ESTIMATES OF 1995 WATER USE FROM THE MISSISSIPPI RIVER ALLUVIAL AQUIFER IN MISSISSIPPI

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INTRODUCTION

Water level declines in the Mississippi River Alluvial Aquifer (alluvial aquifer) have resulted from heavy use of water from the aquifer by agriculture for row crop irrigation, flooding of rice fields, and maintaining levels in catfish ponds. If aquifer water levels continue to decline, the aquifer may eventually be depleted of economically recoverable water and an incredibly valuable natural resource of the region would be severely damaged. To prevent this loss, the YMD Joint Water Management District (YMD) and Area 4 Soil and Water Conservation Districts have undertaken a project with the technical assistance of the Natural Resources Conservation Service (NRCS) to evaluate the feasibility of developing alternative water supplies for the Delta region.

A computer groundwater flow model of the alluvial aquifer is an important and necessary tool for this regional water use planning process. The US Geological Survey (USGS) has agreed to assist in the planning for the development of alternative water supplies by developing the computer model of the alluvial aquifer in a cooperative project with YMD, NRCS, and the Office of Land and Water Resources (OLWR). One component needed for the development of the model is the best possible spatial and temporal estimates of water withdrawals from the aquifer. YMD is providing those estimates for each permitted well in the Delta as one part of their participation in the development of the model. This paper details the development of these water use estimates.

METHODS

A. Summer Water Use

An estimate of water pumped in 1995 from the alluvial aquifer (the most recent completed water use year) was made for each permitted agricultural well in the alluvial aquifer based on the following information.

1. Water use permit database (WUPD) received from the OLW of the Department of Environmental Quality in June of 1995.

2. Land permitted to receive water from permitted wells. Each water use permit application for use of water for row crop irrigation, rice flooding, or catfish pond water maintenance must include a map showing the outline of the land to which the water will be applied. The land boundaries included with the water use applications have been transferred onto 7.5 minute US Geological Survey quadrangle maps by OLW and YMD since 1985. The individual land boundaries were digitized by YMD into YMD's geographical information system (GIS). Approximately 13,000 polygon field boundaries are included in the field boundary GIS database. The boundary polygon data layer provides area in acres served by a water use permit.

3. Field measurements for water use of rice, row crops, and catfish production conducted by YMD, NRCS, or Mississippi State University scientists (Hendricks 1996). See Table 1, Annual Water Use Estimates by Crop Type.

4. Daily discharge data for the Sunflower River at the town of Sunflower for 1988 were supplied by the Corps of Engineers. The discharge data were used to calculate monthly percentages for distributing annual water use through the irrigation season (Pennington 1996).

The general approach to the data analysis was:

1. An acreage served was established for each well.

2. A crop type (rice, row crop, or catfish) was established for each well.

3. The number of acres served by a well was multiplied by the average water use value established by field investigations for each crop type. (Acres Served * Water Use per Acre = Total Annual Water Pumped).

4. The annual water volumes were distributed over individual months according to two methods to be described later.

The specific steps in the completion of the general analysis procedure were:

1. Identify as many wells in the WUPD as possible with a beneficial use of irrigation as either rice or row crop. This was completed by two methods.

a. The crop type could be determined for some wells from information contained in the WUPD designating the well as either rice or row crop.

b. The acres served by some permits could be determined from the digitized polygon boundaries taken from the USGS quadrangle maps. The permitted water volume per acre was calculated by dividing the permitted acre feet of water by the acres served. If the permitted water volume per acre was close to 1.5 acre feet per acre, the well was assigned a crop type of row crop irrigation; if the permitted water volume per acre was close to 3 acre feet per acre, the well was assigned a crop type of rice. Some permits with a beneficial water use of irrigation and sufficient data to calculate a permitted water volume per acre had very high permitted water volumes per acre (>3.5 acre feet per acre). It was assumed that there was an error in at least one component of the data used to calculate the permitted water per acre. Due to the large number of permits with this error, no attempt was made to correct the database at this time. These permits cannot be assigned a crop type of rice or row crop with any confidence and are therefore assumed to be of unknown crop type.

2. If a well has a beneficial use of irrigation but the crop type cannot be determined by either of the previous two methods, a crop type was assigned by the following method.

For each County:

a. Calculating the percent of rice wells of the wells with a beneficial use of irrigation and an identifiable crop type (designated for rice). The following calculation was used.

Equation 1) $R_f = [R_c / (R_c + C_c)]$

where:

R_f = fraction of wells with an identifiable crop type used for rice production,
R_c = count of identifiable rice wells
C_c = count of identifiable row crop wells.

b. Calculating the average acres served for identifiable rice and identifiable row crop irrigation wells.

c. Use R_f to calculate the number of wells with a beneficial use of irrigation and an unknown crop type that serve rice production according to Equation 2. Assume that the ratio of rice to row crop wells is the same for wells with an identifiable crop type as for wells with a crop type that was not identified.

Equation 2) $R_u = R_f * IR_{uct}$

where:

R_u = number of wells with a beneficial use of irrigation and an unknown crop type that will be assigned a crop type of rice

Ir_{uct} = number of wells with a beneficial use of irrigation and an unknown crop type.

d. The first R_u wells with a beneficial use of irrigation and an unknown crop type were assigned a crop type of rice. All remaining wells with a beneficial use of irrigation and an unknown crop type were assigned a crop type of row crop. All wells with a beneficial use of irrigation now have an assigned or identified crop type.

e. Wells that were assigned a crop type were also assigned an acres served equal to the average acreage of the known rice or row crop irrigation permits in each county. All wells with a beneficial use of irrigation now have both a crop type and an acres served associated with it.

f. Rice is grown in an approximately 2 year rotation with soybeans. This means that in any one year only one-half of the land permitted for rice will actually be planted to rice. The other half will usually be in soybeans. This rotation effect was accounted for by assigning the first half of the wells known or assigned to serve rice as row crop. The second half in each group was left assigned as rice.

3. Fish Culture wells are delineated in the WUPD. Initially, acreages were recorded as pond acres instead of water acres. All ponds were reduced by 15 percent to determine water acres (Hendricks 1996). Ponds without an acreage were assigned a constant of 68 water acres. This is the average of all recorded Fish Culture ponds.

Calculations to this point make it possible to estimate the total acres of irrigated row crop and rice in the Delta. Rice acreage is determined every year through the Consolidated Farm Services Agency and reported by the Agricultural Statistics Service. That reported rice acreage can serve as an independent test of the accuracy of the acreage calculated by the previously described method. The total annual water pumped for each well was calculated by multiplying the acres served by the average water use either measured or estimated from 1995 data or observations.

B. Winter Water Use

There is some pumpage of alluvial aquifer water for catfish ponds outside of the summer months. Ponds are drained for levee maintenance about every 10 years. The ponds must then be refilled. Also, some pond managers lower the water levels in their ponds during the winter months to reduce the wind and wave induced bank erosion caused by high winter winds. Although these management practices don't impact every pond every year, the estimated annual use of water is 0.67 Acre feet. This value is then equally distributed among October, March, April, and May as 0.17 Acre feet (Hendricks 1996).

Monthly Distribution of Water Use

Analysis to this point has produced a mechanism for calculating annual volumes of water pumped by each well in the WUPD. This annual amount must now be distributed on a monthly basis throughout the year. This is accomplished by multiplying the annual water use for each well by a monthly percentage. The monthly percentages are intended to show the use of groundwater throughout the year (Pennington 1996).

NON-AG WATER USE

Some wells in the WUPD are designated as Municipal, Rural Water Association, Commercial, or Institutional. The water use determined for these wells was calculated by using the annual permitted water volume. The annual permitted water volume was divided by 12 and that value was the designated pumpage for each month. It should be noted that these values are reported in million gallons per day.

RESULTS

The methods used to calculate water use by crop are based on an estimate of irrigated acres for each crop which require several assumptions to complete. The validity of those assumptions was tested by comparing the calculated acres of rice from the described method with the acres of rice recorded by the Mississippi Agricultural Statistics Service for 1995. See Table 2.

The water pumped from each permitted well with a beneficial use of irrigation or fish culture was grouped by county for reporting. The files were placed into a spreadsheet and made available to the US Geological Survey as part of the data needed to complete a new model of the alluvial aquifer. An example of a county file is given in Table 3. The spreadsheet data included the permit number, longitude and latitude, crop type (fish culture, rice, row crop), and monthly volume of water pumped (in units of acre feet) for each well. A summary sheet was provided that characterized water use data by county and crop type.

The data on individual wells can be grouped by county. Table 4 lists the acres in each of the major crop types and the water use in each crop type for each county for 1995.

Figure 1 shows the number of wells used for analysis by county, broken down by Crop type. Graphic representations of the data in Table 4 are given in Figure 2. Figure 2 displays the volume of water pumped for each crop type in each county.

Row crop water use was unusually high in 1995. This is indirectly related to the dry conditions experienced during the irrigation season. Rice experienced only a moderate increase in water use due to the dry conditions. Catfish water use was higher in 1995 than 1994 (Hendricks 1996).

Although this work is based on the best available information at the time, several improvements can be made in the analysis. Some of these include:

Use actual rainfall data to adjust pumped amounts. Assuming that all wells pump the average water volume for a specific crop type can miscalculate water use in localized areas that received more than average rainfall

amounts. One way this error can be reduced is by using localized rainfall amounts taken from radar data.

Use actual measured row crop irrigation application data instead of estimates from observations.

Knowledge of soil type can also help determine an individual fields water requirements. Soil type identification could also assist in properly locating rice and fish production which are most commonly located on hydric (usually high clay soils) soils.

Farm Services Agency (FSA, formerly ASCS) crop tract information could accurately locate rice and row crop fields. Current field and consequently well locations for these crop types are randomly assigned to a population of potential locations.

Crop water requirement models could further refine summer monthly water requirements.

Improved information concerning water management in fish production for pond filling and winter level changes is needed.

Improved Non-Ag water use estimates could be calculated by determining monthly percentages from known data, applying the more accurate percentage to all similar wells.

REFERENCES

Hendricks, Mike. 1996. Crop water use in the Mississippi Delta. In Proceedings of the Mississippi Water Resources Conference, April 2-3, 1996, edited by B. Jean Daniel, 10-13. Water Resources Research Institute: Mississippi State University.

Pennington, Dean. 1996. Estimating daily agricultural water use in the Mississippi Delta. In Proceedings of the Mississippi Water Resources Conference, April 2-3, 1996, edited by B. Jean Daniel, 14-17. Water Resources Research Institute: Mississippi State University.

Table 1. Annual Water Use Estimates by Crop Type

Crop Type	Water Use (Acre / ft)
Rice	3.17
Row Crops	0.67
Fish Culture	3.58

Table 2. Calculated Rice Acreages and Mississippi Agricultural Statistics Service Estimated Rice Acreages.

Calculated Rice Acres	M.A.S.S Estimated Rice Acres	Difference Acres
239,682	295,000	55,318

Table 3. Example of County Data

PERMITNO	HUC	COUNTY	BENUSE	LATITUDE	LONGITUDE	WATRVOL	ASSIGN_AC	ASSIGN_CT	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
GW-00031	8030207	BOLIVAR	IR	333813	905305	495	165	RC	0.00	0.00	0.00	0.00	0.00	17.04	34.89	36.28	20.99	1.35	0.00	0.00
GW-00039	8030207	BOLIVAR	IR	340237	904718	75	68.37	RC	0.00	0.00	0.00	0.00	0.00	7.06	14.46	15.03	8.70	0.56	0.00	0.00
GW-00068	8030207	BOLIVAR	IR	333716	905404	156	52	RC	0.00	0.00	0.00	0.00	0.00	5.37	11.00	11.43	6.62	0.43	0.00	0.00
GW-00070	8030207	BOLIVAR	IR	333703	905403	116	39	RC	0.00	0.00	0.00	0.00	0.00	4.03	8.25	8.58	4.96	0.32	0.00	0.00
GW-00101	8030207	BOLIVAR	IR	334634	905249	480	160	RC	0.00	0.00	0.00	0.00	0.00	16.52	33.83	35.18	20.36	1.31	0.00	0.00
GW-00102	8030207	BOLIVAR	IR	335313	903957	130	42	RC	0.00	0.00	0.00	0.00	0.00	4.34	8.88	9.24	5.34	0.34	0.00	0.00
GW-00103	8030207	BOLIVAR	IR	334956	905501	900	300	RC	0.00	0.00	0.00	0.00	0.00	30.97	63.44	65.97	38.17	2.45	0.00	0.00
GW-00113	8030207	BOLIVAR	FC	333340	905420	385	59.62	FC	0.00	2.53	2.53	2.53	2.53	31.42	64.35	66.92	38.72	2.49	0.00	0.00
GW-00114	8030207	BOLIVAR	FC	333354	905421	265	63.25	FC	0.00	2.69	2.69	2.69	2.69	33.33	68.27	70.99	41.08	2.64	0.00	0.00
GW-00115	8030207	BOLIVAR	FC	333406	905420	285	61.23	FC	0.00	2.60	2.60	2.60	2.60	32.27	66.09	68.73	39.77	2.55	0.00	0.00
GW-00118	8030207	BOLIVAR	IR	335607	903927	480.000	200.00	RC	0.00	0.00	0.00	0.00	0.00	20.65	42.29	43.98	25.45	1.63	0.00	0.00
GW-00121	8030204	BOLIVAR	IR	334649	905322	525.000	175.00	RC	0.00	0.00	0.00	0.00	0.00	18.07	37.00	38.48	22.27	1.43	0.00	0.00
GW-00129	8030207	BOLIVAR	IR	334412	904559	240.000	80.00	RC	0.00	0.00	0.00	0.00	0.00	8.26	16.92	17.59	10.18	0.65	0.00	0.00
GW-00164	8030207	BOLIVAR	IR	334920	904323	150.000	46.60	RC	0.00	0.00	0.00	0.00	0.00	4.81	9.85	10.25	5.93	0.38	0.00	0.00
GW-00165	8030207	BOLIVAR	IR	334920	904325	150.000	20.00	RC	0.00	0.00	0.00	0.00	0.00	2.06	4.23	4.40	2.54	0.16	0.00	0.00
GW-00187	8030204	BOLIVAR	IR	335940	905510	549.000	374.40	RC	0.00	0.00	0.00	0.00	0.00	38.66	79.17	82.33	47.64	3.06	0.00	0.00
GW-00188	8030207	BOLIVAR	IR	335910	905634	218.000	129.73	RC	0.00	0.00	0.00	0.00	0.00	13.39	27.43	28.53	16.51	1.06	0.00	0.00
GW-00189	8030207	BOLIVAR	IR	335929	905416	185.000	122.15	RC	0.00	0.00	0.00	0.00	0.00	12.61	25.83	26.86	15.54	1.00	0.00	0.00
GW-00190	8030207	BOLIVAR	IR	335952	905427	185.000	117.74	RC	0.00	0.00	0.00	0.00	0.00	12.16	24.90	25.89	14.98	0.96	0.00	0.00
GW-00194	8030209	BOLIVAR	IR	335933	905631	218.000	131.79	RC	0.00	0.00	0.00	0.00	0.00	13.61	27.87	28.98	16.77	1.08	0.00	0.00
GW-00203	8030207	BOLIVAR	IR	333941	905410	2190.000	730.00	RC	0.00	0.00	0.00	0.00	0.00	75.37	154.36	160.52	92.88	5.97	0.00	0.00
GW-00204	8030207	BOLIVAR	IR	334019	905748	366.000	122.00	RC	0.00	0.00	0.00	0.00	0.00	12.60	25.80	26.83	15.52	1.00	0.00	0.00
GW-00218	8030207	BOLIVAR	IR	334418	904725	480.000	100.00	RC	0.00	0.00	0.00	0.00	0.00	10.32	21.15	21.99	12.72	0.82	0.00	0.00
GW-00226	8030209	BOLIVAR	IR	334000	910123	150.000	100.00	RC	0.00	0.00	0.00	0.00	0.00	10.32	21.15	21.99	12.72	0.82	0.00	0.00
GW-00234	8030206	BOLIVAR	IR	333913	910306	240.000	132.65	RI	0.00	0.00	0.00	0.00	0.00	64.80	132.71	138.01	79.83	5.13	0.00	0.00
GW-00239	8030207	BOLIVAR	IR	333356	904645	330.000	90.00	RC	0.00	0.00	0.00	0.00	0.00	9.29	19.03	19.79	11.45	0.74	0.00	0.00
GW-00248	8030207	BOLIVAR	IR	333410	904611	510.000	80.00	RC	0.00	0.00	0.00	0.00	0.00	8.26	16.92	17.59	10.18	0.65	0.00	0.00
GW-00254	8030100	BOLIVAR	IR	340627	904550	215.000	71.00	RC	0.00	0.00	0.00	0.00	0.00	7.33	15.01	15.61	9.03	0.58	0.00	0.00
GW-00278	8030207	BOLIVAR	IR	334705	904704	560.000	160.00	RC	0.00	0.00	0.00	0.00	0.00	16.52	33.83	35.18	20.36	1.31	0.00	0.00
GW-00283	8030207	BOLIVAR	IR	335456	905858	412.000	275.00	RC	0.00	0.00	0.00	0.00	0.00	28.39	58.15	60.47	34.99	2.25	0.00	0.00
GW-00286	8030207	BOLIVAR	IR	333828	905205	770.000	220.00	RC	0.00	0.00	0.00	0.00	0.00	22.71	46.52	48.38	27.99	1.80	0.00	0.00
GW-00381	8030205	BOLIVAR	IR	335607	904807	195.000	130.00	RC	0.00	0.00	0.00	0.00	0.00	13.42	27.49	28.59	16.54	1.06	0.00	0.00
GW-00423	8030207	BOLIVAR	IR	333703	905429	480.000	160.00	RC	0.00	0.00	0.00	0.00	0.00	16.52	33.83	35.18	20.36	1.31	0.00	0.00
GW-00434	8030209	BOLIVAR	IR	333924	905827	342.000	120.00	RC	0.00	0.00	0.00	0.00	0.00	12.39	25.37	26.39	15.27	0.98	0.00	0.00
GW-00435	8030209	BOLIVAR	IR	333912	905829	400.000	120.00	RC	0.00	0.00	0.00	0.00	0.00	12.39	25.37	26.39	15.27	0.98	0.00	0.00
GW-00436	8030206	BOLIVAR	IR	333934	905826	360.000	120.00	RC	0.00	0.00	0.00	0.00	0.00	12.39	25.37	26.39	15.27	0.98	0.00	0.00
GW-00438	8030207	BOLIVAR	IR	334438	905531	320.000	152.00	RC	0.00	0.00	0.00	0.00	0.00	15.69	32.14	33.42	19.34	1.24	0.00	0.00
GW-00439	8030207	BOLIVAR	IR	334438	905544	320.000	152.00	RC	0.00	0.00	0.00	0.00	0.00	15.69	32.14	33.42	19.34	1.24	0.00	0.00
GW-00440	8030207	BOLIVAR	IR	334438	905559	320.000	152.00	RC	0.00	0.00	0.00	0.00	0.00	15.69	32.14	33.42	19.34	1.24	0.00	0.00
GW-00441	8030202	BOLIVAR	IR	334438	905516	160.000	76.00	RC	0.00	0.00	0.00	0.00	0.00	7.85	16.07	16.71	9.67	0.62	0.00	0.00
GW-00447	8030207	BOLIVAR	IR	335231	905615	165.000	200.00	RC	0.00	0.00	0.00	0.00	0.00	20.65	42.29	43.98	25.45	1.63	0.00	0.00

Table 4. The 1995 Water Use Summaries for Rice, Row Crops, and Fish Culture.

	Irrigated Acres			Annual Water Use (Acre feet)		
	Rice	Row Crop	Fish Culture	Rice	Row Crop	Fish Culture
Bolivar	78,008	215,545	6,502	247,284	144,415	23,276
Carroll	0	6,171	361	0	4,135	1,293
Coahoma	20,316	93,842	1,157	64,402	62,874	4,141
DeSoto	1,970	4,484	0	6,245	3,004	0
Grenada	143	4342.6	234.37	453	2,910	839
Holmes	836	40,085	1,998	2,651	26,857	7,154
Humphreys	5,064	47,917	31,764	16,054	32,104	113,714
Issaquena	3,862	17,982	1,915	12,242	12,048	6,857
Leflore	12,670	105,250	15,313	40,164	70,518	54,821
Panola	430	8,865	0	1,363	5,939	0
Quitman	17,285	62,623	527	54,792	41,958	1,885
Sharkey	6,945	29,289	5,190	22,016	19,624	18,580
Sunflower	33,017	169,178	24,686	104,665	113,349	88,377
Tallahatchie	10,478	85,625	1,020	33,214	57,369	3,652
Tate	579	1,464	0	1,835	981	0
Tunica	19,060	74,262	2,921	60,420	49,756	10,459
Warren	0	1,165	68	0	781	243
Washington	28,439	137,805	17,118	90,152	92,329	61,282
Yazoo	580	12,558	4,660	1,839	8,414	16,683
Total	**239,682**	**1,118,453**	**115,434**	**759,792**	**749,364**	**413,255**

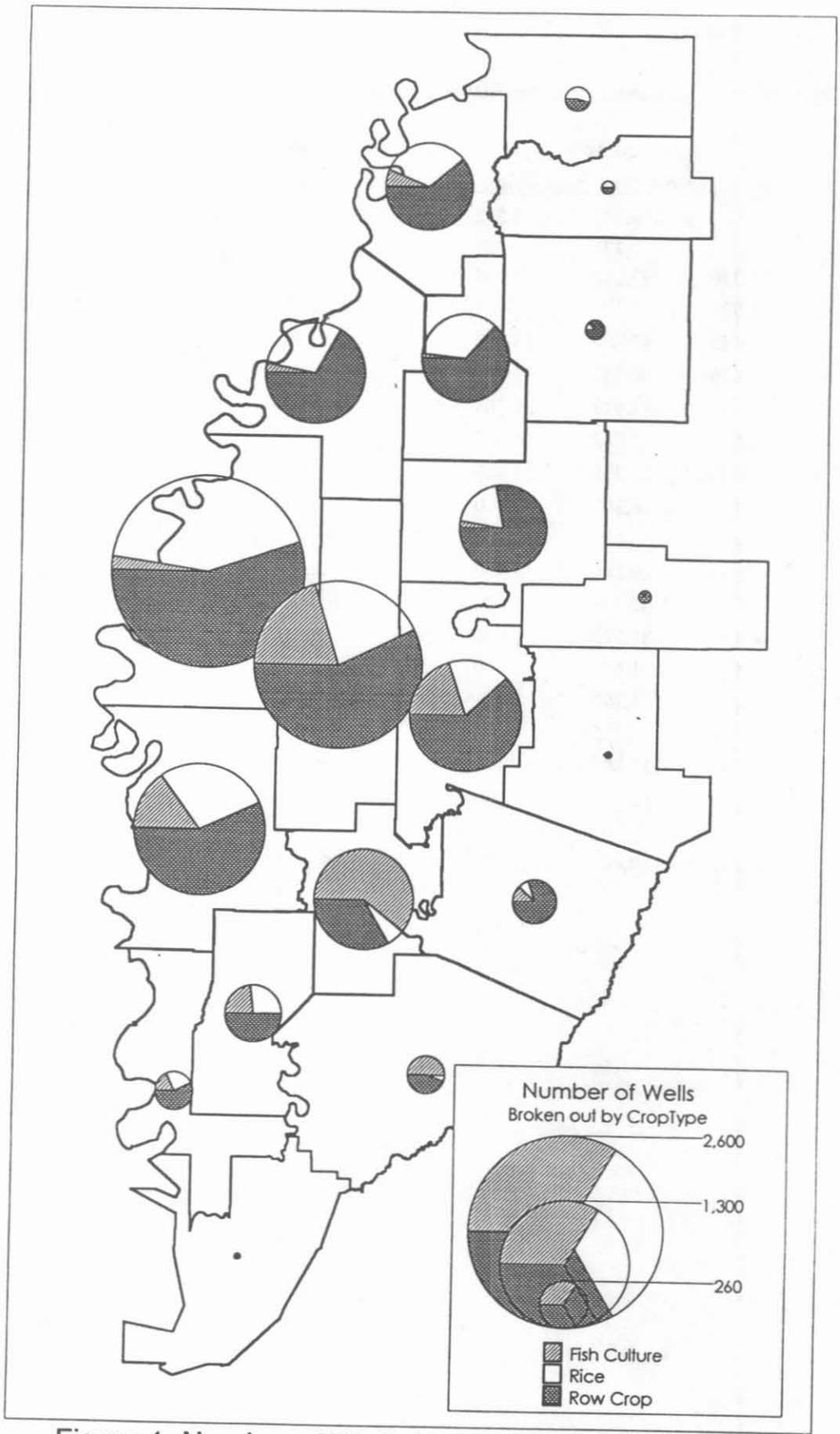

Figure 1. Number of Wells Used in Analysis by County, Broken Out by Crop Type Determinations

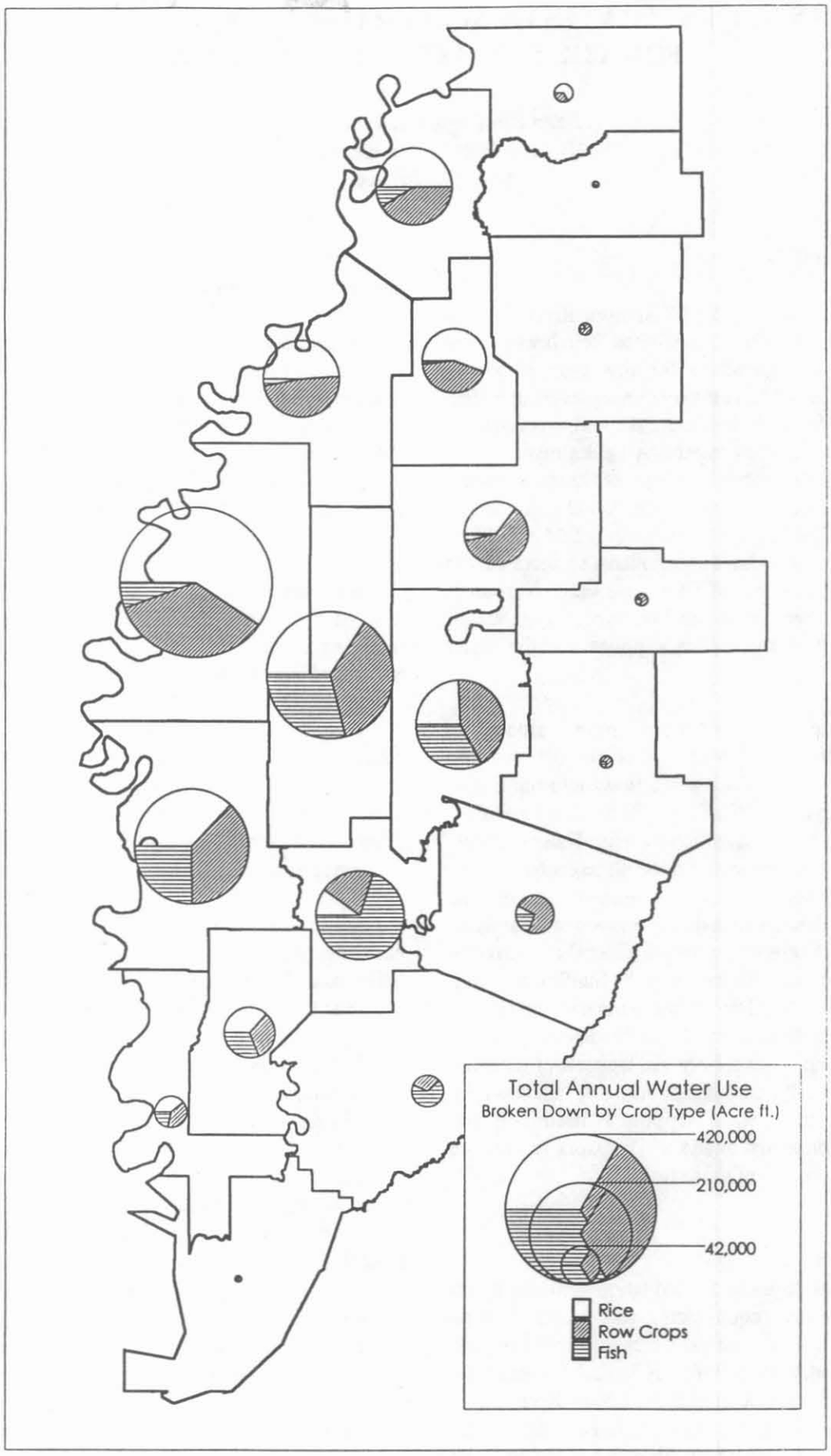

Figure 2. Total Water Use by County, Broken down by Crop type