EVALUATION AND ACCESSING OF DATA FOR A WATER RESOURCES SIMULATOR

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Publication No. 91

March, 1983

Research Project Technical Completion Report A-060-ARK

Arkansas Water Resources Research Center
University of Arkansas
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Prepared for
United States Department of the Interior

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The work upon which this report is based was supported in part by federal funds provided by the U. S. Department of the Interior, as authorized under the Water Research and Development Act of 1978, (P. L. 95-467).

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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
Consultant's Report to Office of Water Planning, U. S. Department of the Interior, March 1983. Washington, D. C., 32 p.
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 anticipated 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.[1] 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 polynominal 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.

---

1 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.

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 groundwater pumping on the downstream availability of surface water.

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APPENDICES

APPENDIX A

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

ACRE (M) = the agricultural acreage in cell M in 1972 (ac)

TAGAC (A) = the total agricultural acreage in county A within the study area in 1972 (ac)

RAGA (A,83) = the expected rice acreage in county A within the study area in 1983 (ac)

SAGA (A,83) = the expected soybean acreage in county A within the study area in 1983, (irrigated) (ac)

RIR (83) = irrigation water used for rice irrigation in average years *

SIR (83) = irrigation water used for soybean irrigation in average years *

QUAT (A) = the percent of the county's irrigation water which is drawn from the Quaternary aquifer

Z (A,83) = RAGA (A,83) x RIR (83) + SAGA (A,83) x SIR (83)

= total expected water need for rice and soybean irrigation in county A in 1983 (ac-ft)

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

= 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.

```
C        ********************************************************************
C
C       COMPUTATIONS
C
        DO 400 N=1,10
         DO 375 L=1,4
         RAX(N,L)=RAGA(N,L)*RIP(N)
         RBY(N,L)=SAGA(N,L)*SIP(N)*0.2915
C   THE FACTOR 0.2915 WAS ADDED TO REDUCED THE ASSUMED
C   SOYBEAN ACREAGE IRRIGATED.
          CAXBY(N,L)=(((RAX(N,L)+RBY(N,L))/TAGAC(L))/12.0)*1.00
C  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
        IL=NJLEFT(I) +1
        IF(I.EQ.8)IL=NJLEFT(I)+2
        IR=NJRIT(I)-1
        DO 480 J=IL,IR
         L=ICOUN(I,J)
         P(N,I,J)=((ACRE(I,J)*(247.11)*CAXBY(N,L)*SHWE(L)+RMWA(I,J)
     * +RAQUA(I,J)-(0.03*640.*9.)+(ADAQUA(N,I,J)))*43560.)
C   DO XEDIT: CH -(EMPREC(I,J))
C   TO THE ABOVE COMPUTATION IF EMPRICAL RECHARGE IS WANTED.
C
C         P3(N,I,J) IS THE PUMPING IN ***** ACRE FEET *****
          P3(N,I,J)=P(N,I,J)/43560.
C
C         P4(N,I,J) IS THE PUMPING IN ***** FEET PER CELL *****
          P4(N,I,J)=P3(N,I,J)/640./9.
C
C         P2(N,I,J) IS THE AGRICULTURAL PUMPING IN ***** ACRE FEET *****
          P2(N,I,J)=(ACRE(I,J)*247.11*CAXBY(N,L)*SHWE(L))
C
C         RICE TOTAL IS P5
          P5(N,L)=(ACRE(I,J)*247.11*RAX(N,L)/TAGAC(L)/12.0)*SHWE(L)+ P5(N,L)
C
C         SOYBEAN TOTAL IS P6
          P6(N,L)=(ACRE(I,J)*247.11*RBY(N,L)*SHWE(L)/TAGAC(L)/12.0)+P6(N,L)
C
C         AQUACULTURAL PUMPING (INITIAL INPUT) IS TAQI(N,L)
C
          TAQI(N,L)=RAQUA(I,J)+TAQI(N,L)
C
C         AQUACULTURAL PUMPING (ADDITIONAL INPUT) IS TAQII(N,L)
          TAQII(N,L)=ADAQUA(N,I,J)+TAQII(N,L)
C
```

```
C      THE CELL NUMBERS FOR READING IN THE MUNICIPAL WATER USE                  AD 01450
C     ARE THE I AND J VALUES                                                    AD 01460
C                                                                               AD 01470
      DO 350 NUMB=1,9                                                           AD 01480
      READ(5,*)I,J                                                              AD 01490
      READ(5,*)RMWA(I,J)                                                        AD 01500
  350 CONTINUE                                                                  AD 01510
C                                                                               AD 01520
C                                                                               AD 01530
C     READ IN THE VALUE FOR THE TOTAL AQUACULTURAL WATER REQUIREMENT            AD 01540
C           (BY CELL NUMBER AS ABOVE) THIS NUMBER WILL BE MULTIPLIED            AD 01550
C           BY 0.9 BECAUSE 90% OF THE WATER COMES FROM THE                      AD 01560
C           QUATERNARY AQUIFER.     ..........(AC.-FT.)                         AD 01570
      DO 360 NUM=1,24                                                           AD 01580
      READ(5,*)I,J                                                              AD 01590
      READ(5,*)RAQUA(I,J)                                                       AD 01600
      RAQUA(I,J)=0.9*RAQUA(I,J)*1.00                                            AD 01610
  360 CONTINUE                                                                  AD 01620
C                                                                               AD 01630
C                                                                               AD 01640
C                                                                               AD 01650
C     **********************************************************************    AD 01660
C                                                                               AD 01670
C                     ADDITIONAL INPUT (RECHARGE & AQUACULTURE)                 AD 01680
C                                                                               AD 01690
C                                                                               AD 01700
C                                                                               AD 01710
C              ADAQUA(K,I,J)  ADDITIONAL AQUACULTURAL PUMPING (AC.-FT.)         AD 01720
C                                   K  IS THE YEAR                              AD 01730
C                                                                               AD 01740
C              EMPREC(I,J)    EMPIRICAL RECHARGE CONSTANT                      AD 01750
C                             (CUBIC FT.)/YEAR X (10 TO THE 7TH.)               AD 01760
C                                                                               AD 01770
      DO 365 NUM2=1,13                                                          AD 01780
      READ(5,*)I,J,FEMP(I,J)                                                    AD 01790
      EMPREC(I,J)=FEMP(I,J)*(10**7)                                             AD 01800
  365 CONTINUE                                                                  AD 01810
CC                                                                              AD 01820
                                                                                AD 01830
      DO 367 NUM3=1,17                                                          AD 01840
      READ(5,*)I,J,ADAQUA(6,I,J)                                                AD 01850
      ADAQUA(6,I,J)=ADAQUA(6,I,J)*1.00                                          AD 01860
      DO 366 NY=7,10                                                            AD 01870
      ADAQUA(NY,I,J)=ADAQUA(6,I,J)                                              AD 01880
  366 CONTINUE                                                                  AD 01890
  367 CONTINUE                                                                  AD 01900
C                                                                               AD 01910
CC                                                                              AD 01920
```

```
C
CC      READ IN THE IRRIGATION REQUIREMENTS FOR RICE FOR EACH YEAR (IN.)
C
        DO 180 N=1,10
        READ(5,*)IRIR(N)
 180    CONTINUE
C
CCC
CC      READ IN THE IRRIGATION REQUIREMENTS FOR SOYBEANS PER YEAR (IN.)
C
        DO 190 N=1,10
        READ(5,*)SIR(N)
 190    CONTINUE
C
CCC
CC      READ IN THE COUNTY THAT EACH CELL IS IN
C
        DO 200 I=2,21
        IL=JLEFT(I)+1
        IR=JRIGHT(I)+1
        READ(5,*)(ICOUN(I,J),J=IL,IR)
 200    CONTINUE
C
CCC
C*************************************
CC      DO 210 I=2,21
C        WRITE(6,910)(ICOUN(I,J),J=1,17)
C 210    CONTINUE
C*************************************
C
CC      READ IN THE AGRICULTURAL AREA IN EACH CELL (SQUARE KM.)
C
        DO 300 I=2,21
        IL=JLEFT(I)+1
        IR=JRIGHT(I)+1
        READ(5,*)(ACRE(I,J),J=IL,IR)
 300    CONTINUE
C
CCC
CC      READ IN THE PERCENTAGE OF AGRICULTURAL WATER COMING FROM
        PUMPING OF THE QUATERNARY AQUIFER
C
        READ(5,*)(SHWE(L),L=1,4)
C
CCC
CC      READ IN THE MUNICIPAL WATER USE BY LOCATION  (AC.-FT.)
C
```

```
AD 00970
AD 00980
AD 00990
AD 01000
AD 01010
AD 01020
AD 01030
AD 01040
AD 01050
AD 01060
AD 01070
AD 01080
AD 01090
AD 01100
AD 01110
AD 01120
AD 01130
AD 01140
AD 01150
AD 01160
AD 01170
AD 01180
AD 01190
AD 01200
AD 01210
AD 01220
AD 01230
AD 01240
AD 01250
AD 01260
AD 01270
AD 01280
AD 01290
AD 01300
AD 01310
AD 01320
AD 01330
AD 01340
AD 01350
AD 01360
AD 01370
AD 01380
AD 01390
AD 01400
AD 01410
AD 01420
AD 01430
AD 01440
```

```
      DATA EMPHEC/468*0./
C
C     ******************************************************************
C
C     READ STATEMENTS
C
C
C     BOUNDARIES -- FOR ENTIRE MODEL --
C
      DO 100 I=2,21
      READ(5,*)JLEFT(I),JRIGHT(I)
  100 CONTINUE
C     BOUNDARIES FOR SUBSET MODEL
C***********************************************************************
C  FIRST PERFORM A NULL READ ON ADSIMPUM DATA
C
              DO 110 I=1,22
              READ(5,*) NLL(I),NRR(I)
  110         CONTINUE
C
C    NOW READ THE LIMITS OF THE SUBSET OF THE GRAND PRAIRIE
C    FOR THE CALIBRATION RUN TO BE PERFORMED BY AQUISIM
C
     DO 112 I=1,22
     READ(9,*)NJLEFT(I),NJRIT(I)
 112 CONTINUE
C
C***********************************************************************
C
C     READ IN THE TOTAL AG. ACREAGE FOR EACH COUNTY  (AC.)
C
      READ(5,*)(TAGAC(L),L=1,4)
  150 CONTINUE
C
C
C     READ IN THE ACREAGE OF IRRIGATED RICE  (AC.)
C
      DO 160 N=1,10
      READ(5,*)(RAGA(N,L),L=1,4)
  160 CONTINUE
C
C
C     READ IN ACREAGE OF IRRIGATED SOYBEAN  (AC.)
C
      DO 170 N=1,10
      READ(5,*)(SAGA(N,L),L=1,4)
  170 CONTINUE
C
```

APPENDIX C

Program Which Estimates Cell by Cell Water Needs

```
C                                                                       AD 00010
C                                                                       AD 00020
C                          NAME: ADSIMPUM FORTRAN A                     AD 00030
C                                                                       AD 00040
C      CALCULATES THE AMOUNT OF PUMPING FROM THE QUATERNARY             AD 00050
C AQUIFER IN THE GRAND PRAIRIE REGION. ONLY CONSIDERING RICE AND        AD 00060
C SOYBEAN ACREAGE (REPORTED FOR EACH COUNTY).                           AD 00070
C                                                                       AD 00080
C                                                                       AD 00090
C       DATA REQUIRED IS IN:                                            AD 00100
C            --ADSIMPUM DATA A--                                        AD 00110
C                                                                       AD 00120
C         THE FILE TO EXECUTE THIS PROGRAM IS UNDER THE NAME OF         AD 00130
C          --ADSIMPUM EXEC A--                                          AD 00140
C                                                                       AD 00150
      DIMENSION JLEFT(26), JRIGHT(26), FEMP(26,18)                      AD 00160
      DIMENSION NJLEFT(26),NJRIT(26)                                    AD 00170
      DIMENSION NLL(26), NRR(26)                                        AD 00180
      DIMENSION TAGAC(4), SHWE(4)                                       AD 00190
      DIMENSION RAGA(10,4), SAGA(10,4), RIR(10), SIR(10)                AD 00200
      DIMENSION ICOUN(26,18), ACRE(26,18), RMWA(26,18)                  AD 00210
      DIMENSION RAQUA(26,18)                                            AD 00220
      DIMENSION PAX(10,4), RRY(10,4), CAXRY(10,4), SUM(10,4)            AD 00230
      DIMENSION SUMT(10) , QN(10,240) , P5(10,4), P6(10,4)              AD 00240
      DIMENSION TAQ(10,4), TAQI(10,4), TAQII(10,4)                      AD 00250
      DIMENSION ADAQUA(10,26,18)                                        AD 00260
      DIMENSION EMPREC(26,18)                                           AD 00270
C                                                                       AD 00280
C                                                                       AD 00290
C                                                                       AD 00300
C                                                                       AD 00310
      DATA QN/2400*0./                                                  AD 00320
      DATA FEMP/468*0./                                                 AD 00330
      DIMENSION TP(10,4)                                                AD 00340
      DIMENSION P(10,26,18), P2(10,26,18), P3(10,26,18)                 AD 00350
      DIMENSION P4(10,26,18)                                            AD 00360
      DIMENSION QNEW(10,30,8)                                           AD 00370
      DATA TAGAC/4*0./, SHWE/4*0./                                      AD 00380
      DATA RAGA/40*0./, SAGA/40*0./, RIR/10*0./, SIR/10*0./             AD 00390
      DATA PAX/40*0./, RRY/40*0./, CAXRY/40*0./, SUM/40*0./             AD 00400
      DATA P5/40*0./,P6/40*0./ ,TAQ/40*0./,TAQI/40*0./,TAQII/40*0./     AD 00410
      DATA ACRE/468*0./, RMWA/468*0./, TP/40*0./                        AD 00420
      DATA RAQUA/468*0./                                                AD 00430
      DATA SUMT/10*0./                                                  AD 00440
      DATA P/4680*0./,  QNEW/2400*0./ , P2/4680*0./                     AD 00450
      DATA P3/4680*0./ , P4/4680*0./                                    AD 00460
      DATA ICOUN/468*2000/                                              AD 00470
      DATA ADAQUA/4680*0./                                              AD 00480
```

APPENDIX B

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

SPECIES OF FISH	ACRES - 1978	ACRES PLANNED - 1979
Golden Shinner	25	40
Fathead Minnows	20	20
Catfish (Food) (Brood)	25	25
Catfish (Fingerling)	315	315
Goldfish	15	25
Trout		
Other (Specify)	White Am 40	40
*Total Acres	400	400

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) .....

```
C       TOTAL AQUACULTURAL PUMPING IS TAQ(N,L)                                  AD 02410
        TAQ(N,L)=RAQUA(I,J)+ADAQUA(N,I,J)+TAQ(N,L)                              AD 02420
C                                                                               AD 02430
C       TP(N,L) IS THE PUMPING FOR THE COUNTY                                   AD 02440
C                                                                               AD 02450
        TP(N,L)=P(N,I,J)                                                        AD 02460
C                                                                               AD 02470
C       SUM(N,L) IS THE TOTAL PUMPING FOR EACH COUNTY                           AD 02480
        SUM(N,L)=SUM(N,L)+TP(N,L)                                               AD 02490
  480   CONTINUE                                                                AD 02500
C                                                                               AD 02510
C       SUMT(N) IS THE TOTAL PUMPING FOR THE YEAR (ACRE FEET)                   AD 02520
        SUMT(N)=SUMT(N)+SUM(N,L)                                                AD 02530
  490   CONTINUE                                                                AD 02540
C    THE NEXT THREE STATEMENTS ADDED 3/3/83.                                    AD 02550
C    THEY ADD RECHARGE TO THE THREE CELLS INCLUDED.                             AD 02560
C    THE RECHARGE IS THE AVERAGE OF THE STEADY STATE PUMPING VALUES             AD 02570
C         FROM THE OUTPUT OF 11/15/82.                                          AD 02580
        P(N,18,11)=P(N,18,11)-61355000.                                         AD 02590
        P(N,19,12)=P(N,19,12)-16103000.                                         AD 02600
        P(N,21,13)=P(N,21,13)-202140000.                                        AD 02610
  500   CONTINUE                                                                AD 02620
C                                                                               AD 02630
C       ********************************************                            AD 02640
C                                                                               AD 02650
C       THIS NEXT PART WAS ADDED TO WRITE OUT THE PUMPING IN A                  AD 02660
C       FORMAT WHICH SIMULAT MUST READ IT                                       AD 02670
C                                                                               AD 02680
        DO 590 N=1,10                                                           AD 02690
          ICO=1                                                                 AD 02700
        DO 570 I=1,22                                                           AD 02710
        LL=NJLEFT(I)                                                            AD 02720
        LR=NJRIT(I)                                                             AD 02730
        DO 550 J=LL,LR                                                          AD 02740
        QN(N,ICO)=P(N,I,J)                                                      AD 02750
C         WRITE(6,907)(ICO,QN(N,ICO))                                           AD 02760
          ICO=ICO+1                                                             AD 02770
  550   CONTINUE                                                                AD 02780
  570   CONTINUE                                                                AD 02790
  590   CONTINUE                                                                AD 02800
        DO 595 N=1,10                                                           AD 02810
          ICO=0                                                                 AD 02820
        DO 594 I=1,26                                                           AD 02830
        DO 592 J=1,8                                                            AD 02840
          ICO=ICO + 1                                                           AD 02850
          QNEW(N,I,J)=QN(N,ICO)                                                 AD 02860
C         WRITE(6,908)(ICO,QNEW(N,I,J),QN(N,ICO))                               AD 02870
  592       CONTINUE                                                          AD 02880
```

```
  594        CONTINUE                                                    AD 02890
  595        CONTINUE                                                    AD 02900
             DO 598 N=1,10                                               AD 02910
             DO 597 I=1,26                                               AD 02920
             WRITE(7,904)(ONEW(N,I,J),J=1,8)                             AD 02930
  597        CONTINUE                                                    AD 02940
  598        CONTINUE                                                    AD 02950
C                                                                        AD 02960
C            ********************************************                AD 02970
C            ********************************************                AD 02980
C                                                                        AD 02990
C           WRITING OUT THE SUM OF THE PUMPING FOR EACH COUNTY BY YEAR   AD 03000
C           FOR THE TOTAL PUMPING, THE PUMPING FOR RICE IRRIGATION,      AD 03010
C           AND THE PUMPING FOR SOYBEAN IRRIGATION                       AD 03020
C                                                                        AD 03030
           DO 620 K2=1,6                                                 AD 03040
           IYEAR=1971                                                    AD 03050
           IF(K2.EQ.6) GO TO 608                                         AD 03060
           IF(K2.EQ.5) GO TO 606                                         AD 03070
           IF(K2.EQ.4) GO TO 604                                         AD 03080
           IF(K2.EQ.3) GO TO 602                                         AD 03090
           IF(K2.EQ.2) GO TO 600                                         AD 03100
           WRITE(6,920)                                                  AD 03110
           GO TO 612                                                     AD 03120
  600      WRITE(6,911)                                                  AD 03130
           GO TO 612                                                     AD 03140
  602      WRITE(6,912)                                                  AD 03150
           GO TO 612                                                     AD 03160
  604      WRITE(6,914)                                                  AD 03170
           GO TO 612                                                     AD 03180
  606      WRITE(6,916)                                                  AD 03190
           GO TO 612                                                     AD 03200
  608      WRITE(6,918)                                                  AD 03210
  612      WRITE(6,925)                                                  AD 03220
           WRITE(6,930)                                                  AD 03230
           DO 618 N=1,10                                                 AD 03240
           IYEAR=IYEAR+1                                                 AD 03250
           IF(K2.EQ.6) GO TO 617                                         AD 03260
           IF(K2.EQ.5) GO TO 616                                         AD 03270
           IF(K2.EQ.4) GO TO 615                                         AD 03280
           IF(K2.EQ.3) GO TO 614                                         AD 03290
           IF(K2.EQ.2) GO TO 613                                         AD 03300
           WRITE(6,900)(IYEAR,(SUM(N,L),L=1,4),SUMT(N))                  AD 03310
           GO TO 618                                                     AD 03320
  613      WRITE(6,900)(IYEAR,(P5(N,L),L=1,4))                           AD 03330
           GO TO 618                                                     AD 03340
  614      WRITE(6,900)(IYEAR,(P6(N,L),L=1,4))                           AD 03350
           GO TO 618                                                     AD 03360
```

```
615  WRITE(6,900)(IYEAR,(TAQI(N,L),L=1,4))                              AD 03370
     GO TO 618                                                          AD 03380
616  WRITE(6,900)(IYEAR,(TAQII(N,L),L=1,4))                             AD 03390
     GO TO 618                                                          AD 03400
617  WRITE(6,900)(IYEAR,(TAQ(N,L),L=1,4))                               AD 03410
618   CONTINUE                                                          AD 03420
620   CONTINUE                                                          AD 03430
                                                                       AD 03440
C                                                                      AD 03450
C      ********************************************************       AD 03460
C                                                                      AD 03470
C      THE NEXT STATEMENTS ARE ONLY TO CREATE THE SAME                 AD 03480
C      DATA INTO A FILE THAT CAN BE USE BY SAS.                        AD 03490
C                                                                      AD 03500
C      DO 700 N=1,10                                                   AD 03510
C         DO 690 L=1,4                                                 AD 03520
CC           WRITE(6,940)N,L,SUM(N,L)                                  AD 03530
C 690        CONTINUE                                                  AD 03540
C 700    CONTINUE                                                      AD 03550
                                                                       AD 03560
C                                                                      AD 03570
C      ********************************************************       AD 03580
C                                                                      AD 03590
C                                                                      AD 03600
C      THIS PART ADDED 8/25/82 TO WRITE THE WATER USE IN MAP FORM      AD 03610
C                                                                      AD 03620
C  A:  AGRICULTURAL LAND, IN ACRES                                     AD 03630
      DO 720 I=1,22                                                    AD 03640
      DO 720 J=1,18                                                    AD 03650
      ACRE(I,J)=ACRE(I,J)*247.11                                       AD 03660
  720 CONTINUE                                                         AD 03670
      WRITE(6,721)                                                     AD 03680
  721 FORMAT(/,'1',20X,'AGRICULTURAL LAND USE CELL BY CELL, AC.',/)    AD 03690
      DO 722 I=1,22                                                    AD 03700
      WRITE(6,724)(ACRE(I,J),J=1,18)                                   AD 03710
  722 CONTINUE                                                         AD 03720
  724 FORMAT(2X,18F7.0,/)                                              AD 03730
C                                                                      AD 03740
C                                                                      AD 03750
C                                                                      AD 03760
C                                                                      AD 03770
C  A2: PUMPING DUE TO AGRICULTURE, ACRE-FT                             AD 03780
C                                                                      AD 03790
  727 FORMAT('1',20X,'PUMPING DUE TO AGRICULTURE, ACRE-FT',3X,I5,//)   AD 03800
      DO 728 N=1,10                                                    AD 03810
        IYEAR=1971+N                                                   AD 03820
      WRITE(6,727)IYEAR                                                AD 03830
  791 FORMAT(////////////,20X,'YEAR = ',I4,//)                         AD 03840
```

```
      DO 728 I=1,22                                                    AD 03850
      WRITE(6,729)(P2(N,I,J),J=1,18)                                   AD 03860
  728 CONTINUE                                                         AD 03870
  729 FORMAT(2X,18F7.0,/)                                              AD 03880
C                                                                      AD 03890
CCCCC                                                                  AD 03900
CCCCC                                                                  AD 03910
CCCCC  B:  MUNICIPAL WATER USE, ACRE-FT                                AD 03920
C                                                                      AD 03930
      WRITE(6,731)                                                     AD 03940
  731 FORMAT('1',20X,'MUNICIPAL WATER USE, ACRE-FT',//)                AD 03950
      DO 732 I=1,22                                                    AD 03960
      WRITE(6,734)(RMWA(I,J),J=1,18)                                   AD 03970
  732 CONTINUE                                                         AD 03980
  734 FORMAT(2X,18F7.0,/)                                              AD 03990
C                                                                      AD 04000
CCCCC                                                                  AD 04010
CCCCC                                                                  AD 04020
CCCCC                                                                  AD 04030
CCCCC                                                                  AD 04040
CCCCC  C:  AQUACULTURAL WATER USE, ACRE-FT                             AD 04050
CCCCC                                                                  AD 04060
C                                                                      AD 04070
      WRITE(6,741)                                                     AD 04080
  741 FORMAT('1',20X,'AQUACULTURAL PUMPING, ACRE-FT',//)               AD 04090
      DO 740 I=1,22                                                    AD 04100
      WRITE(6,744)(RAQUA(I,J),J=1,18)                                  AD 04110
  740 CONTINUE                                                         AD 04120
  744 FORMAT(2X,18F7.0,/)                                              AD 04130
C                                                                      AD 04140
CCCCC                                                                  AD 04150
CCCCC                                                                  AD 04160
CCCCC        ADDITIONAL INPUT                                          AD 04170
C                                                                      AD 04180
       WRITE(6,747)                                                    AD 04190
       DO 746 I=1,22                                                   AD 04200
       WRITE(6,786)(ADAQUA(6,I,J),J=1,18)                              AD 04210
  746  CONTINUE                                                        AD 04220
C                                                                      AD 04230
CC                                                                     AD 04240
       WRITE(6,748)                                                    AD 04250
       DO 749 I=1,22                                                   AD 04260
       WRITE(6,752)(FEMP(I,J),J=1,18)                                  AD 04270
  749  CONTINUE                                                        AD 04280
C                                                                      AD 04290
C                                                                      AD 04300
  747  FORMAT('1',10X,'ADDITIONAL AQUACULTURAL PUMPING 1977-1981 ACRE  AD 04310
```

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     * FT. ',//)                                                          AD 04330
 748      FORMAT('1',10X,'EMPIRICAL RECHARGE CONSTANT EVERY YEAR',5X,'INAD 04340
     * (CUBIC FT.) X (10 TO THE 7TH. ',//)                               AD 04350
C                                                                        AD 04360
CCC                                                                      AD 04370
CCCC                                                                     AD 04380
CCCC  D:  TOTAL PUMPING CELL BY CELL, ACRE-FT                            AD 04390
CCCC                                                                     AD 04400
CCC       WRITE(6,753)                                                   AD 04410
C 753 FORMAT('1',20X,'TOTAL PUMPING CELL BY CELL',//)                    AD 04420
      DO 751  N=1,10                                                     AD 04430
         IYEAR=1971+N                                                    AD 04440
      WRITE(6,756)IYEAR                                                  AD 04450
      DO 750 I=1,22                                                      AD 04460
      WRITE(6,755)(P3(N,I,J),J=1,18)                                     AD 04470
  750 CONTINUE                                                           AD 04480
  751 CONTINUE                                                           AD 04490
  755 FORMAT(2X,18F7.0,/)                                                AD 04500
  756 FORMAT('1',15X,'TOTAL PUMPING CELL BY CELL IN (AC FT)=',3X,I6,//)  AD 04510
C                                                                        AD 04520
CCCCC                                                                    AD 04530
CCCCC                                                                    AD 04540
CCCCC                                                                    AD 04550
C                                                                        AD 04560
      DO 785 N=1,10                                                      AD 04570
      IYEAR=1971+N                                                       AD 04580
      WRITE(6,787)(IYEAR)                                                AD 04590
  787 FORMAT('1',5X,'TOTAL PUMPING IN FT. PER CELL  YEAR = ',I4,//)      AD 04600
      DO 785 I=1,22                                                      AD 04610
      WRITE(6,886)(P4(N,I,J),J=1,18)                                     AD 04620
  886 FORMAT(2X,18F7.3,/)                                                AD 04630
  786 FORMAT(2X,18F7.0,/)                                                AD 04640
  752   FORMAT(2X,18F7.2,/)                                              AD 04650
  785 CONTINUE                                                           AD 04660
C                                                                        AD 04670
CCC       FORMAT STATEMENTS                                              AD 04680
C                                                                        AD 04690
  900   FORMAT(2A,I4,2X,4E14.7,2X,E14.7,/)                               AD 04700
  904     FORMAT(8E10.4)                                                 AD 04710
  907     FORMAT(2X,I5,F10.2)                                            AD 04720
  908     FORMAT(2X,I5,2F10.2)                                           AD 04730
  902     FORMAT(2X,18F5.0)                                              AD 04740
C 901     FORMAT(E10.4)                                                  AD 04750
  910     FORMAT(2X,20I3)                                                AD 04760
  911     FORMAT('1',19X,' RICE IRRIGATION PUMPING IN ACRE-FT.  ',/////) AD 04770
  912     FORMAT('1',19X,'  SOYBEAN IRRIGATION PUMPING IN ACRE-FT.',////)AD 04780
  914     FORMAT('1',19X,' INITIAL AQUACULTURAL PUMPING IN ACRE-FT.',///)AD 04790
  916     FORMAT('1',19X,'ADDITIONAL AQUACULTURAL PUMPING IN ACRE-FT.',/)AD 04800
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  918    FORMAT('1',19X,'TOTAL AQUACULTURAL PUMPING IN ACRE-FT.',//////)AD 04810
  920    FORMAT('1',19X,'      TOTAL PUMPING IN CUBIC FT.    ',//////)  AD 04820
  925    FORMAT(15X,'                    COUNTY                    ',/) AD 04830
  930    FORMAT(/,2X,'YEAR       ARKANSAS       LONOKE          MONROE  AD 04840
     *  PRAIR          TOTAL ',/)                                       AD 04850
  940    FORMAT(2X,I4,13,E14.7)                                         AD 04860
C                                                                       AD 04870
C                                                                       AD 04880
C      ***************************************************************  AD 04890
C                                                                       AD 04900
C                                                                       AD 04910
       STOP                                                             AD 04920
       END                                                              AD 04930
```

APPENDIX D

ST-1054 STATE OF ARKANSAS

REPORT OF WATER WELL CONSTRUCTION

New Well X Work-over Well ..... Replacement Well .....

Owner of Well J. J. Jones

Well Contractor Layne Arkansas Company SE¼

Contractor License No. C-1099

Driller Name and No. Harvey 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'
4. Gallons per Hour 78000
5. Well Disinfected with HTH
6. Casing to 542 Ft.
7. Cased with 12" Diameter .250 Casing
8. Cemented from 0 Ft. to 542 Ft.
9. Use of Well: Domestic Irrigation Municipal X Other

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

County Arkansas (in which well is located)

Well is near ..... Road

Section 5 Township 2S Range 5W

Directions for Reaching Well: On North side of his farm (use permanent landmarks)

about 3 miles North of town

Description and Color of Formation (sand, shale, sandstone, etc.)	Depths from	in feet to
"See Attached Sheet"		

Remarks:

Signed: Hal Kennedy Date: 5/16/79

Form No. AWD-2

Mail to: Committee on Water Well Construction, 2915 So. Pine Street, Little Rock, Arkansas 72204

Geology Copy

TOTAL DEPTH	THICKNESS EACH STRATUM	FORMATION
35	35	Red Sandy Clay
70	35	Red Clay
100	30	Fine Sand
136	36	Coarse Sand&Gravel
235	99	Gumbo
236	1	Rock
244	8	Gumbo
245	1	Rock
280	35	Gumbo
295	15	Fine Sand & Stks. of Shale
369	74	Gumbo
445	76	Sandy Shale
522	77	Gumbo
547	25	Fine Sand
633	86	Medium Sand
648	15	Gumbo
670	22	Sandy Shale