GROUNDWATER SENSITIVITY MODELING USING GIS TECHNOLOGY

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INTRODUCTION

Protection of groundwater resources in Mississippi is administered by the Bureau of Pollution Control of the MS Department of Natural Resources (DNR) through the development of a groundwater protection strategy. The groundwater protection strategy's long-term objective is to develop and administer the regulatory activities necessary to protect the state's groundwater resources. Groundwater classification, quality standards, monitoring, planning and interagency coordination are several issues which are addressed in the strategy to help protect groundwater resources.

The Bureau of Pollution Control of DNR contracted with the Mississippi Automated Resource Information System (MARIS) Technical Center to provide technical services using the MARIS geographic information system (GIS) to model groundwater sensitivity by determining potential contamination sites within one mile of public water supply wells. This model would identify potentially vulnerable water wells and help the Bureau of Pollution Control establish priority areas for future water quality investigations.

MARIS BACKGROUND

The Mississippi Automated Resources Information System (MARIS) is a consortium of 25 state agencies which are involved with natural. cultural, and/or socioeconomic resources. The mission of MARIS is to facilitate the effective achievement of state agencies' responsibilities with respect to the development, management, conservation, protection and utilization of the natural and cultural resources of Mississippi. MARIS does this by providing assistance and a locus for cooperation among agencies in coordinating the gathering, analysis, and dissemination of resource information.

MARIS consists of three parts that serve advisory, communication, and policy functions for the organization. The Executive Committee is made up of five members, three elected from and by the Policy Committee, and two advisory members. The Policy committee is composed of the directors of the state organizations that are members of MARIS. Their responsibility is to oversee MARIS' role within Mississippi state government and provide guidance to the Executive Committee. The third part is the Task Force Committee which consists of two or more delegates from each MARIS organization. These members are technical representatives who service as a liaison between the service capabilities of MARIS and the need of their own agencies. They must have a thorough knowledge of the agency's data needs and continually evaluate ways in which MARIS can complement the agency's activities. MARIS is supported by a technical center which has a staff of GIS specialists and GIS computer system which provides GIS, LANDSAT, and database management services to MARIS members.

GIS OVERVIEW

A computerized geographic information system is an assemblage of computer hardware and software designed to capture, store, analyze, and display geographically oriented data for resource management and planning. Typical GIS computer hardware consists of a processor, disk drives for data storage, terminals, color monitors, digitizing tables for coding map data, magnetic tape drives, and line printers and plotters to produce reports, graphs, and maps.

The data stored in a GIS are spatially related to a given region or area on the earth's surface. This spatial referencing is accomplished through a variety of geographic coordinate systems such as latitude/longitude, state plane, and universal transverse mercator. Individual categories of information in a data base are grouped to form a multi-layered data set for various bounded or unbounded geographic regions, such as a state, county, city, or river basin. Each layer of data is called a variable, and individual items or characteristics of a variable are termed as attributes, (see Figure 1). Examples of variables include soils, land use, census tracts, and political division. Each variable, such as soils, contains one or more attributes, such as clay. silt sand, etc. Attributes of a political divisions variable could be supervisory districts or municipal corporate limits. The numbers and types of variables, and the attributes within each variable. are determined by the user's requirements.

Analysis of GIS data are performed by various software programs which execute the sorting, combining, and sifting functions based on user-defined needs. Relational database management system have recently been integrated with GIS to enhance analytical capabilities of attribute data of variables for reports or mapping. The GIS data can be presented graphically onto color graphic monitors or drawn by plotters to produce maps or charts. The data can also be presented in reports with other related attribute variable data.

PROJECT OVERVIEW

The objective of this project is to identify shallow public water supply wells in the state and determine the identity and location of facilities with# one mile of these wells which may cause potential contamination of the wells. Those wells which are identified as having potential contaminant sites (PC sites) can be given priority for future groundwater water quality investigations. To develop this assessment, the latitude/longitude location of all wells and PC sites were placed in a GIS digitized file. Attribute data for each wells and PC site were stored in a relational database with a unique identification code to correspond to the well and PC site in the GIS digitized file. GIS analyses in the form of a one-mile radial search were made for each well. The project also required that additional research be conducted to determine the hydrology, geology, and locational information of each PC site within one mile of a well. To complement the findings, additional water quality data, such as chemical analyses, for each well were compiled from various sources. The final results of the analyses were presented as maps and reports.

SHALLOW PUBLIC WATER WELLS DATASET

A total of 497 water wells from the USGS database were considered in the project. Criteria were that the wells be for public water supply and less than 351 feet deep. The USGS latitude/longitude coordinates and township, section, range descriptions were used as the initial sources of location. To meet the Bureau of Pollution Control's requirement to verify the locations of the wells, the USGS well locations were plotted onto draft paper plots for corresponding 7 1/2 quadrangle maps. The draft paper plots were overlaid with the Bureau of Land and Water's quadrangle maps to insure locational accuracy.

The Bureau of Land and Water of the Department of Natural Resources is required to permit wells which are 6 inches or greater in diameter. Part of the permit process is to verify each well's location and plot each permitted well onto a quad topo map. It was felt that the Bureau of Land and Water's plotted locations would be the most accurate source to verify well location. Approximately 85% of the dataset wells are permitted wells and are plotted on the Bureau of Land and Water maps. Of that 85%. only 20% of the well sites required redigitizing.

Another source for verifying well locations came from the Department of Health's program to locate the latitude/longitude of each public water supply well during water quality inspections. Approximately 20% of the wells in the overall dataset were derived from the Health Department to complement the Bureau of Land and Water locations.

POTENTIAL CONTAMINANT SITES

Potential contaminant sites in the study were identified from several sources. These sites consist of businesses, industries, and other facilities that could effect groundwater through spillage, intentional or non-intentional dumping, and/or storage of materials. Data on potentially contaminant sites were gathered from DNR's Bureaus of Pollution Control, Land and Water, Underground Storage Tanks, and Geology, the MS Department of Health, the US Geological Survey, and the Environmental Protection Agency. The data were in varied forms, such as paper records, computer diskettes, digital tapes, and maps. It was necessary to convert and combine the information into one dataset format and load into the MARIS relational database.

The PC sites identified from the various sources were underground storage tank facilities (UST). surface impoundment sites, permitted landfills, open dumps, and business and industries registered with the EPA as regulated facilities or in the ERRIS inventory. These sites are located by latitude and longitude coordinates and by section, township, and range. Specific EPA and UST site locations were determined by direct phone contract with the facility owners or administrators. The addresses were then located and marked on corresponding topographic maps. Latitude and longitude coordinates were then digitized from the marked maps. Surface impoundment data were received from the Bureau of Geology and were not verified by MARIS. The landfill and open dump sites had been previously verified by the Bureau of Pollution Control.

GIS RADIAL SEARCH METHODOLOGY

Once all components for the model were referenced by latitude/longitude, GIS analytical capabilities could begin. A one-mile radial search was performed using each well's location as the the center of the one-mile circle. All PC site location was compared with the wells through database query. Any potential contaminant sites within the one-mile circle were reported by site ID number, facility name, type, and specific distance in print outs. Those sites were then organized into a special GIS file and plotted along with the well sites and radial circle on draft paper. After the verification process was completed, the data were replotted directly onto the USGS topographic maps, (see Figure 2).

POTENTIAL CONTAMINANT SITE RESEARCH

As PC sites were identified, further research was conducted to identity the geology and hydrology of each site and stored in the relational database. The USGS and the MS Bureau of Geology data sources were used to determine the soil types and aquifers of particular site, (see Figure 3). Another radial search was conducted to locate any private

wells within one mile of a particular potential contamination site by using each PC site location as the center of the radial search and calculating the distance of private wells from the PC site.

PROJECT OUTPUTS

The output products of the project consist of maps and reports which depicted the wells and their PC sites and additional information on PC sites to help the Bureau of Pollution Control determine the sensitivity of specific wells and establish the priority of site investigations. After all wells with PC sites were identified, the sites and corresponding labels were plotted onto the 7 1/2 minute quads inside the one-mile radial search. Summary and detail reports were generated to support the mapped data by listing the names, identification number, and distances of the PC sites for each well, (see Figures 4 and 5). A list of output products are:

Attribute report of all wells under investigation

Composite report of radial search findings

Site data sheets for each PC site found within one mile of a well

Attribute report of private wells within one mile of a PC site

Water quality reports for public water wells

94 USGS 7 1/2 minute quads with wells, PC sites. and search area

94 paper plots of wells, PC sites, and search areas

One paper and one mylar statewide plot of all shallow public water supply wells and potential contaminant sites except USTs.

FUTURE APPLICATIONS

The project can be expanded by addressing deep public supply wells and private water wells. Moreover, radial searches can be updated when additional facilities are identified as potential contaminant sites and stored in the MARIS database. Ultimately, as new hardware and software upgrades are implemented at MARIS this summer, the Bureau of Pollution Control can perform some of these analyses in-house through remote connections to MARIS. The research can be achieved for specific sites as well as large groups of wells.

Figure 1

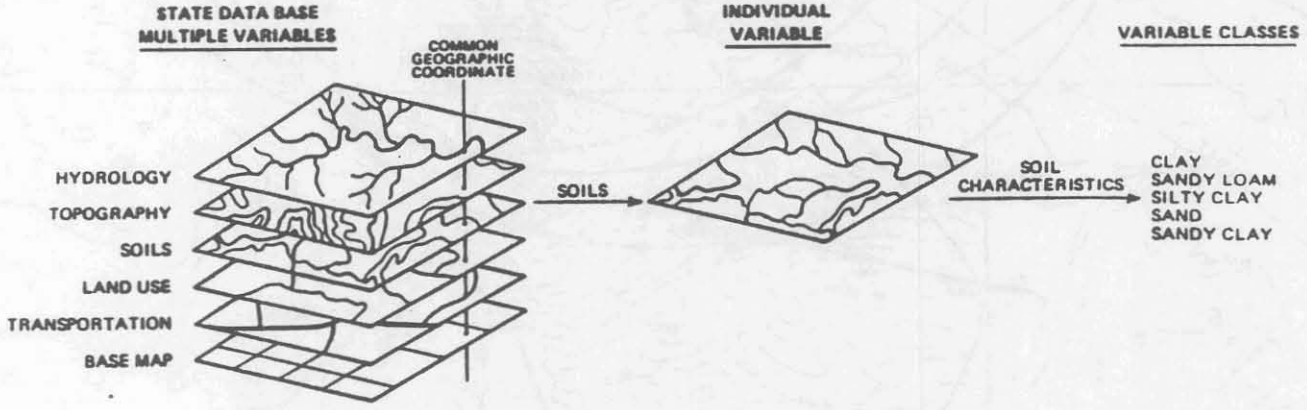

Figure 2

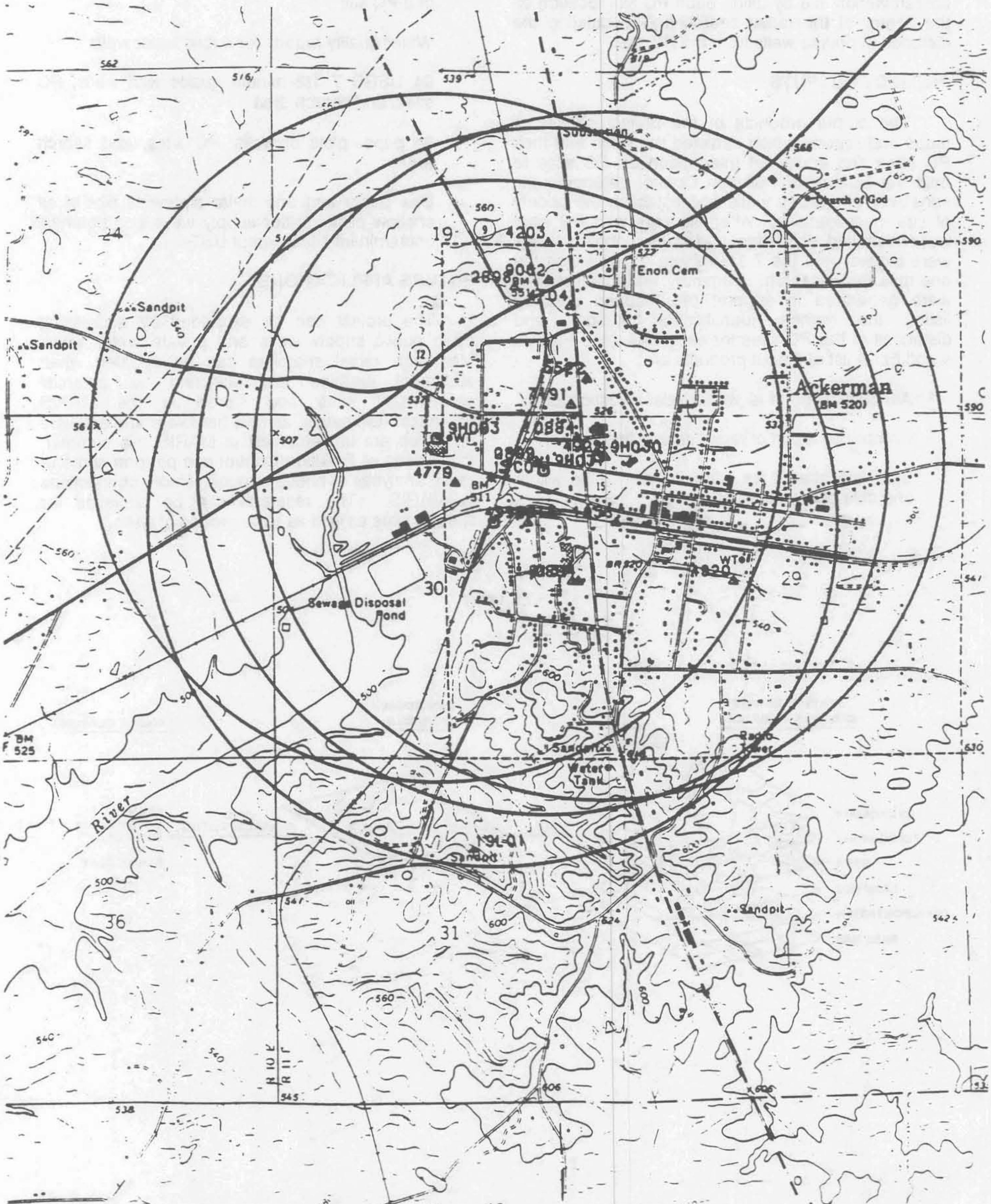
Substation
Church of God
Enon Cem
Ackerman
(BM 520)
Sandpit
Sewage Disposal
Pond
Radio
Tower
Water
Tank
River
4203
4779
19
20
29
30
31
36

Figure 3

SITE DATA SHEET

MARIS ID#: 19C01 EPA ID#: MSD067116178 STATE ID#:

SITE NAME: Gulf & Western Manufacturing

FACILITY TYPE: Manufacturing

COUNTY: CHOCTAW CLOSEST MUNICIPALITY: Ackerman

LAT/LONG COORDINATES IN DEGREES, MINUTES & SECONDS: 33.1843 89.1053

SECTION/TOWNSHIP/RANGE: 30/17N/11E USGS TOPO: Ackerman

SITE SIZE: YEARS IN OPERATION:

PERMIT TYPE: N/A PERMIT DATE: N/A

STATE REGULATORY PROGRAM: CERCLA

OUTCROPPING FORMATION: Wilcox

GENERAL SITE STRATIGRAPHY:
Midway, Selma, Tuscaloosa

GENERAL LITHOLOGY: Sand, Clay & Marl

USDWS BENEATH SITE:
Middle-Lower Wilcox, Ripley, Coffee Sand, Eutaw McShan

SURFACE WATER: Yookaknookany River

MONITORING WELLS: N/A

PUBLIC WATER WELLS WITHIN ONE MILE		DOMESTIC WATER WELLS WITHIN ONE MILE	
H003	0.19	H011	0.61
H015	0.13	H012	0.41
H030	0.32	H014	0.79
H031	0.15		

SHALLOW PUBLIC WATER WELLS (LESS THAN 151 FEET DEEP) AND POTENTIAL CONTAMINANT SITES

COUNTY NAME	USGS WELL ID	WELL OWNER	QUAD	MARIS ID #	POTENTIAL CONTAMINANT SITES TYPE	ID #	SITE NAME	DISTANCE (Miles)
Choctaw	19 H003	Ackerman	Ackerman		UST	0-002898	MS Highway Dept.	0 4951
					UST	0-004203	Chevron U.S.A, Inc.	0 6570
					UST	0-009062	4-Way Superette I	0.5637
					UST	0-004704	Jones Texaco	0 5463
					UST	0-005522	Dixie Oil Co. #98	0.4660
					UST	0-007191	Jr. Food Mart #276	0.3985
					UST	0-000884	Fair Propane Gas Systems, Inc	0.4039
					UST	0-004922	Hodges Pharmacy	0 4880
					UST	0-000502	Choctaw County	0.2982
					UST	0-002899	MS Highway Dept.	0 2982
					UST	0-001956	4-County Electric Power Assoc	0 5702
					UST	0-004779	Hanckney, Inc.	0.1408
					UST	0-004919	Ackerman Plainer Mill Co.	0 3588
					UST	0-008131	Davis Arcade	0.5711
					UST	0-000894	Highway 15 South Service Sta	0 5829
					UST	0-004920	Worrell Oil Company	0.9518
				19C01	EPA	MSD067116178	Gulf & Western Mfg.	0 1945
Choctaw	19 H015	Ackerman	Ackerman		UST	0-002898	MS Highway Dept.	0 6918
					UST	0-004203	Chevron U.S.A., Inc.	0.8356
					UST	0-009062	4-Way Superette I	0.7278
					UST	0-004704	Jones Texaco	0 6725
					UST	0-005522	Dixie Oil Co. #98	0 5002
					UST	0-007191	Jr. Food Mart #276	0.4113
					UST	0-000884	Fair Propane Gase Systems	0 3466
					UST	0-004922	Hodges Pharmacy	0.3765
					UST	0-000502	Choctaw County	0.2138
					UST	0-002899	MS Highway Dept.	0.2138
					UST	0-001956	4-County Electric Power Assoc	0.3519
					UST	0-004779	Hanckney, Inc.	0 1603
					UST	0-004919	Ackerman Plainer Mill Co.	0 0978
					UST	0-008131	Davis Arcade	0.2835
					UST	0-000894	Highway 15 South Service Sta	0.2973
					UST	0-004920	Worrell Oil Company, Inc.	0.7135
				19C01	EPA	MSD067116178	Gulf & Western Mfg.	0.1310
				19L01	Landfill	20375	Ackerman Rubbish	0.9599

Figure 4

DOMESTIC WATER WELLS WITHIN ONE MILE
OF A POTENTIAL CONTAMINANT SOURCE SITE

15-OCT-88

COUNTY	USGS WELL CODE	OWNER	LOCATION	WELL USE	WATER USE	HYDRO UNIT	CONSTRUCTED	DEPTH	ALTITUDE	WATER LEVEL	COLLECTED	CASING DIAMETER
1	C027	L THORNBROUGH	NENW57T07NR02W	H	W	122MDCN	01011970	126	0	85	05011970	2
1	D001	MISS POWER & LT	S12T07NR02W	U	D	122MDCN	01011951	456	192	89	06141982	12
1	D002	MISS POWER & LT	S14T07NR02W	E	W	122MDCN	01011949	324	215	94	03011961	12
1	D003	MISS POWER & LT	S14T07NR02W	E	W	122MDCN	01011949	499	215	142	06141982	12
1	D004	MISS POWER & LT	S14T07NR02W	E	W	122MDCN	01011951	477	189	77	03011961	12
1	D021	NATCHEZ TRACE	NWNW572T07NR02W	-	Z	121CRNL	01131948	100	140	21	01181968	2
1	D022	MIKE SMITH	S57T07NR02W	H	W	122MDCN	01011969	115	0	103	04011969	2
1	D025	ANDREW ROBINSON	SENW539T07NR02W	H	W	122MDCN	01011970	178	0	63	08011970	4
1	D026	W J REED	NWNW533T07NR02W	H	W	122MDCN	01011970	136	0	56	06011970	4
1	D028	B R QUINN	SWSE557T07NR02W	H	W	122MDCN	01011970	93	0	68	12011970	4
1	D030	MCNEELY	S96T07NR02W	U	U	122MDCN	01011967	155	0	50	11011967	6
1	D031	TERRACE MOTEL	NESW596T07NR04W	H	W	122MDCN	01011968	112	0	40	08011968	4
1	D032	WILLIE BRYANT	S13T07NR02W	H	W	122MDCN	01011972	132	0	70	02011972	2
1	D034	J C CAMPBELL	S54T07NR02W	H	W	122MDCN	01011973	137	0	95	03011973	2
1	D035	MISS POWER & LT	S13T07NR02W	N	W	122MDCN	01011974	355	180	90	07011974	12
1	D052	MISS POWER & LT	S12T07NR02W	N	W	122MDCN	06021981	483	200	119	11011981	8
1	D055	R L HENSLEY	---	-	-	122CTHL	01011960	170	190	70	09151981	0
1	D056	RAYBORN DRILLING	S51T07NR02W	H	W	122CTHL	01011962	165	215	95	01011962	4
1	D060	R WILSON	S34T07NR02W	H	W	122MDCN	01011981	150	205	110	05191982	4
1	D069	KCS LUMBER CO	S35T07NR02W	H	W	122MDCN	08201984	115	170	70	08201984	6
1	D070	JAMES WEBB	S59T07NR02W	H	W	121CRNL	06011984	106	200	75	06011984	4
9	H012	FRANKIE TAYLOR	S18T03SR01E	H	W		01011968	130	0	90	12011968	4
9	H027	NAN GIBSON	S06T03SR01E	H	W		01011966	137	0	98	11011966	4
19	G013	BILLY JOE KING	S36T17NR10E	H	W	124MLCXM	01011961	125	0	35	09011961	2
19	H007	L ALEXANDER	S32T17NR11E	H	W	124MLCXL	01011962	347	0	130	10011962	2
19	H010	EDD HODGES	S31T17NR11E	H	W	124MLCXL	01011963	100	0	35	08011963	2
19	H011	ROY YOUNG	S19T17NR11E	H	W	124MLCXM	01011963	54	0	15	10011963	2
19	H012	LEE ROBINSON	S30T17NR11E	H	W	124MLCXL	01011960	167	0	59	11011960	2
19	H014	DAN KING	S19T17NR11E	H	W	124MLCXL	01011965	297	0	80	10011965	2
19	H023	HAZEL BRUCE	SENE531T17NR11E	H	W	124MLCXL	01011973	230	0	90	07011973	2
19	J013	ROBERT H LACOY	S20T16NR10E	H	W	124MUNX	01011963	87	0	0		2
19	J014	MRS A SMITH	S16T19NR10E	H	W	124MLCXM	01011960	167	0	37	07011960	2
19	J021	ROBERT LACY	S20T16NR10E	H	W	124MUNX	01011964	72	0	30	01011964	2
19	K017	ETHEL MCCLURE	NENW505T16NR11E	H	W	124MLCXL	01011971	240	550	90	03011971	2

Figure 5a

USGS WATER QUALITY DATA
FOR SHALLOW PUBLIC WATER WELLS
WITH POTENTIAL CONTAMINANT SITES WITHIN ONE MILE

10-OCT-88

WELL ID	OWNER	DEPTH	COLLECTED	COLOR	Ph	Ph LAB	N	HARDNESS	Ca	Mg	Na	K	CL-	So4	FL	Silica	Ba	Fe	Mn	TDS	ALK	SP Cond
1 D019	OAKLAND WTR WK	135	820614	1	0.00	7.50	0.00	290.00	67.00	30.00	9.10	1.10	6.00	4.00	0.30	29.00	0.00	0.00	0.00	340.00	313.00	590.0
1 D045	BROADMOOR UTL	150	790606	0	6.70	0.00	0.00	260.00	62.00	26.00	8.40	1.20	14.00	27.00	0.20	30.00	0.00	0.01	0.08	354.00	0.00	0.0
19 H003	ACKERMAN	114	700312	0	5.40	0.00	0.00	12.00	4.80	0.00	9.70	1.80	12.00	3.20	0.00	2.40	0.00	0.00	0.00	43.00	0.00	0.0
19 H015	ACKERMAN	112	650829	0	5.40	0.00	0.00	11.00	1.60	1.70	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	31.00	0.00	0.0
19 J006	WEIR	104	650729	0	5.20	0.00	0.00	32.00	6.00	4.10	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	67.00	0.00	0.0
29 D003	CRYSTAL SPRING	108	641102	5	6.00	0.00	0.00	52.00	11.00	6.00	18.00	2.90	30.00	17.00	0.10	14.00	0.00	0.00	0.00	135.00	0.00	0.0
29 D022	CRYSTAL SPRING	111	610911	10	6.00	0.00	0.00	33.00	8.10	3.10	14.00	1.60	25.00	15.00	0.00	13.00	0.00	0.00	0.00	126.00	0.00	0.0
35 D029	PETAL	134	640528	0	5.30	0.00	0.00	6.00	1.40	0.60	2.10	1.10	2.30	0.20	0.00	20.00	0.00	0.00	0.00	19.00	0.00	0.0
41 P001	LEAKESVILLE	140	590805	0	8.80	0.00	0.00	11.00	1.90	0.90	0.00	0.00	3.00	7.10	0.00	18.00	0.00	0.00	0.00	134.00	0.00	0.0
41 P002	LEAKESVILLE	125	590805	0	8.80	0.00	0.00	7.00	1.80	0.40	0.00	0.00	5.00	8.90	0.00	16.00	0.00	0.00	0.00	126.00	0.00	0.0
41 P003	LEAKESVILLE	140	640527	0	8.10	0.00	0.00	3.00	0.80	0.20	41.00	0.50	3.20	5.40	0.10	26.00	0.00	0.00	0.00	111.00	0.00	0.0
71 J002	TAYLOR	91	711021	0	6.00	0.00	0.00	15.00	3.90	1.30	6.00	0.50	6.70	3.00	0.00	18.00	0.00	0.00	0.00	63.00	0.00	0.0
71 J002	TAYLOR	91	711021	0	6.00	0.00	0.00	15.00	3.90	1.30	6.00	0.50	6.70	3.00	0.00	18.00	0.00	0.00	0.00	63.00	0.00	0.0
71 J002	TAYLOR	91	711021	0	6.00	0.00	0.00	15.00	3.90	1.30	6.00	0.50	6.70	3.00	0.00	18.00	0.00	0.00	0.00	63.00	0.00	0.0
71 J002	TAYLOR	91	711021	0	6.00	0.00	0.00	15.00	3.90	1.30	6.00	0.50	6.70	3.00	0.00	18.00	0.00	0.00	0.00	63.00	0.00	0.0
71 J002	TAYLOR	91	711021	0	6.00	0.00	0.00	15.00	3.90	1.30	6.00	0.50	6.70	3.00	0.00	18.00	0.00	0.00	0.00	63.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.00	0.00	49.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.00	0.00	49.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.00	0.00	49.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.10	0.00	49.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.10	0.00	49.00	0.00	0.0
91 L001	COLUMBIA	147	660427	0	6.40	0.00	0.00	8.00	1.80	0.80	3.50	1.40	4.30	0.20	0.10	21.00	0.00	0.10	0.00	49.00	0.00	0.0
101 M045	CHUNKY W A	139	740228	8	7.90	0.00	0.00	57.00	18.00	2.90	37.00	4.10	2.40	17.00	0.10	27.00	0.00	0.06	0.00	181.00	0.00	0.0
101 M045	CHUNKY W A	139	700812	5	7.60	0.00	0.00	58.00	16.00	4.60	50.00	5.50	4.00	41.00	0.00	3.20	0.00	0.00	0.00	199.00	0.00	0.0
127 K005	SANITORIUM	130	780712	5	5.20	0.00	0.00	7.00	1.30	0.90	3.10	0.80	3.80	2.00	0.10	9.60	0.00	0.01	0.04	36.00	0.00	0.0
127 K005	SANITORIUM	130	640505	0	5.20	0.00	0.00	9.00	0.80	0.20	0.00	0.00	5.00	0.00	0.00	4.00	0.00	0.00	0.00	23.00	0.00	0.0
127 K007	SMITH CROSSING	125	690624	0	5.70	0.00	0.00	6.00	1.40	0.60	2.90	0.60	3.60	0.00	0.00	8.80	0.00	0.00	0.00	32.00	0.00	0.0
127 G001	MAGEE	112	600705	0	0.00	0.00	0.00	14.00	2.70	1.70	0.00	0.00	21.00	0.00	0.00	0.00	0.00	0.00	0.00	42.00	0.00	0.0
127 G015	MAGEE	96	701030	0	6.50	0.00	0.00	11.00	3.90	0.30	5.00	0.70	4.60	0.80	0.10	13.00	0.00	0.00	0.00	48.00	0.00	0.0
141 L019	DENNIS W A	131	720613	0	5.00	0.00	0.00	6.00	2.10	0.20	1.50	1.00	2.00	0.00	0.00	10.00	0.00	0.00	0.00	26.00	0.00	0.0
153 N005	WAYNESBORO	118	590710	0	7.20	0.00	0.00	124.00	31.30	6.20	0.00	0.00	3.00	16.30	0.00	15.60	0.00	0.00	0.00	198.00	0.00	0.0
161 C030	WATER VALLEY	74	681106	0	5.40	0.00	0.00	7.00	2.00	0.50	5.80	1.60	11.00	0.00	0.00	0.00	0.00	0.00	0.00	23.00	0.00	0.0
161 C030	WATER VALLEY	74	681003	0	6.60	0.00	0.00	8.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0

Figure 5b