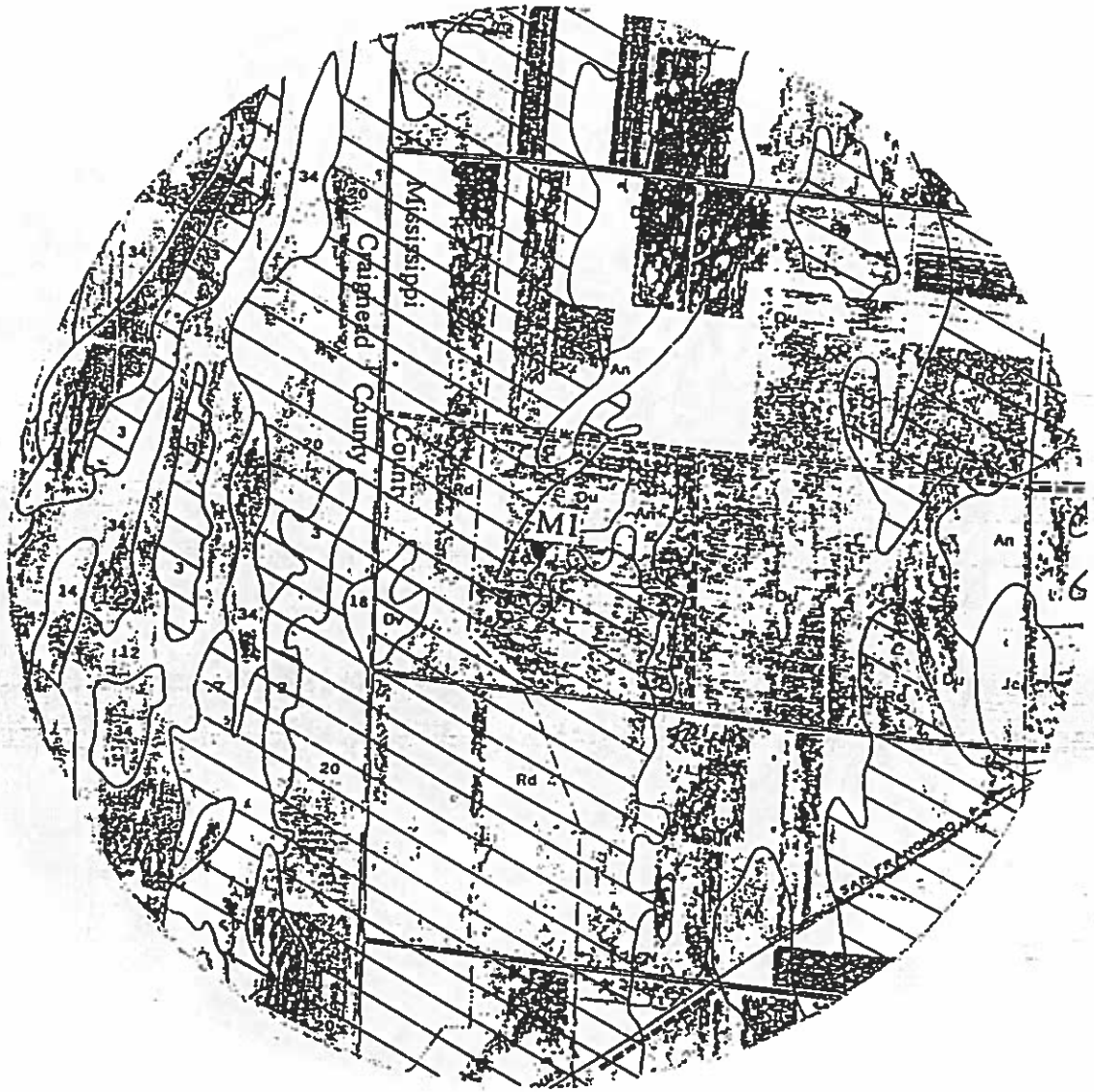
N↑

Figure B13. Soils within one mile of well M1. Permeable soils are indicated by cross lines.
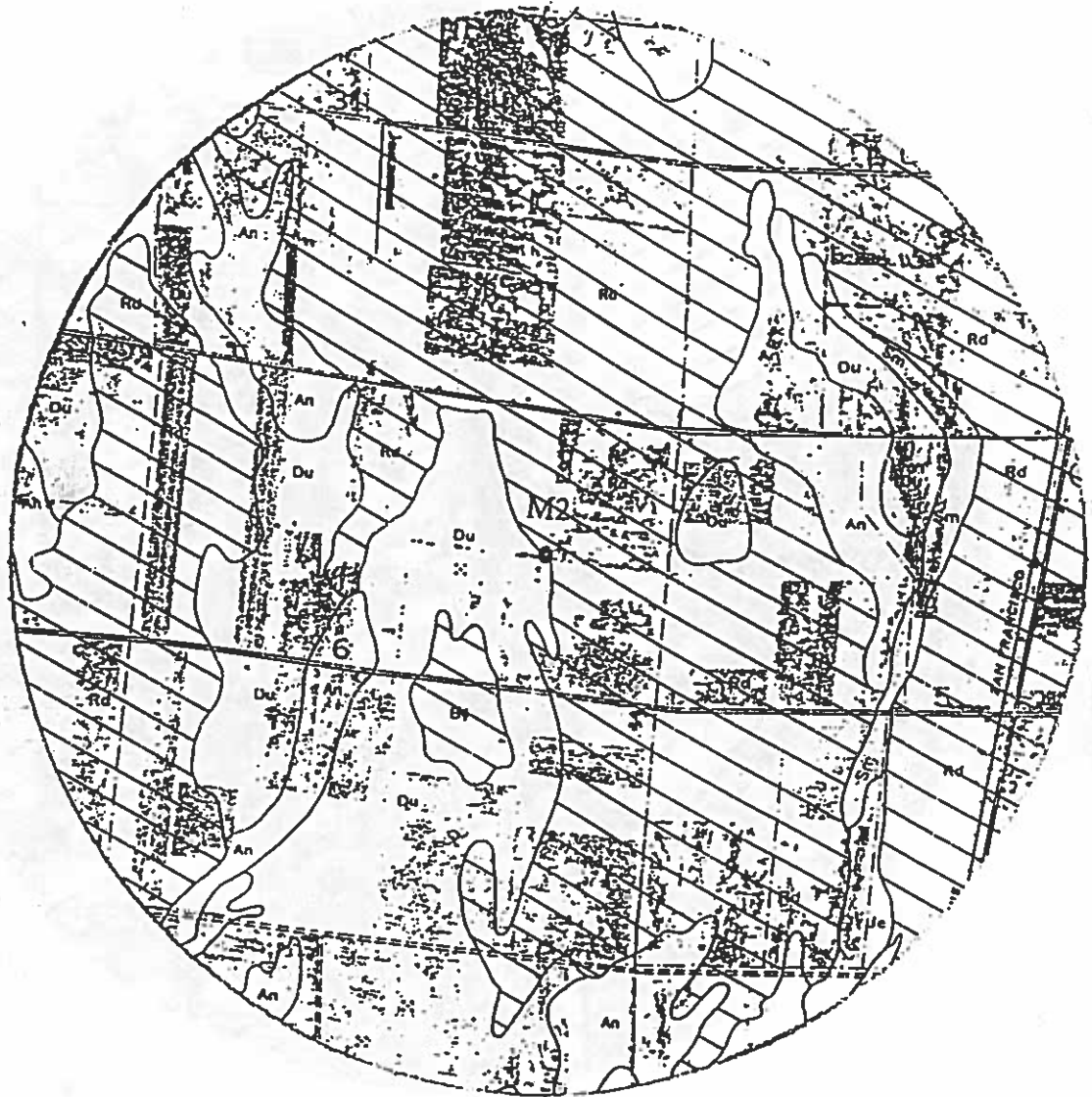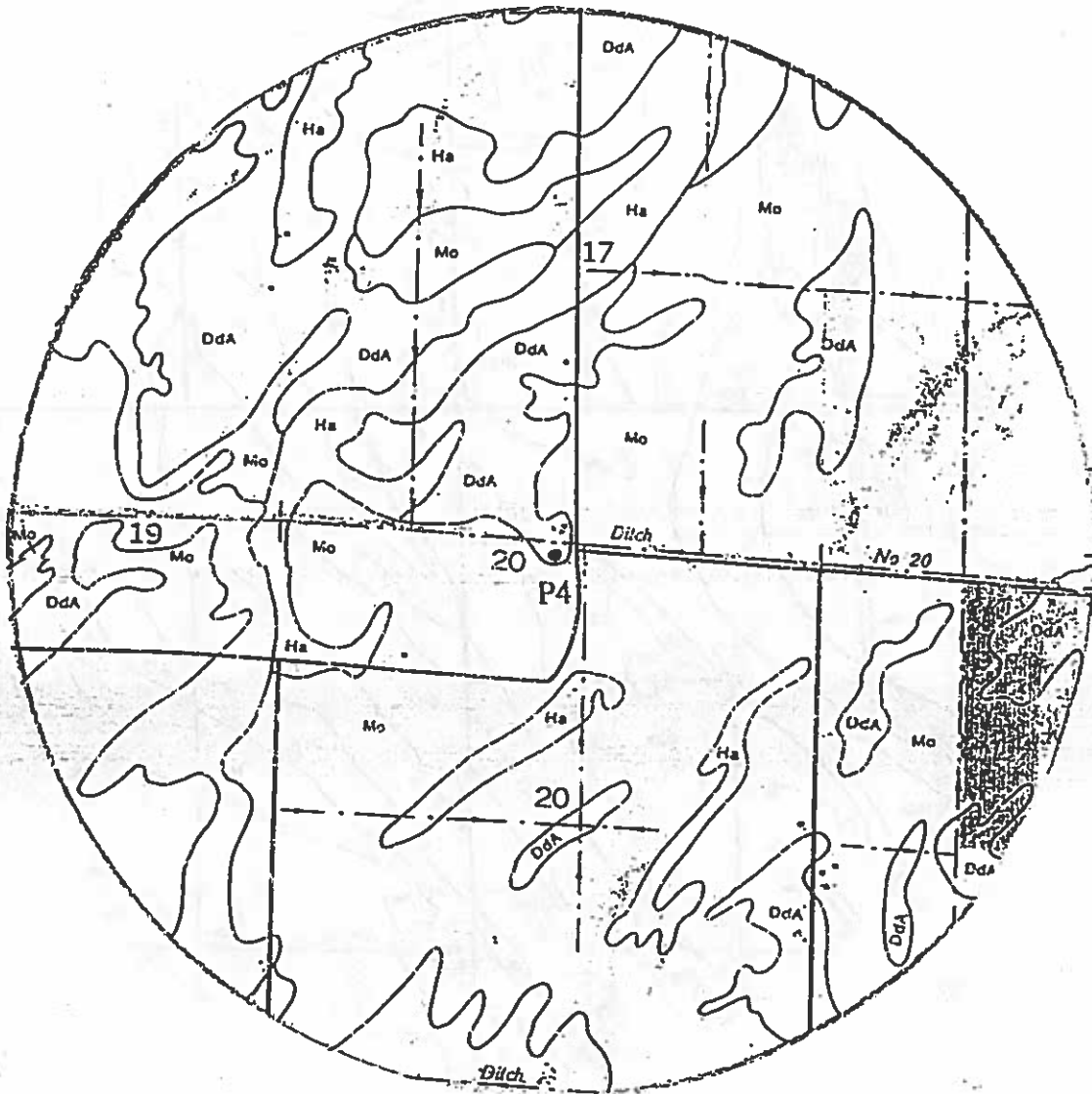
N↑

Figure B14. Soils within one mile of well M2. Permeable soils are indicated by cross lines.
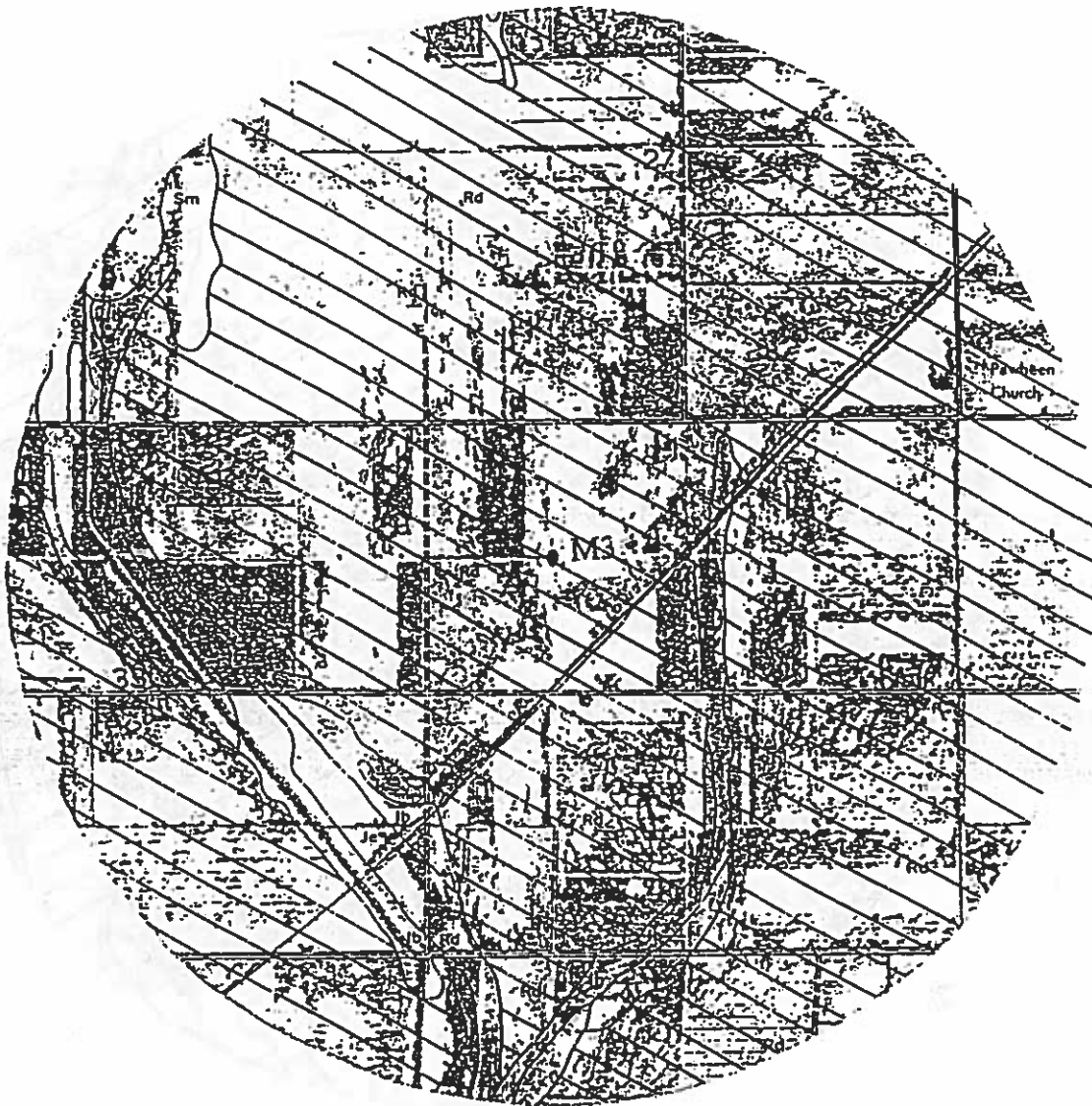
N↑

Figure B15. Soils within one mile of well M3. Permeable soils are indicated by cross lines.
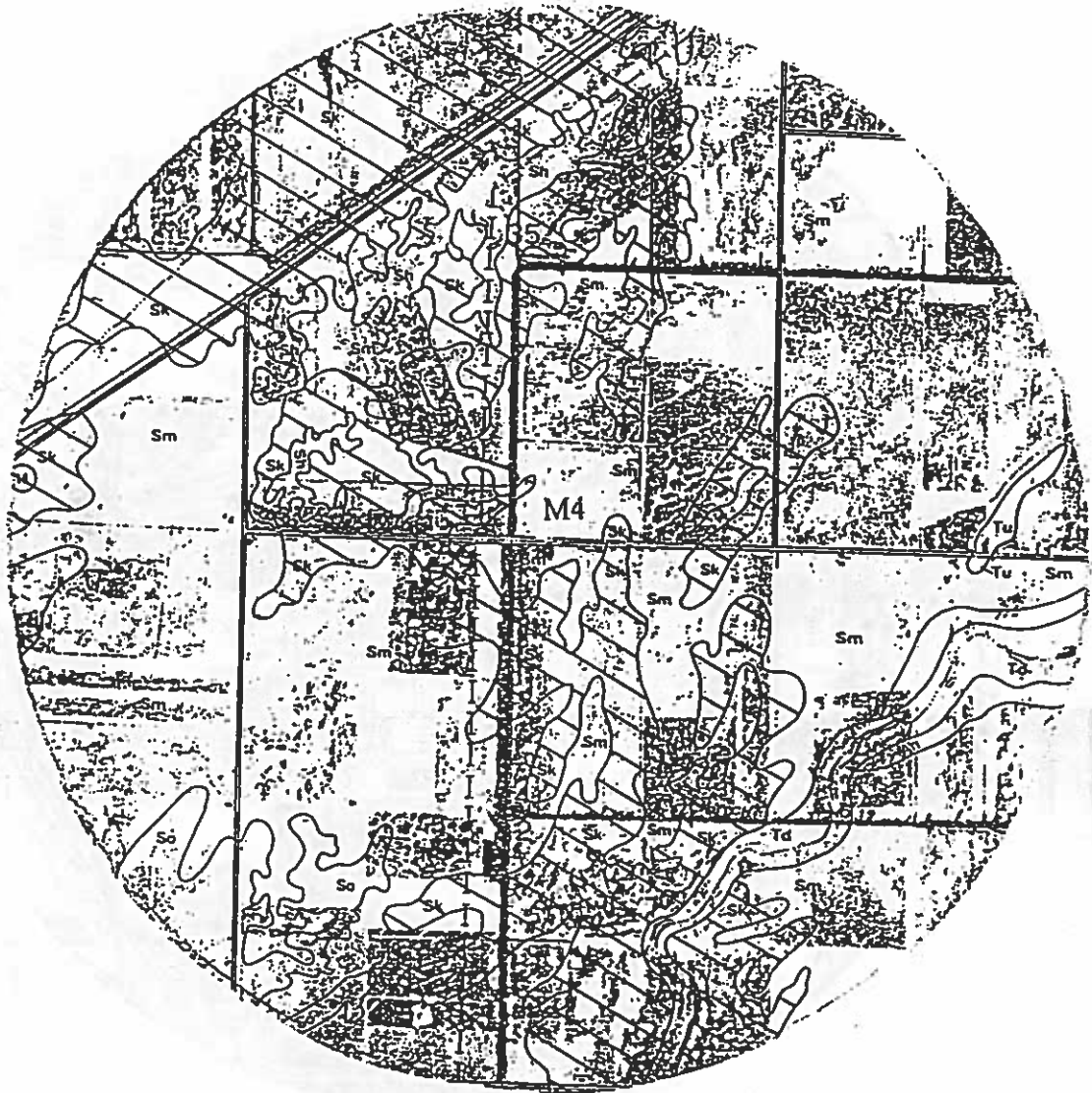
Figure B16. Soils within one mile of well M4. Permeable soils are indicated by cross lines.
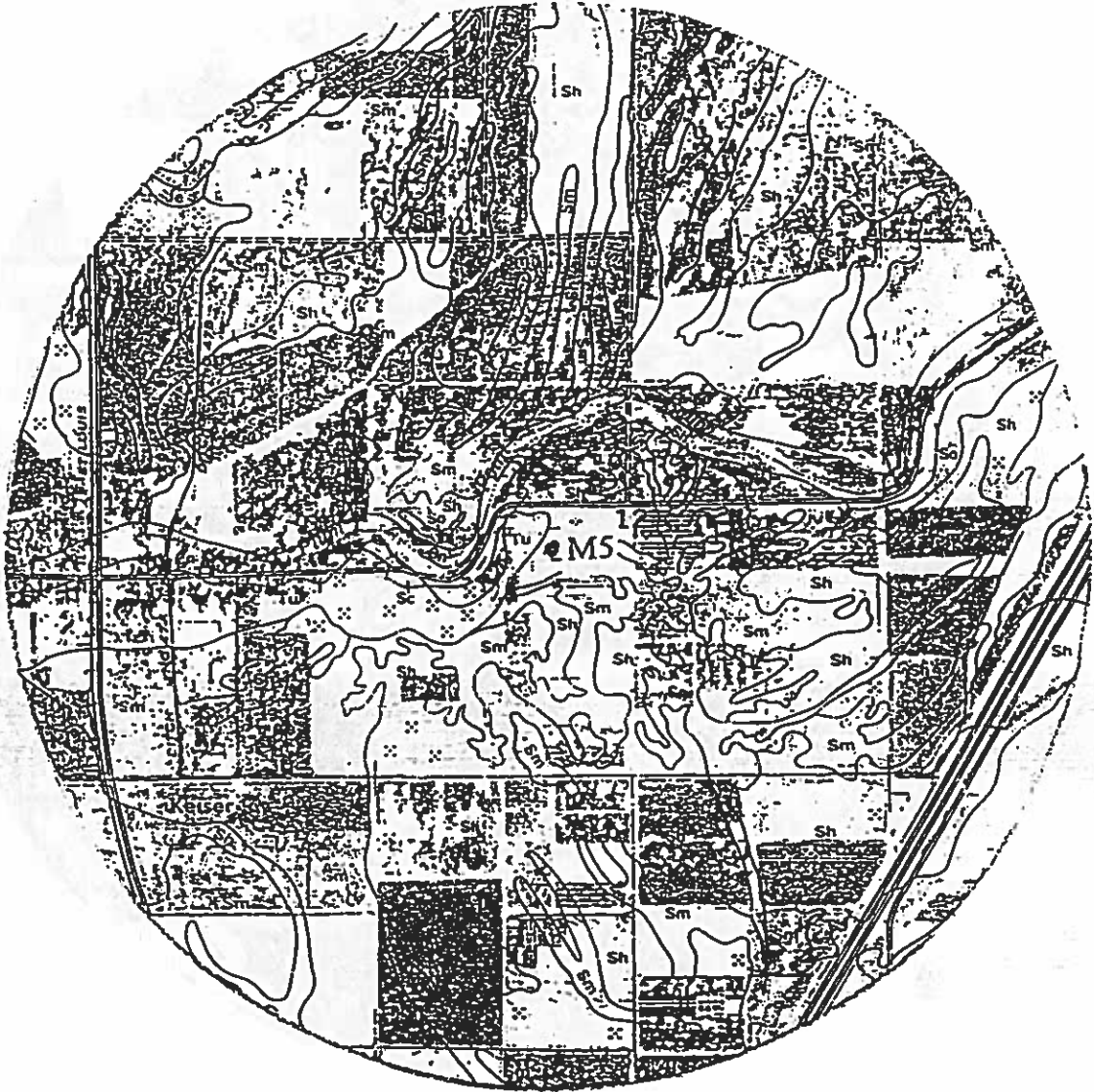
N↑

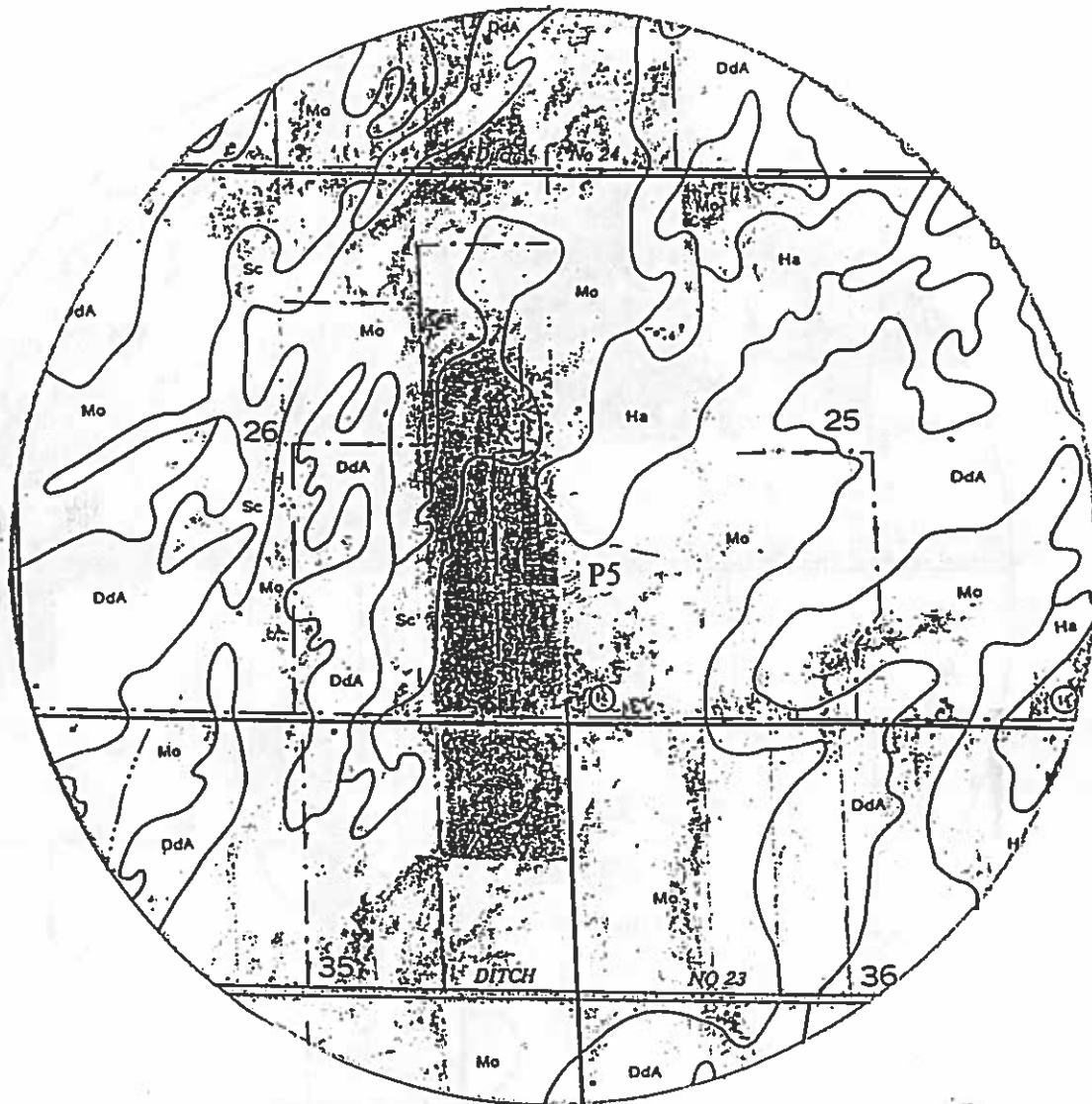**Figure B17.** Soils within one mile of well M5. Permeable soils are indicated by cross lines.
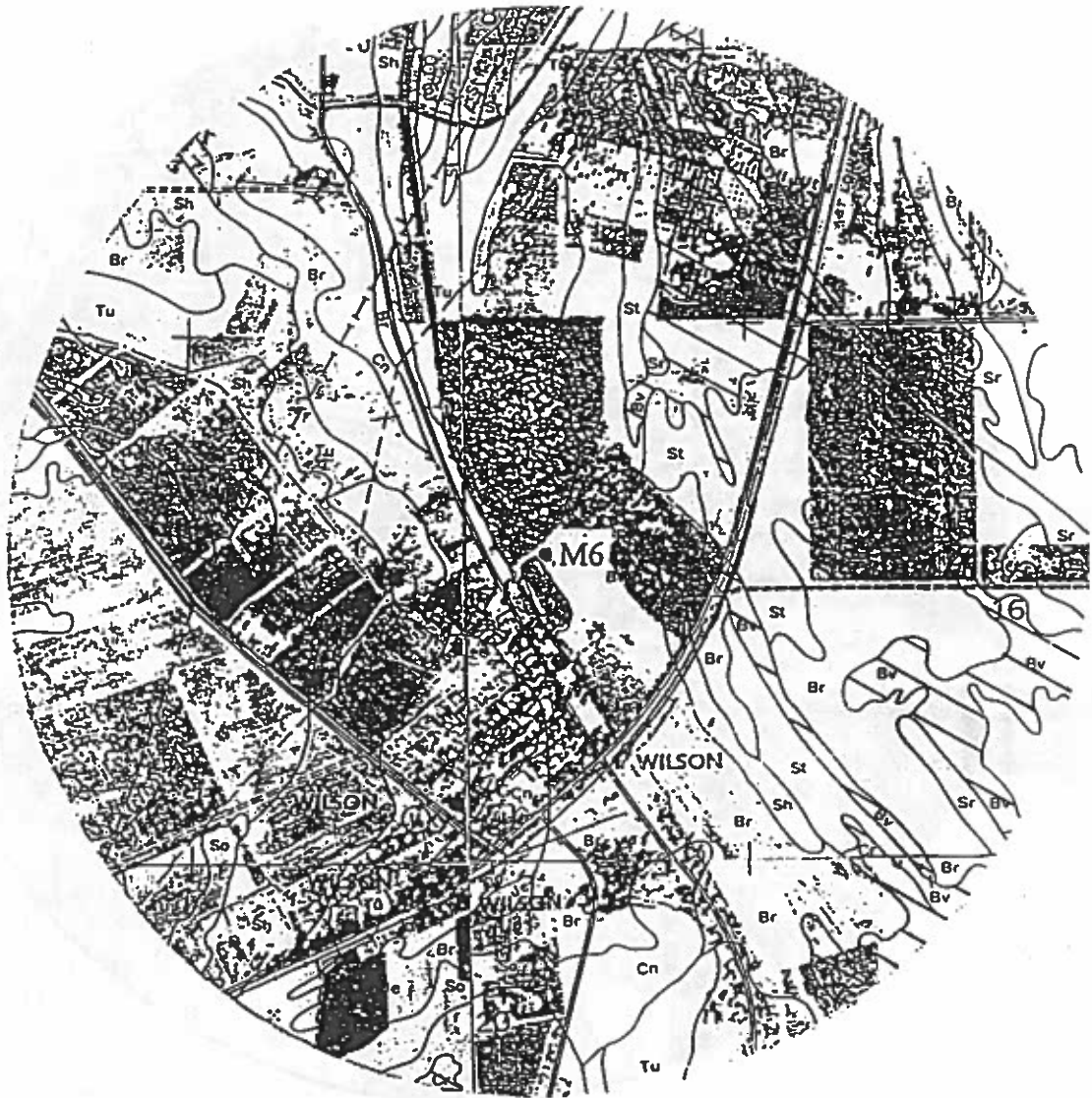
N↑

Figure B18. Soils within one mile of well M6. Permeable soils are indicated by cross lines.
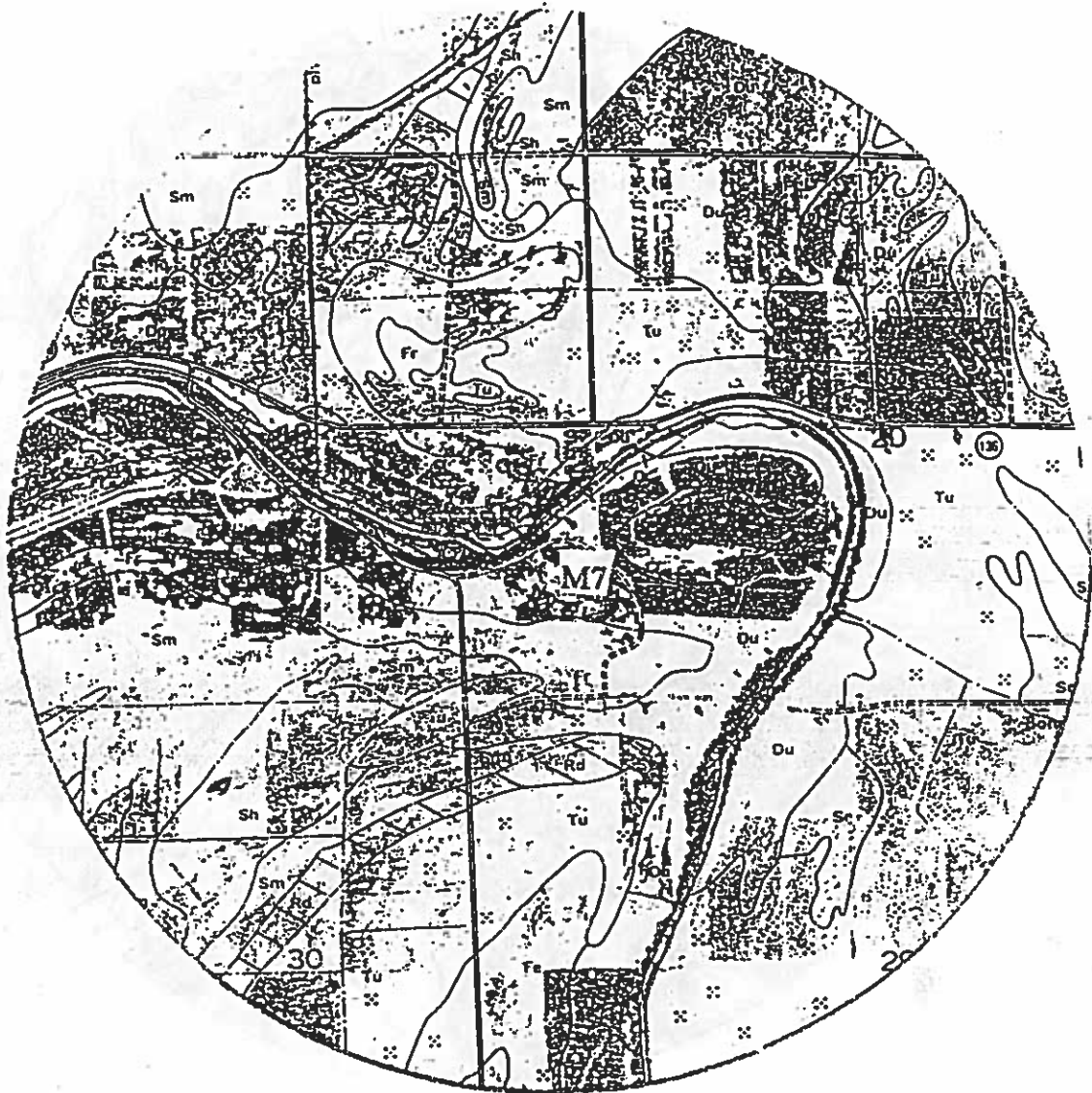
N↑

Figure B19. Soils within one mile of well M7. Permeable soils are indicated by cross lines.
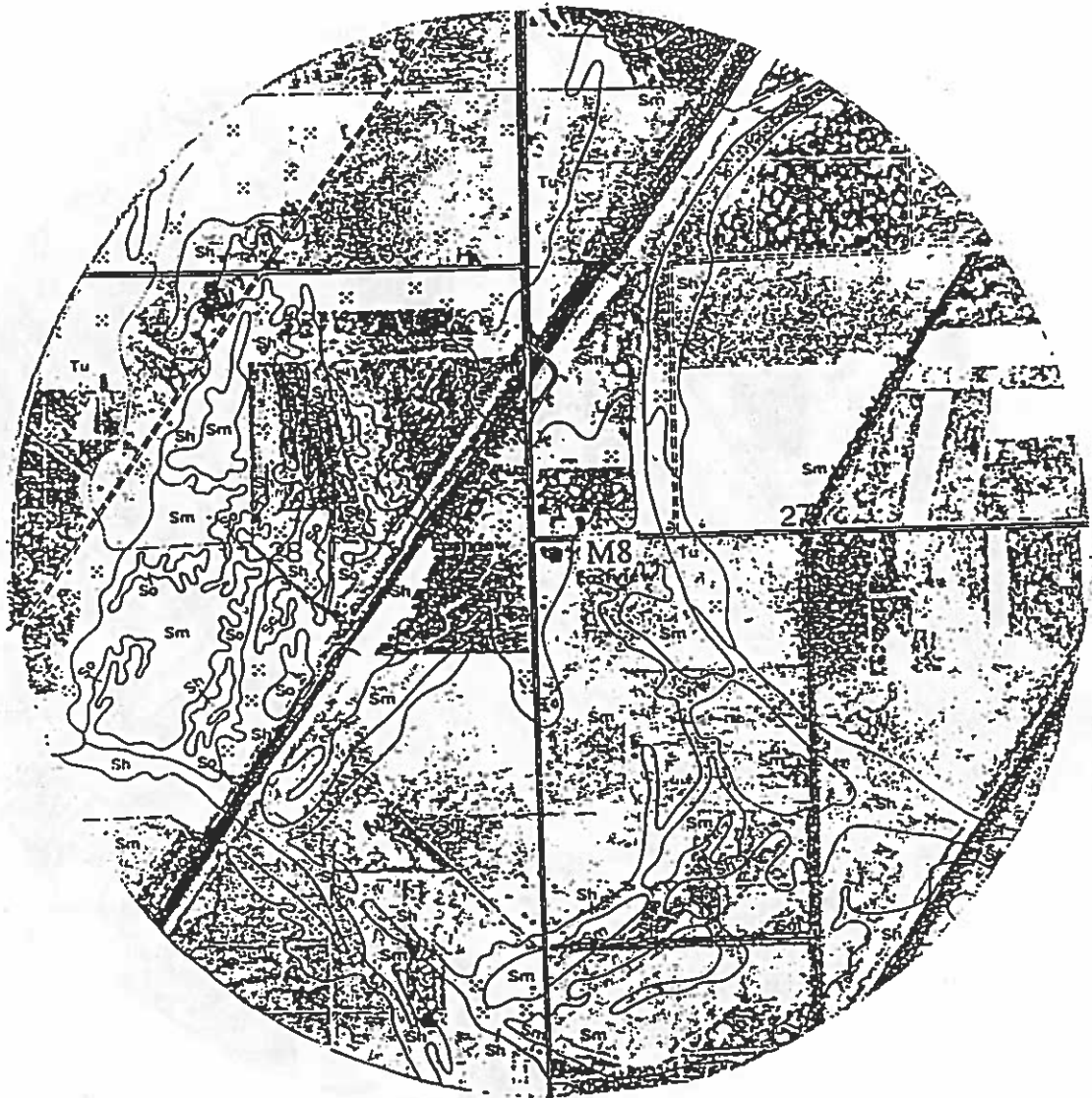
N ↑

Figure B20. Soils within one mile of well M8. Permeable soils are indicated by cross lines.
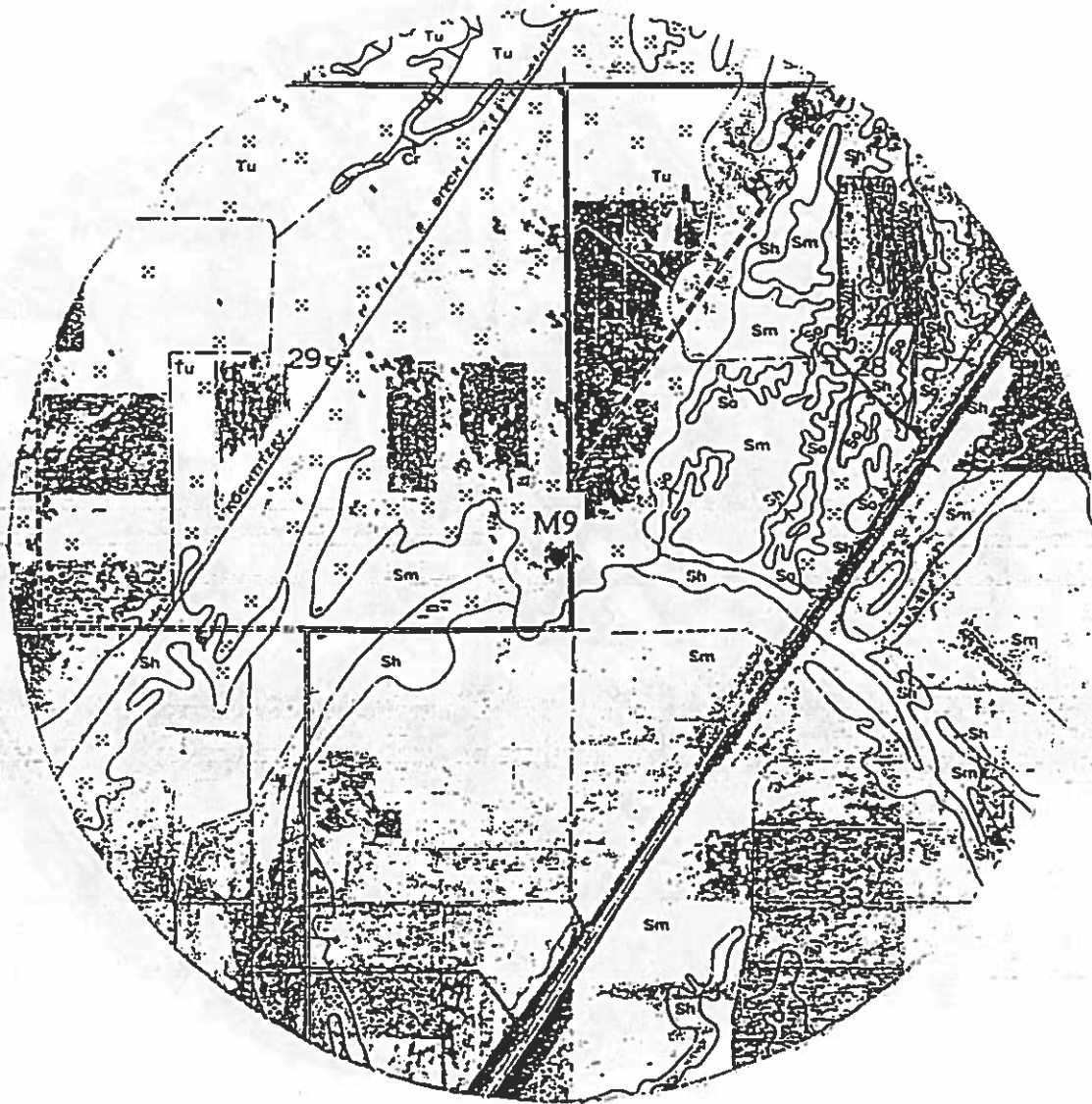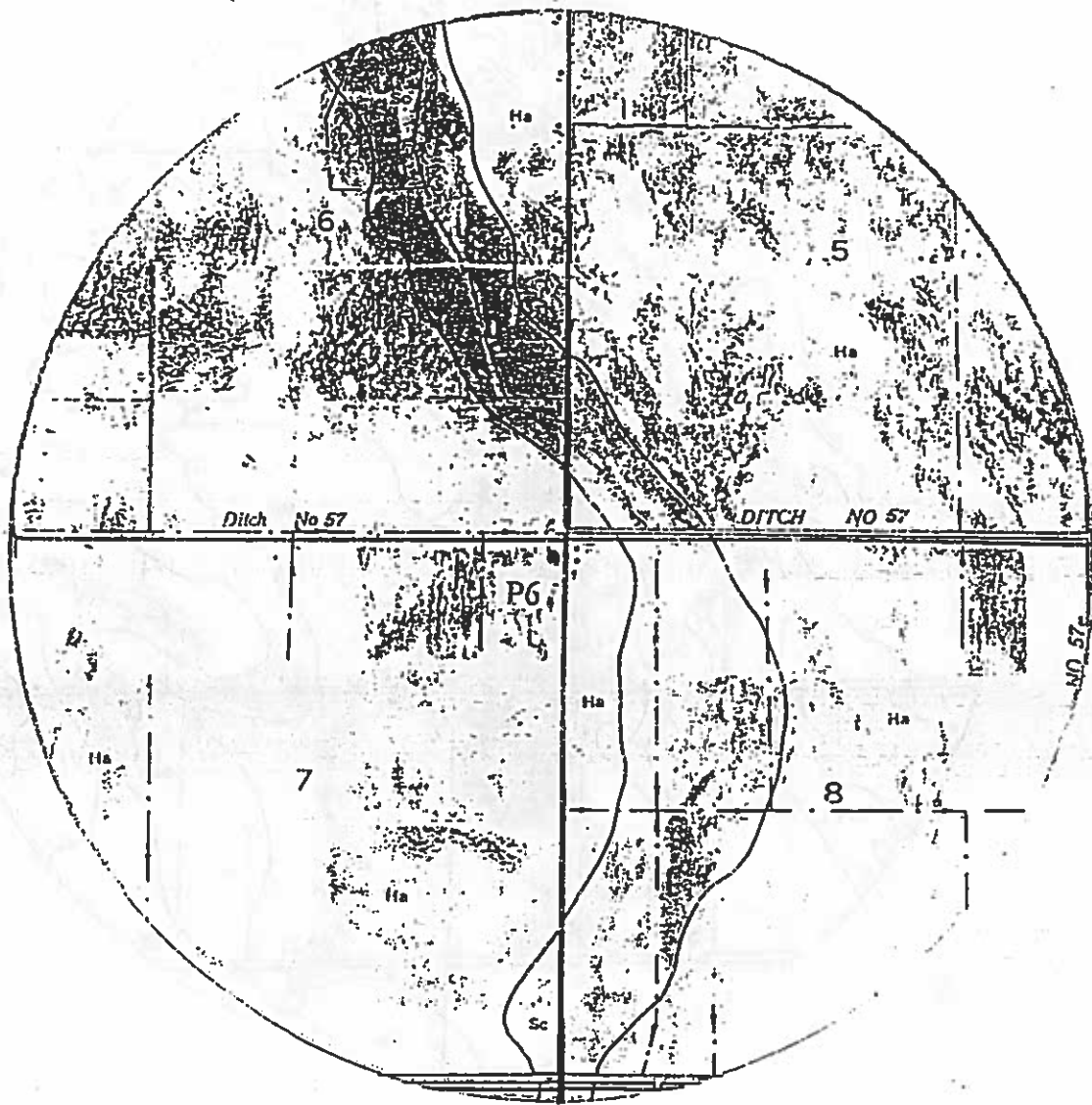
N↑

Figure B21. Soils within one mile of well M9. Permeable soils are indicated by cross lines.
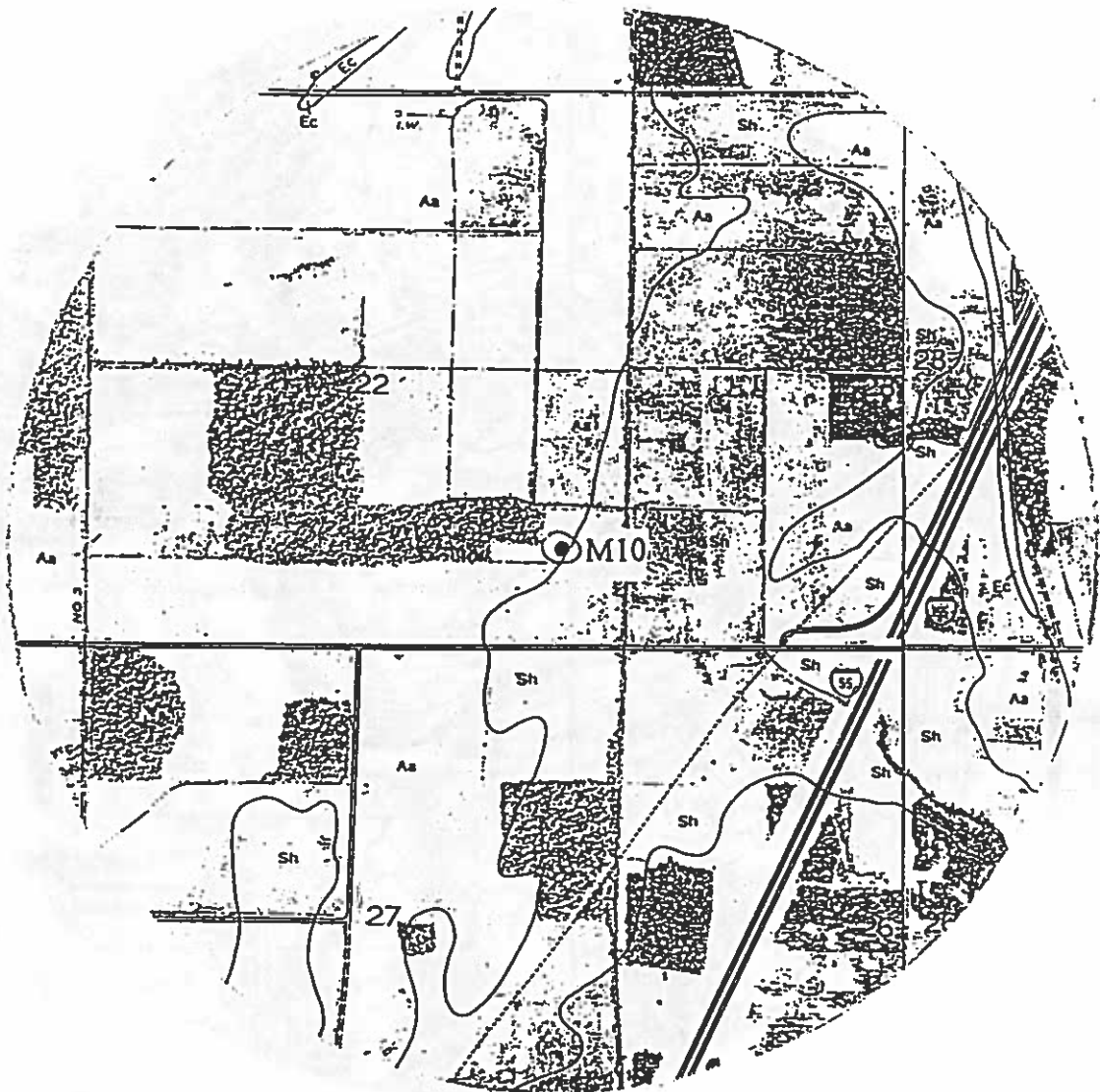
N↑

Figure B22. Soils within one mile of well M10. Permeable soils are indicated by cross lines.

N↑

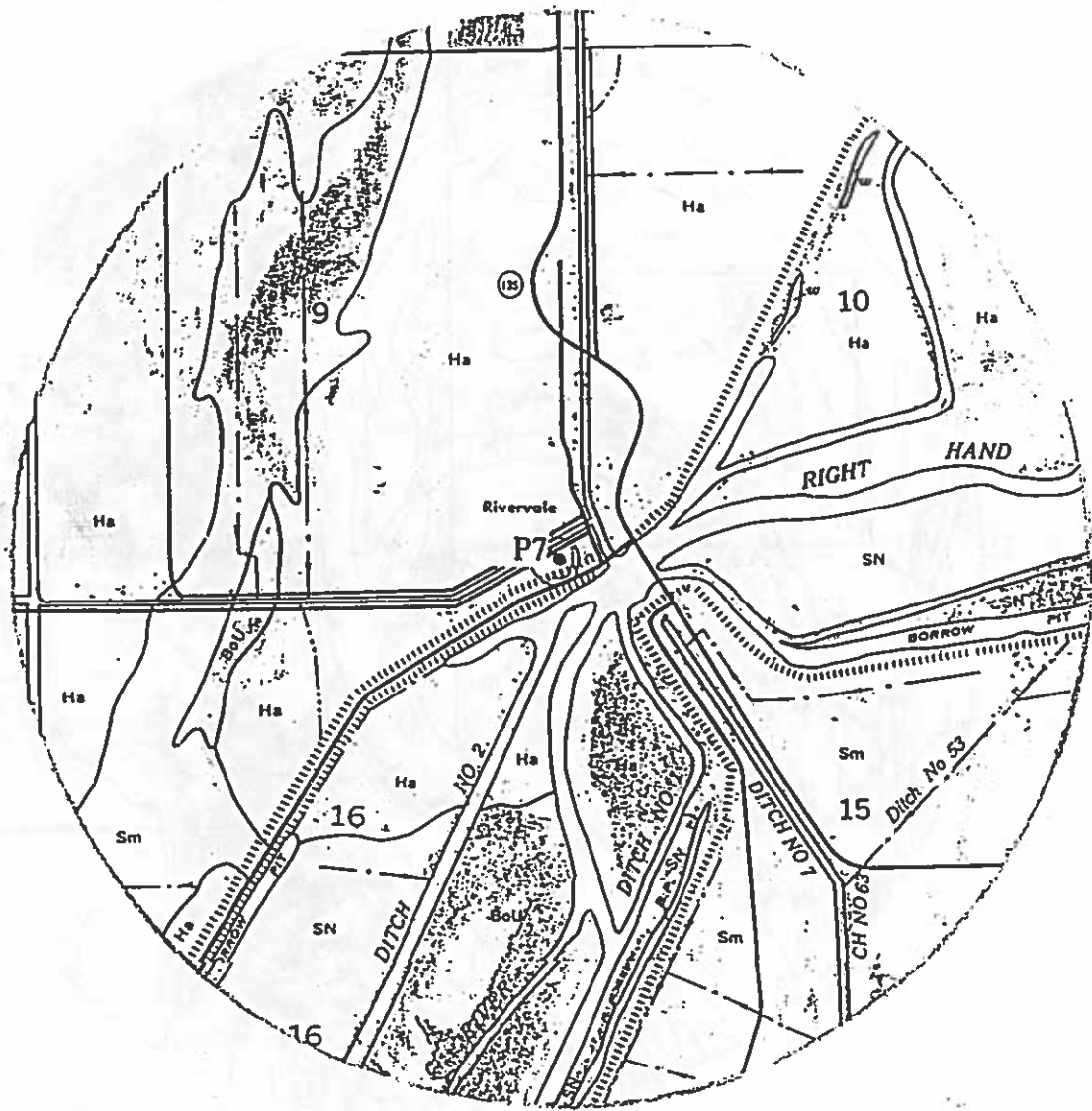**Figure B23.** Soils within one mile of well M11. Permeable soils are indicated by cross lines.

N↑

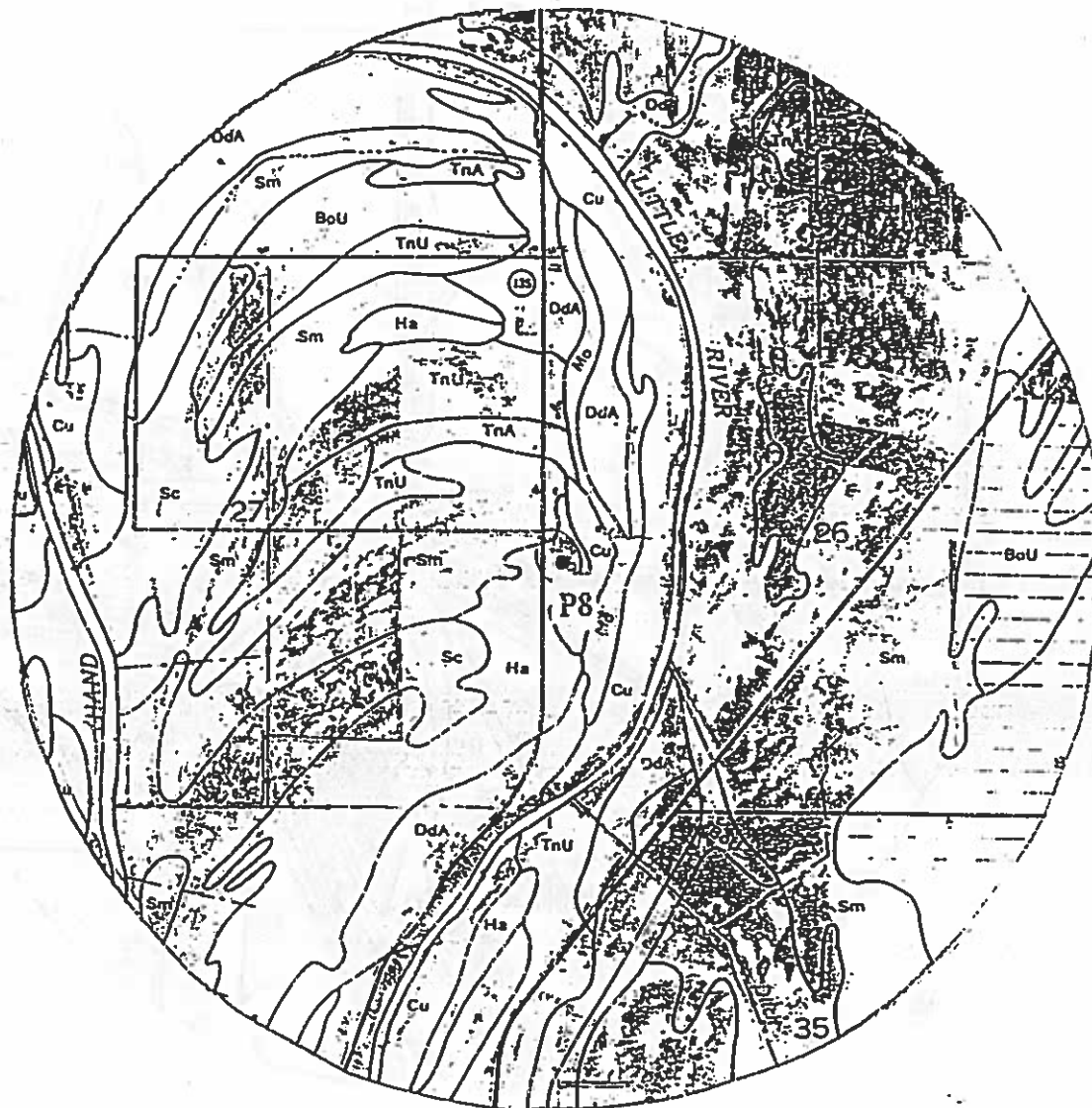**Figure B24.** Soils within one mile of well M12. Permeable soils are indicated by cross lines.

N↑

Figure B25. Soils within one mile of well M13. Permeable soils are indicated by cross lines.

Figure B26. Soils within one mile of well M14. Permeable soils are indicated by cross lines.

N↑

Figure B27. Soils within one mile of well M15. Permeable soils are indicated by cross lines.

Figure B28. Soils within one mile of well P1. Permeable soils are indicated by cross lines.

N↑

Figure B29. Soils within one mile of well P2. Permeable soils are indicated by cross lines.

Figure B30. Soils within one mile of well P3. Permeable soils are indicated by cross lines.

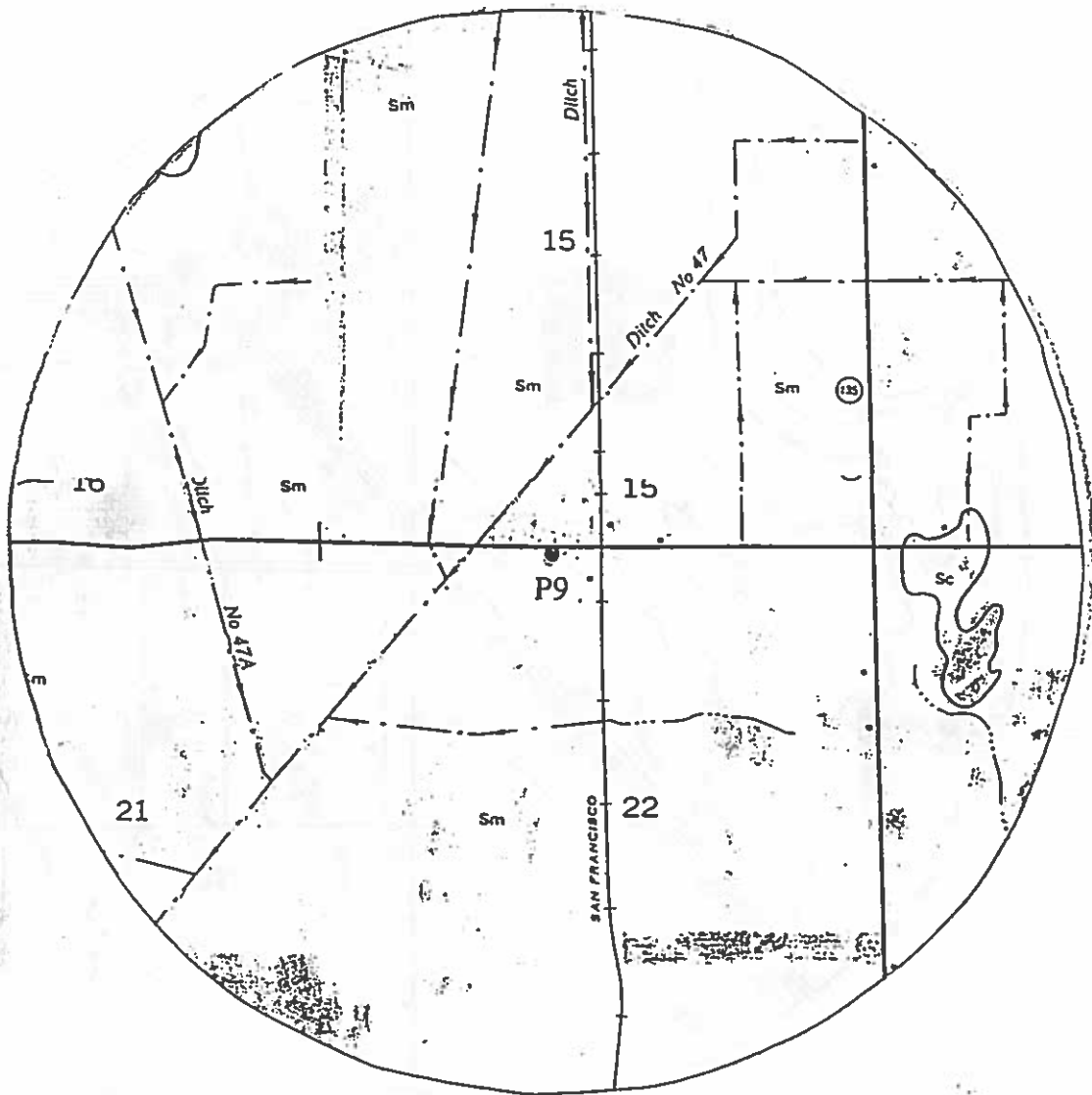**Figure B31.** Soils within one mile of well P4. Permeable soils are indicated by cross lines.

Figure B32. Soils within one mile of well P5. Permeable soils are indicated by cross lines.

N↑

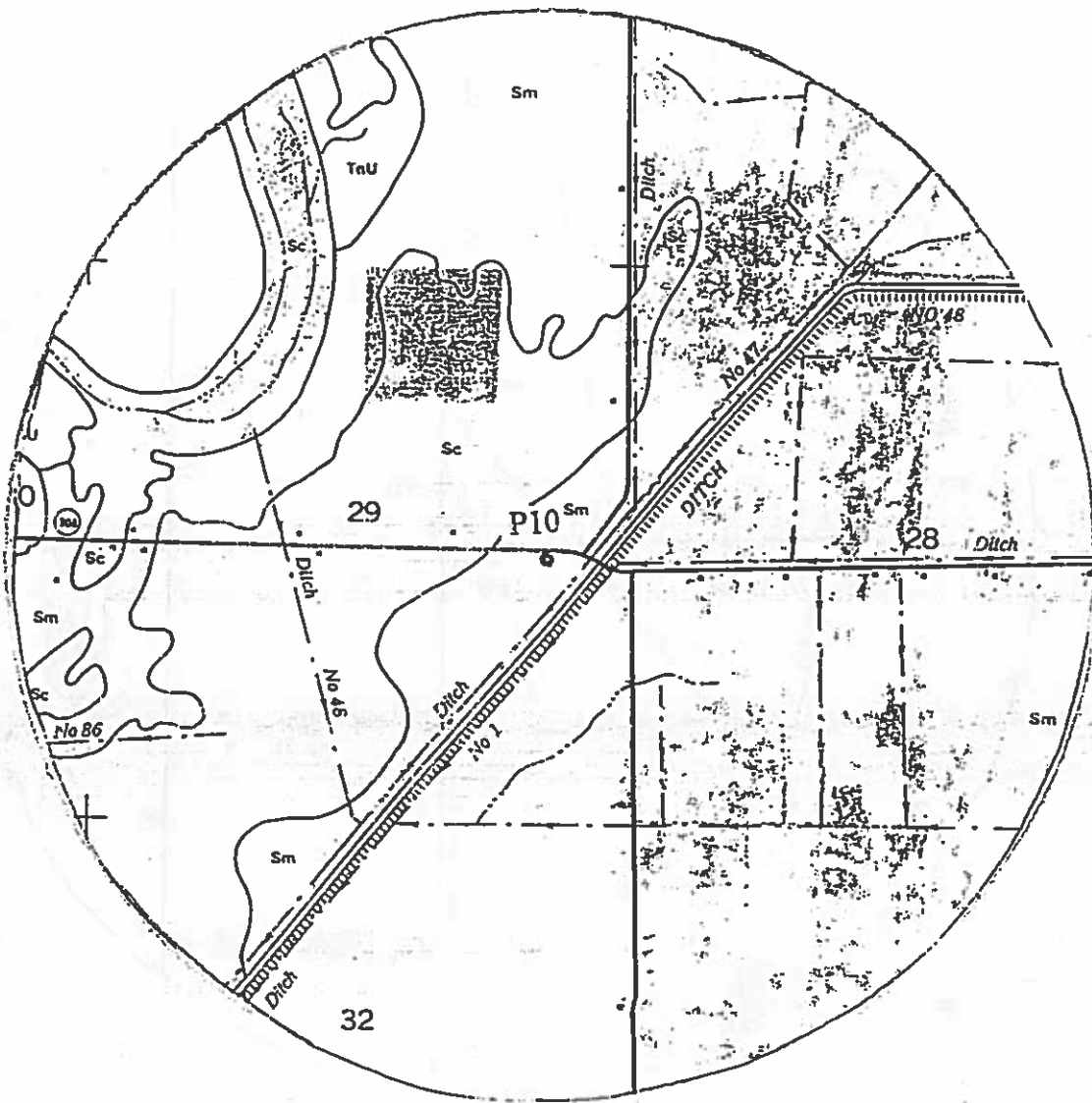Figure B33. Soils within one mile of well P6. Permeable soils are indicated by cross lines.

N↑

Figure B34. Soils within one mile of well P7. Permeable soils are indicated by cross lines.

N↑

Figure B35. Soils within one mile of well P8. Permeable soils are indicated by cross lines.
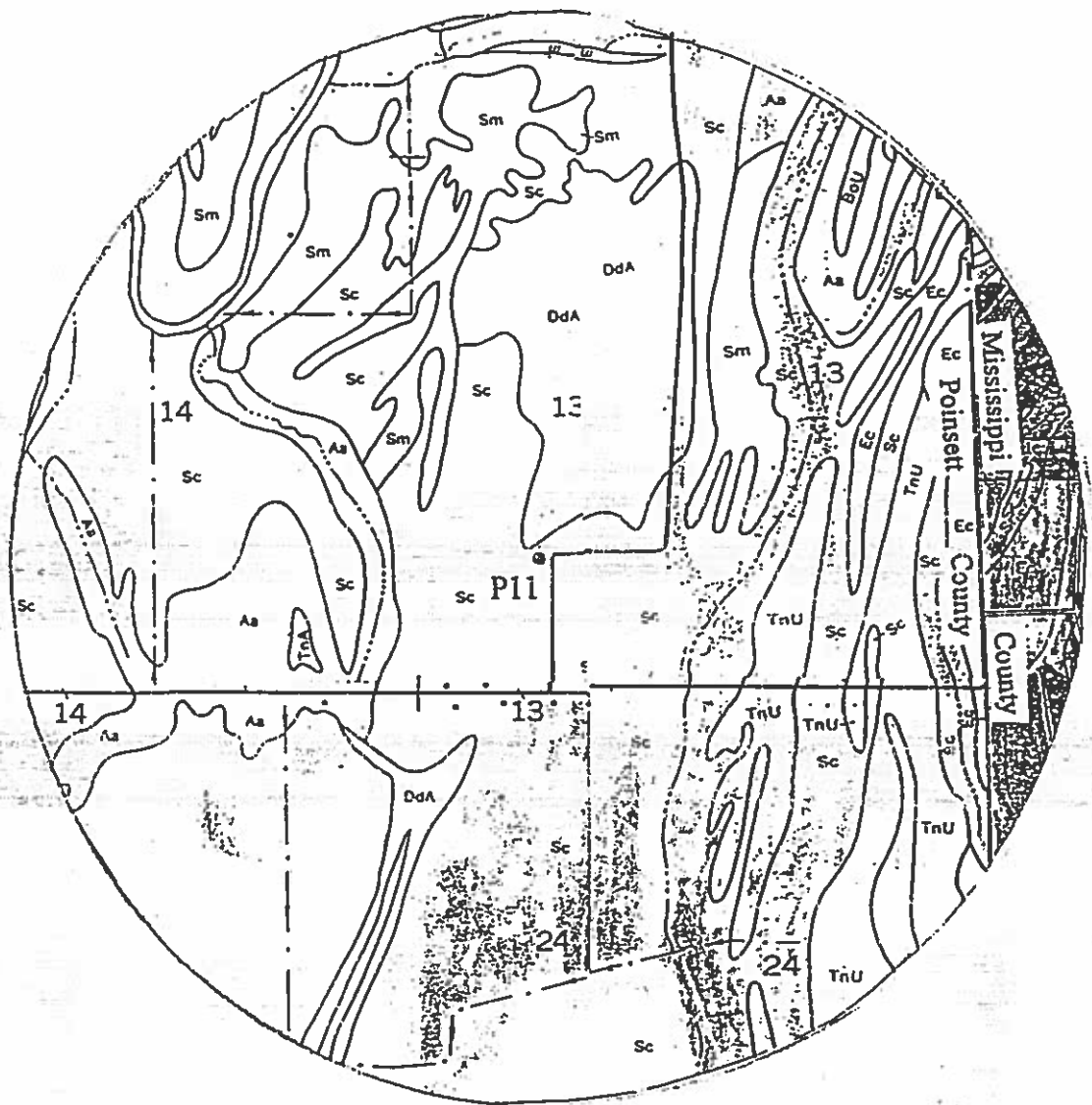
Figure B36. Soils within one mile of well P9. Permeable soils are indicated by cross lines.

N↑

Figure B37. Soils within one mile of well P10. Permeable soils are indicated by cross lines.

N↑

Figure B38. Soils within one mile of well P11. Permeable soils are indicated by cross lines.