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Evaluation and Accessing of Data for a Water Resources Simulator

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EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

Richard C. Peralta
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Timothy Skergan

Agricultural Engineering Dept. University of Arkansas

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Research Project Technical Completion Report A-060-ARK

Arkansas Water Resources Research Center
University of Arkansas
Fayetteville, Arkansas 72701

Arkansas Water Resources Research Center

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EVALUATION AND ACCESSING OF DATA
FOR A WATER RESOURCES SIMULATOR

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Fayetteville, Arkansas 72701

Research Project Technical Completion Report
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ABSTRACT

EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

This report evaluates the availability of data needed to use a groundwater simulation model for real time conjunctive water management in the Arkansas Grand Prairie. It is assumed that the goal of such management is to protect existing groundwater rights by maintaining water levels so that wells do not go dry, even in time of drought.

Sufficient hydrogeologic data exists to use the simulation model to predict the effect of known pumping rates on groundwater levels. Developing an optimal set of "target" levels and annually managing pumping to achieve those levels requires additional data: fall groundwater levels, degree of connection between aquifer and recharge streams, and annual cell by cell prediction of aquaculture and irrigated agriculture acreages. Successful management also requires continuous monitoring in the critical area where saturated thicknesses are small.

Peralta, Richard C., Roberto Arce and Timothy Skergan
EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR
KEYWORDS--data collections/ monitoring/ data acquisition/ well data/ groundwater management

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INTRODUCTION AND OBJECTIVES

Arkansas established a Water Code Commission to make recommendations for legislation and rules concerning how Arkansas' water resources should be managed. An option which gained considerable support is the establishment of sub-state water management districts. The Grand Prairie of Arkansas represents a possible prototype water management district. The Arkansas Soil and Water Conservation Commission funded the calibration of a groundwater simulation model for the Quaternary aquifer underlying the Grand Prairie (13). This report supplements that effort by determining data needs appropriate for using the simulator for management.

In this report groundwater management refers to those acts which are necessary: to protect existing water rights by preventing water levels from dropping so much that wells go dry, or to assure the long-term adequacy of the water supply, even in times of drought. The authors assume that the water users themselves should decide if the latter goal is appropriate or desirable. With this in mind, the objectives of this study are to:

1) Determine data needs for the effective utilization of a groundwater simulation model for the Grand Prairie Quaternary aquifer.

2) Develop appropriate procedures to access available data bases.

3) Make recommendations for additional data needs.

The approach is first to report what data is needed for the effective use of the simulation model. Available data and data
bases are subsequently evaluated concerning suitability in meeting data needs. Software and/or procedures to retrieve appropriate data are presented. Finally, recommendations for additional data needs are made.

PROCEDURE

**Determination of Data Needs**

It is judged desirable to make groundwater management as administratively simple as can be successful. Probably, the period of pumping which a water agency can most readily manage is one year. In other words the agency can, using the simulator, determine how much water can be pumped out of each part of the Prairie in one year's time to meet the area-wide goals of the water users. In practice, the agency will regularly determine whether actual resulting water levels do indeed agree with predictions. Adjustments in permitted pumping may be made as the resources, goals, or needs of the users change.

The user-related data needed for this purpose are estimates of the water requirements in each 3 mile by 3 mile cell of the study area, as affected by climatological conditions. The necessary hydrogeologic information includes:

- effective porosity and hydraulic conductivity of the aquifer (including spatial variations, if significant).
- elevations of the top and bottom of the aquifer material.
spring and fall elevations of the groundwater level.

degree of connection between the aquifer and streams which serve as recharge or discharge sites.

At the very least, groundwater levels must be measured annually (in the spring) over the entire area. The USGS has historically made annual measurements in the spring (8,16). Continuity of records must be preserved. It is preferable, however, to make the area-wide measurements on a semi-annual basis (spring and fall). The most important reason for this is that almost all the water is pumped during the summer. Simulation verified every spring and fall could provide more accurate information on the next year's permitted pumping than simulation verified only in the spring. That information would also be available six months earlier. A third reason is that recharge into the study area from its periphery depends largely on the hydraulic gradient from the recharge source towards the area interior. The only estimates of the gradient currently available are those in the spring. At that time the rivers which border and recharge the area are at their highest stage and the aquifer has recovered, as much as it will have opportunity to, from the previous summer's pumping. It is important to know also what the gradient is like in the fall, when recharge streams are at low stage and aquifer water levels have not recovered much from the summer's pumping. Estimates of the degree of connection between the aquifer and penetrating streams are needed to permit approximation of the maximum feasible recharge to or discharge from the aquifer.
Measurements more frequent than semi-annual, over the entire area, would provide little useful information, since the effect of pumping wells during the summer distorts the water levels in their proximity. The process of compensating for that effect to estimate average water levels in the summer would be too time consuming to be justified.

The preceding paragraphs have addressed the necessary data for determining annual permitted pumping volumes. This volume/year flowrate, since it is simple, is necessarily fairly "crude." The temporal distribution of pumping during the summer by independent users can only be estimated. Therefore, resulting summertime saturated thicknesses in some parts of the area could be less than anticipated. For this reason more frequent observations should be made in that part of the study area where saturated thicknesses are critically small. Weekly, daily, or possibly continuous observation and subsequent management action may be necessary to prevent the litigation which can result when wells go dry. Such monitoring also provides a check on the simulation model. This check is needed since no model of an area the size of the Grand Prairie is a perfect predictor.

Evaluation of Available Data Bases and Development of Software for Data Utilization

Predicted water needs for an upcoming year (on a cell by cell basis) are not available in any existing data base. They may,
however, be estimated. The water need for irrigable crops and
given climatological conditions (7) can be approximated using a
daily simulated water balance. Appendix A contains a procedure
which uses the resulting crop water needs, the USGS's 1972 RIDS
data base (2,11,12,14) and projected crop acreages to estimate
annual water needs for each cell.

The Crop Reporting Service is the most likely source of anti­
cipated acreages (1). An additional source of general information
on water use is the excellent periodic water use summary prepared
by the USGS (17,18). A more accurate means of estimating the
acreages of irrigated crops in each cell is desirable.

Adequate estimates of municipal use of Quaternary groundwater
can be made from data in the Arkansas State Water Plan (4).
Estimates of aquacultural acreage in each cell can be made from
the State Water Plan (3), and records of the Arkansas Fish and
Wildlife Service (see Appendix B). It is a common opinion among
extension agents that there are thousands of acres of unreported
aquaculture. The annual water needs of aquacultural activities
range from 3-8 acre-ft/acre. Accordingly, accurate knowledge of
aquacultural water needs are important for any management effort.

A simple program was written which sums agricultural,
aquacultural and municipal water needs and estimates the pumping
from the Quaternary aquifer on a cell by cell basis (Appendix C).
Probably, water needs are greater than permissible pumping under
most desirable management strategies. Therefore, an alternative source of water will probably be needed. The physical availability of divertable surface water from the Arkansas or White Rivers can be determined using USGS streamflow records (19).

Several USGS reports (6,10,14) cite estimates of effective porosity or hydraulic conductivity. A review of these is found in a recent report by Peralta, et al. (13). Estimates of the top and bottom of the Quaternary aquifer are found in existing maps (5,9). They may also be created using data from Reports of Water Well Construction (Appendix D) which are filed with the state.\footnote{It would aid groundwater protection and management in the state if information concerning all strata and their color, and the quarter section in which the well is located were included in all such reports.} These reports contain useful information on the formation, type of water user, well characteristics, etc. The Soil Conservation Service also has a comprehensive listing of wells and surface water diversions. Spring elevations of the piezometric surface are available from USGS reports (8,16). Fall elevations are not available.

Standard programs are available on most computer mainframes to grid random three-dimensional observations. Sample procedures include polynomial fitting, spline fitting, and universal kriging. Such programs are used to prepare gridded estimates of the saturated thickness of the aquifer from the data discussed above.
Until recently, one well in the Grand Prairie's Quaternary aquifer was continuously monitored. Encrustation of the well ended its usefulness. A new monitoring station has not yet been established (possibly for economic reasons). Continuous monitoring site(s) need to exist in that part of the Prairie where saturated thicknesses are smallest. Preferably, data from the site(s) would be retrieved weekly or as collected (by telemetry). Determination of the number of continuous monitoring sites requires prediction of the effect of future pumping strategies and is beyond the scope of this report.

Estimates of the degree of connection between aquifer and penetrating stream are not available.

CONCLUSIONS AND RECOMMENDATIONS

A program has been written which estimates cell by cell water needs based on available data bases. However, no data base accurately reflects the acreage of irrigated cropland or aquaculture which will probably exist in each cell in the next year. This is an important need. The availability of such information would enable the water management agency better to fill water needs with available groundwater and diverted surface water resources.

Sufficient data is available to estimate the effect of different pumping strategies on future Quaternary groundwater availability in the Grand Prairie. Thus regional pumping strategies can
be developed using a calibrated simulation model (13) and existing
data bases. Optimizing or successfully using such strategies will
require some additional information.

For most of the Grand Prairie, only spring water levels are
currently being measured. This means that a management agency can
determine the effect of its management strategy only after every
spring. This provides inadequate lead time for determining the
subsequent summer's groundwater withdrawal strategy. Thus it is
recommended that observations be made in the fall as well as in
the spring for all sites currently being annually monitored. It
is also suggested that continuous monitoring be used in areas
where saturated thicknesses are critically small. The resulting
data should be retrieved and analyzed regularly to protect against
unexpected dewatering.

The degree of connection between penetrating streams and the
aquifer is currently unknown. This should be determined to permit
estimation of maximum feasible recharge and the effect of ground-
water pumping on the downstream availability of surface water.

2) Arkansas County Profile. Little Rock, AR: Arkansas Department of Local Services, 1977.


5) "Bottom of Pleistocene, Grand Prairie Rice Region." Confidential Map, Federal Land Bank of St. Louis, MO, 1936.


9) "Elevations of Top of Water Bearing Sand (Shallow Wells)", Unpublished Map, Agricultural Engineering Department, University of Arkansas, Fayetteville.


19) Water Resources Data for Arkansas Water Year 1977 (and other years). USGS Water-Data Report AR-77-1. Little Rock, AR.
APPENDIX A

Procedure to Estimate 1983 Agricultural Pumping in Cell M, County A

\[ \text{ACRE (M)} = \text{the agricultural acreage in cell M in 1972 (ac)} \]

\[ \text{TAGAC (A)} = \text{the total agricultural acreage in county A within the study area in 1972 (ac)} \]

\[ \text{RAGA (A,83)} = \text{the expected rice acreage in county A within the study area in 1983 (ac)} \]

\[ \text{SAGA (A,83)} = \text{the expected soybean acreage in county A within the study area in 1983, (irrigated) (ac)} \]

\[ \text{RIR (83)} = \text{irrigation water used for rice irrigation in average years} \]

\[ \text{SIR (83)} = \text{irrigation water used for soybean irrigation in average years} \]

\[ \text{QUAT (A)} = \text{the percent of the county's irrigation water which is drawn from the Quaternary aquifer} \]

\[ \text{Z (A,83)} = \text{RAGA (A,83) x RIR (83) + SAGA (A,83) x SIR (83)} \]

\[ = \text{total expected water need for rice and soybean irrigation in county A in 1983 (ac-ft)} \]

\[ \text{AGPUMP (M,83)} = \frac{\text{ACRE (M)} \times \text{ACRE (M)}}{\text{TAGAC (A)}} \times \text{QUAT (A)} \]

\[ = \text{the volume of water need expected for rice and soybean irrigation in cell M in 1983 (ac-ft) which is pumped from the Quaternary aquifer} \]

* The irrigation water used for rice and soybean irrigation was computed by daily water balance simulation.
APPENDIX B

* PLEASE ESTIMATE PRODUCTION ACRES SO THAT WE CAN ASSIST YOU IN PLANNING BY ESTABLISHING CHANGING TRENDS IN FISH FARMING.

<table>
<thead>
<tr>
<th>SPECIES OF FISH</th>
<th>ACRES - 1978</th>
<th>ACRES PLANNED - 1979</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Shiner</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Fathead Minnows</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Catfish (Food) (Brood)</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Catfish (Fingerling)</td>
<td>315</td>
<td>315</td>
</tr>
<tr>
<td>Goldfish</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Trout</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (Specify)</td>
<td>White Am 40</td>
<td>40</td>
</tr>
<tr>
<td>*Total Acres</td>
<td>400</td>
<td>400</td>
</tr>
</tbody>
</table>

Lonoke

ENCLOSED IS CHECK OF $25.00 FOR 1979 RENEWAL OF

- FISH FARMER CERTIFICATE NUMBER 220 $25.00
- BULLFROG PERMIT NUMBER $25.00 DEC 5 8

SIGNATURE OF OWNER OR AGENT ..................................................

ADDRESS IF CHANGED ...................................................................

(PLEASE PRINT) ............................................................................
NAME: ADSIMPUM FORTRAN A

CALCULATES THE AMOUNT OF PUMPING FROM THE QUATERNARY
AQUIFER IN THE GRAND PRAIRIE REGION. ONLY CONSIDERING RICE AND
SOYBEAN ACREAGE (REPORTED FOR EACH COUNTY).

DATA REQUIRED IS IN:
--ADSIMPUM DATA A--

THE FILE TO EXECUTE THIS PROGRAM IS UNDER THE NAME OF
--AUSIMPUM EXEC A--

DIMENSION JLEFT(26), JRIGHT(26), EMP(26,18)
DIMENSION NLEFT(26), NRIGHT(26), EMP(26,18)
DIMENSION NLL(26), NR(26), EMP(26,18)
DIMENSION TAGAC(4), SME(4), EMP(26,18)
DIMENSION RAGA(10,4), SAGA(10,4), EMP(26,18)
DIMENSION ICON(26,1), ACER(26,18), EMP(26,18)
DIMENSION AQUA(26,18), EMP(26,18)
DIMENSION PAX(10,4), EMP(26,18)
DIMENSION TAGAC(4), SME(4), EMP(26,18)
DIMENSION AQUA(26,18), EMP(26,18)
DIMENSION EMPREC(26,18)

DATA ON/400*0. /
DATA FMW/468*0. /
DIMENSION TP(10,6)
DIMENSION P1(10,26,18), P2(10,26,18), P3(10,26,18)
DIMENSION P4(10,26,18)
DIMENSION KNEW(10,30,8)
DATA TAGAC/400*0. , SME/400*0. , HIP/400*0. , SIR/400*0. , EMP(26,18)
DATA PAX/400*0. , RHY/400*0. , EMP(26,18)
DATA P4/400*0. , P5/400*0. , P6/400*0. , EMP(26,18)
DATA ICON/4680*0. , EMP(26,18)
DATA R4/4680*0. , EMP(26,18)
DATA R3/4680*0. , EMP(26,18)
DATA R2/4680*0. , EMP(26,18)
DATA R1/4680*0. , EMP(26,18)
DATA R0/4680*0. , EMP(26,18)
DATA EMPH/C4/*0.,/
             ****************************************************************************
READ STATEMENTS
             ROUNDARIES -- FOR ENTIRE MODEL -- ,
DO 100 I=2,2
   READ(5,*),JLFT(I),JRIGHT(I)
   CONTINUE
BOUNDARIES FOR SUBSET MODEL
             ****************************************************************************
C FIRST PERFORM A NULL READ ON ANSIM-PUM DATA
C
C110 I=1,22
   READ(5,*),NLL(I),NRR(I)
   CONTINUE
C
C110 I=1,22
   READ(9,*),NJLFT(I),NJRIT(I)
   CONTINUE
C
C READ IN THE TOTAL AG. ACREAGE FOR EACH COUNTY (AC.)
C   READ(5,*),(TAGAC(L),L=1,4)
C   CONTINUE
C
C READ IN THE ACREAGE OF IRRIGATED RICE (AC.)
C   DO 160 N=1,10
C   READ(5,*),(RAGA(N,L),L=1,4)
C   CONTINUE
C
C READ IN ACAREAGE OF IRRIGATED SOYREAN (AC.)
C   DO 170 N=1,10
C   READ(5,*),(SAEG(N,L),L=1,4)
C   CONTINUE

(Continued)
READ IN THE IRRIGATION REQUIREMENTS FOR RICE FOR EACH YEAR (IN.)

\[ \text{DO 100 N=1,10} \]
\[ \text{READ (5,* ) RIP(N)} \]
\[ \text{CONTINUE} \]

READ IN THE IRRIGATION REQUIREMENTS FOR SOYBEANS PER YEAR (IN.)

\[ \text{DO 100 N=1,10} \]
\[ \text{READ (5,* ) SIR(N)} \]
\[ \text{CONTINUE} \]

READ IN THE COUNTY THAT EACH CELL IS IN

\[ \text{DO 200 I=2,21} \]
\[ \text{IL=JLEFT(I)+1} \]
\[ \text{IR=JRIGHT(I)+1} \]
\[ \text{READ (5,* ) (ICOUN(I,J),J=IL,IR)} \]
\[ \text{CONTINUE} \]

READ IN THE AGRICULTURAL AREA IN EACH CELL (SQUARE KM.)

\[ \text{DO 300 I=2,21} \]
\[ \text{IL=JLEFT(I)+1} \]
\[ \text{IR=JRIGHT(I)+1} \]
\[ \text{READ (5,* ) (ACRE(I,J),J=IL,IR)} \]
\[ \text{CONTINUE} \]

READ IN THE PERCENTAGE OF AGRICULTURAL WATER COMING FROM PUMPING OF THE QUATERNARY AQUIFER

\[ \text{READ (5,* ) (SHWE(L),L=1,4)} \]

READ IN THE MUNICIPAL WATER USE BY LOCATION (AC,-FT.)
THE CELL NUMBERS FOR READING IN THE MUNICIPAL WATER USE ARE THE I AND J VALUES.

```plaintext
DO 350 NUM=1,9  
PFAAD(5,*)I,J  
FREAD(5,*)READA(I,J)  
CONTINUE

PEAD IN THE VALUE FOR THE TOTAL AQUACULTURAL WATER REQUIREMENT BY CELL NUMBER AS ABOVE! THIS NUMBER WILL BE MULTIPLIED BY 0.9 BECAUSE 90% OF THE WATER COMES FROM THE QUARTERNARY AQUIFER. *********(AC.-FT.)

```

360  
```plaintext
DO 360 NUM=1,24  
PFAAD(5,*)I,J  
PREAD(5,*)READA(I,J)  
READA(1,J)=0.9*READA(I,J)*1.00  
CONTINUE

```

ADDITIONAL INPUT (RECHARGE & AQUACULTURE)
```

```plaintext
ADAQUA(K,I,J) ADDITIONAL AQUACULTURAL PUMPING (AC.-FT.)  
K IS THE YEAR  
EMPREC(I,J) EMPIRICAL RECHARGE CONSTANT  
(CUBIC FT./YEAR x 10 TO THE 7TH.)

```

```plaintext
DO 365 NUM=1,13  
PFAAD(5,*)I,J,EMPRE(I,J)  
EMPREC(I,J)=EMPRE(I,J)*1000  
CONTINUE

```

```plaintext
DO 367 NUM=1,17  
PREAD(5,*)I,J,ADAQUA(K,I,J)  
ADAQUA(K,I,J)=ADAQUA(K,I,J)*1.00  
DO 366 NY=7,10  
ADAQUA(NY,I,J)=ADAQUA(K,I,J)  
CONTINUE

```

(continued)
Computations

DO 400 N=1,10
DO 375 L=1,4
RAX(N,L)=SAGA(N,L)*RIP(N)
RBY(N,L)=SAGA(N,L)*SIP(N)*0.2915

THE FACTOR 0.2915 WAS ADDED TO REDUCED THE ASSUMED

SOYBEAN ACREAGE IRRIGATED.

CAXBY(N,L)=((RAX(N,L)*RBY(N,L))/TAGAC(L))/12.01)*0.0

THE FACTOR 1.00 IN THE ABOVE LINE IS FOR THE CONVEYANCE LOSS

375 CONTINUE

400 CONTINUE

DO 500 N=1,10
DO 490 I=2.21
IF (1.ED.8) IL=NJLEFT(I)+2
IP=NJRIGHT(I)-1
DO 480 J=IL,IR
LCOUNT(I,J)
PL(N,I,J)=(ACRE(I,J)*(247.11)*CAXBY(N,L)*SHWE(L)+RMW(I,J)*RAQUA(I,J))/(0.03*640.*9.3)+(ADQUA(N,I,J))*43560.

DO XEDIT: CA - (EMPREC(I,J))
TO THE ABOVE COMPUTATION IF EMPIRICAL RECHARGE IS WANTED.

P3(N,I,J) IS THE PUMPING IN ACRE FEET

P3(N,I,J)=(PL(N,I,J))/43560.

P4(N,I,J) IS THE PUMPING IN FEET PER CELL


P2(N,I,J) IS THE AGRICULTURAL PUMPING IN ACRE FEET

P2(N,I,J)=(ACRE(I,J)*247.11*CAXHY(N,L)*SHWE(L))/12.0)

P5(N,L) IS THE RICE TOTAL

P5(N,L)=(ACRE(I,J)*247.1)*RAX(N,L)/TAGAC(L)/12.0)*SHWE(L)+P5(N,L)

SOYBEAN TOTAL IS P6

P6(N,L)=(ACRE(I,J)*247.11*RBY(N,L)*SHWE(L)/TAGAC(L)/12.0)+P6(N,L)

AQUACULTURAL PUMPING (INITIAL INPUT) IS TAQI(N,L)

TAQI(N,L)=ADQUA(I,J)+TAQU(N,L)

AQUACULTURAL PUMPING (ADDITIONAL INPUT) IS TAQI(N,L)

TAQI(N,L)=ADQUA(I,J)+TAQI(N,L)
TOTAL AQUACULTURAL PUMPING IS 
\[ \text{TAQ(N+L)} = \text{TPAQUA}(N+I,J) + \text{ADAQUA}(N,I,J) \times \text{TAQ}(N,L) \]

\[ \text{TP(N+L)} = \text{PRP}(N,I,J) \]

\[ \sum(N+L) \text{ IS THE TOTAL PUMPING FOR EACH COUNTY} \]
\[ \sum(N+L) = \sum(N,L) + \text{TP(N+L)} \]

CONTINUE

\[ \sum(N) \text{ is the total pumping for the year (acre feet)} \]
\[ \sum(N) = \sum(N,L) \times \sum(N,L) \]

CONTINUE

The next three statements added 3/3/P3.
They add recharge to the three cells included.

Recharge is the average of the steady state pumping values from the output of 11/15/82.

\[ \text{P}(N,18,11) = \text{P}(N,18,11) - 613500. \]
\[ \text{P}(N,19,12) = \text{P}(N,19,12) - 1610300. \]
\[ \text{P}(N,21,13) = \text{P}(N,21,13) - 20274000. \]

CONTINUE

 Dodgers added to write out the pumping in a format which SimuLat must read it.

DO 590 N=1,10
  ICO=1
DO 570 I=1,22
  LM=LFF(L)
  B=WM(L)
DO 550 J=1,12
  ON(N,ICO)=P(N,I,J)
  WRITE(9,077)(ICO,ON(N,ICO))
  ICO=ICO+1
CONTINUE

CONTINUE

DO 590 N=1,10
  ICO=0
DO 550 I=1,26
  ON=N(I)
  ICO=ICO+1
  ON(N+1,J)=ON(N,J)
  WRITE(9,077)(ICO,ON(N+1,J))
CONTINUE

CONTINUE

CONTINUE
Writing out the sum of the pumping for each county by year for the total pumping, the pumping for rice irrigation, and the pumping for soybean irrigation.

DO 620 K2 = 1, 6
IF (K2, EQ, 6) GO TO 608
IF (K2, EQ, 5) GO TO 606
IF (K2, EQ, 4) GO TO 604
IF (K2, EQ, 3) GO TO 602
IF (K2, EQ, 2) GO TO 600
WRITE (6, 900) (IYEAR, (SUM(N, L), L = 1, 4), SUMT(N))
GO TO 618
613 WRITE (6, 900) (IYEAR, (P5(N, J), L = 1, 4), SUP(N))
GO TO 618
614 WRITE (6, 900) (IYEAR, (P6(N, L), L = 1, 4))
GO TO 618
612 WRITE (6, 925)
GO TO 618
608 WRITE (6, 918)
612 WRITE (6, 925)
GO TO 618
N = 1, 10
IYEAR = IYEAR * 1
IF (K2, EQ, 6) GO TO 617
IF (K2, EQ, 5) GO TO 616
IF (K2, EQ, 4) GO TO 615
IF (K2, EQ, 3) GO TO 614
IF (K2, EQ, 2) GO TO 613
WRITE (6, 900) (IYEAR, (SUM(N, L), L = 1, 4), SUP(N))
GO TO 618
613 WRITE (6, 900) (IYEAR, (P5(N, J), L = 1, 4), SUP(N))
GO TO 618
614 WRITE (6, 900) (IYEAR, (P6(N, L), L = 1, 4))
GO TO 618
612 WRITE (6, 925)
GO TO 618
608 WRITE (6, 918)
612 WRITE (6, 925)
GO TO 618

(continued)
THE NEXT STATEMENTS ARE ONLY TO CREATE THE SAME DATA INTO A FILE THAT CAN BE USED BY SAS.

DO 700 N = 1,10
DO 690 L = 1,4
WRITE (6,940) N, L, SUM(N,L)
690 CONTINUE
700 CONTINUE

THIS PART ADDED 8/25/82 TO WRITE THE WATER USE IN MAP FORM

A: AGRICULTURAL LAND, IN ACRES
DO 720 I = 1,22
DO 720 J = 1,18
ACRE(I, J) = ACRE(I, J) + C247.1
720 CONTINUE
WRITE (*,721)
721 FORMAT(/,'AGRICULTURAL LAND USE CELL BY CELL, ACRES/')
DO 722 I = 1,22
WRITE (*,724)(ACRE(I, J), J = I, 18)
722 CONTINUE
724 FORMAT(2X,18F7.0,/)
DO 728 I = 1, 22
WRITE (6, 728) (P2(N, I, J), J = 1, 18)
728 CONTINUE
729 FORMAT (2X, 18E7.0, /)

B: MUNICIPAL WATER USE, ACRE-FT
WRITE (6, 731)
731 FORMAT (1', 'MUNICIPAL WATER USE, ACRE-FT', ',', '1X, /)
DO 732 I = 1, 22
WRITE (6, 734) (PMWA(I, J), J = 1, 18)
732 CONTINUE
734 FORMAT (2X '18F7.0, /)

C: AQUACULTURAL WATER USE, ACRE-FT
WRITE (6, 741)
741 FORMAT (1', 'AQUACULTURAL PUMPING, ACRE-FT', ',', '1X, /)
DO 742 I = 1, 22
WRITE (6, 744) (AQUA(I, J), J = 1, 18)
742 CONTINUE
744 FORMAT (2X '18F7.0, /)

ADDITIONAL INPUT
WRITE (6, 747)
DO 748 I = 1, 22
WRITE (6, 746) (ADQUA(I, J), J = 1, 18)
746 CONTINUE
747 FORMAT (1', 'ADDITIONAL AQUACULTURAL PUMPING 1977-1981 ACRE-FT', '1X, /)

(Continued)
*FT. ( )/

748 FORMAT (L), 10X, 'EMPIRICAL RECHARGE CONSTANT EVERY YEAR', 5X, 'IN (CUBIC FT. / (10 TO THE 7TH. POWER))

D: TOTAL PUMPING CELL BY CELL, ACRE-FT

WRITE (6,753)

753 FORMAT (L), 20X, 'TOTAL PUMPING CELL BY CELL'

DO 751 N=1,10

WRITE (6,756) I YEAR

750 CONTINUE

751 CONTINUE

756 FORMAT (2X,18E7,0,/) 755 FORMAT (' ',15X,'TOTAL PUMPING CELL IN ACRE-FT')

DO 785 N=1,10

I YEAR=1971+N

WRITE (6,787) (I YEAR)

787 FORMAT (L), 5X, 'TOTAL PUMPING IN FT. PER CELL YEAR = ', 14, '/', 14

DO 786 I=1,22

WRITE (6,889) (P3 (N,I,J), J=1,18)

785 CONTINUE

786 FORMAT (2X 'I8E7,3,/) 784 FORMAT (L), 15X, 'RICE IRRIGATION PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,792) (I YEAR)

782 FORMAT (L), 15X, 'SOYBEAN IRRIGATION PUMPING IN ACRE-FT'

DO 785 I=1,22

WRITE (6,900) (P4 (N,I,J), J=1,18)

785 CONTINUE

790 FORMAT (L), 18E5,0

900 FORMAT (L), 20X, 'INITIAL AQUACULTURAL PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,910) (I YEAR)

795 CONTINUE

910 FORMAT (L), 20X, 'ADDITIONAL AQUACULTURAL PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,920) (I YEAR)

795 CONTINUE

920 FORMAT (L), 15X, 'SUGARBEAN IRRIGATION PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,930) (I YEAR)

795 CONTINUE

930 FORMAT (L), 15X, 'INITIAL AQUACULTURAL PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,940) (I YEAR)

795 CONTINUE

940 FORMAT (L), 20X, 'ADDITIONAL AQUACULTURAL PUMPING IN ACRE-FT'

DO 785 N=1,10

WRITE (6,950) (I YEAR)
010  FORMATT('1X,14X,TOTAL AQUACULTURAL PUMPING IN ACRE-FT.',/)/)  AD 04810
020  FORMATT('1X,19X,TOTAL PUMPING IN CUBIC FT.',/)/)  AD 04820
025  FORMATT('1X,COUNTY')  AD 04830
035  FORMATT('/.2X,YEAR  ARKANSAS  LONOKE  MONROE')  AD 04840
040  FORMATT('TOTAL ',/)  AD 04850
045  FORMATT('CX,14,13,E14,7')  AD 04860

STOP

END
APPENDIX D

STATE OF ARKANSAS

REPORT OF WATER WELL CONSTRUCTION

Owner of Well: J. J. Jones

Well Contractor: Layne Arkansas Company

Contractor License No.: C-1099

Driller Name and No.: Harley Bullock = D-2204

Date Well was Completed: May 9, 1979

1. Total Depth of Well: 636 ft

2. Water Producing Formation: From 556 ft to 636 ft

3. Water Level Below Land Surface: 134 ft

4. Gallons per Hour: 78,000

5. Well Disinfected with: HTH

6. Casing to: 542 ft

7. Cased with: 12" Diameter 250 ft Casing

8. Cemented from 0 ft to 542 ft

9. Use of Well: Domestic

This well is guaranteed against defective material or workmanship for a period of 1 Year

Map of Committee on Water Well Construction:

4403 Sc Fine Street

Little Rock, Arkansas 72204

Geology Copy

<table>
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<th>TOTAL DEPTH</th>
<th>THICKNESS STATION</th>
<th>FORMATION</th>
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<tr>
<td>70</td>
<td>35</td>
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<tr>
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<td>Fine Sand</td>
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