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Evaluation and Accessing of Data for a Water Resources Simulator

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Research Project Technical Completion Report A-060-ARK

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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.

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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 <u>all</u> strata and their <u>color</u>, and the quarter section in which the well is located were included in <u>all</u> 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)

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

= 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.

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

137

ENCLOSED IS CHECK OF $25.00 FOR 1979 RENEWAL OF

FF 25.00

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) ....

APPENDIX C

Program Which Estimates Cell by Cell Water Needs

```
C
C
C                               NAME: ADSIMPUM FORTRAN A
C
C       CALCULATES THE AMOUNT OF PUMPING FROM THE QUATERNARY
C AQUIFER IN THE GRAND PRAIRIE REGION. ONLY CONSIDERING RICE AND
C SOYBEAN ACREAGE (REPORTED FOR EACH COUNTY).
C
C
C         DATA REQUIRED IS IN:
C               --ADSIMPUM DATA A--
C
C           THE FILE TO EXECUTE THIS PROGRAM IS UNDER THE NAME OF
C            --ADSIMPUM EXEC A--
C
      DIMENSION JLEFT(26), JRIGHT(26), FEMP(26,18)
      DIMENSION NJLEFT(26),NJRIT(26)
      DIMENSION NLL(26), NRR(26)
      DIMENSION TAGAC(4), SHWE(4)
      DIMENSION RAGA(10,4), SAGA(10,4), RIR(10), SIR(10)
      DIMENSION ICOUN(26,18), ACRE(26,18), RMWA(26,18)
      DIMENSION RAQUA(26,18)
      DIMENSION RAX(10,4), RBY(10,4), CAXBY(10,4), SUM(10,4)
      DIMENSION SUMT(10) , QN(10,240) , P5(10,4), P6(10,4)
      DIMENSION TAQ(10,4), TAQI(10,4), TAQII(10,4)
      DIMENSION ADAQUA(10,26,18)
      DIMENSION EMPREC(26,18)
C
C
C
C
      DATA QN/2400*0./
      DATA FEMP/468*0./
      DIMENSION TP(10,4)
      DIMENSION P(10,26,18), P2(10,26,18), P3(10,26,18)
      DIMENSION P4(10,26,18)
      DIMENSION QNEW(10,30,8)
      DATA TAGAC/4*0./, SHWE/4*0./
      DATA RAGA/40*0./, SAGA/40*0./, RIR/10*0./, SIR/10*0./
      DATA RAX/40*0./, RBY/40*0./, CAXBY/40*0./, SUM/40*0./
      DATA P5/40*0./,P6/40*0./ ,TAQ/40*0./,TAQI/40*0./,TAQII/40*0./
      DATA ACRE/468*0./, RMWA/468*0./, TP/40*0./
      DATA RAQUA/468*0./
      DATA SUMT/10*0./
      DATA P/4680*0./,  QNEW/2400*0./ , P2/4680*0./
      DATA P3/4680*0./ , P4/4680*0./
      DATA ICOUN/468*2000/
      DATA ADAQUA/4680*0./
```

```
      DATA EMPREC/468*0./
C
C     ************************************************************
C
C     READ STATEMENTS
C
C
C     BOUNDARIES -- FOR ENTIRE MODEL --
C
      DO 100 I=6,21
      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
```

```
C
C       READ IN THE IRRIGATION REQUIREMENTS FOR RICE FOR EACH YEAR (IN.)
C
        DO 180 N=1,10
        READ(5,*)RIR(N)
 180    CONTINUE
C
C
C       READ IN THE IRRIGATION REQUIREMENTS FOR SOYBEANS PER YEAR (IN.)
C
        DO 190 N=1,10
        READ(5,*)SIR(N)
 190    CONTINUE
C
C
C       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
C
C
C*****************************************************
C       DO 210 I=2,21
C        WRITE(6,910)(ICOUN(I,J),J=1,17)
C 210     CONTINUE
C****************************************************
C
C       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
C
C       READ IN THE PERCENTAGE OF AGRICULTURAL WATER COMING FROM
C       PUMPING OF THE QUATERNARY AQUIFER
C
        READ(5,*)(SHWE(L),L=1,4)
C
C
C       READ IN THE MUNICIPAL WATER USE BY LOCATION  (AC.-FT.)
C
```

```
C      THE CELL NUMBERS FOR READING IN THE MUNICIPAL WATER USE
C     ARE THE I AND J VALUES
C
C
        DO 350 NUMB=1,9
        READ(5,*)I,J
        READ(5,*)RMWA(I,J)
 350    CONTINUE
C
C
C       READ IN THE VALUE FOR THE TOTAL AQUACULTURAL WATER REQUIREMENT
C              (BY CELL NUMBER AS ABOVE) THIS NUMBER WILL BE MULTIPLIED
C              BY 0.9 BECAUSE 90% OF THE WATER COMES FROM THE
C              QUATERNARY AQUIFER.     ..........(AC.-FT.)
          DO 360 NUM=1,24
          READ(5,*)I,J
          READ(5,*)RAQUA(I,J)
          RAQUA(I,J)=0.9*RAQUA(I,J)*1.00
 360     CONTINUE
C
C
C
C      *****************************************************************
C
C                      ADDITIONAL INPUT (RECHARGE & AQUACULTURE)
C
C
C               ADAQUA(K,I,J)  ADDITIONAL AQUACULTURAL PUMPING (AC.-FT.)
C                                   K  IS THE YEAR
C
C               EMPREC(I,J)    EMPIRICAL RECHARGE CONSTANT
C                              (CUBIC FT.)/YEAR X (10 TO THE 7TH.)
C
           DO 365 NUM2=1,13
                READ(5,*)I,J,FEMP(I,J)
                EMPREC(I,J)=FEMP(I,J)*(10**7)
 365       CONTINUE
C
C
           DO 367 NUM3=1,17
                READ(5,*)I,J,ADAQUA(6,I,J)
          ADAQUA(6,I,J)=ADAQUA(6,I,J)*1.00
                    DO 366 NY=7,10
                    ADAQUA(NY,I,J)=ADAQUA(6,I,J)
 366                CONTINUE
 367       CONTINUE
C
C
```

```
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: CA -(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
```

APPENDIX C

(Continued)

```
C       TOTAL AQUACULTURAL PUMPING IS TAQ(N,L)
        TAQ(N,L)=RAQUA(I,J)+ADAQUA(N,I,J)+TAQ(N,L)
C
C       TP(N,L) IS THE PUMPING FOR THE COUNTY
C
        TP(N,L)=P(N,I,J)
C
C       SUM(N,L) IS THE TOTAL PUMPING FOR EACH COUNTY
        SUM(N,L)=SUM(N,L)+TP(N,L)
 480     CONTINUE
C
C        SUMT(N) IS THE TOTAL PUMPING FOR THE YEAR (ACRE FEET)
         SUMT(N)=SUMT(N)+SUM(N,L)
 490     CONTINUE
C     THE NEXT THREE STATEMENTS ADDED 3/3/83.
C     THEY ADD RECHARGE TO THE THREE CELLS INCLUDED.
C     THE RECHARGE IS THE AVERAGE OF THE STEADY STATE PUMPING VALUES
C           FROM THE OUTPUT OF 11/15/82.
        P(N,18,11)=P(N,18,11)-61355000.
        P(N,19,12)=P(N,19,12)-16103000.
        P(N,21,13)=P(N,21,13)-202140000.
 500     CONTINUE
C
C        ***************************************************
C
C        THIS NEXT PART WAS ADDED TO WRITE OUT THE PUMPING IN A
C        FORMAT WHICH SIMULAT MUST READ IT
C
         DO 590 N=1,10
           ICO=1
         DO 570 I=1,22
         LL=NJLEFT(I)
         LR=NJRIT(I)
         DO 550 J=LL,LR
         QN(N,ICO)=P(N,I,J)
C          WRITE(6,907)(ICO,QN(N,ICO))
            ICO=ICO+1
 550      CONTINUE
 570      CONTINUE
 590      CONTINUE
          DO 595 N=1,10
           ICO=0
          DO 594 I=1,26
          DO 592 J=1,8
           ICO=ICO + 1
           QNEW(N,I,J)=QN(N,ICO)
C          WRITE(6,908)(ICO,QNEW(N,I,J),QN(N,ICO))
 592         CONTINUE
```

```
  594      CONTINUE
  595      CONTINUE
        DO 598 N=1,10
        DO 597 I=1,26
        WRITE(7,904)(QNEW(N,I,J),J=1,8)
  597      CONTINUE
  598      CONTINUE
C
C       ***********************************************
C       ***********************************************
C
C      WRITING OUT THE SUM OF THE PUMPING FOR EACH COUNTY BY YEAR
C      FOR THE TOTAL PUMPING, THE PUMPING FOR RICE IRRIGATION,
C      AND THE PUMPING FOR SOYBEAN IRRIGATION
C
      DO 620 K2=1,6
      IYEAR=1971
      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(6,920)
      GO TO 612
  600 WRITE(6,911)
      GO TO 612
  602 WRITE(6,912)
      GO TO 612
  604 WRITE(6,914)
      GO TO 612
  606 WRITE(6,916)
      GO TO 612
  608 WRITE(6,918)
  612 WRITE(6,925)
      WRITE(6,930)
      DO 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),SUMT(N))
      GO TO 618
  613 WRITE(6,900)(IYEAR,(P5(N,L),L=1,4))
      GO TO 618
  614 WRITE(6,900)(IYEAR,(P6(N,L),L=1,4))
      GO TO 618
```

```
615  WRITE(6,900)(IYEAR,(TAQI(N,L),L=1,4))
     GO TO 618
616  WRITE(6,900)(IYEAR,(TAQII(N,L),L=1,4))
     GO TO 618
617  WRITE(6,900)(IYEAR,(TAQ(N,L),L=1,4))
618   CONTINUE
620   CONTINUE
C
C
C         ************************************************************
C
C         THE NEXT STATEMENTS ARE ONLY TO CREATE THE SAME
C         DATA INTO A FILE THAT CAN BE USE BY SAS.
C
C        DO 700 N=1,10
C            DO 690 L=1,4
CC           WRITE(6,940)N,L,SUM(N,L)
C 690          CONTINUE
C 700     CONTINUE
C
C
C         ************************************************************
C
C
C        THIS PART ADDED 8/25/82 TO WRITE THE WATER USE IN MAP FORM
C
C   A:   AGRICULTURAL LAND, IN ACRES
     DO 720 I=1,22
     DO 720 J=1,18
     ACRE(I,J)=ACRE(I,J)*247.11
720  CONTINUE
     WRITE(6,721)
721  FORMAT(/,'1',20X,'AGRICULTURAL LAND USE CELL BY CELL, AC.',/)
     DO 722 I=1,22
     WRITE(6,764)(ACRE(I,J),J=1,18)
722  CONTINUE
724  FORMAT(2X,18F7.0,/)
C
C
C
C
C   A2: PUMPING DUE TO AGRICULTURE, ACRE-FT
C
727  FORMAT('1',20X,'PUMPING DUE TO AGRICULTURE, ACRE-FT',3X,I5,//)
     DO 728 N=1,10
       IYEAR=1971+N
     WRITE(6,72?)IYEAR
791  FORMAT(///////////,20X,'YEAR = ',I4,//)
```

```
      DO 728 I=1,22
      WRITE(6,729)(P2(N,I,J),J=1,18)
  728 CONTINUE
  729 FORMAT(2X,18F7.0,/)
C
C
C
C
C  B:  MUNICIPAL WATER USE, ACRE-FT
C
      WRITE(6,731)
  731 FORMAT('1',20X,'MUNICIPAL WATER USE, ACRE-FT',//)
      DO 732 I=1,22
      WRITE(6,734)(RMWA(I,J),J=1,18)
  732 CONTINUE
  734 FORMAT(2X,18F7.0,/)
C
C
C
C
C
C  C:  AQUACULTURAL WATER USE, ACRE-FT
C
C
      WRITE(6,741)
  741 FORMAT('1',20X,'AQUACULTURAL PUMPING, ACRE-FT',//)
      DO 740 I=1,22
      WRITE(6,744)(RAQUA(I,J),J=1,18)
  740 CONTINUE
  744 FORMAT(2X,18F7.0,/)
C
C
C
C          ADDITIONAL INPUT
C
           WRITE(6,747)
           DO 746 I=1,22
           WRITE(6,786)(ADAQUA(6,I,J),J=1,18)
 746       CONTINUE
C
C
           WRITE(6,748)
           DO 749 I=1,22
           WRITE(6,752)(FEMP(I,J),J=1,18)
 749       CONTINUE
C
C
 747       FORMAT('1',10X,'ADDITIONAL AQUACULTURAL PUMPING 1977-1981 ACRE
```

```
     * FT. ',//)
 748       FORMAT('1',10X,'EMPIRICAL RECHARGE CONSTANT EVERY YEAR',5X,'IN
     * (CUBIC FT.) X (10 TO THE 7TH. ',//)
C
C
C
C   D:  TOTAL PUMPING CELL BY CELL, ACRE-FT
C
C     WRITE(6,753)
C 753 FORMAT('1',20X,'TOTAL PUMPING CELL BY CELL',//)
      DO 751  N=1,10
          IYEAR=1971+N
      WRITE(6,756)IYEAR
      DO 750 I=1,22
      WRITE(6,755)(P3(N,I,J),J=1,18)
  750 CONTINUE
  751 CONTINUE
  755 FORMAT(2X,18F7.0,/)
  756 FORMAT('1',15X,'TOTAL PUMPING CELL BY CELL IN (AC FT)',3X,I6,//)
C
C
C
C
C
      DO 785 N=1,10
      IYEAR=1971+N
      WRITE(6,787)(IYEAR)
  787 FORMAT('1',5X,'TOTAL PUMPING IN FT. PER CELL  YEAR = ',I4,//)
      DO 785 I=1,22
      WRITE(6,886)(P4(N,I,J),J=1,18)
  886 FORMAT(2X,18F7.3,/)
  786 FORMAT(2X,18F7.0,/)
 752    FORMAT(2X,18F7.2,/)
  785 CONTINUE
C
C       FORMAT STATEMENTS
C
  900    FORMAT(2X,I4,2X,4E14.7,2X,E14.7,/)
 904       FORMAT(6E10.4)
 907       FORMAT(2X,I5,F10.2)
 906       FORMAT(2X,I5,2F10.2)
 902       FORMAT(2X,18F5.0)
C 901       FORMAT(E10.4)
  910      FORMAT(2X,20I3)
  911      FORMAT('1',19X,' RICE IRRIGATION PUMPING IN ACRE-FT.   ',/////)
  912      FORMAT('1',19X,'  SOYBEAN IRRIGATION PUMPING IN ACRE-FT.',////)
  914      FORMAT('1',19X,' INITIAL AQUACULTURAL PUMPING IN ACRE-FT.',///)
  916      FORMAT('1',19X,'ADDITIONAL AQUACULTURAL PUMPING IN ACRE-FT.',/)
```

```
 918     FORMAT('1',19X,'TOTAL AQUACULTURAL PUMPING IN ACRE-FT.',//////)
 920     FORMAT('1',19X,'      TOTAL PUMPING IN CUBIC FT.    ',/////)
 925     FORMAT(15X,'                     COUNTY                  ',/)
 930     FORMAT(/,2X,'YEAR      ARKANSAS      LONOKE        MONROE
     *  PRARIE         TOTAL ',/)
 940     FORMAT(2X,I4,I3,E14.7)
C
C
C       ****************************************************************
C
C
      STOP
      END
```

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 X Municipal ..... 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 about 3 miles North of town (use permanent landmarks)

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

Remarks: ......

Signed: [signature] 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