[DNR-078]

DRINKING WATER AND GROUNDWATER QUALITY IN THE LOWER WISCONSIN RIVER VALLEY

INTRODUCTION

The Lower Wisconsin River Valley (LWRV), from Prairie du Sac to Boscobel, is a broad level valley consisting of sandy soils over deep, coarse textured subsurface geological materials. Most of the drinking water in the LWRV comes from the shallow sand and gravel aquifer where depth to groundwater ranges from 5 to 15 feet. The exception to this is a relatively small area in the valley located north of the river near Byrds Creek and Eagle Corners on the Bridgeport Terrace where a Late Wisconsin loess cap is present (Knox and Attig, 1988). In this area the soils are deep and medium-textured; depth to water is generally 30-60 feet. The Wisconsin River is a regional, groundwater discharge point; groundwater flows from the flanks of the valley toward the river in a slight westerly direction, although locally streams and wetland areas may affect this flow pattern.

The LWRV is an intensively farmed area consisting of irrigated and non-irrigated fields producing mint, vegetables, ginseng, corn, soybeans and alfalfa. Many farm enterprises include dairy cattle, hogs, beef and poultry. Because of the high degree of agricultural use combined with the nature of the site conditions, the valley is a highly susceptible area to groundwater contamination. Therefore, the Departments of Natural Resources (DNR) and Agriculture, Trade and Consumer Protection (DATCP) and Ciba Geigy (the manufacturer of the pesticide atrazine) have conducted studies to determine the nature and extent of groundwater contamination.

Approximately 50 domestic wells were sampled by the DNR in 1989 primarily in the intensely irrigated area from Arena to Lone Rock where the soils are coarse-textured and the depth to groundwater is around 10-12 feet. Most of the wells in the sampling area were sandpoints. Atrazine was detected in approximately half of the drinking water wells and concentrations of nitrate (NO3-N) often exceeded the drinking water standard. Atrazine use was banned in several areas where atrazine levels were found over the enforcement standard (ES), which at the time was 3.5 ppb (for parent atrazine only). New groundwater standards are currently being implemented to include the metabolites of atrazine. These new standards set the Preventive Action Limit (PAL) at 0.3 ppb and the ES at 3.0 ppb. Retesting of 17 of these wells by DATCP in 1991 showed that 5 of them exceeded the new ES because of the metabolite analysis and that several others went over the PAL (Postle, 1991).

Ciba Geigy conducted its study in the same area of the river valley using 27 irrigation wells where the screened interval ranged from 40-120 feet with the average interval between 60-100 feet. Atrazine was detected in 25 of the 27 wells, metolachlor in 13 and nitrate concentrations were over the drinking water standard in all 27 samples (Yeary, 1990). Six of the 27 samples had NO3-N concentrations over 20 ppm.

DATCP installed nests of monitoring wells downgradient from irrigated fields on sandy soils at 15 sites from Prairie du Sac to Bosbocel. The PAL (0.35 ppb) for atrazine was exceeded at 13 out of 15 of these sites and the ES

(3.5 ppb) at 7 of the 15 sites (Postle, 1989). Because of the new groundwater standards, the wells were resampled several times from April to August, 1991. The number of samples at each depth and at each site which actually exceeded the new PAL was 33 of 100 (33%) while 19 (19%) exceeded the new ES (Postle, 1991). In addition 23 (23%) of these samples had metabolite detects but no parent compound. These results and the results from resampling the DNR domestic wells indicate what a profound affect the new standards have in samples taken from the LWRV when metabolite information is available.

From these previous studies, it was found that drinking water and groundwater contamination was a problem in the irrigated sandy soils in some areas of the LWRV. Therefore this study was proposed to expand the data base in the LWRV to determine the extent of contamination in other areas of the valley not previously sampled. These data should help evaluate the overall importance of site conditions, namely the soil and subsurface geological materials as well as depth to groundwater, as they relate to contaminant movement. In addition, sampling would be conducted upgradient of the intensively farmed valley floor along the flanks of the river valley, at the mouths of non-irrigated tributary valleys and outside the valley area. These data should help answer questions about groundwater quality before it enters the river valley.

METHODS

78 samples were taken from October, 1990 through July, 1991 (Maps 1-4). 73 of these samples were from private domestic wells, 2 from barn wells, 2 from monitoring wells, 1 from a well serving a recreational vehicle park and 1 from a municipal well. 20 of the 78 (25%) samples were from agricultural areas, where an irrigated field was directly upgradient from the well, while the other samples were from non-irrigated areas. Samples were collected throughout the valley although emphasis was placed in areas that had not been previously sampled by the DNR and the DATCP.

Pesticide concentrations for atrazine, alachlor (Lasso), metolachlor (Dual), cyanazine (Bladex) and simazine (Princep) were determined by the State Lab of Hygiene. Twelve samples taken prior to January 1, 1991 were not analyzed for metabolites of these compounds. The next 42 samples were analyzed for metabolites detects although the metabolites concentrations were not determined. Concentrations of specific metabolites were reported for the last 24 samples submitted after February, 1991.

Nitrate-nitrogen concentrations as well as other water quality parameters such as chloride, electrical conductivity (EC), pH, hardness, sulfate, and iron were analyzed by a university lab. All results were sent to the homeowners immediately after analyses were completed.

RESULTS

Atrazine was by far the most frequently detected pesticide in the 78 samples although a few other chemicals were also present (Table 1). Atrazine exceeded the ES (old and new standards) in 2 of the samples taken. Of the first 12 samples taken, when only parent atrazine was analyzed, 2 (17%) had a detect of atrazine (Table 2). After July 1, 1991 when metabolite detects were included in the analysis, 28 out of the 66 samples (43%) had atrazine and/or a metabolite detect. It is important to note that 11 (17%) of the samples had detects of atrazine metabolites only; no parent atrazine was present. Previous testing procedures (including the triazine screen and the first 12 samples taken in this study) would not have recognized these detects. Analyses for the last 24 samples determined concentrations of the 2 metabolites-deethyl and deisopropyl atrazine. Of the 6 detects in this group, 5 were over the PAL (0.3 ppb) and 1 sample exceeded the ES (3.0 ppb). The highest level of atrazine detected in a sample was 79 ppb. This sample also included detects of both atrazine metabolites, alachlor and its metabolite, and simazine.

Nitrate-nitrogen results showed 25 of 78 (32%) samples with concentrations less than 2 ppm, 26 of 78 (33%) at 2-10 ppm and 27 of 78 (35%) greater than 10 ppm (Tables 1 and 2). 8 of 78 (10%) of the samples had NO3-N concentrations over 20 ppm. Table 3 lists the other water quality parameters such as chloride, electrical conductivity, pH, hardness, sulfate and iron.

Non-Irrigated Areas

Fifty eight (75%) of the samples taken were from non-irrigated areas. This included samples taken along the flanks of the valley, on the terraces, in the valley floor, and some outside the valley area. In the non-irrigated areas, atrazine and/or its metabolites were found in 17 (29%) of the samples while NO3-N over 10 ppm was in 15 (26%).

Five samples were taken from the Brideport terrace where the soils are primarily silt loams and depth to water ranges from 30-60 feet. There was some evidence of nitrate movement through the soil as several samples had nitrate levels near or above the drinking water standard (EF218, EF219, EF220,and EG948) while only 1 sample had NO3-N concentrations < 2ppm. An atrazine metabolite was detected in only one of these samples (EG948).

Along the flanks of the valley the results varied. When farmsteads or rural homes were nestled immediately at the valley wall with no fields upgradient from the well, then samples showed no detects of pesticides although a few samples had nitrate concentrations over 2 ppm (EF206, EF207, EG944. EF217, EG921, EC776, EG925, EC788). However, many farmsteads sampled along the valley flanks were downgradient from a non-irrigated field. In these cases, it was not uncommon to find elevated NO3-N concentrations (some over the drinking water standard) and detects of atrazine and/or a metabolite (EG934, EC783, EG922, EG933, EG928, EF216, EG941) although some samples, like EC774, were uncomtaminated.

Samples were also taken in some tributary valleys. Results varied because of land use and site conditions. Wells that were drilled, and hence deeper in the groundwater flow system, include EF208, CE935, EC773, EG930 and EC786 were not contaminated. Some shallow wells sampled in tributary areas had contaminant detects (EC782 and EG935) while others did not (EC787 and EG927).

A few samples were taken outside the valley area. Two sites north of Sauk City/ Prairie du Sac on finer textured, loam and silt loam soils of the Elderon terrace (EF214 and EC790) showed no contamination. Depth to water is around 30-60 feet. EG523, EF210 and EF209 were also located outside the Lower

Wisconsin River Valley and had very good water quality. Only well EG950 had elevated NO3-N levels.

Irrigated Areas

Of the 20 wells sampled in the irrigated areas 13 (65%) had detects of atrazine and /or metabolite(s) and 12 (60%) had NO3-N over 10 ppm. Irrigated areas were sampled from Boscobel to Prairie du Sac although the largest irrigated area, in the Arena to Lone Rock area, was not sampled as much because of previous sampling.

Near Sauk City/Prairie du Sac samples EG527, EC789, EG528, EG529 and EF215 were all downgradient from irrigated fields and all were contaminated. One well (EG527) had a NO3-N concentration of 44 ppm. Well EG530 was downgradient from an irrigated field (outside of the study area) on the Elderon Terrace and the water sample was uncontaminated.

Near Spring Green samples EG937, EG924, EC775, and EC772 were contaminated as was EC785, northwest of Lone Rock. EC772 was one of the few samples where atrazine was over the ES (3.0 ppb). In addition NO3-N was at 25 ppm and metolachlor was detected at 0.27 ppb. Samples EG938, EG939, EF205, EF201 and EF203 near Muscoda were also contaminated. Sample EF205 was from a 100 ft. drilled well and contaminated with atrazine and metolachlor. In the Blue River to Boscobel area, well samples EC781, EG943 were also contaminated. EG942, EF202 and EF204 were samples taken from irrigated areas although no contaminants were detected.

CONCLUSIONS

Overall drinking water/groundwater contamination from pesticides and nitrates is a widespread problem in the intensively farmed area of the LWRV. However, areas with medium textured soils on the terraces, where depth to water is much greater, are much less likely to have pesticides in the drinking water although elevated nitrate concentations were detected. Along the valley flanks, where land use immediately upgradient of the well is mostly woodland, no evidence of contamination by pesticides and nitrates was detected.

Irrigated areas with coarse textured soils over shallow water tables are the most susceptible for drinking water and groundwater contamination. Contaminant attenuation on these soils is much reduced. Whatever materials are not taken up by the plants or immobilized in the soil move through the soil and unlithified materials to the groundwater. Non-irrigated sandy soils in intensively farmed areas are also problem areas as significant rainfall events can also move contaminants to the groundwater. Although most wells in the valley floor are shallow sandpoints, results from the Ciba Geigy study of irrigation wells from Arena to Lone Rock and this study (well EF205 near Muscoda) suggest that contamination reaches deep into the aquifer.

Cropland applications of pesticides on irrigated or non-irrigated soils are not the only source of pesticide contamination. The highest concentration of agricultural pesticides found in a well (EG932) was probably not from application of pesticides on cropland but rather a problem with back-siphoning when mixing chemicals or from spills at the mixing and loading site. Proper storage and disposal of pesticides is also important. Potential contamination sources of nitrogen are also varied: from over-application on cropland, to manure in barnyards or storage areas, or from septic systems to name a few. Location and condition of the well also affect whether potential contaminants may seep into the well and thus directly to the groundwater.

RECOMMENDATIONS

Groundwater, in highly susceptible areas of the state (sandy soil, shallow water table, shallow depth to bedrock), where land-use practices can potentially affect the groundwater, should be monitored for pesticides and nitrates in order to determine if these contaminants are impacting the drinking water quality. Water analyses can be a useful tool to aid educational efforts to address sources of potential contaminants and how to keep them out of the groundwater. However pesticide/metabolite testing is expensive. Other, less expensive tests can be used as screening tools to determine whether atrazine and its metabolites may be present in the drinking water. One test is the triazine immuno-assay which determines atrazine concentrations only. In most parts of the state when atrazine concentrations are < 1 ppb, the chances of exceeding the enforcement standard are relatively small. However, in the LWRV, this is not always the case. There are many examples in the LWRV, where metabolite concentrations have pushed the results over the ES. Additionally, approximately 20% of the samples taken in this study and others in the LWRV have metabolite detects when no parent compound is present. The immuno-assay would not recognize these detects so it should be used cautiously in areas like the LWRV. Another inexpensive screening tool is a nitrate analysis. In the LWRV, 22 of the 26 (85%) samples had atrazine and/or metabolite detected when the nitrate concentrations exceeded 10 ppm. However, atrazine and/or its metabolites are present in 8 of the 52 (15%) samples when nitrate levels are < 10 ppm. Therefore, with the new groundwater standards for atrazine being implemented, there is a need to collect more data on atrazine metabolites and the extent of their contribution to drinking water and groundwater contamination in many different site conditions, so appropriate recommendations can be made.

Knox, James C. and John W. Attig., 1988. Geology of the Pre-Illinoian Sediment in the Bridegeport Terrace. Lower Wisconsin River Valley, Wisconsin. Journal of Geology. Vol. 96.

Postle, Jeffrey K., 1989. Results of the WDATCP Groundwater Monitoring for Pesticides. Wisconsin Department of Agriculture, Trade and Consumer Protection.

Postle, Jeffrey K., 1991. Groundwater Specialist, Wisconsin Department of Agriculture, Trade and Consumer Protection.

Yeary, JoAnne, 1990. Sampling Irrigation Wells for Atrazine and Metolachlor in the Lower Wisconsin River Valley. Ciba Geigy Corporaton, Document #CG02846.2.1.

Table 1. Pesticide and Nitrate Results for Samples taken in the Lower Wisconsin River Valley

Date-Unique Well Number	Atrazine (ppb)	Atrazine Metabolite (ppb)	NO3-N (ppm)	Other Pesticide (ppb)
10/08/90				
EF201	0	NA	24	
EF202	0	NA	<1	
EF203	0.19	NA	19	
EF204	0	NA	3	
EF205	0.23	NA	<1	Metolachlor-.25
EF206	0	NA	1	
EF207	0	NA	<1	
EF208	0	NA	1	
EF209	0	NA	<1	
EF210	0	NA	<1	
10/09/90				
EF211	0	NA	2	
EF212	0	NA	2	
1/08/91				
EG921	0	0	0.5	
EG922	0	0	9	
EG923	0	0	<.1	Alachlor-.12
EG924	0.16	*	21	
EG925	0	0	1.1	
EG926	0	0	8.7	
1/14/91				
EG927	0	0	0.8	
EG928	0.18	0	14	
EG929	0	0	5.8	
EG930	0	0	<.1	
EG931	0	*	7.2	
EG932	79	**	17	Alachlor-82 * Simazine-.4
EG933	0.10	0	8.6	
EG934	0.48	*	24	
EG935	0	*	15	
2/04/91				
Village of Spring Green	0	0	3.8	
EG937	0.72	*	15	
EG938	0.17	*	23	
2/20/91				
EG939	0.21	*	18	
EG940	0.12	*	12	
EG941	0	*	11	
EG942	0	0	0.8	
EG943	0.56	*	3.2	
EG944	0	0	3.5	
EG945	0	*	11	
EG946	0	0	7.9	
EG947	0	0	<.1	

Table 1. Continued

Date- Unique well Number	Atrazine (ppb)	Atrazine Metabolite (ppb)	NO3-N (ppm)	Other Pesticides (ppb)
2/20/91				
EG948	0	*	6.7	
EG949	0.12	*	8.0	
EG950	0	0	8.0	
2/25/91				
EG521	0.47	*	25	
EG522	0	*	24	
EG523	0	0	<.1	
EG524	0	0	<.1	
EG525	0	0	<.1	
EG526	0	0	<.1	
EG527	0	*	44	
EG528	0.19	*	16	
EG529	0	*	13	
EG530	0	0	<.1	
EF214	0	0	4	
EF215	0	*	19	
		deethyl, deisopropyl		
5/20/91		= total (atrazine plus metabolites)		
EF216	0.19	0, 0 = 0.19	4.6	
EF217	0	0, 0 = 0	4.7	
EF218	0	0, 0 = 0	12	
EF219	0	0, 0 = 0	5.7	
EF220	0	0, 0 = 0	6.3	
EC781	0	0, 0 = 0	13	
EC782+	0.17	0.91, 0 = 1.08	9.7	
EC783	0	0, 0 = 0	16	
EC784	0	0.47, 0 = 0.47	20	
EC785	0.67	1.5, 0 = 2.17	22	
CE935	0	0, 0 = 0	0.6	
5/29/91				
EC771	0	0, 0 = 0	6.3	
EC786	0	0, 0 = 0	0.3	
EC787	0	0, 0 = 0	3.6	
EC788	0	0, 0 = 0	3.5	
EC789	0	0.32, 0 = 0.32	11	
EC790	0	0, 0 = 0	1.9	
EC772	2.0	1.2, 0.6= 3.8	25	Metolachlor-.27
EC773	0	0, 0 = 0	0.5	
EC774+	0	0, 0 = 0	1.1	
EC775	0	0, 0 = 0	7.1	Metolachlor-.66
EC776	0	0, 0 = 0	2.7	
6/26/91				
EC777	0	0, 0 = 0	5	
EC778	0	0, 0 = 0	<1	

* Metabolite detect (not quantified)

\+ Wisconsin Unique Well Number may be different as well was installed in the last 2 years and should have a number already assigned to it

Table 2. Summary of Nitrate and Atrazine Results for samples taken in the Lower Wisconsin River Valley

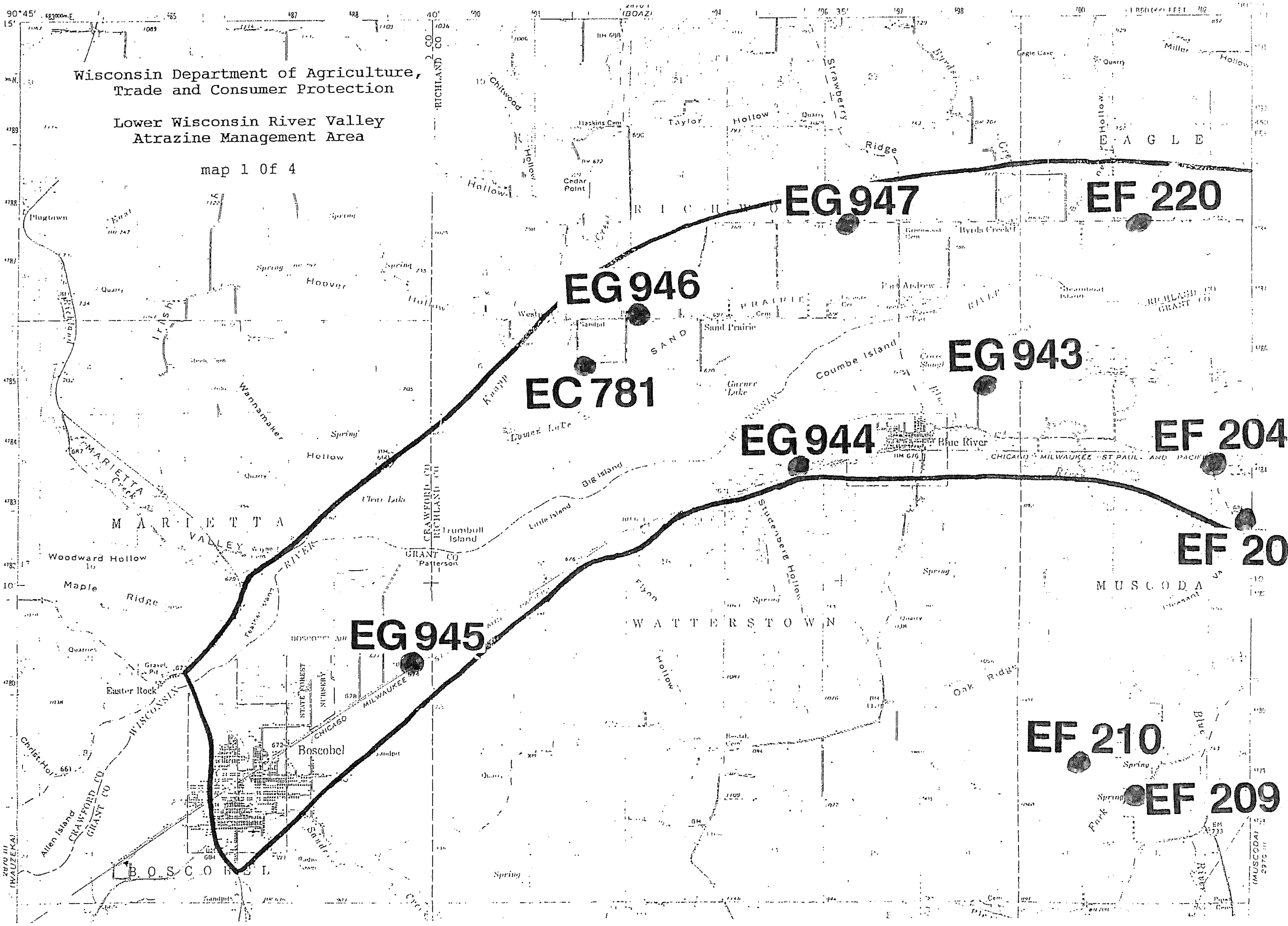
	samples with detect/samples taken	%
Nitrate Analyses-(NO3-N)		
< 2 ppm NO3-N	25/78	32
2-10 ppm NO3-N	26/78	33
> 10 ppm NO3-N	27/78	34
Atrazine Analyses		
Samples with Atrazine testing only (no metabolite analyses)		
-Atrazine (parent compound only)	2/12	17
Samples with metabolite testing (metabolites not identified or quantified)		
-Atrazine only	2/42	5
-Atrazine plus metabolite	11/42	26
-Metabolite only	9/42	21
Samples with metabolites identified and quantified		
-Atrazine only	1/24	4
-Atrazine plus metabolites	3/24	13
-Metabolite only	2/24	8

Table 3. Additional Water Quality Parameters for Samples Taken in the Lower Wisconsin River Valley

Unique Well Number	EC (μmhos/cm)	Hardness (mg/l ($CaCO_3$))	Cl (mg/l)	Iron (mg/l)	lab ph	SO_4 (mg/l)
EF201	440	192	22	<.1	7.4	15
EF202	360	204	1	<.1	8.3	14
EF203	460	218	24	<.1	8.3	15
EF204	460	174	57	<.1	9.1	9
EF205	670	380	23	2.5	7.5	6
EF206	360	201	1	<.1	8.0	12
EF207	460	280	1	.5	8.2	19
EF208	310	175	1	.1	7.7	13
EF209	390	219	1	<.1	8.7	18
EF210	320	180	1	.3	7.5	16
EF211	102	39	1	.5	7.0	13
EF212	118	49	6	2.6	7.1	15
EG921	260	137	2	<.1	8.3	7
EG922	330	154	30	<.1	8.5	18
EG923	290	158	<1	<.1	8.3	<1
EG924	470	214	33	<.1	8.2	22
EG925	420	240	7	<.1	8.1	21
EG926	360	101	55	<.1	8.9	15
EG927	350	197	<1	<.1	8.0	13
EG928	320	114	8	<.1	8.5	24
EG929	210	98	8	<.1	8.7	3
EG930	350	198	<1	<.1	8.2	<1
EG931	230	102	14	.3	8.7	16
EG932	470	184	12	<.1	8.4	17
EG933	310	150	6	<.1	8.4	4
EG934	640	258	59	<.1	8.3	25
EG935	410	172	32	<.1	7.8	17
Village of Spring Green	450	202	34	<.1	8.6	8
EG937	500	230	31	<.1	8.2	17
EG938	460	186	23	<.1	8.3	14
EG939	560	290	19	<.1	7.7	16
EG940	450	220	12	<.1	8.5	18
EG941	270	123	9	<.1	8.4	12
EG942	240	40	39	.1	7.5	18
EG943	220	102	4	<.1	8.3	19
EG944	480	252	6	<.1	8.0	5
EG945	360	173	8	<.1	8.4	13
EG946	330	155	13	<.1	8.4	18
EG947	460	264	<1	.1	7.8	10
EG948	550	272	14	<.1	8.0	2
EG949	440	218	12	<.1	7.9	15
EG950	540	286	18	<.1	7.8	19
EG521	550	264	16	<.1	7.9	18
EC522	650	322	16	<.1	7.6	<1

Table 3. continued

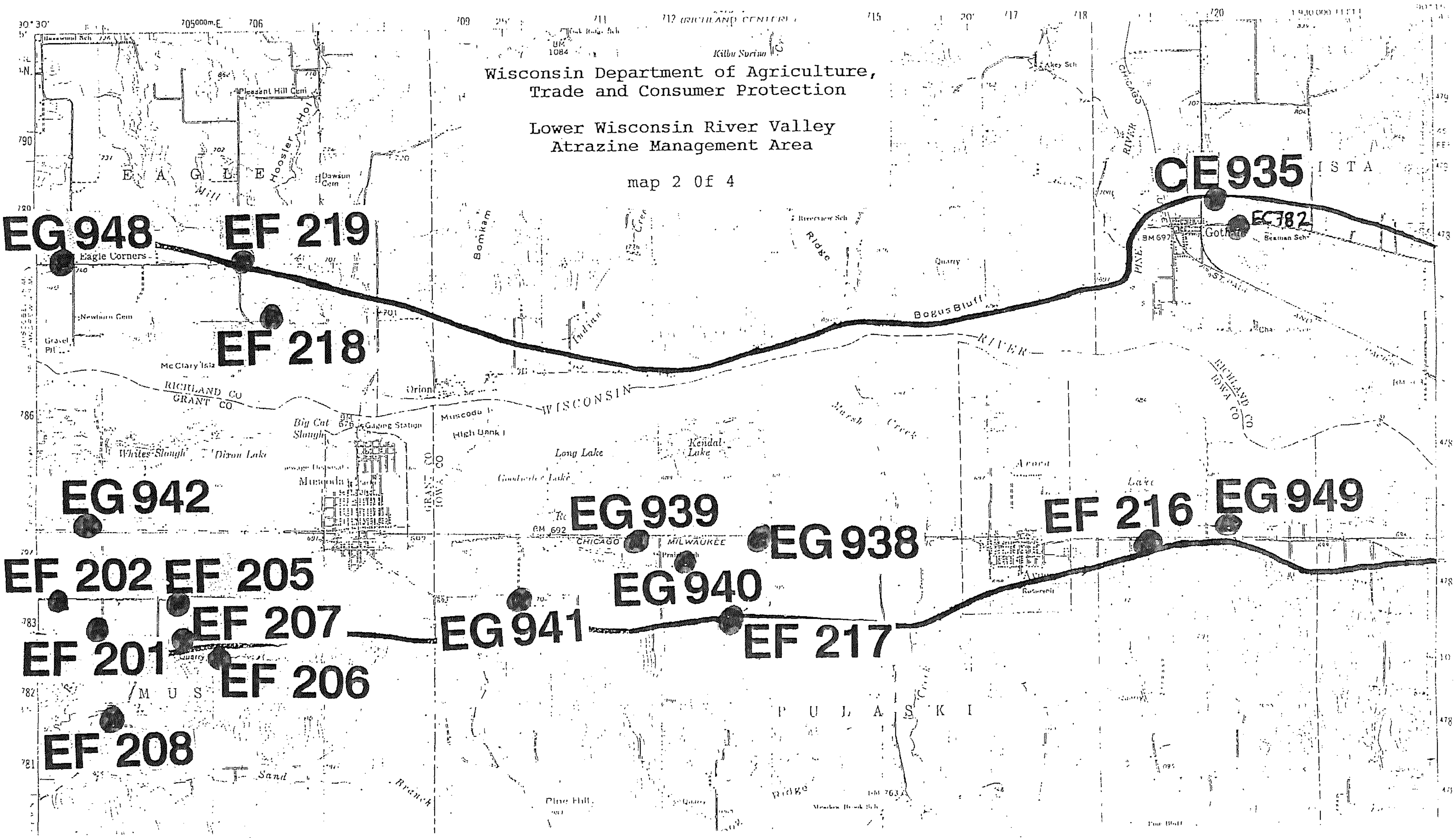
Unique Well Number	EC (μmhos/cm)	Hardness (mg/l (CaCO$_3$))	Cl (mg/l)	Iron (mg/l)	lab ph	SO$_4$ (mg/l)
EG523	440	240	<1	.3	7.9	8
EG524	470	248	19	.1	8.4	120
EG525	570	306	11	<.1	7.8	90
EG526	550	2	<1	<.1	8.7	<1
EG527	660	304	26	.1	7.9	19
EG528	560	284	15	<.1	7.9	<1
EG529	530	254	22	<.1	7.9	10
EG530	380	205	<1	.1	8.0	<1
EF214	440	230	5	.2	7.9	2
EF215	630	320	27	<.1	7.9	2
EF216	440	214	12	<.1	7.7	13
EF217	460	234	8	<.1	7.6	26
EF218	270	98	24	<.1	7.1	12
EF219	420	210	11	<.1	7.6	3
EF220	530	248	19	<.1	8.0	23
EC781	550	264	23	<.1	8.1	16
EC782	500	240	33	<.1	8.6	19
EC783	660	300	19	<.1	8.9	31
EC784	490	202	25	<.1	7.8	18
EC785	400	166	24	<.1	8.3	18
EC786	420	218	4	<.1	8.1	8
EC787	600	296	14	.3	7.7	23
EC788	400	208	4	<.1	8.2	12
EC789	570	276	19	<.1	8.0	20
EC790	300	138	6	<.1	8.1	15
CE935	400	210	4	.2	7.8	14
EC771	740	312	58	<.1	8.2	33
EC772	440	162	23	<.1	8.2	22
EC773	330	174	4	<.1	8.1	<1
EC774	500	256	5	<.1	8.1	22
EC775	200	78	10	<.1	8.3	15
EC776	500	264	9	<.1	7.8	20
EC777	540	263	13	<.1	8.4	2.5
EC778	580	271	36	.1	8.3	1.0



Wisconsin Department of Agriculture, Trade and Consumer Protection

Lower Wisconsin River Valley Atrazine Management Area

map 1 0f 4



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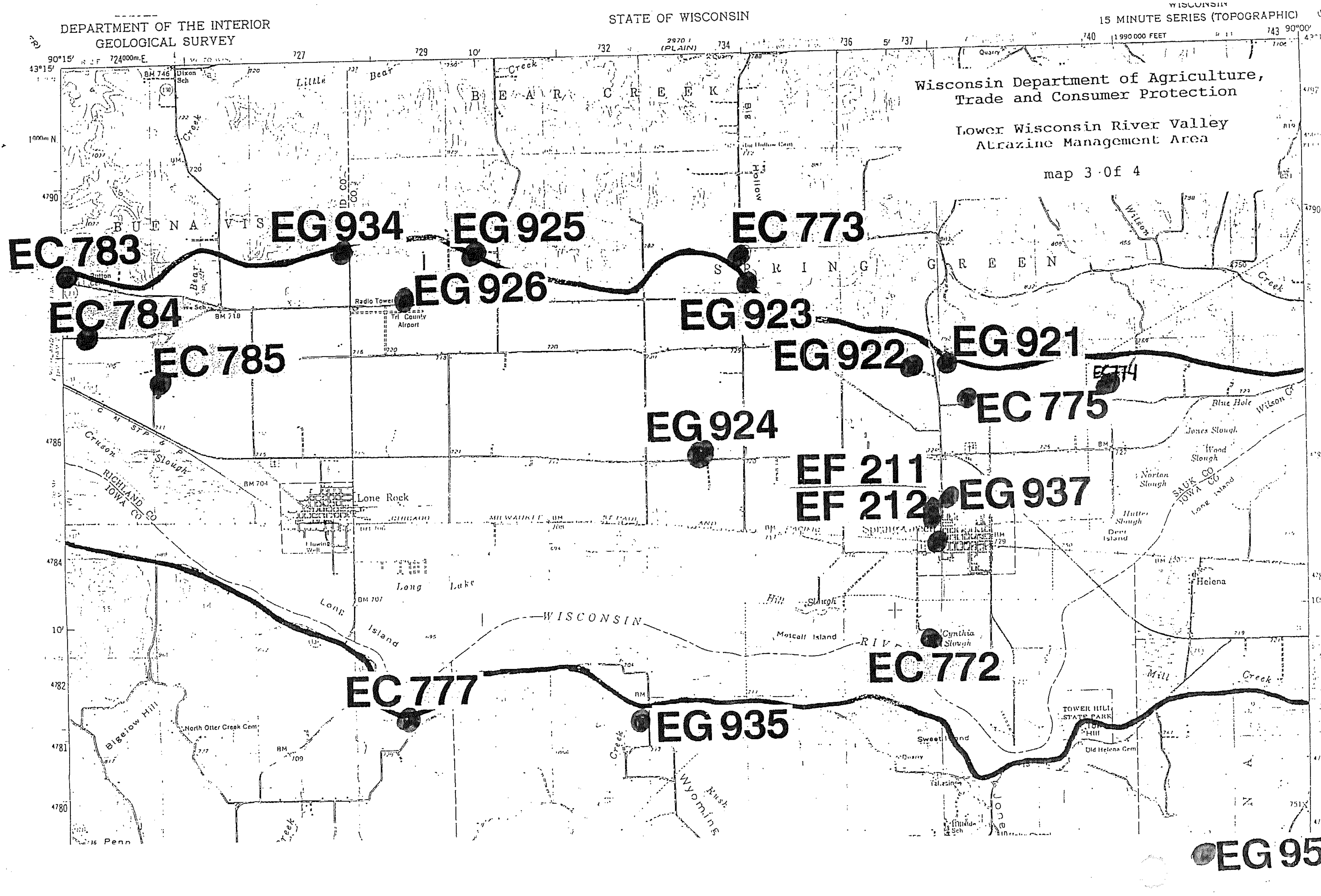
Lower Wisconsin River Valley
Atrazine Management Area

map 2 0f 4



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Lower Wisconsin River Valley
Atrazine Management Area

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

STATE OF WISCONSIN

Wisconsin Department of Agriculture,
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Lower Wisconsin River Valley
Atrazine Management Area

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