

**KANSAS GEOLOGICAL SURVEY
OPEN-FILE REPORT 95-53**

Republican River Stream/Aquifer Study:
Model Development and Application

1995 KWO Year-end Progress Report to KWO

by

M.A. Sophocleous
S.P. Perkins
S. Moustakas
R. Kaushal

Disclaimer

The Kansas Geological Survey does not guarantee this document to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations based on data used in the production of this document or decisions based thereon. This report is intended to make results of research available at the earliest possible date, but is not intended to constitute final or formal publications.

Kansas Geological Survey
1930 Constant Avenue
University of Kansas
Lawrence, KS 66047-3726

**Republican River Stream/Aquifer Study:
Model Development and Application**

1995 Year-end Progress Report to KWO

Sophocleous, M.A., Perkins, S.P., Moustakas, S., and Kaushal, R.

Kansas Geological Survey, Open-File Report 95-53

September 1995

Lawrence, KS

**Republican River Stream/Aquifer Study:
Model Development and Application
1995 Year-end Progress Report to KWO**
Sophocleous, M.A., Perkins, S.P., Moustakas, S., and Kaushal, R.
Kansas Geological Survey, Open-File Report 95-53, Sept. 1995

Report Outline

1. Abstract
2. Introduction and study purpose
3. Summary of work and findings from the first year of study
4. Specific tasks for the second year of study
5. Preliminary results
 - I. Objective 1: Stream-aquifer model implementaton
 - a. Introduction to MODFLOW
 - b. MODFLOW input data requirements
 - c. Lower Republican River basin stream-aquifer model-related deficiencies
 - d. Ground-water level survey
 - e. MODFLOW model grid design
 - f. Boundary conditions for stream-aquifer model
 - g. MODFLOW input data preparation
 - h. Initial MODFLOW runs
 - i) Input and parameter estimation
 - ii) Preliminary equilibrium water budget for the Lower Republican River Valley
 - iii) 1976-77 to 1994 MODFLOW transient simulations
 - II. Objective 2: Combine watershed and stream-aquifer models
 - a. Linking SWAT and MODFLOW
 - b. Testing the linked SWAT-MODFLOW model on the Lower Republican River basin
 - III. Objective 3: Refine and calibrate the combined model
 - a. Additional subbasins
 - b. Updating soils information
 - c. Combined SWAT-MODFLOW simulations
6. References
7. Appendices
 - Appendix A. November 1994 ground-water level survey data
 - Appendix B. Water rights and record numbers displayed in Fig. 9
 - B1: Updated ground-water and surface water rights in the active MODFLOW-simulated area.
 - B2: Reported water use data for the MODFLOW-simulated area.
 - Appendix C. Testing the combined model with simplified test cases.
 - C1: MODSWB input file for the Y7 watershed case
 - C2: Summary output for Y7 watershed test cases using the combined SWAT-MODFLOW model

1. Abstract

A comprehensive watershed model that can handle distributed stream-aquifer interaction processes has been developed by KGS and is now being implemented in the lower Republican River basin between Concordia and Clay Center, KS. The purpose of this comprehensive model is to evaluate the impacts of ground-water-based irrigation, land use, and climate on the Republican River streamflows between Concordia and Clay Center, which have been declining since 1988. Initial results indicate that the combined stream-aquifer/watershed model is able to reproduce observed streamflows during both dry and wet years fairly well. Ground-water simulations indicate that no significant ground-water level declines have been indicated, implying that surface runoff processes, affected by land use, vegetation, and climate may be the dominant factors in the study area. The model is now being calibrated, and vegetation and land use impacts are being analyzed.

2. Introduction and study purpose

Since 1988, stream flows in the Republican River have been low relative to historic levels. Low flow conditions were especially pronounced in the reach between Concordia and Clay Center, thus affecting the inflows into Milford reservoir. This reach is in an area where large ground water appropriations exist, necessitating an assessment of the impact of ground-water pumpage on streamflow. As there are competing interests for the water and finite amounts of the resource, decisions balancing ground water rights and surface water benefits must be made. The former relate to the administration of water rights for irrigation, the latter primarily to minimum streamflow standards and to desired inflows to the Milford Reservoir.

The purpose of this project is to evaluate the water budget for the Lower Republican River basin and evaluate the impact of water rights, various land uses and irrigation alternatives on streamflows in the reach between Concordia and Clay Center. The goal is to develop a comprehensive PC-based model capable of assessing the impact of selective administration of water rights on streamflows in the study area, and demonstrate its capabilities in the Lower Republican basin.

3. Summary of work and findings from the first year of study

In the first year of study (Koussis et al., 1994) we have compiled the data necessary for the analysis and modeling of the hydrologic behavior of the Lower Republican River Basin. This information has been organized in two data bases, a geographic data base and a hydrologic data base. The former has been manipulated with the GIS software package Arc/Info to provide appropriate coverages which have been displayed as maps of the quantities of interest. Estimates

of several hydrologic modeling parameters have been developed by additional mathematical manipulations of these data.

After careful screening of the field of basin-scale hydrologic models, we have selected the Soil and Water Assessment Tool model (SWAT; Arnold et al., 1994) for this study. SWAT is, largely (but not completely), a physically-based model. In addition to the parameters of the model that could be determined directly from measurements of the physical properties of the basin, we have estimated the remaining parameters indirectly by using hydrologic judgment, and directly by comparing the model's predictions with the streamflow record.

We have performed a rather comprehensive sensitivity analysis using data for the period 1986-1990. We have found that the water stress factor, a measure of irrigation scheduling, affects basin yield most strongly, followed by landuse (crop type) and the SCS curve number. The model was found to be insensitive to ground water-related parameters. However, we found the ground-water processes handling by the SWAT model to be overly simplistic. From the modeling results we conclude that the most sensitive parameters, water stress factor and landuse, should be time-variable (at least annually), not constant during the simulation. The model's performance may be also judged reasonable based on the analysis of the basin-wide storage balance, as well as the separate storage balances for the soil profile and for the shallow aquifer. The dominant terms of the overall balance are found to be evapotranspiration and water yield. Water yield is a composite quantity dominated by surface runoff, which is significantly impacted by land use. This set of initial results are encouraging.

4. Specific tasks for the second year of study

The study objectives for the second year are to:

- 1) compile all necessary data required to develop and apply a distributed stream-aquifer model for the Republican River valley between Concordia and Clay Center;
- 2) combine the watershed and stream-aquifer models into a comprehensive working modeling system for the Lower Republican River basin;
- 3) refine and initially calibrate the developed model, and provide initial results of modeling the impacts of drought, land use, and irrigation pumping on streamflows.

5. Preliminary results

I. Objective 1: Stream-aquifer model

For a distributed two-dimensional stream-aquifer model, we chose the USGS MODFLOW model (McDonald and Harbaugh, 1988) as the most suitable one for our purpose.

a. Introduction to MODFLOW

MODFLOW is a mostly physically-based model, developed by combining the well known Darcy's law, governing fluid movement through saturated porous media, and the mass balance or continuity equation for subsurface flow. It is a modular three-dimensional block-centered finite difference code for layered aquifer systems. It has an exceptionally long history of use and acceptance within the modeling community. It is peer reviewed, verified and validated public domain code.

MODFLOW can represent a host of aquifer conditions including confined, unconfined, leaky, delayed yield, and variably confined/unconfined conditions. Isotropic as well as anisotropic medium can be represented in either homogeneous or heterogeneous settings. Both steady state and transient conditions can be simulated for laminar flow. The option for deactivating regions within the domain permits the modeler to model complex irregular systems with ease. All of the common boundary conditions generally encountered in practice can be accounted for by the model. These include constant head or pressures, variable or constant fluxes, time dependent head or fluxes, ground-water recharge/discharge, point withdrawals, and drains. Several processes including evapotranspiration and surface/ground water interaction can be adequately accounted for by MODFLOW. The surface water characteristics include time variability of stage/discharge in lakes, rivers, and ponds.

The choice of a number of equation-solving techniques equips MODFLOW with powerful tools for solving even the most intransigent problems encountered in the field. Solvers based on the Line Successive Over Relaxation, Strongly Implicit Procedure, Slice Successive Over Relaxation, and the Conjugate Gradient methods are included. Its core storage requirement is

only 512k, and works in expanded memory on the IBM PC/XT/AT compatible machines. Its modular structure permits ease for integrating it with other surface water models as well as Geographical Information Systems.

b. MODFLOW input data requirements

The data requirements for MODFLOW are presented in detail in table 1.

c. Lower Republican River basin stream-aquifer model-related deficiencies

A comparison of the required MODFLOW input data (Table 1) and data actually available for the Lower Republican River basin revealed a number of data deficiencies for the study. We outline here the major data deficiencies as follows.

- i) Hydrogeologic parameter data (hydraulic conductivity and storativity) are few, especially storativity values, thus causing problems in establishing an areal distribution of these parameters in a two-dimensional areal model, and also in obtaining representative average values of these parameters. Fader (1968) listed a number of hydraulic conductivity values in the Republican River area for Republic and Cloud Counties, based predominantly on specific capacity and step-drawdown tests. The average hydraulic conductivity for Cloud Co. based on 31 such tests (Fader, 1968) is 422 ft/day, which indicates that the Republican River alluvium in Cloud Co. is highly permeable. Walters and Bayne (1959) reported the results of one pump test in the Republican River valley of Clay Co. resulting in a hydraulic conductivity of 300 ft/day. Storativity values, however, are generally lacking.
- ii) Recharge amounts and distribution: Again, these data are few, especially the spatial and temporal distribution of recharge over the historic record. Initially we plan to use a certain percentage of annual precipitation in the area as the annual recharge amount. Based on our experience in south-central Kansas, a 10% of annual precipitation replenishes the aquifer as recharge. In a USGS study prepared in co-operation with the KWO (Hansen, 1991), recharge in the lower Republican River valley was also estimated as approximately 10% of average annual precipitation. Running the SWAT model also outputs recharge estimates on a continuous basis, depending on the time step used.
- iii) Ground-Water evapotranspiration(ET_g) amounts and distribution. Measured data are practically non-existent. However, the model requires only a maximum ET_g rate and

Table 1. Summary of input data required in applying MODFLOW model to Rattlesnake Creek Basin (Numerical solution-related data excluded)

BASic Module

- Number of layers, rows and columns
- Number of "stress periods" within which all external stresses are constant
- For each stress period: the length of the period and the number of time steps
- Active, inactive and constant head boundary nodes
- Initial head for each layer

OutputControl Module

- Options for printing/saving head/drawdown
- Specification of time intervals for printing/saving head/drawdown

BlockCenterFlow Module

For each layer specify:

- Steady state or transient simulation
- Layer type code: confined (0), unconfined (1), combination (2 or 3)
- Transmissivity or hydraulic conductivity depending on layer type
- Storage coefficient or specific yield depending on layer type for transient simulations
- Layer bottom elevation for certain layer types
- Leakance (vertical hydraulic conductivity divided by the thickness from a layer to a layer beneath it) if layer is not the bottom layer
- Layer top elevation for certain layer types
- Anisotropy ratio
- Grid spacing along rows and columns

ReCHarge Module

For each stress period specify spatial distribution (row, column, layer) and amount of recharge.

WELl Module

For each stress period specify layer, row, column and withdrawal rate

EVaPotranspiration Module

For each stress period specify spatial distribution (row, column, layer) of ground-water evapotranspiration (ET_g), land surface elevation, maximum ET_g rate and ET_g extinction depth

STream Module

- Number of stream segments (in which streamflow from surface sources are added at the beginning of the segment or subtracted (in the case of a diversion) at the end of the segment), stream reaches (parts of segments that correspond to individual grid cells), and tributary segments
 - Layer, row, column of each segment and reach
 - Streamflow entering the first reach of each segment
 - Stream stage for each reach in a segment
 - Streambed hydraulic conductance for each reach in a segment
 - Elevation of top and bottom of the streambed for each reach in a segment
 - Stream channel width, slope, and Manning's roughness coefficient for each reach in a segment
 - Tributaries and diversions for each segment.
-

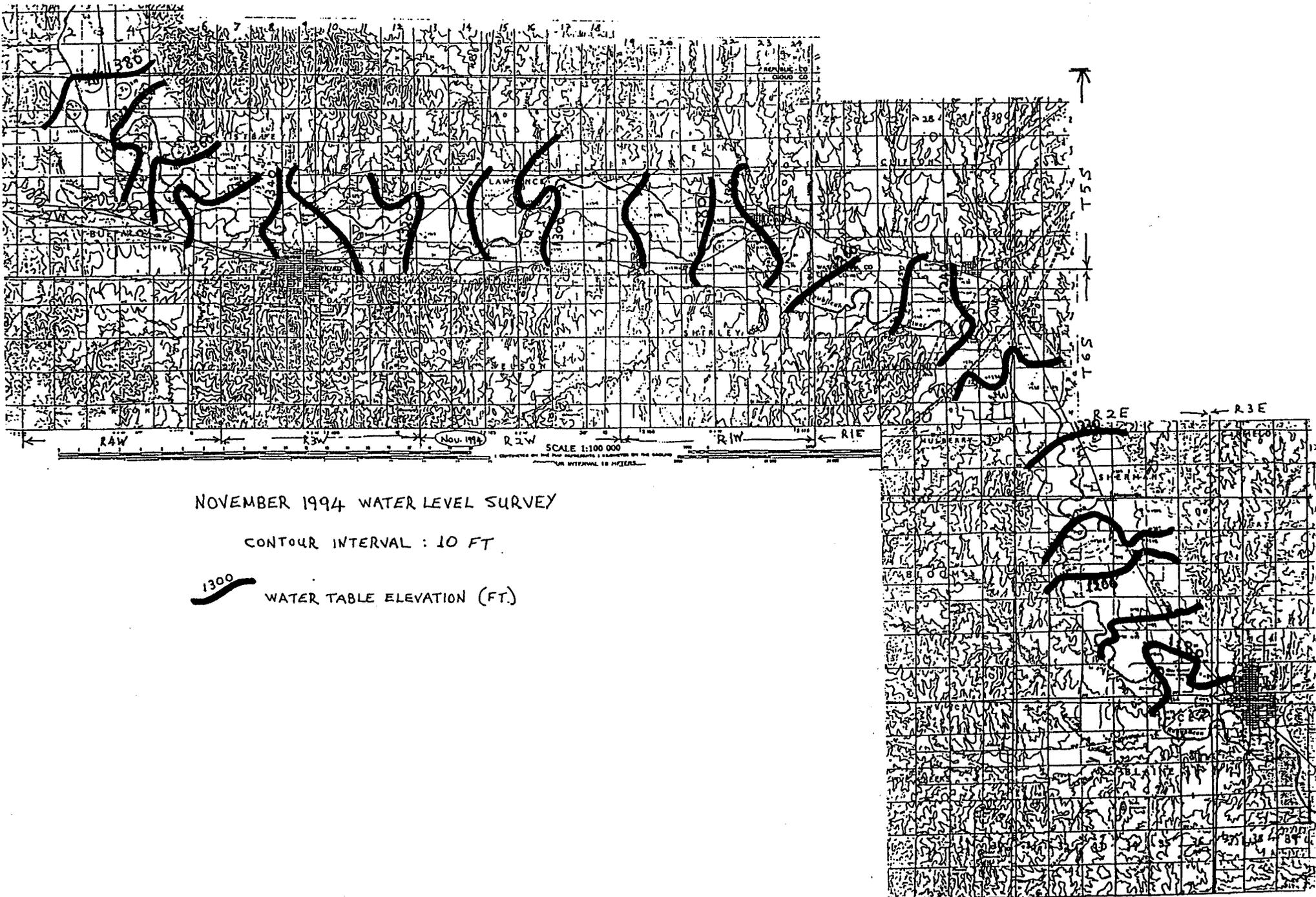
an ET_g extinction depth, which may be estimated from available information based on plant root zones. It should be noted that ET_g is active only in areas where the water table elevation is within the root zone of plants, which means that this process may affect only a small portion of the watershed.

- iv) Temporal distribution of actual pumpage in the region. SCS irrigation guides and irrigation extension offices may provide some assistance along these lines, in addition to observational experience from other local entities. From our previous modeling experience in central Kansas, we found that the amount of ground-water actually pumped for irrigation is approximately 70-80% of the appropriated amounts. An initial comparison of water rights with reported water-use information during the 1987 and 1989 through 1991 period indicated that reported water use varied from year to year depending on whether it was a dry or wet year, but it averaged at approximately 71% in the study area.
- v) Streambed thickness and hydraulic properties (streambed conductance). Data along these lines are lacking, not only in the study area, but also across the U.S. Previous modeling studies in south-central Kansas indicated that these data may not be critical (not very sensitive) to modeling results.
- vi) Tributary streamflows: Data on tributary streamflows are lacking. We will be relying on SWAT model runs to estimate the surface runoff from each tributary subbasin.
- vii) Water table data at different years since major irrigation development took place are lacking. The last water-level survey available was the spring 1977 survey resulting in a water table map presented in Dunlap (1982), which we employed as our initial condition for MODFLOW simulations.

Through sensitivity analysis we plan to bracket the range and impact of the above-mentioned data deficiencies on the project results.

d. Ground-water level survey

Recognizing the lack of water level data, we organized and carried out a water level survey in the lower Republican River basin between Concordia and Clay Center during the week of November 7-11, 1994. We measured 80 alluvial wells distributed throughout the valley as shown in Fig. 1, and the results are plotted and contoured in Fig. 2. A table of the measured data is presented in Appendix A. During the water level measurement survey, we encountered Mr. Wilber Taddiken of Clay Center, who collected and made available to us monthly water levels of his wells in the Republican River valley near Clifton since 1991. We plotted these data in Fig. 3, where the impact of the 1993 flood on ground-water levels is clearly visible.



NOVEMBER 1994 WATER LEVEL SURVEY

CONTOUR INTERVAL : 10 FT

1300
WATER TABLE ELEVATION (FT.)

Well depth to water measurements made by Wilbur Taddiken

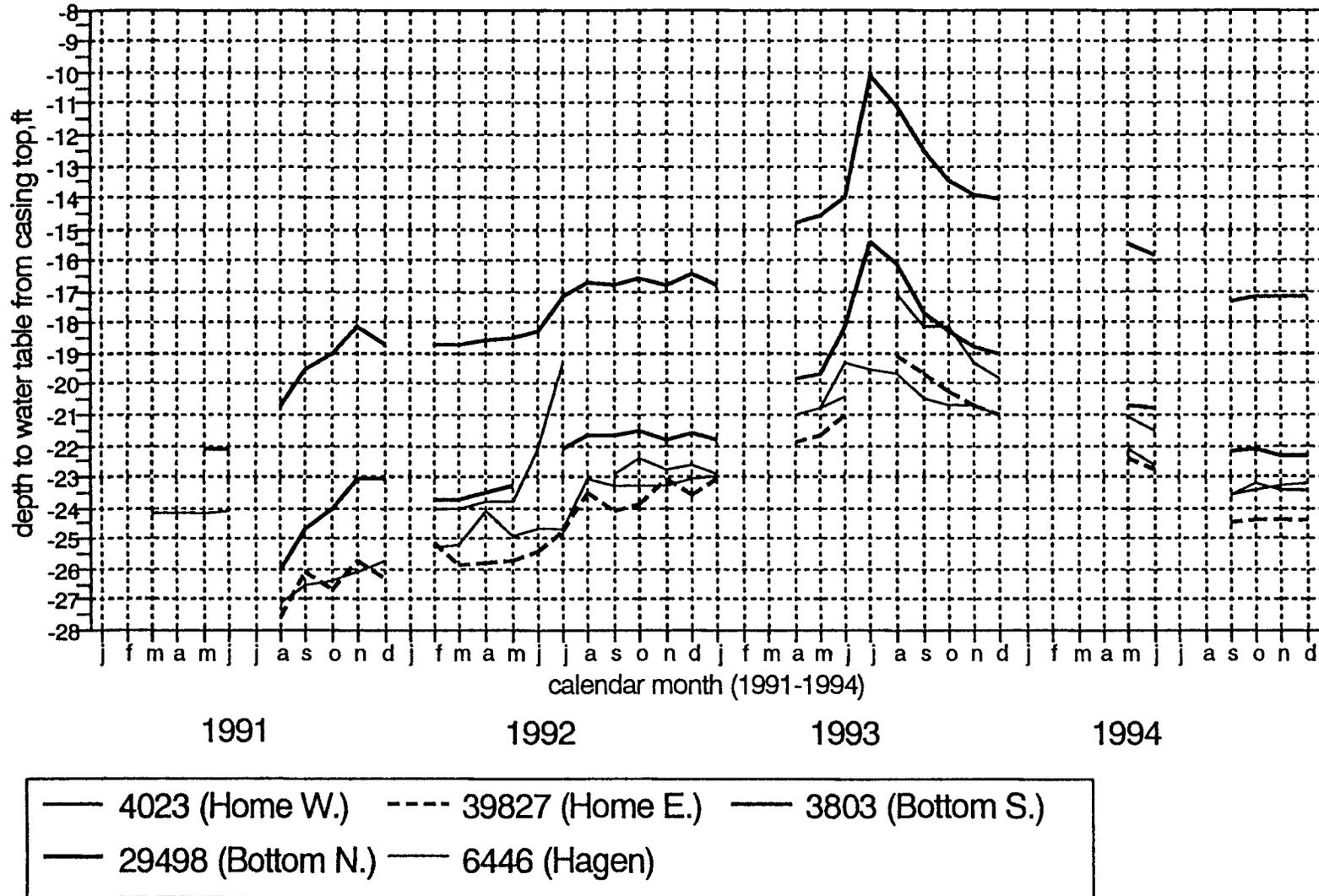


Figure 3

e. MODFLOW model grid design

For this study we adopted a uniform 1 mi x 1 mi square grid for the Lower Republican River alluvial aquifer between Concordia and Clay Center. Such a grid resulted in a 23 rows by 39 columns square mesh covering the study area. Fig. 4 depicts this grid.

f. Boundary conditions for stream-aquifer model

The Republican River alluvial valley walls are being simulated as no flow boundaries. The upstream end of the simulated region north-west of Concordia, and the downstream end near Clay Center and Milford reservoir are being simulated as constant head boundaries.

g. MODFLOW input data preparation

The ARC/INFO GIS data base developed for this study proved to be extremely useful in our MODFLOW simulations as well. By superimposing the MODFLOW grid (1 mi x 1 mi square mesh) on the various data coverages, we were able to extract most MODFLOW required data quickly, accurately, and efficiently. A utility module named REGRID was programmed to read the GIS output files containing the grid cell indices, location (latitude and longitude), and elevations (water level, bedrock, ground surface) and set up appropriate MODFLOW input files. Figs. 5 through 8 depict the grid values extracted through the GIS system for bedrock elevations, 1977 water table elevations, land surface elevations, and spring 1977 aquifer saturated thickness, respectively. Fig. 4 also displays GIS-derived stream lengths and slopes.

Another utility module (WRBASIN) was also programmed to read legal locations of water rights appropriations and convert them to the appropriate locations on the grid as required for MODFLOW's WELL module input file. Appendix B lists ground-water (file WR_GR) and surface water (file WR_SURF) rights ordered by grid row. For each water right, a file record shows the water-right application number, legal location, cell ID assigned by ARC-INFO grid coordinates (row, column), appropriated and reported use quantities (acre-feet/yr), and record number. Fig. 9 displays ground-water and surface water rights superimposed on the MODFLOW grid, identifying water rights by record number of the files in Appendix B. The record numbers for the water rights displayed in Fig. 9 are tabulated in Appendix B together with the corresponding water rights information. These data are currently being updated as per DWR's newly revised computerized and reformatted water rights data. Appendix B1 tabulates these updated ground-water and surface water data, and also displays graphs of cumulative ground-water and surface water rights (fig. B1), as well as their spatial location within the MODFLOW finite-difference grid (figs. B2—ground-water rights, and B3—surface water rights). Recently received reported water use data from 1980 to 1993 have been processed in Appendix B2 under the heading "afu_yr" (acre-ft used for each particular year).

Slope and Elevation

Lower Republican Basin

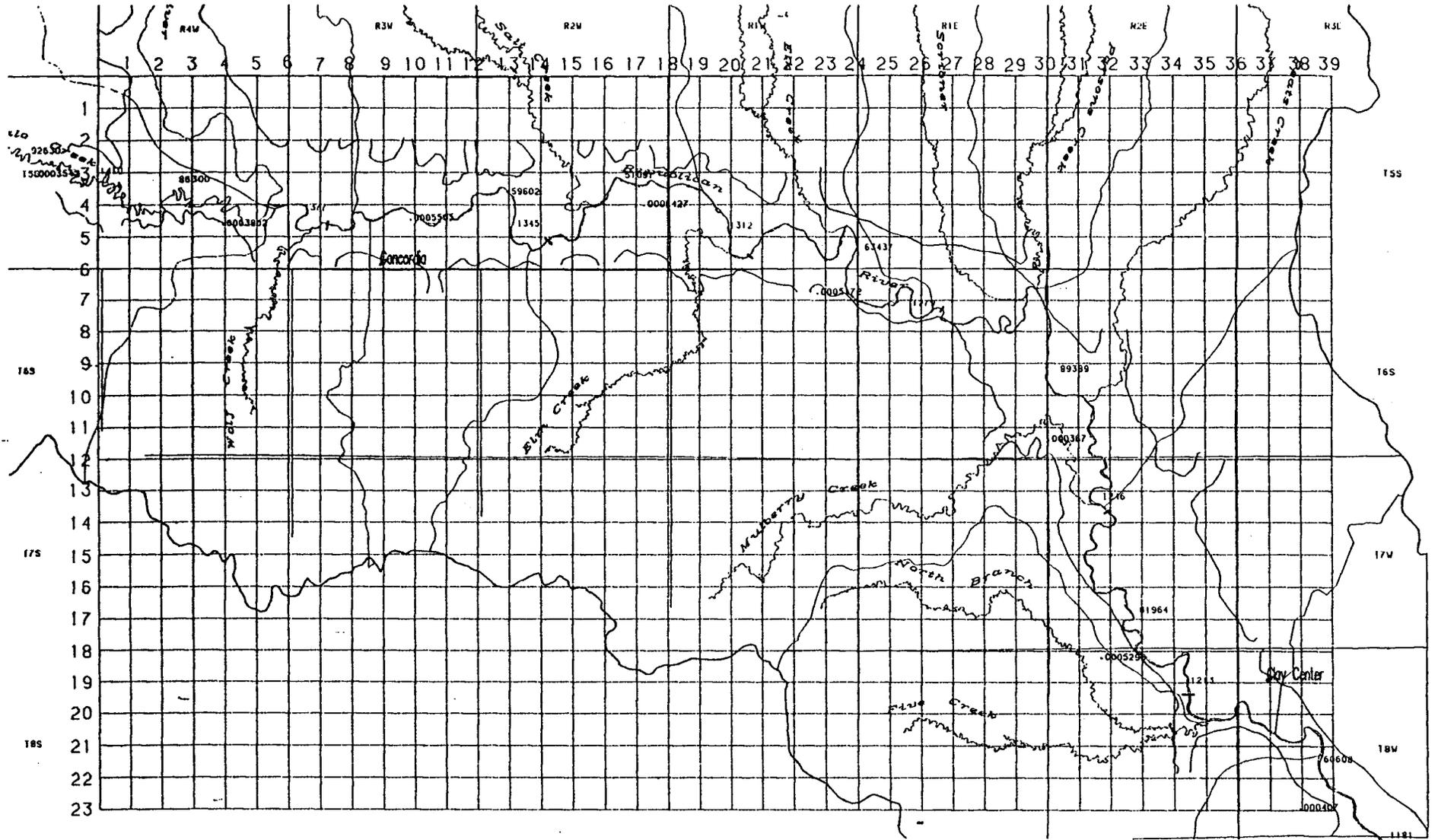
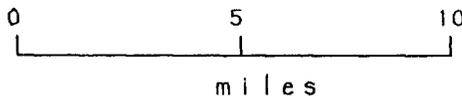


Figure 4



2:26 PM
2/20/00 1:13

Republican R grid: bedrock elevation(ft) May 17, 1995)

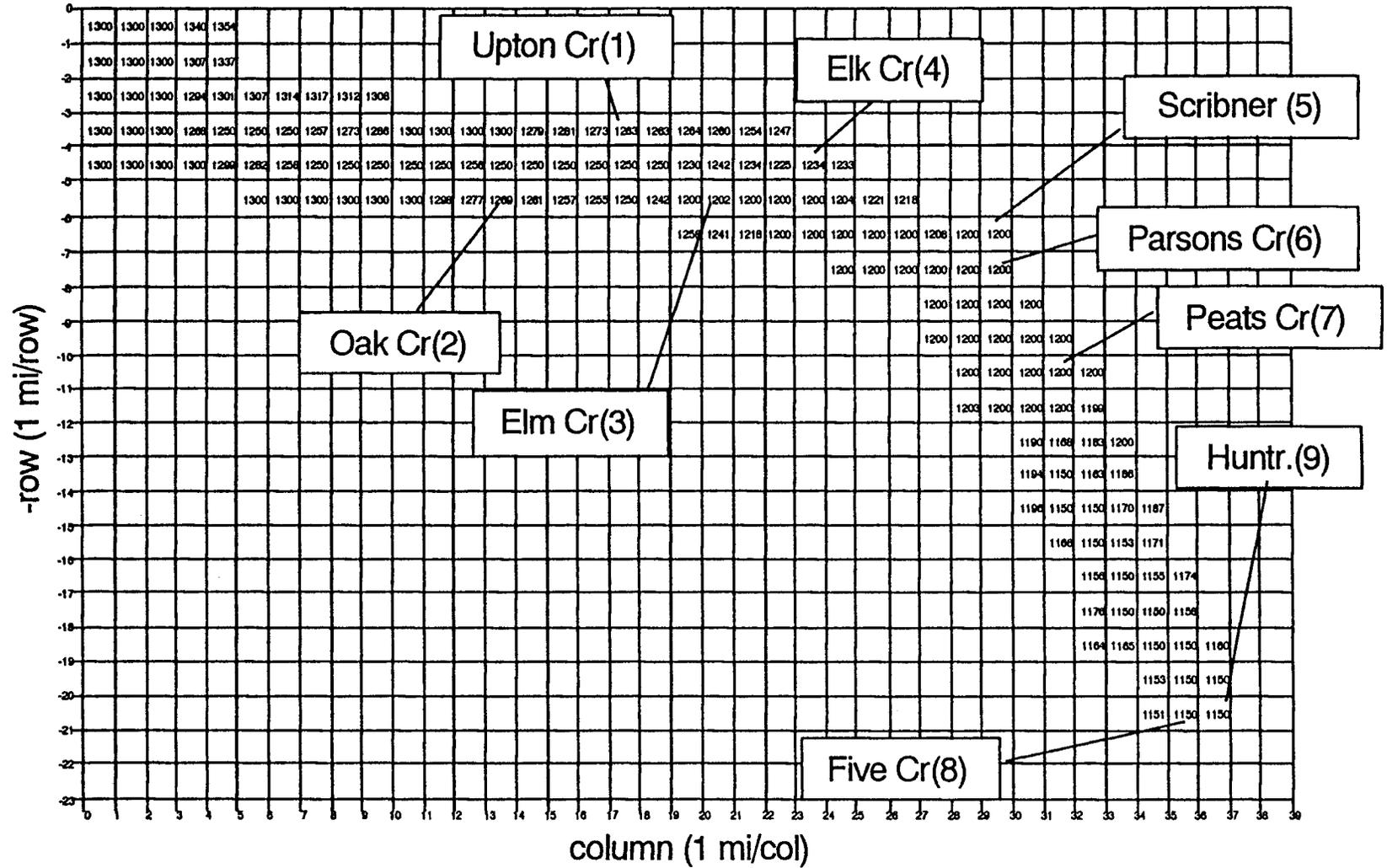


Figure 5

Republican R grid: water level (ft) May 17, 1995

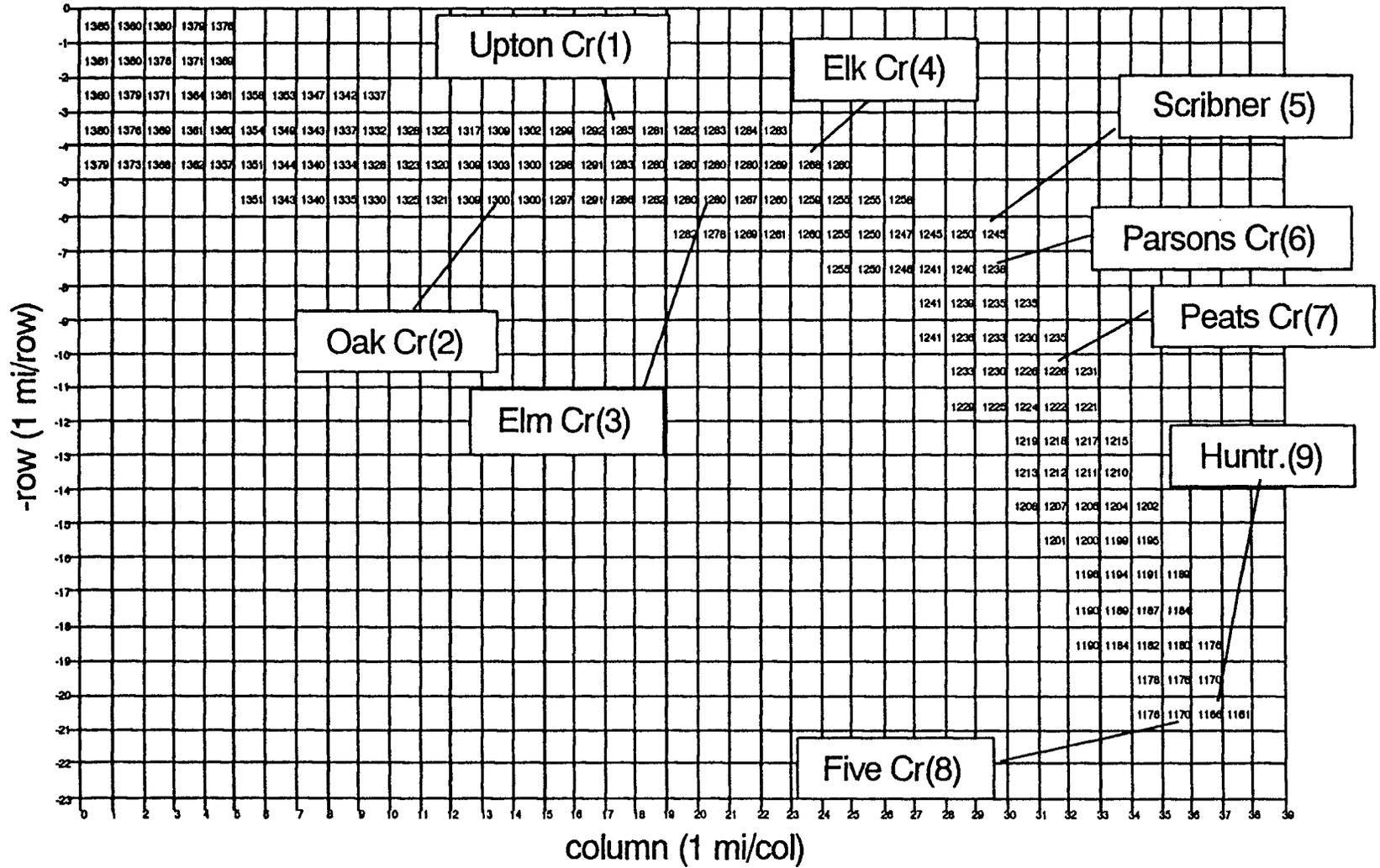


Figure 6

Republican R grid: ground surface elevation(ft) May 22, 1995)

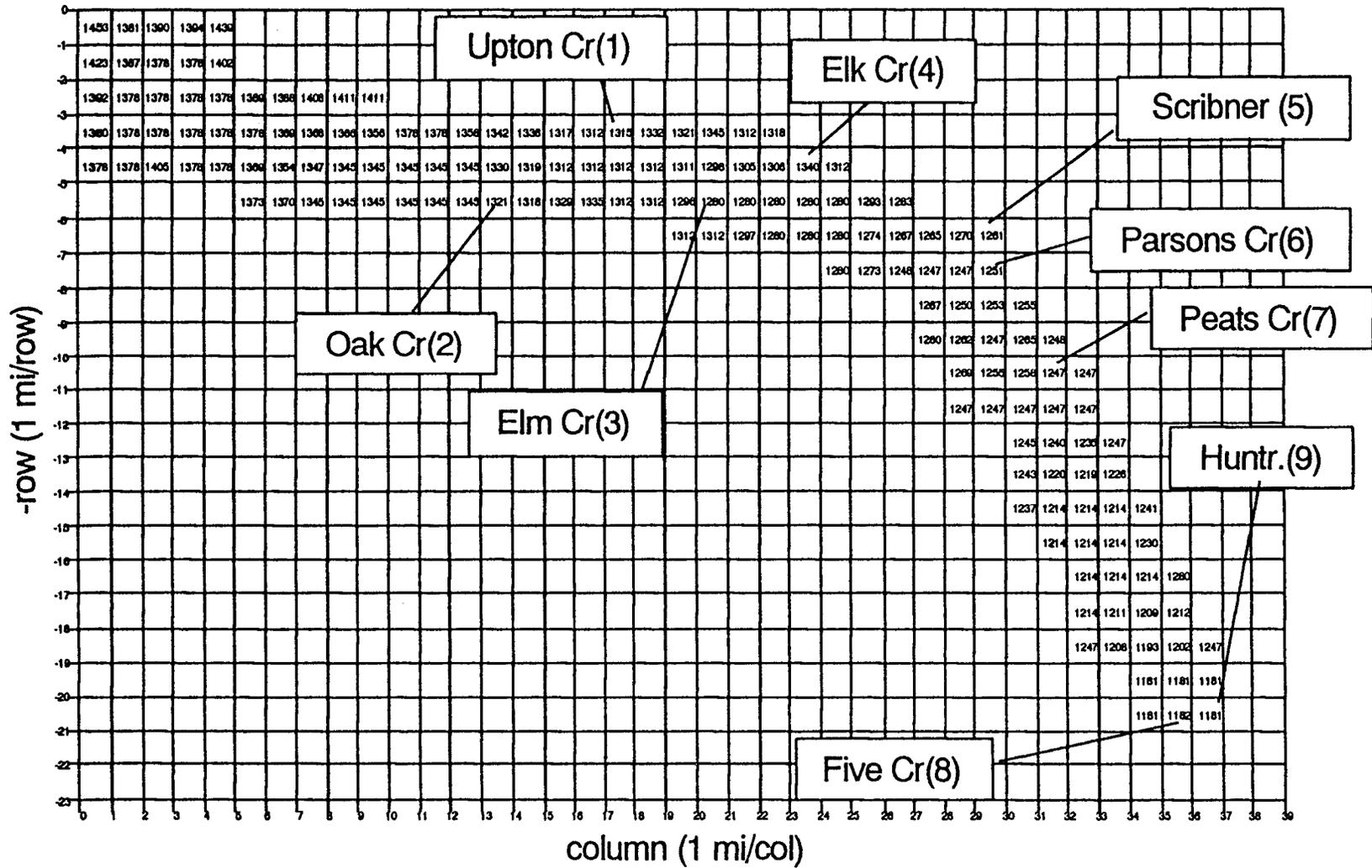


Figure 7

Republican R grid: saturated thickness(ft) May 17, 1995

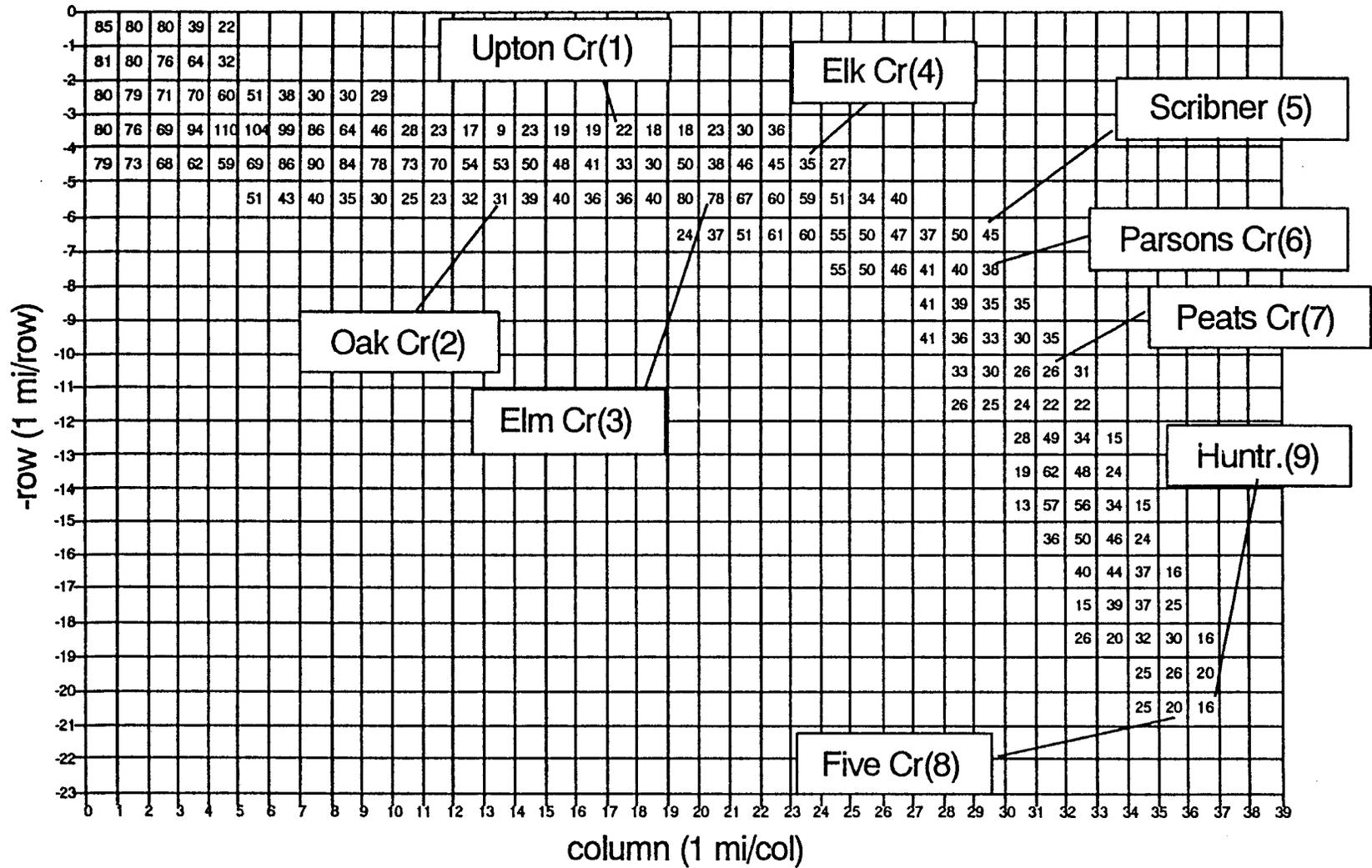


Figure 8

Water Rights

Lower Republican Basin

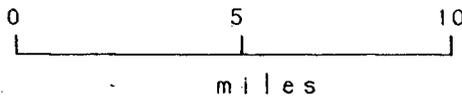
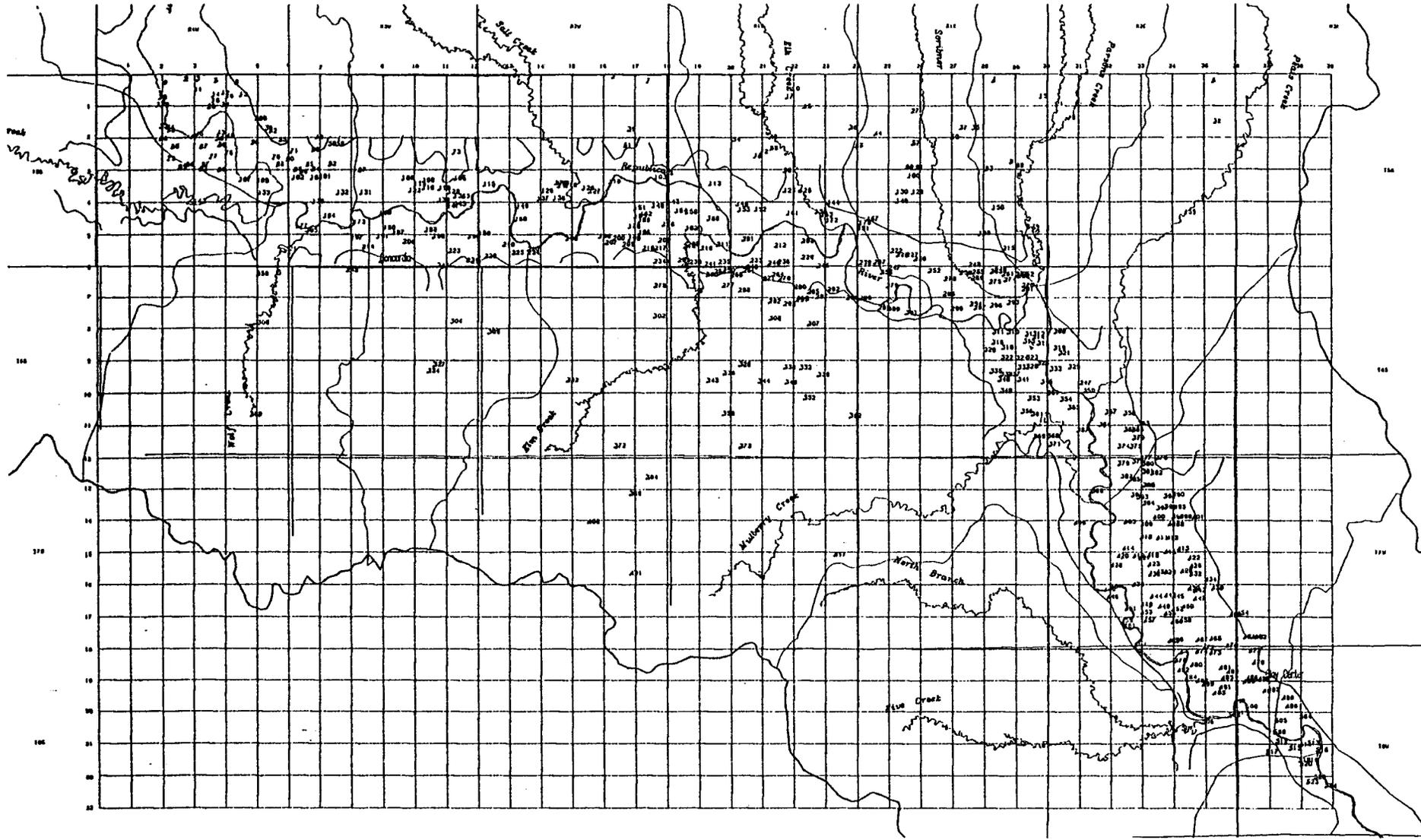


Figure 9

4:23 PM
2/1/2001

h. Initial MODFLOW runs

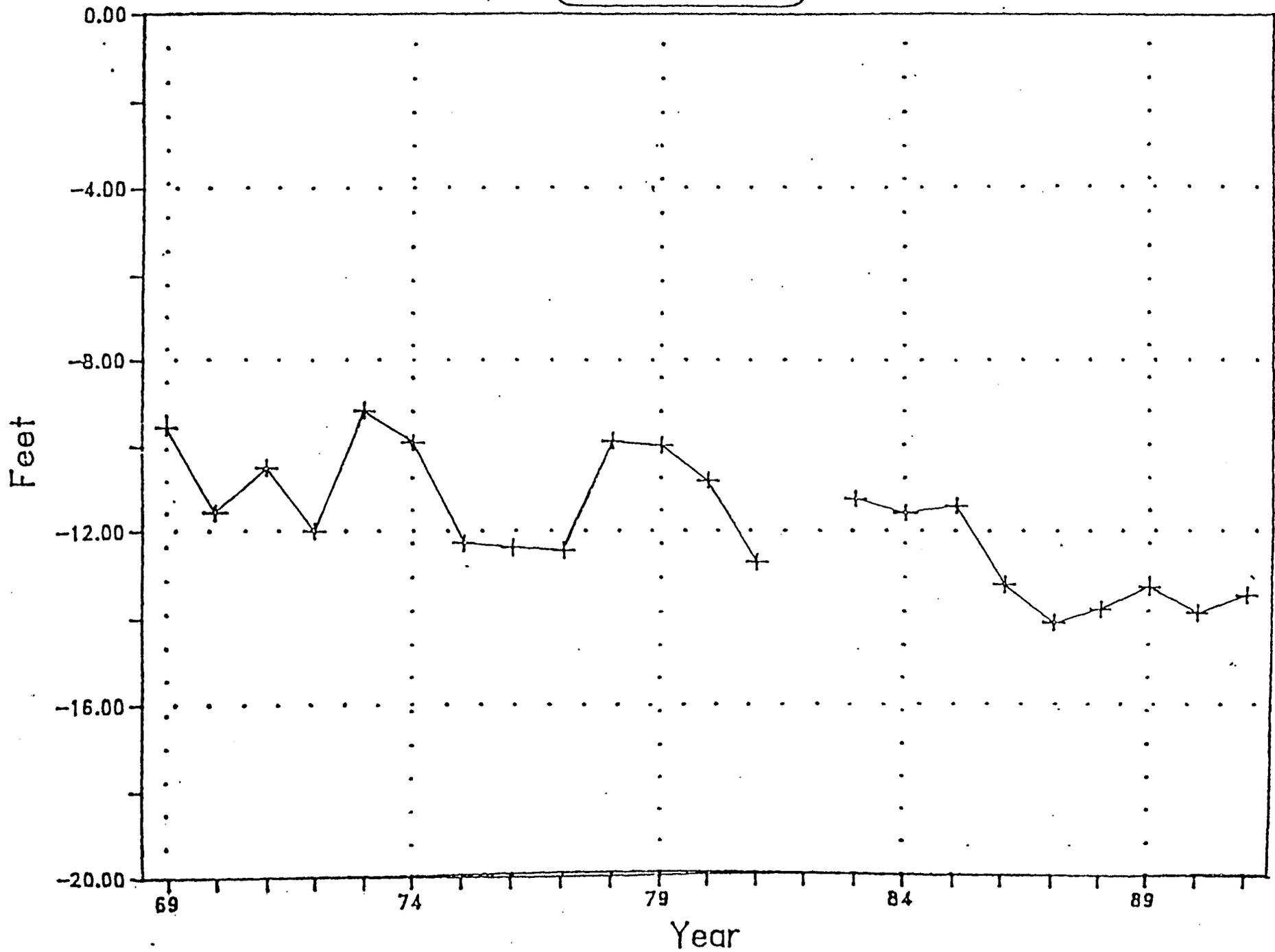
(i) Input and parameter estimation

We tentatively assume that the Spring 1977 ground-water level survey (Dunlap, 1982) represents a near-equilibrium (steady state) hydrologic condition, that is all ground-water discharge from the Republican River alluvial aquifer from Concordia to Clay Center is approximately balanced by ground-water recharge, resulting in near-stable water levels. (A 1969-1991 well hydrograph from the Republican River alluvium west of Clay Center, shown in Fig. 10, indicated near stable water levels until the mid-1980's.) Given this assumption, we run the stream-aquifer model repeatedly by varying the various input parameters within their expected ranges with the objective of approximately minimizing the differences between measured and simulated ground-water levels. The model region consisted of 160 active grid cells, covering an area of 160 mi² of the L. Republican alluvial valley. The watershed area covered by the MODFLOW finite difference is shown in fig. 10a. The following input parameters were employed:

- Avg. aquifer hydraulic conductivity, K: 422 ft/day (based on Fader, 1968)
- Avg. streambed conductance, C: 2.85 ft²/sec (It varied from 0.9 to 7.6 ft²/sec
 $\left[C = \frac{k'}{b'} (L * W) \right]$ depending on actual stream length (L) within the grid cell, and the ratio of streambed hydraulic conductivity to streambed thickness $\left(\frac{k'}{b'} \right)$; the range of this ratio was estimated from 0.17 to 0.33 ft/day/ft; avg. stream width (W) for the L. Republic River was approximated at 150 ft.)
- Natural ground-water recharge was set at approximately 10% of average annual precipitation based on the climatic stations of Concordia, Clifton and Clay Center (Avg. annual precip. at Clay Center: 31 in.; at Concordia: 27 in. Approximate area-weighted precipitation for the model area 28 in./yr.).
- Irrigation pumpage was set at 70% of appropriated amounts.
- Republican River and tributary inflows to the model area: Since the initial ground-water levels employed in the modeling were measured during the Spring of 1977, we run two stream inflow scenarios, representing 1976 and 1977 stream inflows, respectively. Running the USGS HYSEP2 streamflow separation program (White and Sloto, 1990), we obtained the following total streamflows (Q_T) and surface runoff contributions (Q_{SRO}) to stream flow, in cfs, at the Concordia and Clay Center stream-gaging stations:

8-2e-2cca

REPUBLICAN RIVER ALLUVIUM



Year
Figure 10 (from Munson, 1991)

SWAT Sub Basins

Lower Republican Basin

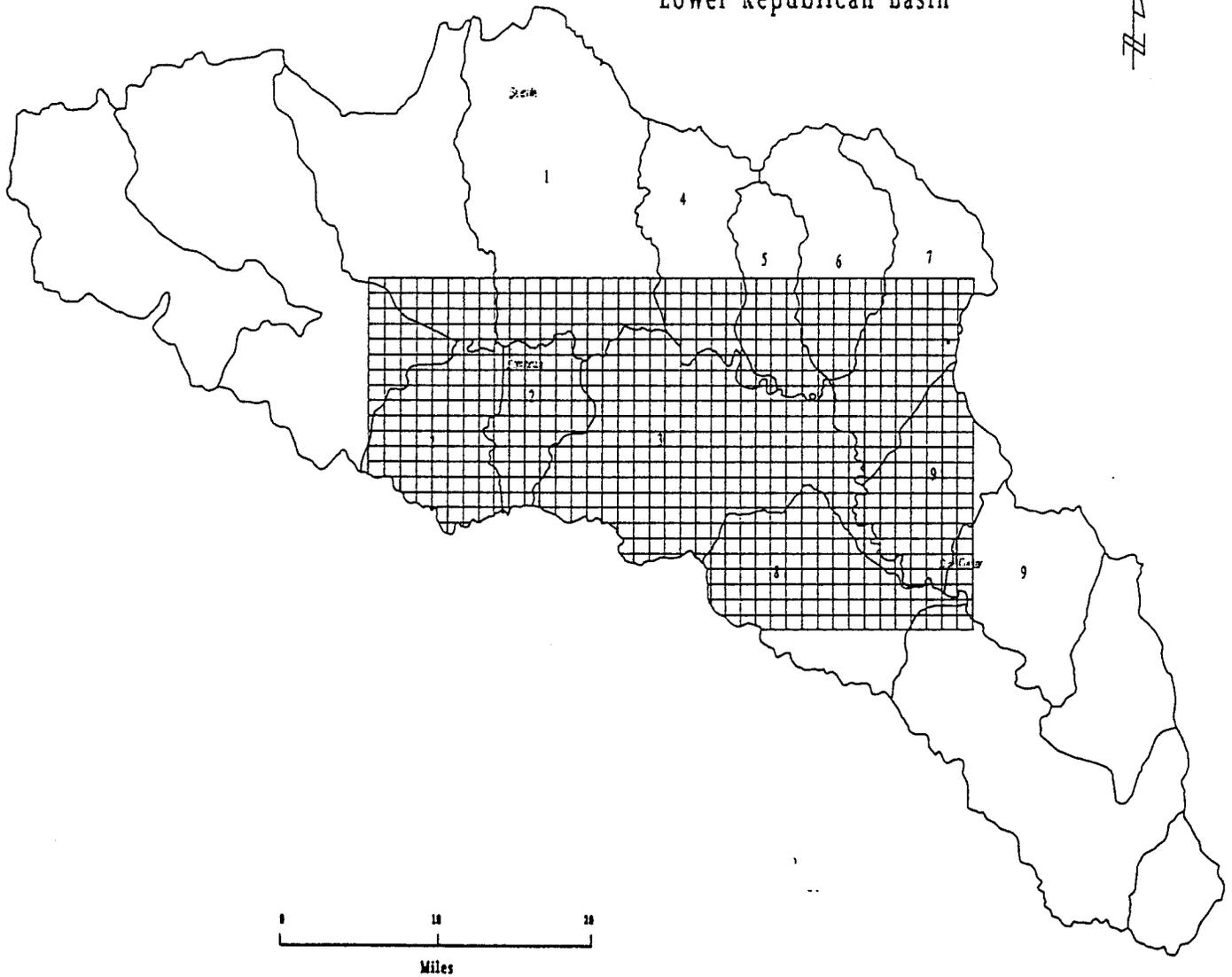


Figure 10a

Year	Concordia (C)		Clay Center (CC)		flow gains between C and CC	
	Q_T	Q_{SRO}	Q_T	Q_{SRO}	ΔQ_T	ΔQ_{SRO}
1976	213	62	277	92	64	30
1977	410	208	621	355	211	147

Running the SWAT model for the 1977-1990 period (as will be detailed later), we obtained the fractional surface runoff contributions to streamflow from each of the nine sub-basins (see Fig. 11) employed (see Table 2). We assumed that these fractional contributions to surface runoff remain constant (although as the model is being refined, these fractional contributions may be modified). Table 2 also contains the employed L. Republican River tributary inflows in the model simulation. The total streamflow at Concordia gaging station was used as the main stream channel inflow to the model area.

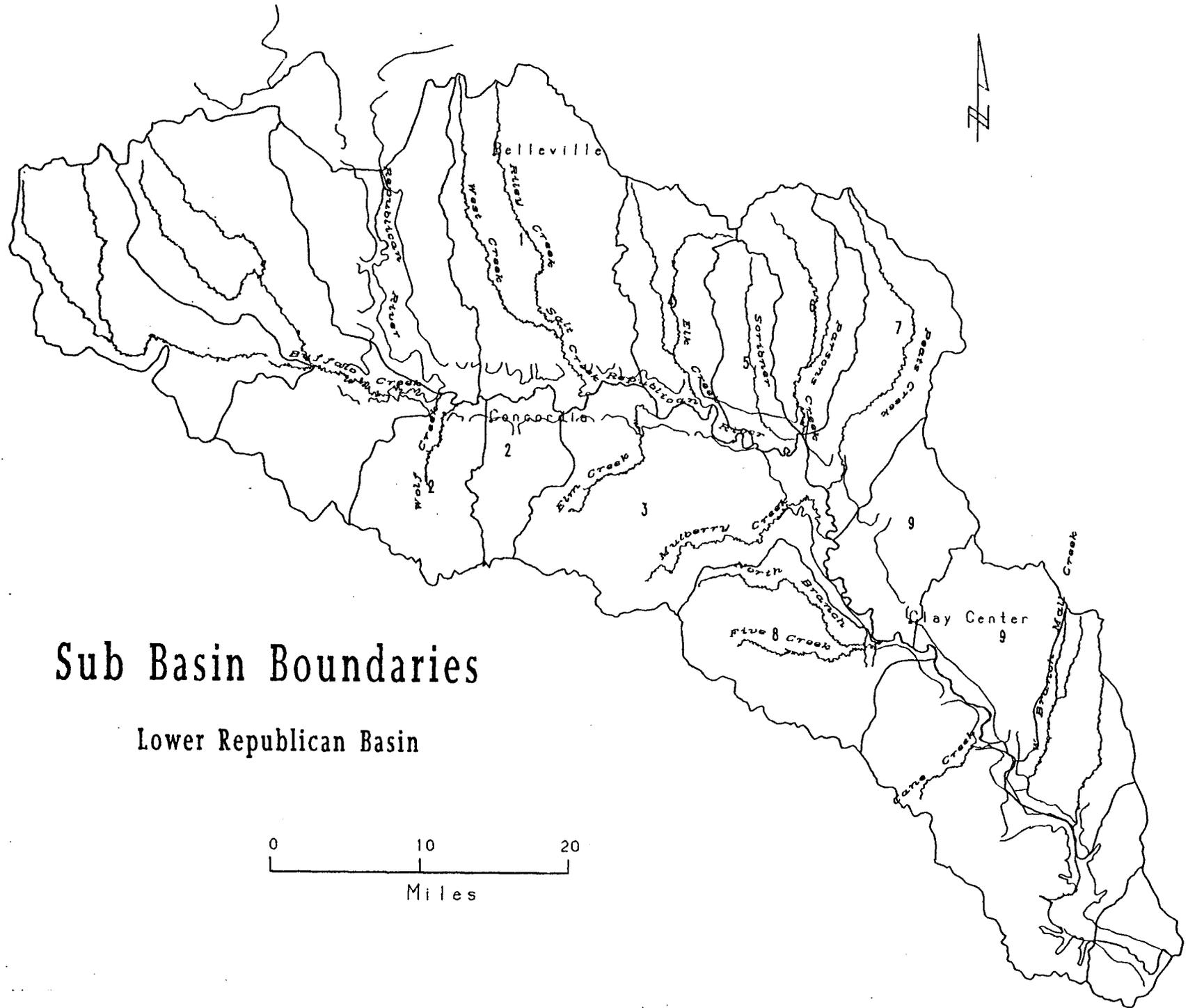
Table 2: Surface runoff (SRO) contribution fractions of the various subbasins in the Lower Republican River basin.

Subbasin No.	SRO fractional contribution (%)	1976 SRO sub-basin contribution to Streamflow (cfs)	1977 SRO Subbasin contribution to Streamflow (cfs)
1	32.0*	9.6	47.0
2	6.1	1.8	9.0
3	14.6	4.4	21.5
4	7.7	2.3	11.3
5	5.4	1.6	7.9
6	6.4	1.9	9.4
7	2.3	0.7	3.4
8	15.8	4.7	23.2
9	<u>9.7</u>	<u>2.9</u>	<u>14.3</u>
Total	100	30	147

*Includes modelled region upstream from the Concordia streamgaging station—west of subbasins 1 and 2 (see fig. 10a)

(ii) Preliminary equilibrium water budget for the Lower Republican River Valley.

Given the previously-mentioned input data and assumptions, we obtained the following water budget components (expressed in inches over the 160 square-mile model area) by running the MODFLOW model for the two streamflow input (mainstem and tributary 1976 and 1977) scenarios.



Sub Basin Boundaries

Lower Republican Basin

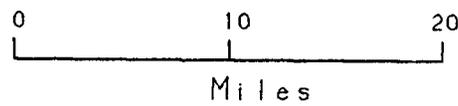


Figure 11

10/18/1995 2:00 PM
 14/1100 2.14.2000.12.1

<u>Aquifer Input (in.)</u>	<u>1976 Streamflows</u>	<u>1977 Streamflows</u>
Downstream lateral inflows	0.55	0.55
Recharge	2.82	2.82
Stream leakage (losses)	<u>1.56</u>	<u>1.97</u>
Total Input	4.93	5.34
<u>Aquifer Output (in.)</u>		
Downstream lateral outflows	0.14	0.17
Irrigation pumping	2.28	2.28
Stream leakage (gains)	<u>2.51</u>	<u>2.89</u>
Total Output	4.93	5.34

The goodness of fit of simulated versus Spring 1977-measured water levels is satisfactory, as shown by the distribution of residuals (observed-simulated water levels) throughout the model grid (Fig. 12). As can be inferred from Fig. 12, 74% of simulated grid cell water-level values were within 0 to less than 5 ft of measured values, and only less than 4% of grid cell values were in the highest discrepancy range of 10-13 ft. The modeling results also showed that despite the overall gaining nature of the Lower Republican River, there were a number of losing stream stretches, especially in the downstream area from the town of Clyde, and in the stream stretch between near the confluence with Peats Creek and Mulberry Creek.

(iii) 1976-1977 to 1994 MODFLOW transient simulations.

Using the 1976-77 simulated steady-state water level surface as our initial (starting) condition, and a storage coefficient of 0.15, typical of productive unconfined aquifers, we run a transient state simulation to the present (1994). We employed annual stress periods during which pumping (assumed as 70% of appropriations), recharge as a function of precipitation (assumed as 10% of annual precipitation of Concordia, Clifton and Clay Center stations; the Republican River valley between Concordia and Clay Center was divided into three subregions according to Thiessen polygons based on these climatic stations), incoming streamflows at the western edge of the model region (assumed same as measured at Concordia), and surface runoff within the model region, estimated from streamflow separation (using the USGS HYSEP2 model) and distributed via tributaries according to the fractional runoff contribution of each subbasin, as explained previously, were varied as per the available data (see tables 3 and 4).

The model-predicted streamflows at the Clay Center gaging station during the 1976-94 period were compared with the gaged streamflows (fig. 13). In addition, the 1994 simulated ground-water level data were compared with the 1994 water-level survey

Figure 12

Table 3. Annual precipitation and assumed recharge(10% of annual precipitation) employed in the 1976-1994 transient MODFLOW simulations.

year	recharge= 0.1 x precipitation		CLAY CENTER		CONCORDIA	
	CLIFTON pcp(in/yr)	rch(ft/s)	pcp(in/yr)	rch(ft/s)	pcp(in/yr)	rch(ft/s)
1976	20.97	5.54E-09	24.19	6.39E-09	17.43	4.61E-09
1977	33.68	8.9E-09	42.52	1.12E-08	35.23	9.31E-09
1978	27.45	7.25E-09	27.44	7.25E-09	30.36	8.02E-09
1979	30.45	8.05E-09	35.55	9.39E-09	26.57	7.02E-09
1980	22.21	5.87E-09	22.47	5.94E-09	19.44	5.14E-09
1981	34.43	9.1E-09	27.94	7.38E-09	33.67	8.9E-09
1982	31.27	8.26E-09	32.44	8.57E-09	36.99	9.77E-09
1983	27.00	7.13E-09	24.94	6.59E-09	25.59	6.76E-09
1984	28.30	7.48E-09	31.63	8.36E-09	28.73	7.59E-09
1985	31.29	8.27E-09	36.49	9.64E-09	25.77	6.81E-09
1986	43.88	1.16E-08	46.12	1.22E-08	40.18	1.06E-08
1987	33.00	8.72E-09	29.69	7.85E-09	34.14	9.02E-09
1988	15.63	4.13E-09	17.75	4.69E-09	14.54	3.84E-09
1989	26.59	7.03E-09	24.49	6.47E-09	24.82	6.56E-09
1990	24.96	6.6E-09	30.67	8.1E-09	25.67	6.78E-09
1991	24.8	6.55E-09	24.64	6.51E-09	19.95	5.27E-09
1992	35.43	9.36E-09	37.14	9.81E-09	38.00	1E-08
1993	49.75	1.31E-08	45.08	1.19E-08	44.79	1.18E-08
1994	25.3	6.69E-09	23.61	6.24E-09	19.00	5.02E-09

NOTE. Cells in squares: some data missing; where number is rounded, an estimate was made.

Table 4. Incoming and tributary-streamflows and active cell ground-water pumpage-rate data employed in the 1976-1994 transient MODFLOW simulations.

year	Concordia			Clay Center			DQsro	Subbasin #: sro fractional contribution; subbasin sro(tributary inflows)									Qgw (70%) (cfs)
	Qin (cfs)			Qout (cfs)				1	2	3	4	5	6	7	8	9	
	tot.	bas.	Qsro	tot.	bas.	Qsro		0.320	0.061	0.146	0.077	0.054	0.064	0.023	0.158	0.097	
1976	213	151	62	277	185	92	30	9.60	1.83	4.38	2.31	1.62	1.92	0.69	4.74	2.91	26.22
1977	410	202	208	621	266	355	147	47.04	8.97	21.46	11.32	7.94	9.41	3.38	23.23	14.26	29.74
1978	377	196	181	588	276	312	131	41.92	7.99	19.13	10.09	7.07	8.38	3.01	20.70	12.71	31.06
1979	591	237	354	942	381	561	207	66.24	12.63	30.22	15.94	11.18	13.25	4.76	32.71	20.08	31.84
1980	369	214	155	547	235	312	157	50.24	9.58	22.92	12.09	8.48	10.05	3.61	24.81	15.23	32.09
1981	299	159	140	467	233	234	94	30.08	5.73	13.72	7.24	5.08	6.02	2.16	14.85	9.12	33.43
1982	646	315	331	1056	512	544	213	68.16	12.99	31.10	16.40	11.50	13.63	4.90	33.65	20.66	33.92
1983	701	473	228	964	635	329	101	32.32	6.16	14.75	7.78	5.45	6.46	2.32	15.96	9.80	34.62
1984	731	479	252	1079	652	427	175	56.00	10.68	25.55	13.48	9.45	11.20	4.03	27.65	16.98	34.71
1985	605	322	283	860	443	417	134	42.88	8.17	19.56	10.32	7.24	8.58	3.08	21.17	13.00	34.81
1986	602	326	276	1302	542	760	484	154.88	29.52	70.66	37.27	26.14	30.98	11.13	76.47	46.95	35.16
1987	1027	536	491	1613	806	807	316	101.12	19.28	46.14	24.33	17.06	20.22	7.27	49.93	30.65	36.07
1988	267	175	92	345	218	127	35	11.20	2.14	5.11	2.70	1.89	2.24	0.81	5.53	3.40	38.75
1989	253	121	132	464	161	303	171	54.72	10.43	24.97	13.17	9.23	10.94	3.93	27.02	16.59	39.57
1990	261	143	118	364	210	154	36	11.52	2.20	5.26	2.77	1.94	2.30	0.83	5.69	3.49	41.44
1991	110	54	56	176	78	98	42	13.44	2.56	6.13	3.23	2.27	2.69	0.97	6.64	4.07	41.81
1992	440	168	272	757	300	457	185	59.20	11.29	27.01	14.25	9.99	11.84	4.26	29.23	17.95	42.1
1993	2174	894	1280	3932	1666	2266	986	315.52	60.15	143.96	75.92	53.24	63.10	22.68	155.79	95.64	42.1
1994	484	377	107	718	532	186	79	25.28	4.82	11.53	6.08	4.27	5.06	1.82	12.48	7.66	42.26

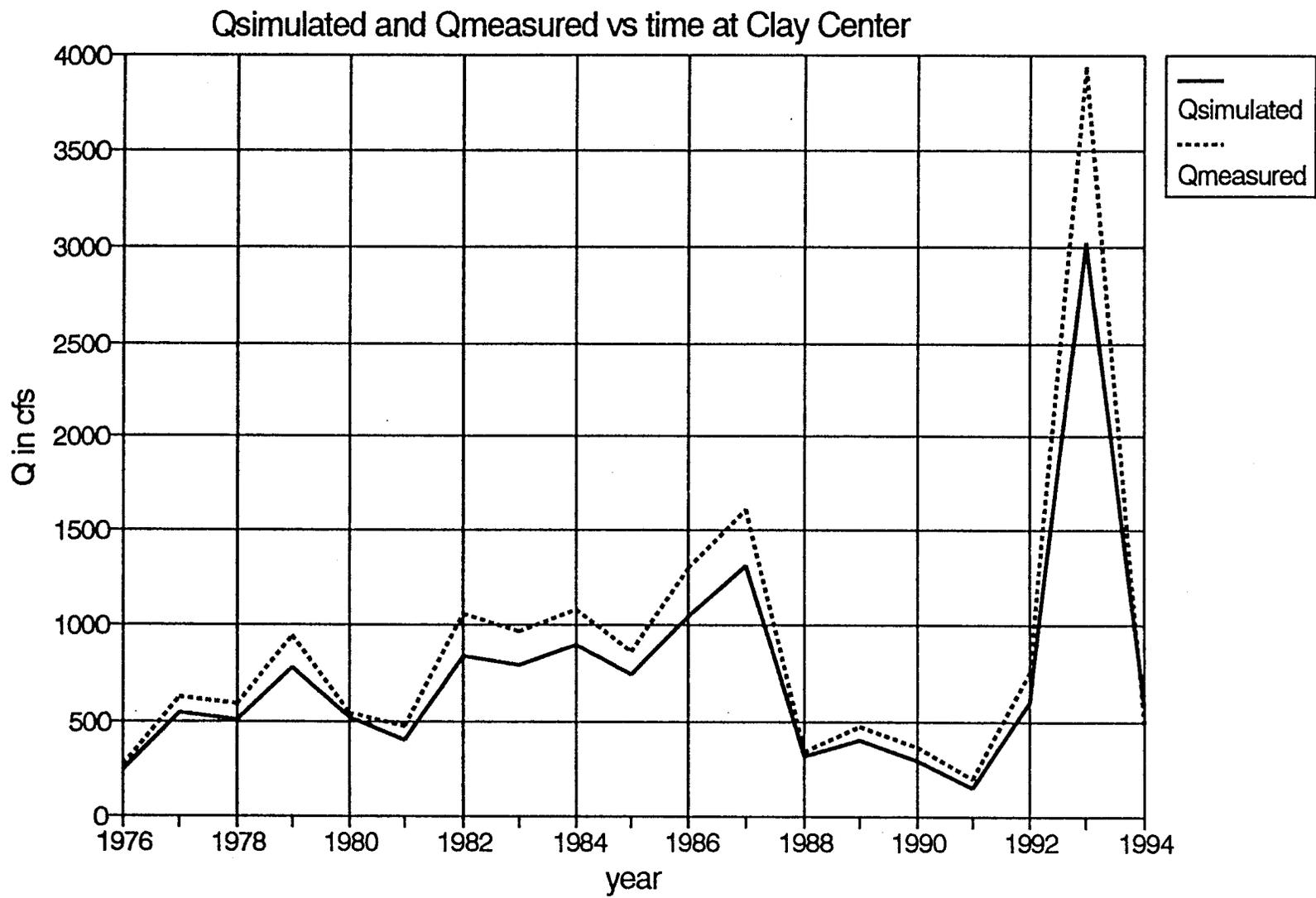


Figure 13

we conducted in the study area, and the results are shown in fig. 14. Both figs 13 and 14 indicate that the model simulates observed events satisfactorily. The next step would be to possibly improve upon these simulation results by employing the combined SWAT-MODFLOW simulation program. In addition, as reported water-use data recently received from DWR are being processed, actual, time-varying water-use data will be employed in the simulations, as opposed to the average 70% water use employed in this report.

An interesting observation from these transient simulations is that the simulated ground-water levels do not show any significant water level declines as can be seen from fig. 15 through figs. 17. These figures depict simulated ground-water level hydrographs from the beginning of 1977 (end of 1976) to the end of 1994 at three index grid cells along the Lower Republican River valley: one (grid cell 4, 5) west of Concordia, one (grid cell 5, 22) near Clyde, and one (grid cell 16, 34) in between Clay Center and Morganville. Although the impact of the 1988 drought and the 1993 flood are prevalent in all these hydrographs, there does not appear to be any major declining trend during the 1977 to 1994 period.

II. Objective 2: Combine watershed and stream-aquifer models

a. Linking SWAT and MODFLOW

SWAT is a linked model consisting of an existing basin-scale surface water and root zone model (SWRRB; Arnold et al., 1990) to which a reach routing structure and a ground-water component, among others, were added. The ground-water component, however, is not detailed enough and is too simplistic for handling distributed parameters and variable pumping. As a result, SWAT cannot predict ground-water levels accurately. Therefore, it is deemed necessary to replace the ground-water component of SWAT with the more detailed and sophisticated ground-water MODFLOW simulator.

The linkage between the two programs is shown schematically in fig. 18 and is intended to represent the significant interactions among a watershed and its stream network and the associated aquifer. Surface runoff and interflow become lateral inflow to a stream. Infiltration that percolates downward beyond the root zone is the source of recharge to the aquifer. Groundwater pumped from the aquifer is applied as irrigation at the surface. Groundwater within reach of plant roots evapotranspires. The stream and aquifer interact via leakage driven by a hydraulic gradient across the streambed.

Ground Water Hydrograph
cell 4,5



Figure 15

Ground Water Hydrograph
cell 5,22

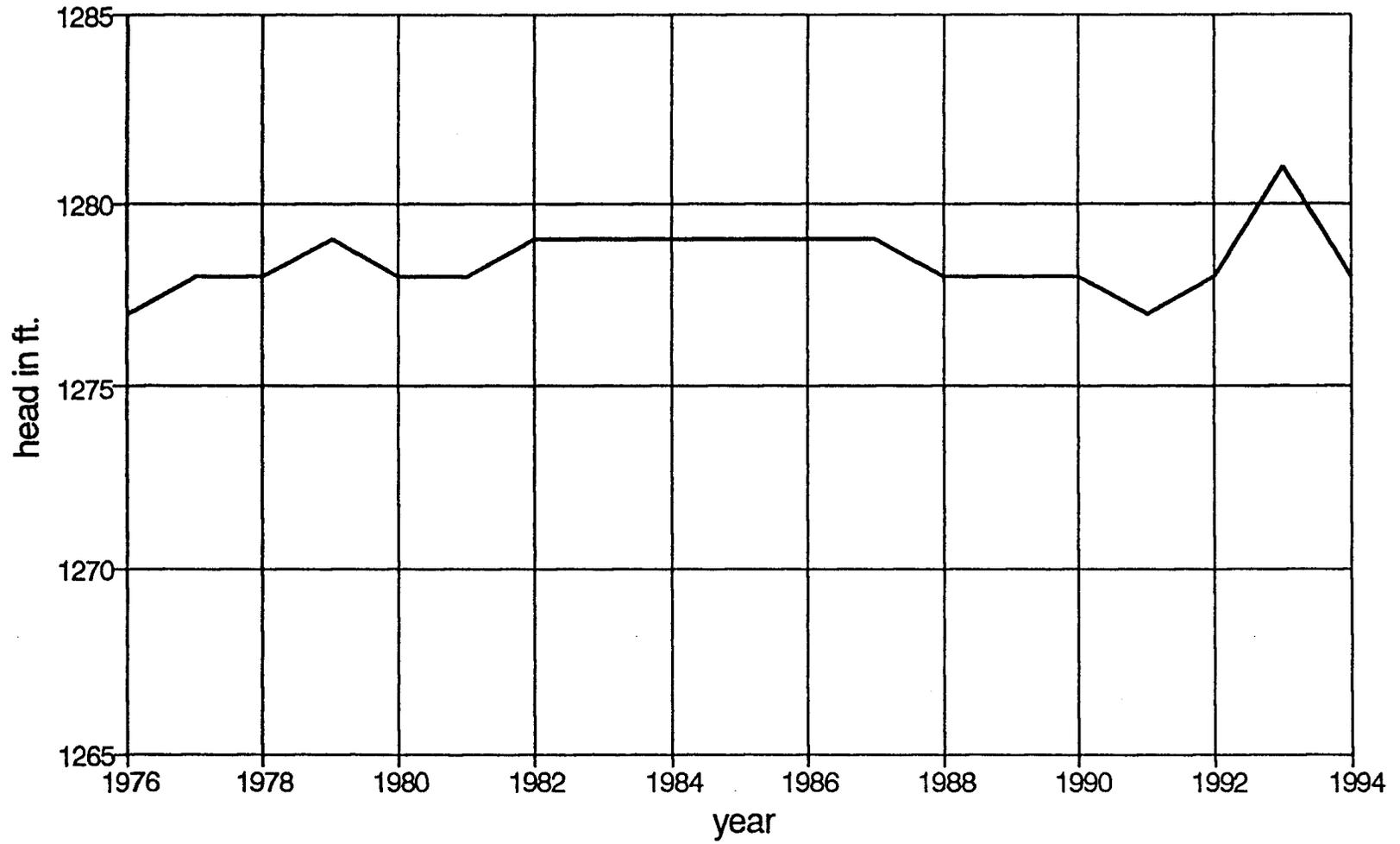


Figure 16

Ground Water Hydrograph
cell 16,34

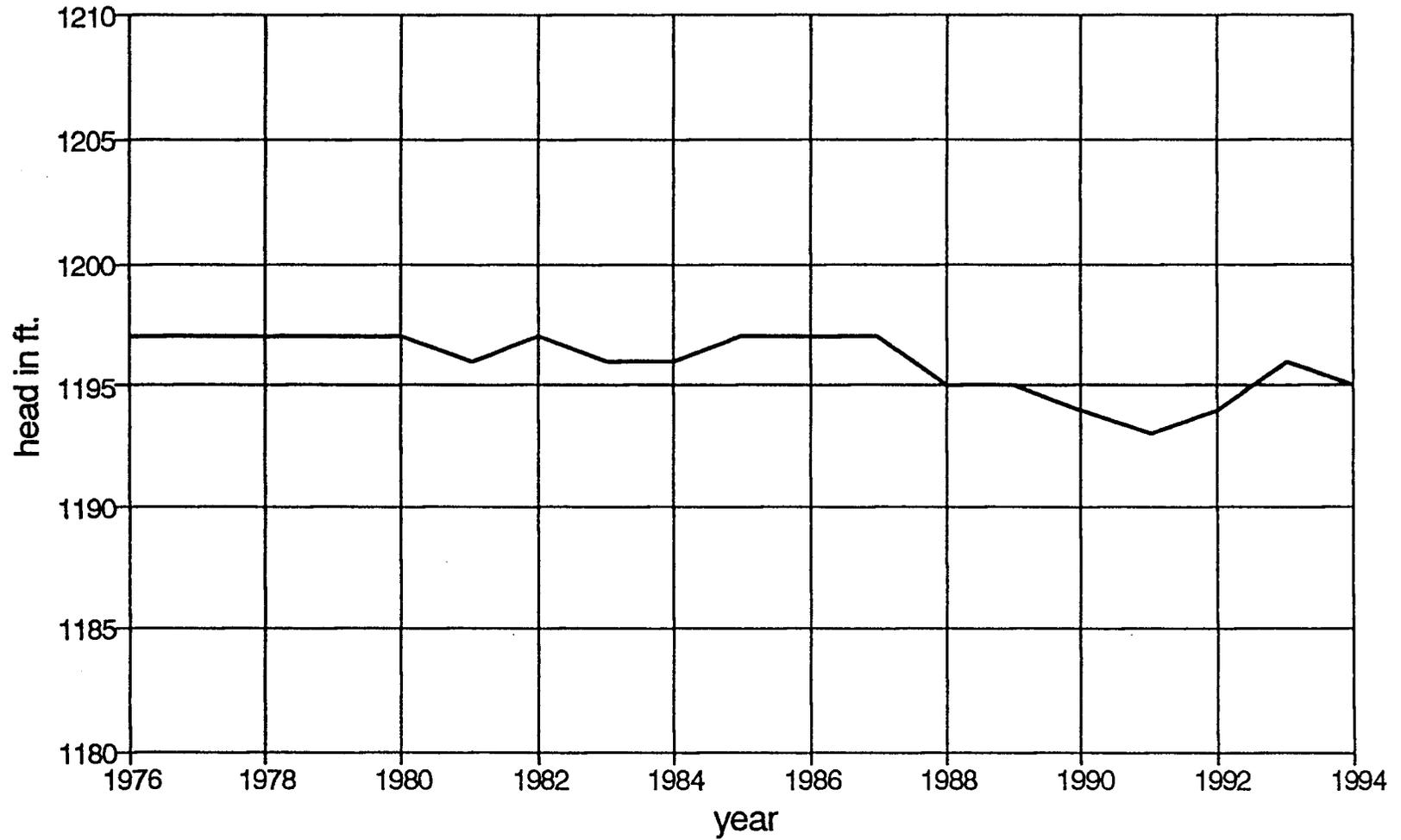


Figure 17

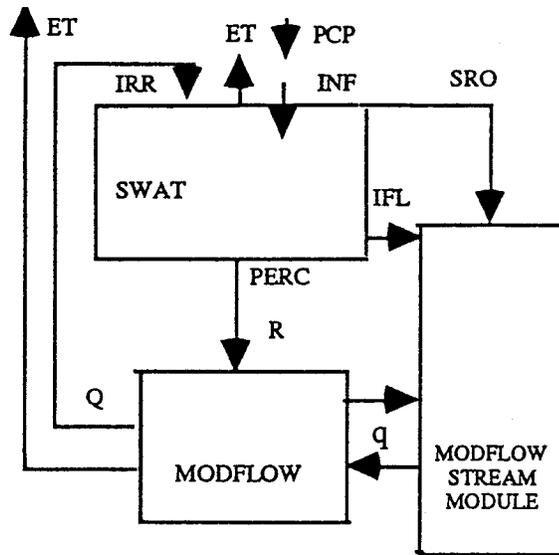


fig. 18

Both SWAT and MODFLOW have been modified to implement the linkage shown in fig. 18. Interaction of the two programs can occur indirectly via data files or directly by calls from SWAT to MODFLOW according to one of several options added to SWAT which are accessible through SWAT's `~.cod` input file. Program modules to handle interactions between SWAT and MODFLOW were written and are referred to as HYDBAL, called by SWAT, and MODSWB, called by MODFLOW. HYDBAL passes hydrologic fluxes calculated by SWAT (surface runoff, lateral flow, percolation from root zone, irrigation and surface evaporation) to MODFLOW, and retrieves fluxes calculated by MODFLOW (baseflow and ground-water evapotranspiration). HYDBAL also retrieves annual constraints on fluxes set by MODFLOW (appropriation limits on irrigation), and evaluates a hydrologic balance at each time step (daily, monthly or annual) for which fluxes are retrieved from MODFLOW. On the other hand, MODSWB associates the SWAT subbasins with aquifer grid domains, and watershed outflows with the stream network defined in MODFLOW; evaluate water rights appropriations for each subbasin at the beginning of each stress period; maps hydrologic fluxes calculated by SWAT onto the aquifer grid, and summarizes for each subbasin the fluxes relevant to SWAT's hydrologic balance.

Specifically, the MODSWB module consists of three subroutines.

- a) SWB1AL: Allocate memory requirements for the module in a manner consistent with the standard MODFLOW modules
- b) SWB1RP: Read the input required to associate the morphology of the watershed, stream network and aquifer. Specifically, this subroutine defines
 - i) watershed subbasin outflow to main channel tributaries;
 - ii) junctions of tributaries to main channel reaches;
 - iii) correspondences of watershed subbasin domain to aquifer grid cells.

- c) SWBHYD: For each time step, hydrologic fluxes for each subbasin as computed and written by SWAT are read. These fluxes are mapped onto the groundwater model as follows:
- i) Subbasin runoff and subsurface lateral flow (interflow) are combined as tributary outflow, which is treated as lateral inflow to the corresponding reach of the stream network represented by MODFLOW's STREAM module.
 - ii) Percolation from the root zone from each subbasin is applied to the corresponding aquifer grid cells as groundwater recharge represented in MODFLOW's RECHARGE module.
 - iii) Irrigation scheduling controlled by SWAT on the basis of soil moisture for each subbasin can optionally be used to control the pumping rates of corresponding wells represented in MODFLOW's WELL module. Alternatively, irrigation water-use amounts specified on MODFLOW's WELL module can be used as specified irrigation amounts in SWAT. In any case, pumping amounts in MODFLOW's WELL module are used as upper limits in SWAT's irrigation scheduling.

The hydrologic balance is evaluated by HYDBAL both for a total control volume and for the components into which it is partitioned that include the soil profile, vadose zone, aquifer and stream. The balance for each of these control volumes is expressed as a statement of continuity: the time rate of change within the control volume ($ds_{\text{control volume}}$) = net flux into the control volume. The balances are evaluated as follows:

$$\begin{aligned}
 ds_{\text{soil}} &= \text{precipitation} + \text{irrigation} - \text{evapotranspiration from surface and root} \\
 &\quad \text{zone} - \text{surface runoff} + \text{transmission loss} - \text{subsurface (lateral) flow} - \\
 &\quad \text{percolation from root zone}; \\
 ds_{\text{vadose}} &= \text{percolation from root zone} - \text{recharge}; \\
 ds_{\text{aquifer}} &= -\text{irrigation} + \text{recharge} - \text{evapotranspiration from groundwater} - \text{baseflow}; \\
 ds_{\text{stream}} &= \text{surface runoff} + \text{subsurface (lateral) flow} + \text{baseflow}; \\
 ds_{\text{total}} &= \text{precipitation} - \text{evapotranspiration}
 \end{aligned}$$

The purpose of calculating these balances is to provide a physically meaningful quality control check on the SWAT-MODFLOW linkage. An example of HYDBAL output is shown in the next section.

SWAT evaluates water fluxes with a daily time step; we anticipate accumulating these for monthly or yearly time steps in MODFLOW. The linked model has been initially tested on a small watershed in Texas that has already been modeled with SWAT and reported in the SWAT

manual (Arnold et al., 1994) as an example (watershed Y at Riesel with seven subbasins). The results of this testing, which were encouraging, are presented in Appendix C. We also tested the linked module on the lower Republican River basin in Kansas.

b. Testing the linked SWAT-MODFLOW on the Lower Republican River basin.

We first tested the combined SWAT-MODFLOW model using the 1977 Lower Republican River basin hydrological conditions, which were also employed in the steady-state calibration runs mentioned previously. First the MODFLOW finite difference grid was superimposed on the Lower Republican River nine-subbasin map (Fig. 10a) and MODFLOW grid cells corresponding to each subbasin were identified. In addition the stream outlets from each subbasin were identified as tributaries to a particular stream segment and reach of the main Republican River channel. The strategy we followed in testing/calibrating the combined model consisted of two steps. First, run under steady-state conditions and evaluate two scenarios, one where "optimal" irrigation scheduling is employed via the plant water stress factor procedure employed by the model but limited by the maximum limit of appropriated amounts, and one where the irrigation amount employed was equal to the appropriated amount by employing no water stress to the plants. In both cases detailed hydrologic balances for all model components (soil, aquifer, stream) were checked to ensure correct water flux allocations from and to SWAT and MODFLOW. Second, run under transient conditions for several years to ensure that appropriate water fluxes are passed back and forth between the two model components (SWAT and MODFLOW) of the combined model, and hydrologic mass balance is preserved.

An example of partial output (from subroutine HYDBAL added to SWAT) for the case where the ground-water appropriation in 1977 was employed for surface irrigation, is presented below. Excerpt I presents, in a compact form, the hydrologic budgets for the entire portion of the modeled Lower Republican River basin (fig. 19) as well as for each one of the nine subbasins contributing surface runoff to the Lower Republican River from Concordia to Clay Center. All hydrologic balance components are expressed in millimeter units over the entire portion of the modeled Lower Republican River basin (column labelled "basin") and also for each of the above-mentioned nine subbasins (columns labelled one through nine, followed by the fraction of the total modeled watershed they represent).

Excerpt II presents the SWAT-calculated output for the entire modeled watershed and for each one of the nine subbasins that is passed to MODFLOW in the combined SWAT-MODFLOW model through subroutine MODSWB.

avg annual hydrologic balance:

component basin	1	2	3	4	5	6	7	8	9	
basin, km**2	2569.6	0.22015	0.04909	0.20435	0.08729	0.05282	0.08247	0.10945	0.11788	0.07649
PREC MM	937.93	982.78	895.30	907.73	973.11	893.90	931.45	746.70	1032.32	1042.35
IRR MM	11.13	11.25	10.13	19.01	4.09	22.75	0.68	5.68	0.00	26.61
ET MM	905.34	885.94	895.31	920.27	901.65	877.33	908.77	847.76	948.77	963.19
SURQ MM	78.81	85.05	75.59	52.93	100.25	80.15	85.59	33.24	110.58	115.60
TLOSS MM	4.21	3.49	6.45	6.14	5.52	2.85	2.43	3.45	2.80	4.35
LATQ MM	0.85	0.88	0.47	1.26	1.34	0.72	0.54	0.30	1.02	0.34
PERC MM	24.27	28.93	19.54	31.27	14.87	28.24	8.47	7.67	21.60	48.07
GWRE MM	-24.27	28.93	19.54	31.27	14.87	28.24	8.47	7.67	21.60	48.07
REV MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GW Q MM	14.59	22.89	22.80	15.77	8.89	-12.30	17.11	0.73	18.50	18.41
GWPER MM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Fig. 19. (Excerpt I.) Average annual 1977 hydrologic budget for the modeled Lower Republican River basin and each of the nine subbasins considered. The hydrologic components, expressed in mm, are as follows: PREC=precipitation, IRR= irrigation, ET=evapotranspiration, SURQ=surface runoff, TLOSS=transmission loss, LATQ=subsurface lateral flow (interflow), PERC= deep percolation, GWRE=ground-water recharge, REV=Revap (not used), GW Q=ground-water contribution to streamflow, and GWPER=ground-water percolation through bedrock.

MODSWB (soil water balance module) summary:

No. active nodes	155	42	14	48	8	11	1	9	3	19	
Active/subbasin area ratios	0.1562	0.1923	0.2875	0.2368	0.0924	0.2099	0.0122	0.0829	0.0257	0.2504	
Watershed to aquifer	Flux	Flux									
	(mm/yr)	(L ³ /T)									
Recharge	24.27	69.8	18.3	2.8	18.4	3.7	4.3	2.0	2.4	7.3	10.6
Surf. evap.	905.35	2605.1	561.2	126.5	541.1	226.5	133.3	215.7	267.0	321.8	212.0
Pumping	-11.13	-32.0	-7.1	-1.4	-11.2	-1.0	-3.5	-0.2	-1.8	0.0	-5.9
Watershed outflow (=SURQ+LATQ)	79.66	229.2	54.4	10.7	31.9	25.5	12.3	20.4	10.6	37.9	25.5

Excerpt II. SWAT-calculated output passed to MODFLOW

Excerpt III presents the MODFLOW-calculated output that is passed to SWAT in the combined SWAT-MODFLOW model. In all above-mentioned outputs, the first numerical column refers to the entire modeled watershed portion, whereas the next nine numerical columns refer to each of the nine subbasins. Please note that the units of MODFLOW are in cfs (L^3/T), whereas those of SWAT are in mm, and therefore both units are represented in the output. Also please note that the mm-units refer to the entire modelled watershed-portion area or to each of the nine-subbasin areas. The mm-values from both excerpt II and III are correctly passed to the appropriate hydrologic budget components presented in excerpt I (fig. 19).

subbasin	1	2	3	4	5	6	7	8	9	
gridded active areas as fractions of subbasin areas	0.15623	0.19229	0.28745	0.23676	0.09238	0.20991	0.01222	0.08288	0.02565	0.25037
Irrigation specified by Modflow .wel input file:										
9 AppropL3/T	32.03	7.13	1.43	11.18	1.03	3.46	0.16	1.79	0.00	5.86
9 Approp,mm	11.13	11.25	10.13	19.01	4.09	22.75	0.68	5.68	0.00	26.61
Hydrologic flow rates computed by Modflow:										
16 GWET L ³ /T	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 Basfl L ³ /T	41.97	14.50	3.22	9.27	2.23	-1.87	4.06	0.23	6.28	4.05
Hydrologic fluxes computed by Modflow for hydrologic balance:										
16 GW ET mm	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17 Basflow mm	14.59	22.89	22.80	15.77	8.89	-12.30	17.11	0.73	18.50	18.41

Excerpt III. MODFLOW output passed to SWAT

We also run the combined SWAT-MODFLOW model under transient conditions from 1977 and 1990. The results of this initial combined run were not only successful mechanically (ensuring that the right water fluxes are passed back and forth between SWAT and MODFLOW modules, and mass balance is preserved), but also yielded respectable results, as can be seen from figs. 20 and 21, depicting comparisons of simulated and measured streamflow yield (streamflow difference between Clay Center and Concordia) and Clay Center streamflows, respectively.

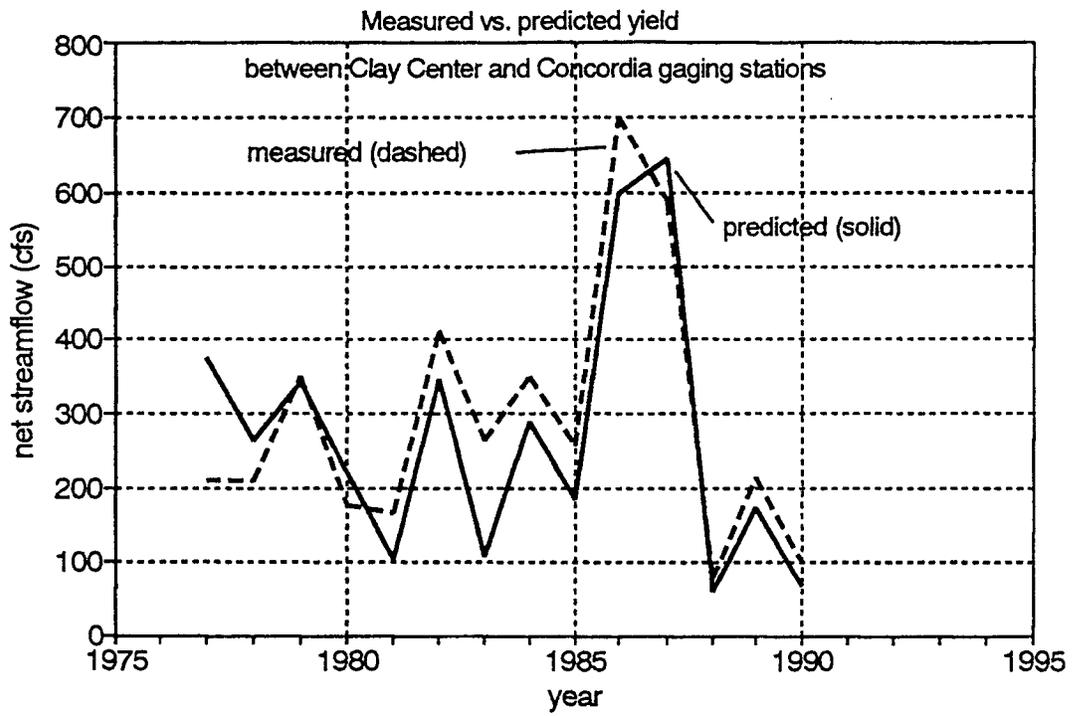


Figure 20

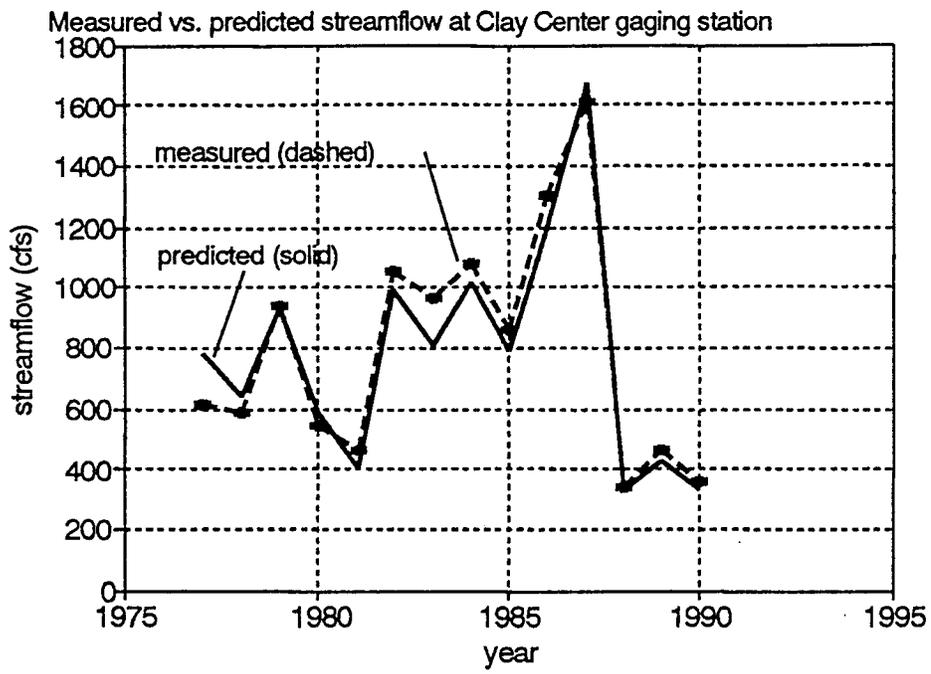


Figure 21

III. Objective 3: Refine and calibrate the combined model

The following refinements with regard to watershed modeling have been completed:

a. Additional subbasins.

The Lower Republican River basin was subdivided into a number of subbasins as presented in our first year report (Koussis et al., 1994). However, in working with the combined SWAT-MODFLOW model, we realized that subbasins 2 and 9 were extending beyond the area of detailed study. Therefore, these two subbasins were further subdivided as shown by the red lines in Fig. 11. In addition, we realized that further subdivision of the established subbasins may be needed, because several different streams contribute streamflow to the Republican River mainstem as different tributaries within the same subbasin. Therefore, we further subdivided the watershed subbasins so that each subbasin contributes only one tributary flow to the main channel. This further subdivision, although involving additional work, would probably better enhance the watershed model by making it more distributed, as each subbasin is treated as a lumped-parameter model in SWAT.

b. Updating soils information

The original soils-related input to SWAT (Koussis et al., 1994) was primarily based on SCS County Soil Survey reports. With the readily available GIS soil databases, we have now updated and refined the soils input for the combined SWAT-MODFLOW model. Fig. 22 depicts the GIS soils coverage and the MODFLOW model grid.

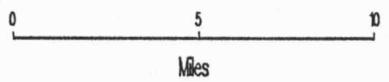
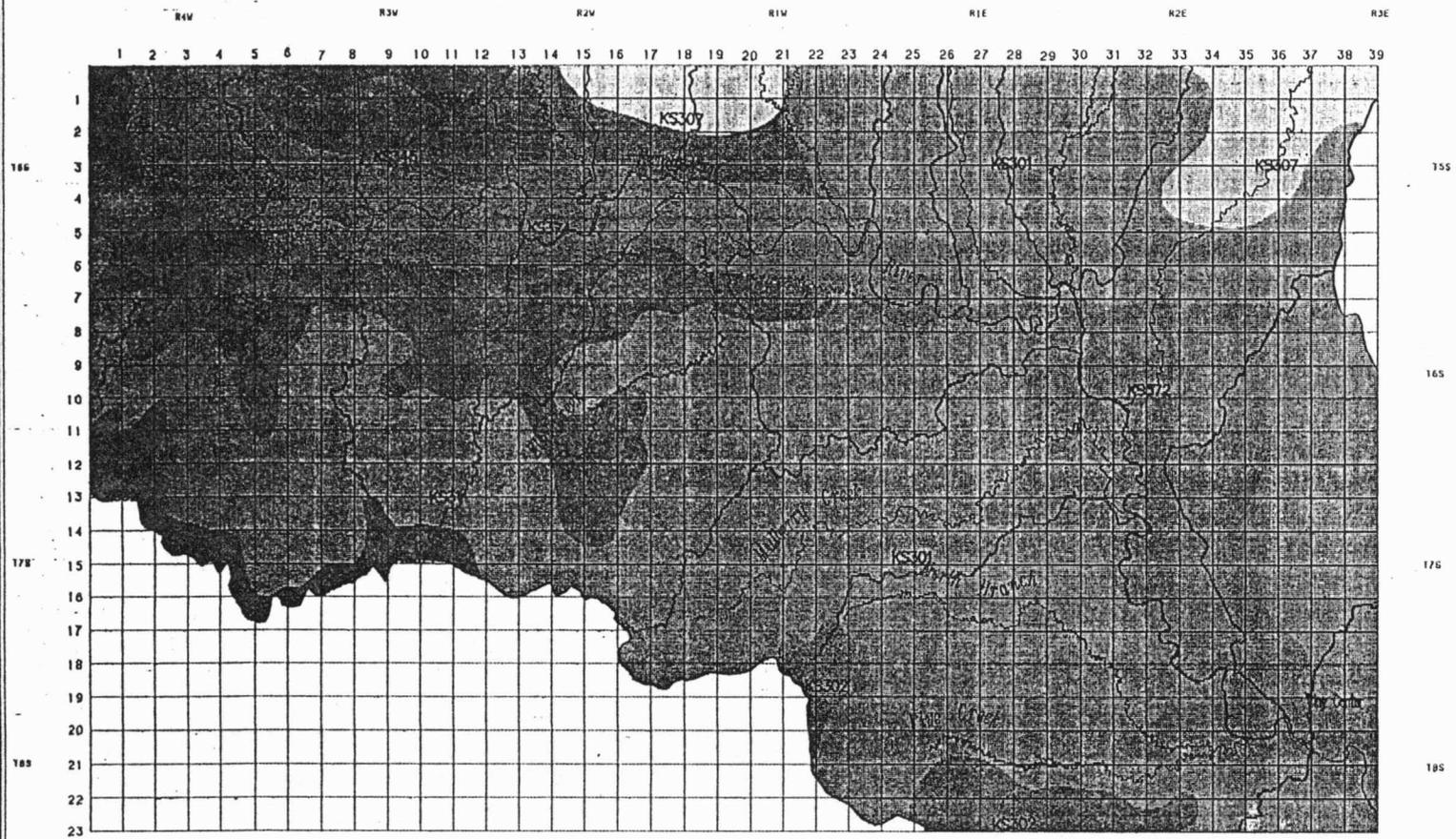
c. Combined SWAT-MODFLOW simulations

The results of the initial combined SWAT-MOD transient simulations were encouraging. The combined model was able to simulate both wet and dry years well (Figs. 20 and 21). The land use and crop cover we simulated was irrigated winter wheat-sorghum rotations, assumed repeated for all years of simulation (1977-1994) and for all subbasins. According to Kansas Dept. of Agriculture, Statistics Division's "Kansas Farm Facts" for recent years, wheat is approximately 50% of the planted acreage in Clay and Cloud Counties, sorghum approximately 20%, followed by soybean, hay, corn, alfalfa in lesser percentages (5-7%).

As we noted earlier, ground-water levels do not seem to be declining to any significant, long-term manner as observed in western Kansas, for example. This modeling result lead us to infer that surface runoff processes, as opposed to groundwater processes, may be the dominant influences on the streamflow regimen of the Lower Republican River. Therefore, as we refine our model calibration, we will be concentrating in analyzing surface-runoff-impacting processes, such as land use, vegetation patterns, and of course climatic impacts.

Soils

Lower Republican Basin



- | | | |
|----------------------------|------------------------------------|-----------------------------|
| KS301 Crete-Crete-Crete | KB307 Crete-Crete-Lancaster | KS503 Hord-Roxbury-McCook |
| KS372 Mulr-Eudora-Sutphen | KS302 Hedville-Lancaster-Lancaster | KS507 Harney-Harney-Crete |
| KS374 Carr-Mulr-Humbarger | KS314 Kipson-Hastings-Armo | KS304 Kipson-Hastings-Crete |
| KS345 Hastings-Crete-Crete | KS327 Crete-Crete-Hastings | |

Figure 22

This map was prepared by the
 Agricultural Research Service
 in cooperation with the
 State of Kansas

6. References

- Arnold, J.G., J.R. Williams, A.D. Nicks and Sammons, 1990. SWRRB: A basin scale simulation model for soil and water resources management, Texas A&M University Press, College Station, TX, 264 p.
- Arnold, J.G., Williams, J.R., Srinivasan, R., King, K.W., and Griggs, R.H., 1994. SWAT, Soil and Water Assessment Tool. USDA, Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, TX.
- Dunlap, L.E., 1982. Geohydrology of principal aquifers in the Republican River Basin, Kansas. U.S. Geological Survey, Open-File Report 82-79 (5 plates).
- Fader, S.W., 1968. Ground water in the Republican River area, Cloud, Jewell, and Republic Counties, Kansas. Kansas Geological Survey, Bulletin, 188, 27 p.
- Hansen, C.B., 1991. Estimates of freshwater storage and potential natural recharge for principal aquifers in Kansas. U.S. Geological Survey, Water-Resources Investigations Report 87-4230, 100 p.
- Koussis, A.D., Sophocleous, M.A., Bian, L., Zou, S., 1994. Lower Republican River Basin: Stream-Aquifer study. First year report to KWO, 142 p.
- McDonald, M.G., and Harbaugh, A.W., 1988. A modular three-dimensional finite-differences ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations Book 6, Ch. A1, 586 p.
- Munson, J.W., 1991. Availability of ground-water in the Lower Republican River basin and the Belleville Formation extending into the Little Blue River basin. KSBA, DWR, Topeka, KS.
- Walters, K.L. and Bayne, C.K., 1959. Geology and ground-water resources of Clay County, Kansas. Kansas Geological Survey, Bulletin 136, 106 p.
- White, K.E. and Sloto, R.A., 1990. Base-flow-frequency characteristics of selected Pennsylvania streams. U.S. Geological Survey, Water-Resources Investigations Report 90-4160, 67 p.

Appendix A

November 1994 ground-water level survey data

NOVEMBER 1994 GROUND-WATER LEVEL SURVEY DATA

No.	Location	Land Surface Elevation (ft)	Depth to Water Table (ft)	Water Table Elevation (ft)	7.5' USGS Quad.
1	5 S 4 W 3 dbbd	1393	12.13	1380.9	KACKLEY
2	5 S 4 W 3 cdc d	1381	7.51	1373.5	KACKLEY
3	4 S 4 W 33 ccd	1386	9.6	1376.4	KACKLEY
4	5 S 4 W 8 dadb	1392	19.8	1372.2	KACKLEY
5	5 S 4 W 17 aaaa	1389	14.05	1375	JAMESTOWN
6	5 S 4 W 16 aaaa	1380	19.32	1370.7	JAMESTOWN
7	5 S 4 W 22 abba	1380	12.92	1367.1	JAMESTOWN
8	5 S 4 W 3 dccd	1385	18.6	1366.4	CONCORDIA NW
9	5 S 3 W 22 daaa	1337	8.45	1328.6	CONCORDIA
10	5 S 3 W 19 babd	1370	13.25	1356.8	CONCORDIA
11	5 S 4 W 14 daca	1365	8.09	1356.9	CONCORDIA
12	5 S 4 W 24 cbbc	1362	11.61	1350.4	CONCORDIA
13	5 S 4 W 15 abca	1375	8.98	1366	JAMESTOWN
14	5 S 3 W 18 cc dc	1375	22	1353	CONCORDIA
15	5 S 3 W 18 bccc	1382	25.33	1356.7	CONCORDIA
16	5 S 4 W 13 dadd	1377	27.3	1349.7	CONCORDIA
17	5 S 3 W 19 dcac	1359	11.92	1347.1	CONCORDIA
18	5 S 3 W 20 dcab	1350	8.5	1341.5	CONCORDIA
19	5 S 3 W 21 babb	1370	41.96	1328	CONCORDIA
20	5 S 3 W 20 bb bc	1370	21.67	1348.3	CONCORDIA
21	5 S 2 W 22 cada	1312	12.26	1299.7	RICE
22	5 S 2 W 35 bcbb	1323	22.54	1300.5	RICE
23	5 S 2 W 32 dbbb	1335	25.73	1309.3	RICE
24	5 S 2 W 21 cbcc	1320	13.55	1306.5	RICE
25	5 S 2 W 30 cc da	1327	9.97	1317	RICE
26	5 S 3 W 24 cccb	1333	13.92	1319.1	RICE
27	5 S 3 W 24 cdac	1330	14.4	1315.6	RICE
28	5 S 2 W 25 cbbb	1317	19.32	1297.7	CLYDE
29	5 S 1 W 29 bccb	1294	10.16	1283.8	CLYDE
30	5 S 1 W 27 acca	1288	9.13	1278.9	CLYDE
31	5 S 1 W 35 bb ad	1280	9.09	1270.9	CLYDE
32	6 S 1 W 2 abbd	1280	9.18	1270.8	CLYDE
33	5 S 1 W 34 dccb	1285	11.08	1273.9	CLYDE
34	5 S 1 W 32 dc bc	1307	24.22	1282.8	CLYDE
35	5 S 1 W 26 ad cd	1291	50	1241	CLYDE
36	5 S 1 W 22 abaa	1308	49.67	1258.3	CLYDE
37	6 S 2 E 18 cbdc	1245	15.06	1229.9	CLIFTON
38	6 S 2 E 18 cc ad	1245	14.63	1230.4	CLIFTON
39	6 S 1 E 13 bc dd	1259	28.95	1230.1	CLIFTON
40	6 S 1 E 13 abcc	1248	16.43	1231.6	CLIFTON
41	6 S 1 E 14 dcc c	1259	26.54	1232.5	CLIFTON
42	6 S 1 E 23 bc dc	1265	31.52	1233.5	CLIFTON
43	6 S 1 E 24 bb dd	1253	25.51	1227.5	CLIFTON
44	6 S 1 E 2 abcc	1264	18.53	1245.5	CLIFTON
45	6 S 1 E 10 bdaa	1255	8.98	1246	CLIFTON
46	6 S 1 E 9 abab	1262	9.04	1253	CLIFTON
47	6 S 1 E 10 bc bc	1259	10.14	1248.9	CLIFTON
48	5 S 1 E 34 dcc c	1274	23.73	1250.3	CLIFTON
49	6 S 1 E 5 bb bc	1267	12.82	1254.2	CLIFTON
50	6 S 1 E 6 accc	1269	8.64	1260.4	CLIFTON
51	6 S 1 E 6 bb ba	1275	13.23	1261.8	CLIFTON
52	6 S 2 E 20 cc bb	1236	11.08	1224.9	LINN SW

No.	Location	Land Surface Elevation (ft)	Depth to Water Table (ft)	Water Table Elevation (ft)	7.5' USGS Quad.
53	6 S 2 E 19 acab	1240	14.56	1225.4	LINN SW
54	7 S 2 E 34 bbcc	1200	10.17	1189.8	CLAY CTR NW
55	7 S 2 E 28 dddd	1198	11.71	1186.3	CLAY CTR NW
56	7 S 2 E 27 cdaa	1218	24.25	1193.8	CLAY CTR NW
57	7 S 2 E 34 abaa	1215	23.43	1191.6	CLAY CTR NW
58	7 S 2 E 27 ddad	1215	25.67	1189.3	CLAY CTR NW
59	7 S 2 E 34 adaa	1209	19.9	1189.1	CLAY CTR NW
60	7 S 2 E 34 ddad	1201	19.7	1181.3	CLAY CTR NW
61	8 S 2 E 2 aaab	1209	29.1	1179.9	CLAY CTR NW
62	8 S 2 E 1 aca	1203	24.25	1178.7	CLAY CTR NW
63	8 S 2 E 1 bdbb	1206	25.65	1180.4	CLAY CTR NW
64	8 S 2 E 1 cacc	1207	24.78	1182.2	CLAY CTR NW
65	8 S 2 E 1 abaa	1205	24.59	1180.4	CLAY CTR NW
66	7 S 2 E 22 aadc	1220	17.46	1202.5	CLAY CTR NW
67	7 S 2 E 16 badc	1215	10.17	1204.8	CLAY CTR NW
68	7 S 2 E 16 dadd	1225	17.67	1207.3	CLAY CTR NW
69	7 S 2 E 15 cad	1223	17.13	1205.9	CLAY CTR NW
70	7 S 2 E 15 bcbc	1225	16.13	1208.9	CLAY CTR NW
71	7 S 2 E 11 ccc	1227	15	1212	CLAY CTR NW
72	7 S 2 E 11 bccc	1231	18.08	1212.9	CLAY CTR NW
73	7 S 2 E 4 caed	1240	25.67	1214.3	CLAY CTR NW
74	7 S 2 E 3 bcbc	1235	20.9	1214.1	CLAY CTR NW
75	7 S 2 E 25 cccd	1210	26.14	1183.9	CLAY CTR NW
76	8 S 2 E 13 dac	1198	13.25	1184.8	CLAY CTR SW
77	8 S 2 E 12 dbbc	1200	29.44	1170.6	CLAY CTR SW
78	8 S 2 E 12 acbb	1205	27.38	1177.6	CLAY CTR NW
79	8 S 2 E 12 abbb	1205	26.75	1178.3	CLAY CTR NW
80	8 S 2 E 13 dbb	1190	12.18	1177.8	CLAY CTR SW

Appendix B

Water rights and record numbers displayed in Fig. 9

Lower Republican River Basin Water Rights

WR_GR

3/27/95

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A01744700	05S02W0201	875	1	17	G	70	70	0	-	1
A00254900	05S04W0401	861	1	3	G	170	170	187	-	2
A00730900	05S04W0303	862	1	4	G	73	73	50	-	3
A03167700	05S01E0201	887	1	29	G	140	140	0	-	4
A00749900	05S04W0304	862	1	4	G	170	170	140	-	5
A03176200	05S02E0101	894	1	36	G	81	81	0	-	6
A01147400	05S02W0102	876	1	18	G	62	62	55	-	7
A01632300	05S04W0203	863	1	5	G	120	120	0	-	8
A03992400	05S04W0402	861	1	3	G	82	82	44	-	9
A02411600	05S01W0302	880	1	22	G	50	50	32	-	10
A03561200	05S04W0307	862	1	4	G	63	63	119	-	11
A03937000	05S04W0308	862	1	4	G	57	57	5	-	12
A01074100	05S04W0201	863	1	5	G	148	148	333	-	13
A03370100	05S04W0306	862	1	4	G	23	23	33	-	14
A03146100	05S01E0101	888	1	30	G	74	74	0	-	15
A03942000	05S04W0204	863	1	5	G	220	220	0	-	16
A01055500	05S01W0301	880	1	22	G	123	123	88	-	17
A02691800	05S04W0502	860	1	2	G	110	109	52	-	18
A00584700	05S04W0302	862	1	4	G	97	97	93	-	19
A01937600	05S04W0501	821	2	2	G	33	33	104	-	20
A02958700	05S04W0803	821	2	2	G	52	52	72	-	23
A00468400	05S04W0301	823	2	4	G	78	78	53	-	24
A00985900	05S01W1101	842	2	23	G	190	190	70	-	25
A00667100	05S04W1002	823	2	4	G	45	45	46	-	26
A01330100	05S01E0801	845	2	26	G	93	93	0	*	27
A01111500	05S04W1201	825	2	6	G	38	38	0	-	29
A01074000	05S04W1101	824	2	5	G	150	150	150	-	30
VWS000400	05S02E1201	855	2	36	G	2	2	0	*	31
A02141400	05S02E1201	855	2	36	G	18	15	0	*	32
A00320900	05S04W0801	821	2	2	G	330	330	113	-	33
A01981200	05S04W0905	822	2	3	G	31	31	22	-	34
A02457300	05S01E1001	847	2	28	G	180	180	0	-	35
A02779200	05S01W1201	843	2	24	G	132	132	111	-	36
A03124500	05S01E1002	847	2	28	G	194	194	0	-	37
A01187400	05S04W1202	825	2	6	G	44	44	44	-	38
A02686800	05S02W1101	836	2	17	G	90	90	89	-	39
A00220700	05S04W0901	822	2	3	G	113	53	0	*	40
VCDO00800	05S04W0901	822	2	3	G	60	60	88	*	41
A02928800	05S04W1203	825	2	6	G	76	76	23	-	42
A01713600	05S04W1003	823	2	4	G	81	81	116	-	43
A01215200	05S01E0701	844	2	25	G	103	103	0	-	44
A03036000	05S04W1103	824	2	5	G	27	27	40	-	46
A03177900	05S04W1605	783	3	3	G	98	98	97	-	47

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03199000	05S01W1503	802	3	22	G	57	57	67	-	48
A02637100	05S03W0701	787	3	7	G	41	41	71	-	49
A03486000	05S01E1601	808	3	28	G	80	80	0	*	50
A01882300	05S04W1701	782	3	2	G	100	100	0	*	51
A00705700	05S04W1701	782	3	2	G	40	40	138	*	52
A00039900	05S04W1501	784	3	4	G	80	80	73	-	53
A01172000	05S01W1601	801	3	21	G	93	93	44	-	54
A01338500	05S04W1304	786	3	6	G	116	116	95	-	55
A00563400	05S04W1401	785	3	5	G	262	262	101	-	56
A03357700	05S01E1702	806	3	26	G	82	82	0	-	57
A01938400	05S03W1704	788	3	8	G	143	143	75	-	58
A00670600	05S03W1701	788	3	8	G	83	83	29	-	59
A03178000	05S04W1506	784	3	4	G	120	120	80	-	60
A01401700	05S02W1401	797	3	17	G	67	67	53	-	61
A00818500	05S01W1301	804	3	24	G	33	33	106	*	63
A03272800	05S01W1301	804	3	24	G	207	207	0	*	64
A00230100	05S04W1601	783	3	3	G	86	86	0	*	65
A00171300	05S04W1601	783	3	3	G	146	146	204	*	66
A01535200	05S04W1504	784	3	4	G	107	107	86	-	67
A00808200	05S01W1501	802	3	22	G	285	285	104	-	68
A02912400	05S03W1804	787	3	7	G	68	68	86	*	69
A03986300	05S03W1804	787	3	7	G	128	128	0	*	70
A03526100	05S03W1807	787	3	7	G	120	120	72	-	71
A03605500	05S01W1603	801	3	21	G	195	195	0	-	72
A03028700	05S03W1301	792	3	12	G	25	25	55	-	73
A03054800	05S04W1502	784	3	4	G	21	0	0	*	74
A00630200	05S04W1502	784	3	4	G	96	96	124	*	75
A03532400	05S01W1602	801	3	21	G	85	85	0	-	76
A00632600	05S04W1503	784	3	4	G	83	83	56	-	77
A01301100	05S04W1303	786	3	6	G	160	160	94	-	78
A00444800	05S04W1604	783	3	3	G	40	40	39	-	79
A00607100	05S04W1301	786	3	6	G	68	68	137	-	80
A02286300	05S01E1401	809	3	29	G	6	6	0	-	81
A01199000	05S03W1702	788	3	8	G	77	77	18	-	82
A02369000	05S04W1305	786	3	6	G	83	83	107	*	83
A03401300	05S04W1305	786	3	6	G	19	19	0	*	84
A02758900	05S03W1803	787	3	7	G	83	83	79	-	85
A00438800	05S04W1603	783	3	3	G	82	82	29	-	86
A02229100	05S04W1505	784	3	4	G	87	87	77	-	87
A04008600	05S01E1301	810	3	30	G	21	21	0	-	88
A00231800	05S04W2101	783	3	3	G	88	88	83	-	89
A02767400	05S01E1701	806	3	26	G	117	117	0	-	90
A03530900	05S01E1703	806	3	26	G	118	118	0	-	91

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03611200	05S04W2202	745	4	4	G	86	86	89	-	92
A03285500	05S01E2301	770	4	29	G	49	49	0	*	93
A03109800	05S03W1806	748	4	7	G	114	114	118	-	94
A03056900	05S03W1805	748	4	7	G	132	132	146	-	95
A02382000	05S04W2201	745	4	4	G	90	90	82	-	96
A02673400	05S03W2103	750	4	9	G	11	11	0	-	97
A01425500	05S01W2202	763	4	22	G	108	108	76	-	98
A02908000	05S03W1903	748	4	7	G	77	77	43	-	99
A03991100	05S01E2003	767	4	26	G	195	195	0	-	100
A03800700	05S03W2002	749	4	8	G	105	105	55	-	101
A02921300	05S03W1904	748	4	7	G	181	181	0	-	102
A03851500	05S03W1905	748	4	7	G	225	225	75	-	104
A02433600	05S03W2402	753	4	12	G	29	29	13	-	105
A03511400	05S03W2201	751	4	10	G	76	76	78	-	106
A03594400	05S04W2302	746	4	5	G	50	50	50	-	107
A01483500	05S03W2301	752	4	11	G	32	32	27	-	108
A02657100	05S04W2402	747	4	6	G	85	85	70	-	109
A01309100	05S02W2104	756	4	15	G	105	105	38	-	111
A03118200	05S02W2107	756	4	15	G	52	52	87	-	112
A00868800	05S01W2003	761	4	20	G	29	29	29	-	113
A03990500	05S03W2203	752	4	11	G	72	72	56	-	114
A00988900	05S02W1901	754	4	13	G	187	187	166	-	115
A00701700	05S02W2108	756	4	15	G	111	111	89	-	116
A02533600	05S02W2106	756	4	15	G	189	189	157	-	117
A03076900	05S03W2303	752	4	11	G	70	70	70	-	118
A02587900	05S03W2302	752	4	11	G	45	45	2	-	119
A00150500	05S02W2201	757	4	16	G	78	78	124	*	120
A00652500	05S02W2201	757	4	16	G	135	60	0	*	121
A03987200	05S03W2204	751	4	10	G	170	170	0	-	122
A01363100	05S01W2201	763	4	22	G	142	142	149	-	123
A03824400	05S02W2103	756	4	15	G	108	108	0	*	124
A01249900	05S02W2103	756	4	15	G	60	60	183	*	125
A01096900	05S01W2301	764	4	23	G	102	102	110	-	126
A01282300	05S02W2202	757	4	16	G	100	100	92	-	127
A03938400	05S03W2405	753	4	12	G	156	156	81	-	128
A02637200	05S01E2002	767	4	26	G	121	121	0	-	129
A02246700	05S01E2001	767	4	26	G	83	83	0	-	130
A00695600	05S03W2102	750	4	9	G	17	17	10	-	131
A00602500	05S03W2001	749	4	8	G	159	159	156	-	132
A00481900	05S04W2401	747	4	6	G	120	120	0	-	133
A00578800	05S03W2401	753	4	12	G	56	56	12	-	134
A03993200	05S03W2408	753	4	12	G	45	45	0	-	135
A02114100	05S02W2105	756	4	15	G	67	67	44	-	136

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETG	AUTHG	AF USED	PD	rec num
A01415000	05S02W2003	755	4	14	G	204	204	147	-	137
A03920400	05S03W2304	752	4	11	G	120	120	62	-	138
A01338400	05S03W1906	709	5	7	G	103	103	139	-	139
A02284500	05S01E2903	728	5	26	G	49	49	0	*	140
A01744400	05S01E2903	728	5	26	G	154	154	0	*	141
A03950000	05S02W2405	721	5	19	G	180	0	0	-	143
A01159800	05S01W2503	726	5	24	G	94	94	99	-	144
A03981300	05S03W2502	714	5	12	G	165	165	0	-	145
A01197600	05S01W2803	723	5	21	G	108	108	107	-	146
A03657000	05S03W2501	714	5	12	G	151	151	156	*	147
A03031200	05S02W2506	720	5	18	G	237	237	92	-	148
A03272900	05S01E2601	731	5	29	G	20	20	0	-	150
A00170900	05S02W2601	719	5	17	G	97	97	43	-	151
A00641500	05S01W2802	723	5	21	G	100	100	105	-	152
A02373000	05S01W2804	723	5	21	G	141	141	140	-	153
A00900800	05S01W3004	721	5	19	G	94	94	0	-	154
A03649500	05S01W2602	725	5	23	G	75	0	0	*	155
VCD000100	05S01W2602	725	5	23	G	110	110	137	*	156
A03649400	05S01W2603	725	5	23	G	50	50	0	*	157
A00446300	05S01W3001	721	5	19	G	14	14	0	-	158
A04044900	05S01W2702	724	5	22	G	95	95	0	-	161
A00418700	05S02W2505	720	5	18	G	228	228	213	-	162
A01425400	05S01W2601	725	5	23	G	14	0	4	-	163
A02754900	05S03W2905	710	5	8	G	56	56	20	-	164
A03164800	05S02W2604	719	5	17	G	12	12	10	-	165
A02985200	05S01W2902	722	5	20	G	39	39	44	*	166
A03276900	05S01E3004	727	5	25	G	97	97	0	-	167
VCD001100	05S02W2501	720	5	18	G	100	100	156	*	169
A00463600	05S02W2501	720	5	18	G	330	330	0	*	170
A00339000	05S02W2501	720	5	18	G	65	65	0	*	171
A00912100	05S01W2501	726	5	24	G	102	102	72	-	172
A01147500	05S01E3001	727	5	25	G	112	112	0	*	174
A01249800	05S01E3001	727	5	25	G	233	121	0	*	175
A00115200	05S02W2502	720	5	18	G	110	110	157	-	176
A00512000	05S02W2603	719	5	17	G	111	111	130	-	178
A03052600	05S03W2703	712	5	10	G	307	307	168	-	180
A02526800	05S01E3003	727	5	25	G	96	96	0	-	181
A00470500	05S01W3003	721	5	19	G	189	189	25	-	182
A889116HD	05S03W2602	713	5	11	G	414	414	1123	*	183
A889116IN	05S03W2602	713	5	11	G	68	68	60	*	184
A00338900	05S02W2503	720	5	18	G	120	120	159	*	186
A02777100	05S03W3402	712	5	10	G	252	252	203	-	187
A02322800	05S02W3001	676	6	13	G	29	29	178	-	188

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETG	AUTHG	AF USED	PD	rec num
A03355500	05S01E3402	691	6	28	G	40	40	0	-	189
A00154500	05S03W3601	675	6	12	G	98	98	143	*	190
A00602000	05S03W3302	672	6	9	G	60	60	30	-	191
A00451800	05S03W3501	674	6	11	G	81	81	0	*	192
A00598500	05S03W3501	674	6	11	G	446	143	0	*	193
A00391100	05S03W3501	674	6	11	G	222	222	107	*	194
A00800200	05S02W3401	679	6	16	G	270	70	0	*	195
A00499100	05S02W3401	679	6	16	G	240	240	309	*	196
VCD000400	05S03W3206	672	6	9	G	1044	1044	60	-	197
A02442900	05S02W3301	678	6	15	G	135	135	83	-	198
A03110800	05S02W3505	680	6	17	G	120	90	22	-	199
A01322800	05S02W3502	680	6	17	G	98	98	71	-	200
A00639900	05S01W3301	684	6	21	G	90	90	0	-	201
A00662300	05S02W3603	681	6	18	G	60	60	51	-	202
A03875400	05S01W3501	686	6	23	G	230	158	0	*	203
A03190000	05S01W3501	686	6	23	G	72	72	64	*	204
A03816000	05S03W3405	673	6	10	G	95	95	0	*	205
A03474900	05S03W3405	673	6	10	G	112	112	183	*	206
A02440700	05S02W3503	680	6	17	G	109	109	65	-	207
A00704200	05S01W3103	682	6	19	G	159	159	135	-	208
A00658300	05S02W3501	680	6	17	G	100	100	113	-	209
A02984800	05S02W3102	676	6	13	G	46	46	18	-	210
A00565800	05S01W3202	683	6	20	G	51	51	0	-	211
A03027100	05S01W3402	685	6	22	G	36	36	5	-	212
A00457500	05S01W3101	682	6	19	G	107	107	111	-	213
A90906500	05S03W3304	672	6	9	G	25	25	23	-	214
A03568700	05S01E3501	692	6	29	G	129	129	0	-	215
A00607200	05S01W3203	683	6	20	G	189	189	152	-	216
A00701500	05S02W3604	681	6	18	G	126	126	109	-	217
A01296100	05S02W3602	681	6	18	G	59	0	0	*	218
A00354100	05S02W3602	681	6	18	G	68	68	60	*	219
A02549000	05S02W3204	677	6	14	G	147	147	55	-	220
A00756100	05S01E3202	689	6	26	G	63	63	0	-	222
A02776800	05S03W3607	675	6	12	G	65	65	53	-	223
A00461100	05S02W3202	677	6	14	G	212	212	96	-	224
A00455700	05S02W3201	677	6	14	G	48	48	74	-	225
VW5002800	05S01E3201	689	6	26	G	88	88	0	-	226
A00819500	05S01E3203	689	6	26	G	86	39	0	-	227
A00815300	05S02W3101	676	6	13	G	41	41	75	-	228
A03262700	05S01W3502	686	6	23	G	120	120	3	-	229
A02813300	05S01E3204	689	6	26	G	360	360	0	-	230
A00910500	05S03W3604	675	6	12	G	84	84	85	-	231
A00625900	05S01W3102	682	6	19	G	75	75	64	-	232

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03292200	05S01W3303	684	6	21	G	152	152	182	-	233
A01823600	05S02W3605	681	6	18	G	98	98	27	-	234
A00704300	05S01W3204	683	6	20	G	175	175	166	-	235
A01197500	05S01W3401	685	6	22	G	173	173	267	-	236
A02117900	05S01E3102	688	6	25	G	282	282	0	-	237
A01642200	05S01W3104	682	6	19	G	30	30	14	-	238
A03910600	06S01E0604	688	6	25	G	127	127	126	-	239
A03469900	05S01W3403	685	6	22	G	128	128	134	-	240
A00459400	05S01W3201	683	6	20	G	180	180	194	-	241
A03891900	05S01E3401	652	7	28	G	87	87	0	*	242
A01787000	05S01E3401	652	7	28	G	69	69	0	*	243
A03972000	05S03W3502	635	7	11	G	242	0	0	-	244
A00471400	06S01W0201	647	7	23	G	49	49	42	-	245
A01183200	06S01W0403	645	7	21	G	116	116	221	-	246
A03812300	06S01E0501	650	7	26	G	103	103	37	-	247
VCY000100	06S01E0205	653	7	29	G	61	61	91	-	248
A03918300	06S03W0501	632	7	8	G	35	35	0	-	249
A02595500	06S01W0501	644	7	20	G	105	105	178	-	250
A01058500	06S01W0405	645	7	21	G	62	62	66	-	251
A03250800	06S01E0405	651	7	27	G	135	135	52	-	252
A01317700	06S01E0204	653	7	29	G	51	51	42	-	253
A02595600	06S01W0502	644	7	20	G	103	103	152	-	254
A01184700	06S01E0302	652	7	28	G	90	90	144	-	255
A00704100	06S01E0601	649	7	25	G	110	110	196	-	256
A03881800	06S01E0303	652	7	28	G	144	17	0	*	257
A02993400	06S01E0303	652	7	28	G	144	144	161	*	258
A02971400	06S04W0201	630	7	6	G	57	57	29	-	259
A00129900	06S01E0102	654	7	30	G	80	80	8	-	260
A00444300	06S01E0202	653	7	29	G	128	128	173	-	261
A03528800	06S01E0111	654	7	30	G	143	143	89	-	262
A03098500	06S01W0503	644	7	20	G	132	132	111	-	263
A01135200	06S01W0302	646	7	22	G	171	171	199	-	264
VCY000800	06S01E0112	654	7	30	G	115	115	8	-	265
A00819400	06S01W0406	645	7	21	G	101	35	0	*	266
A00298300	06S01W0406	645	7	21	G	75	75	80	*	267
A00920300	06S01E0104	654	7	30	G	66	66	11	-	268
A00497500	06S01E0301	652	7	28	G	177	177	242	-	269
A01116500	06S01W0301	646	7	22	G	202	202	147	-	270
A03084600	06S01W0303	646	7	22	G	102	102	113	-	271
A00521300	06S01E0406	651	7	27	G	160	160	75	*	272
A00684000	06S01E0406	651	7	27	G	44	44	0	*	273
A00420200	06S01E0201	653	7	29	G	144	144	78	-	274
A00460900	06S01E0203	653	7	29	G	130	130	152	-	275

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A01101800	06S01E0109	654	7	30	G	129	129	115	-	276
A03914600	06S01W0504	644	7	20	G	198	198	162	-	277
A03938000	06S02W0102	642	7	18	G	150	150	0	-	278
A01226900	06S01E0602	649	7	25	G	95	95	93	-	279
A02165200	06S01W0203	647	7	23	G	65	65	96	-	280
A00641800	06S01E0108	654	7	30	G	34	34	54	-	281
A00470400	06S01W0101	648	7	24	G	120	120	133	-	282
A02854300	06S01W0404	645	7	21	G	75	75	73	*	283
A03673200	06S01W0404	645	7	21	G	102	45	0	*	284
A02595700	06S01W0204	647	7	23	G	105	105	0	-	285
A03579300	06S01E0402	651	7	27	G	255	255	75	-	286
A01266600	06S01W1102	608	8	23	G	56	56	53	-	287
A00718500	06S01W1202	609	8	24	G	186	186	149	-	288
A01572300	06S01E0701	610	8	25	G	120	120	78	-	289
A01114300	06S01W1101	608	8	23	G	39	39	32	-	290
A01978500	06S01W1105	608	8	23	G	110	110	66	-	291
A03928600	06S01W1003	607	8	22	G	198	198	185	-	292
A03364200	06S01E1103	614	8	29	G	87	87	115	*	293
A01112400	06S01E1001	613	8	28	G	165	165	186	-	294
A01649000	06S01W1001	607	8	22	G	94	94	104	-	295
A03007600	06S01E1102	614	8	29	G	184	184	153	-	296
A01619700	06S01E1002	613	8	28	G	63	63	0	-	297
A03145900	06S01E0702	610	8	25	G	94	94	53	-	298
A03579400	06S01E0901	612	8	27	G	170	170	66	-	299
A00778600	06S01E0801	611	8	26	G	152	152	106	-	300
A00997300	06S01E0802	611	8	26	G	110	110	49	-	301
A03475800	06S02W1203	603	8	18	G	36	36	23	-	302
A03908400	06S01W1002	607	8	22	G	315	315	277	-	303
A02613700	06S04W1101	591	8	6	G	11	11	7	-	306
A01373300	06S01W1103	608	8	23	G	16	16	18	-	307
A03342700	06S02E1803	577	9	31	G	69	69	6	-	308
A02776900	06S02W1801	559	9	13	G	17	17	24	-	309
A02781100	06S01E1402	575	9	29	G	94	94	80	-	310
A02781200	06S01E1403	575	9	29	G	114	114	127	-	311
A00380300	06S01E1301	576	9	30	G	175	175	156	-	312
A01430100	06S01E1306	576	9	30	G	92	92	69	-	313
A02949800	06S01E1305	576	9	30	G	185	185	184	-	314
A01068600	06S01E1303	576	9	30	G	152	152	423	-	315
A02959800	06S01E1404	575	9	29	G	210	210	92	-	316
A00810500	06S01E1302	576	9	30	G	112	112	97	-	317
A01004400	06S01E1401	575	9	29	G	244	244	147	-	318
A02074300	06S02E1801	577	9	31	G	114	114	119	-	319
A03569900	06S01E1501	575	9	29	G	48	48	76	-	320

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03232700	06S02E1802	577	9	31	G	147	147	0	-	321
A03566100	06S01E1405	575	9	29	G	132	132	78	-	322
A03984100	06S01E2407	576	9	30	G	43	43	50	-	323
A02959900	06S01E2404	576	9	30	G	55	55	48	-	324
A00346700	06S01E2401	537	10	30	G	120	120	206	-	325
A03097500	06S01W2102	528	10	21	G	123	123	127	-	326
A03545200	06S03W2302	518	10	11	G	35	35	31	-	327
A03982700	06S01E2406	537	10	30	G	92	0	120	-	328
A01588900	06S02E1901	538	10	31	G	72	72	33	-	329
A01108900	06S01W2201	529	10	22	G	128	128	104	-	330
A00402300	06S01E2402	537	10	30	G	195	195	50	-	331
A01167400	06S01W2301	530	10	23	G	76	76	95	-	332
A03223200	06S02E1902	538	10	31	G	180	180	87	-	333
A01300300	06S03W2301	518	10	11	G	38	38	19	-	334
A00949200	06S01E2301	536	10	29	G	157	157	386	-	335
A04006700	06S01W2004	527	10	20	G	198	198	0	-	336
A03668900	06S01E2304	536	10	29	G	99	99	125	-	337
A01260400	06S01E2303	536	10	29	G	103	103	42	-	338
A02419800	06S01W2302	530	10	23	G	109	109	101	-	339
A01146200	06S01E2302	536	10	29	G	162	162	123	-	340
A02221000	06S01E2403	537	10	30	G	160	160	157	-	341
A02293700	06S02W2101	522	10	15	G	148	148	71	-	342
A01537500	06S01W2001	527	10	20	G	124	124	124	-	343
A01294200	06S01W2101	528	10	21	G	57	57	59	-	344
A03852500	06S01E2405	537	10	30	G	192	192	214	-	345
A01771000	06S01W2202	529	10	22	G	105	105	53	-	346
A03015800	06S02E2001	539	10	32	G	200	88	28	-	347
A01716000	06S01E2601	536	10	29	G	130	130	77	*	348
A01983000	06S01E2601	536	10	29	G	80	80	0	*	349
A00644600	06S02E3003	499	11	31	G	91	91	111	-	351
A02710100	06S01W2601	491	11	23	G	51	51	69	-	352
A01097200	06S01E2504	498	11	30	G	155	155	0	*	353
A00547500	06S02E3002	499	11	31	G	141	141	206	-	354
A00458600	06S02E3001	499	11	31	G	220	220	192	-	355
A02338100	06S01E2503	498	11	30	G	180	180	162	-	356
A00492000	06S02E2902	500	11	32	G	100	100	0	*	357
A02085500	06S02E2801	501	11	33	G	66	66	118	-	358
A01294100	06S01W2901	488	11	20	G	161	161	129	-	359
A01346200	06S04W2601	473	11	5	G	46	46	44	-	360
A00601100	06S01E2501	498	11	30	G	55	55	85	-	361
A03060900	06S01W2501	492	11	24	G	120	120	74	-	362
A01086900	06S02E3301	501	11	33	G	30	30	37	-	363
A02794000	06S02E3201	461	12	32	G	103	103	105	-	364

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A00633400	06S02E3302	462	12	33	G	120	120	88	-	365
A02886500	06S02E3309	462	12	33	G	94	94	69	-	366
A03579000	06S02E3103	460	12	31	G	201	201	181	-	367
A03007900	06S02E3102	460	12	31	G	165	165	149	-	368
A01700500	06S01E3601	459	12	30	G	194	194	176	-	369
A02883800	06S02E3304	462	12	33	G	284	9	81	-	370
A01700600	06S02E3101	460	12	31	G	220	220	230	-	371
A02725200	06S02W3501	446	12	17	G	99	99	100	-	372
A03948900	06S01W3301	450	12	21	G	200	200	84	-	373
A02799800	06S02E3305	462	12	33	G	110	80	144	-	374
A00322600	06S02E3310	462	12	33	G	268	268	131	-	375
A00667700	07S02E0302	424	13	34	G	34	34	11	-	376
A01043400	07S02E0303	423	13	33	G	120	120	80	-	377
A01645300	07S02E0402	423	13	33	G	139	139	80	-	378
A03578900	07S02E0405	423	13	33	G	109	109	60	-	379
A01661100	07S02E0304	424	13	34	G	131	131	126	-	380
A01709700	07S02E0305	424	13	34	G	140	140	86	-	381
A03015900	07S02E0306	424	13	34	G	171	171	389	-	382
A01841600	07S02E0403	423	13	33	G	125	125	125	-	383
A01968500	07S02W0101	408	13	18	G	149	149	55	-	384
A92903200	07S02E0406	423	13	33	G	18	18	0	*	385
A03718000	07S02E0308	424	13	34	G	50	39	0	-	386
VCY000300	07S02E0301	424	13	34	G	11	11	53	-	387
A03552600	07S02E0801	383	14	32	G	10	10	8	-	388
A02883900	07S02W1101	368	14	17	G	168	168	124	-	389
A03364100	07S02E1102	385	14	34	G	192	192	119	-	390
A01621500	07S02E0901	384	14	33	G	133	133	149	-	391
A02892400	07S02E1002	385	14	34	G	162	162	128	-	392
A01766000	07S02E0902	384	14	33	G	51	51	20	-	393
A03364000	07S02E1004	385	14	34	G	183	183	162	-	394
A01613000	07S02E1101	386	14	35	G	104	104	104	-	395
A02892300	07S02E1001	385	14	34	G	84	84	70	-	396
A03342800	07S02E1003	385	14	34	G	92	92	93	-	397
A02339400	07S02E1403	386	14	35	G	75	75	86	-	398
A03903800	07S02E1104	385	14	34	G	165	0	165	-	399
A02390600	07S02E1502	385	14	34	G	219	219	211	-	400
A03007800	07S02E1402	386	14	35	G	101	101	104	-	401
A03650300	07S02W1502	328	15	16	G	4	4	0	*	402
A03686300	07S02E1601	345	15	33	G	221	221	130	-	403
A03650200	07S02W1501	328	15	16	G	4	4	0	*	404
VCD000300	07S02W1501	328	15	16	G	9	9	5	*	405
A00313600	07S02E1801	343	15	31	G	218	218	16	-	406
A03830300	07S02E1503	346	15	34	G	68	68	67	-	407

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A00770600	07S02E1401	346	15	34	G	165	165	137	-	408
A03950900	07S02E1505	345	15	33	G	102	102	44	-	409
A03863700	07S02E1602	345	15	33	G	100	100	98	-	410
A03903700	07S02E1504	346	15	34	G	152	152	156	-	411
A00692300	07S02E1501	346	15	34	G	107	107	224	*	412
A01702900	07S02E1501	346	15	34	G	64	64	0	*	413
A03084700	07S02E2104	345	15	33	G	23	23	13	-	414
A01960300	07S02E2303	347	15	35	G	453	453	304	-	415
A02341500	07S02E2204	307	16	34	G	70	70	80	-	416
A01688700	07S01W2402	297	16	24	G	27	27	0	-	417
A02298500	07S02E2203	307	16	34	G	80	80	75	-	418
A03868000	07S02E2105	306	16	33	G	109	109	109	-	419
A02073200	07S02E2103	306	16	33	G	135	135	167	-	420
A01466300	07S02E2102	306	16	33	G	57	57	41	-	421
A03313600	07S02E2306	308	16	35	G	117	117	164	-	422
A03909000	07S02E2206	307	16	34	G	120	120	102	-	423
A03903100	07S02E2001	306	16	33	G	95	95	0	*	424
A01579500	07S02E2001	306	16	33	G	115	115	210	*	425
A01144300	07S02E2301	308	16	35	G	133	133	121	-	426
A02685500	07S02E2304	308	16	35	G	75	75	161	*	427
A03944800	07S02E2304	308	16	35	G	92	92	0	*	428
A01250700	07S02E2202	307	16	34	G	114	114	61	-	429
A00465500	07S02E2207	307	16	34	G	120	120	0	-	430
A03022500	07S02W2301	290	16	17	G	140	140	0	-	431
A01579100	07S02E2302	308	16	35	G	51	51	0	-	432
A03872400	07S02E2205	307	16	34	G	180	180	180	-	433
A03084800	07S02E2401	309	16	36	G	60	60	59	-	434
A03935400	07S02E2802	267	17	33	G	85	85	0	*	435
A02712000	07S02E2802	267	17	33	G	107	107	188	*	436
A01494500	07S02E2501	270	17	36	G	75	75	177	-	438
A03714700	07S02E2605	269	17	35	G	90	90	97	-	439
A01699700	07S02E2602	269	17	35	G	80	80	87	-	442
A01463100	07S02E2705	268	17	34	G	40	40	69	-	443
A03659300	07S02E2708	268	17	34	G	160	160	151	-	444
A01854300	07S02E2603	268	17	34	G	69	69	113	-	445
A02087000	07S02E2901	266	17	32	G	54	54	8	-	446
A02298300	07S02E2604	269	17	35	G	110	110	156	-	447
A00572000	07S02E2703	267	17	33	G	70	70	99	-	448
A03496400	07S02E2707	268	17	34	G	180	180	117	-	449
A00605900	07S02E2601	269	17	35	G	155	155	13	-	450
A02119400	07S02E2801	267	17	33	G	147	147	150	-	451
A01300900	07S02E2709	268	17	34	G	135	135	82	-	452
A04009700	07S02E2710	267	17	33	G	189	189	0	-	453

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03853600	07S03E3104	271	17	37	G	131	131	146	-	454
A03930600	07S02E3406	268	17	34	G	61	61	78	-	455
A01515000	07S02E3601	270	17	36	G	90	90	55	-	456
A04016100	07S02E3407	229	18	34	G	212	212	101	-	457
A02085400	07S02E3501	230	18	35	G	94	94	71	-	458
A02279600	07S02E3403	229	18	34	G	98	98	96	-	460
A03483500	07S03E3103	232	18	37	G	135	135	45	-	462
A00437900	07S03E3101	232	18	37	G	70	70	43	-	463
A03483400	07S03E3102	232	18	37	G	135	135	80	-	464
A01709800	07S02E3602	231	18	36	G	99	99	160	-	465
A02279700	07S02E3411	229	18	34	G	73	22	0	-	466
A02390500	07S02E3502	230	18	35	G	91	91	91	-	467
A02152500	07S02E3402	229	18	34	G	264	264	219	-	468
A03853400	08S02E0105	231	18	36	G	130	110	0	*	470
A00279000	08S02E0105	231	18	36	G	85	85	198	*	471
A03853500	08S02E0202	191	19	35	G	113	113	193	-	472
A00595500	08S03E0602	193	19	37	G	163	163	93	-	473
A03853700	08S02E0203	191	19	35	G	102	102	129	-	474
A03007700	08S02E0103	192	19	36	G	95	95	134	-	475
A88911500	08S02E0204	191	19	35	G	335	335	326	-	476
A889117IN	08S02E0206	191	19	35	G	26	26	19	*	477
A889117HD	08S02E0206	191	19	35	G	557	0	677	*	478
A00594300	08S03E0601	193	19	37	G	104	104	112	-	479
A03934200	08S02E0205	191	19	35	G	68	68	0	-	480
A01640100	08S02E0102	192	19	36	G	129	129	82	-	481
A00196200	08S02E0201	191	19	35	G	130	130	0	-	482
A04006400	08S02E0106	192	19	36	G	99	0	0	-	483
A01724600	08S02E1203	192	19	36	G	210	210	83	-	485
A03957700	08S03E0710	193	19	37	G	368	0	305	-	486
A92909800	08S03E0711	193	19	37	G	81	81	0	-	487
A00090500	08S02E1107	152	20	35	G	89	89	68	-	488
A03606000	08S03E0708	154	20	37	G	368	368	112	-	489
A03892400	08S02E1106	152	20	35	G	320	320	0	-	490
A03133700	08S02E1204	153	20	36	G	414	221	67	-	491
VCY0012IN	08S03E0803	154	20	37	G	1841	1841	72	*	492
VCY0012RE	08S03E0803	154	20	37	G	61	20	0	*	493
VCY000400	08S03E0701	154	20	37	G	522	522	0	-	494
A01501700	08S02E1202	153	20	36	G	179	0	199	-	495
A03838100	08S03E0804	155	20	38	G	368	368	219	-	496
A00906700	08S03E1701	155	20	38	G	90	90	122	-	499
A02346200	08S03E1601	116	21	38	G	59	59	37	-	504
A02957500	08S03E1702	116	21	38	G	201	201	215	-	505
A03823900	08S03E1703	116	21	38	G	15	15	0	*	509

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A03251200	08S03E1703	116	21	38	G	23	23	47	*	510
A03824000	08S03E2004	116	21	38	G	13	13	0	*	511
A03251100	08S03E2004	116	21	38	G	19	19	26	*	512
A03934300	08S03E2104	78	22	39	G	117	117	210	-	513
A03934400	08S03E2105	77	22	38	G	117	117	95	-	514
A01937900	08S03E2001	77	22	38	G	232	232	0	-	515
A03104200	08S03E2103	78	22	39	G	36	26	35	-	516
A03173000	08S03E1901	76	22	37	G	1	1	1	-	517
A00694300	08S03E2102	78	22	39	G	96	96	93	-	518
A02192200	08S03E2005	77	22	38	G	85	85	80	-	519
A02192300	08S03E2106	77	22	38	G	90	90	0	-	520
A00712000	08S03E2802	39	23	39	G	103	103	106	*	521
A03910100	08S03E2802	39	23	39	G	218	115	0	*	522
A02224700	08S03E2803	39	23	39	G	120	120	118	-	523
A00416100	08S03E2801	39	23	39	G	178	178	119	-	524

FILE ID	LOCATION	CELL ID	ROW	COL	SC	NETQ	AUTHQ	AF USED	PD	rec num
A0020970	05S02E07	850	2	31	S	46	46	0	-	21
A0020980	05S02E07	850	2	31	S	42	42	0	-	22
A0023800	05S02E07	850	2	31	S	22	22	0	-	28
A0063250	05S04W10	823	2	4	S	24	24	18	-	45
A0254430	05S03E18	817	3	37	S	135	135	0	-	62
A0394990	05S02W24	759	4	18	S	180	180	22	-	103
A0045720	05S02W23	758	4	17	S	90	90	126	-	110
A0176860	05S04W27	706	5	4	S	28	28	19	-	142
VCD00090	05S02W29	716	5	14	S	258	258	206	-	149
A0223020	05S02E26	737	5	35	S	61	61	0	-	159
A0263810	05S03W28	711	5	9	S	51	51	0	-	160
A0124250	05S02W29	716	5	14	S	151	151	269	-	168
A0026680	05S03W28	711	5	9	S	83	83	48	*	173
A0050240	05S03W30	709	5	7	S	144	144	56	-	177
A0193620	05S01E25	732	5	30	S	187	187	0	-	179
A0392990	05S03W30	709	5	7	S	60	60	29	-	185
A0392640	05S04W36	669	6	6	S	306	306	0	-	221
A0314400	06S03W12	597	8	12	S	20	20	0	-	304
A0261380	06S04W11	591	8	6	S	189	167	1	-	305
A0099280	06S02E29	500	11	32	S	152	152	0	-	350
A0357490	07S02E28	267	17	33	S	90	90	98	-	437
A0271210	07S02E29	266	17	32	S	30	30	125	*	440
A0345200	07S02E29	266	17	32	S	47	47	0	*	441
A0398590	07S02E33	228	18	33	S	120	120	0	-	459
A0371480	07S02E33	228	18	33	S	98	98	98	-	461
A0398580	07S02E33	228	18	33	S	150	150	0	-	469
A0153600	08S02E11	191	19	35	S	468	382	176	-	484
A0391690	08S02E12	153	20	36	S	232	232	70	*	497
A0056790	08S02E12	153	20	36	S	83	83	53	*	498
A0395490	08S03E07	154	20	37	S	335	335	173	-	500
A0059610	08S02E13	114	21	36	S	122	122	0	*	501
A0259830	08S02E13	114	21	36	S	103	103	79	*	502
A0303940	08S02E13	114	21	36	S	20	20	0	*	503
A0171090	08S02E14	113	21	35	S	88	88	33	-	506
A0176390	08S02E15	112	21	34	S	65	65	70	-	508

Appendix B1

Updated ground-water and surface water rights in the active
MODFLOW—simulated area

Lower Republican River Basin appropriations within active grid cells

Groundwater rights (see p.7 for surface water rights and grid domain):

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
1	1941	36.67	4.34	22.68	-97.393	39.591	G	VCD00010005S01W2604 34951700
2	1941	104.34	19.38	36.60	-97.135	39.374	G	VCY00040008S03E0712 33002100
3	1941	30.70	6.20	28.32	-97.287	39.564	G	VCY00010006S01E0205 42003600
4	1941	104.34	19.48	36.91	-97.130	39.373	G	VCY00040008S03E0701 27500500
5	1941	104.34	19.58	36.93	-97.129	39.371	G	VCY00040008S03E0702 22000350
6	1941	60.00	1.81	2.19	-97.778	39.627	G	VCD00080005S04W0901 NESWSW
7	1941	149.14	5.42	8.48	-97.660	39.575	G	VCD00040005S03W3303 30752769
8	1941	149.14	5.28	7.98	-97.669	39.577	G	VCD00040005S03W3211 38020122
9	1941	10.74	12.99	33.07	-97.200	39.467	G	VCY00030007S02E0301 00504920
10	1941	100.00	4.56	17.06	-97.498	39.587	G	VCD00110005S02W2501 NWNWSW
11	1941	36.67	4.33	22.68	-97.393	39.591	G	VCD00010005S01W2603 35201700
12	1941	149.14	5.10	7.99	-97.668	39.580	G	VCD00040005S03W3206 47580046
13	1941	36.67	4.33	22.68	-97.393	39.591	G	VCD00010005S01W2602 35351700
14	1941	149.14	5.08	7.91	-97.670	39.580	G	VCD00040005S03W3209 48670474
15	1941	114.77	6.38	29.01	-97.274	39.561	G	VCY00080006S01E0112 32505230
16	1941	30.70	6.20	28.33	-97.287	39.564	G	VCY00010006S01E0206 42003550
17	1942	87.50	5.69	25.25	-97.345	39.571	G	VWS00280005S01E3201 NCS2N2SW
18	1948	80.00	2.06	3.69	-97.750	39.624	G	A0003990005S04W1501 NENWNE
19	1952	89.00	19.18	34.78	-97.169	39.377	G	A0009050008S02E1107 43501150
20	1953	130.00	18.81	34.19	-97.180	39.383	G	A0019620008S02E0201 NESWSW
21	1953	110.00	4.69	17.81	-97.484	39.586	G	A0011520005S02W2502 SWNESE
22	1953	78.00	3.56	15.31	-97.531	39.602	G	A0015050005S02W2201 NWNESW
23	1953	79.79	6.36	29.01	-97.274	39.562	G	A0012990006S01E0102 34005230
24	1953	98.00	5.16	11.51	-97.602	39.579	G	A0015450005S03W3601 44502600
25	1953	48.50	4.19	16.69	-97.505	39.593	G	A0017090005S02W2602 SENWNE
26	1953	48.50	4.19	16.94	-97.500	39.593	G	A0017090005S02W2601 SENENE
27	1953	146.00	2.37	2.37	-97.774	39.619	G	A0017130005S04W1601 33503340
28	1954	54.50	14.06	30.56	-97.246	39.451	G	A0031360007S02E1804 NWNWNE
29	1954	88.00	3.00	2.50	-97.772	39.610	G	A0023180005S04W2101 NECRNENW
30	1954	165.00	1.81	1.94	-97.782	39.627	G	A0032090005S04W0802 NESESE
31	1954	54.50	14.19	30.81	-97.241	39.449	G	A0031360007S02E1801 SWNESE
32	1954	43.00	2.37	2.37	-97.774	39.619	G	A0023010005S04W1601 33503340
33	1954	75.00	6.39	20.02	-97.443	39.562	G	A0029830006S01W0406 32205200
34	1954	268.00	11.76	32.68	-97.207	39.484	G	A0032260006S02E3310 12501700
35	1954	43.00	2.69	2.31	-97.775	39.615	G	A0023010005S04W1602 SWNESW
36	1954	54.50	14.19	30.81	-97.241	39.449	G	A0031360007S02E1802 SWNESE
37	1954	85.00	18.01	35.72	-97.151	39.394	G	A0027900008S02E0105 52501470
38	1954	53.00	1.81	2.19	-97.778	39.627	G	A0022070005S04W0901 NESWSW
39	1954	54.50	14.19	30.56	-97.246	39.449	G	A0031360007S02E1803 SWNWNE
40	1954	165.00	1.69	1.94	-97.782	39.629	G	A0032090005S04W0801 SESESE
41	1955	120.00	6.81	23.06	-97.386	39.555	G	A0047040006S01W0101 NWSWSW
42	1955	144.00	6.50	28.50	-97.284	39.560	G	A0042020006S01E0201 CNNWSE
43	1955	120.00	15.75	33.51	-97.192	39.427	G	A0046550007S02E2207 13202610
44	1955	120.00	4.94	17.06	-97.498	39.582	G	A0033890005S02W2503 SWSWSW
45	1955	212.00	5.56	13.56	-97.564	39.573	G	A0046110005S02W3202 NWNWSE
46	1955	67.50	5.44	17.19	-97.495	39.575	G	A0035410005S02W3602 SESWNW
47	1955	100.00	10.24	31.82	-97.223	39.506	G	A0049200006S02E2912 40150950
48	1955	107.00	5.50	18.50	-97.471	39.574	G	A0045750005S01W3101 CESENW
49	1955	111.00	5.06	10.56	-97.620	39.580	G	A0039110005S03W3501 NWNWNE
50	1955	220.00	10.56	30.69	-97.244	39.501	G	A0045860006S02E3001 NENWSE
51	1955	82.00	2.50	2.50	-97.772	39.617	G	A0043880005S04W1603 NCS2SE
52	1955	120.00	9.19	29.69	-97.262	39.521	G	A0034670006S01E2401 SENWNE
53	1955	189.00	4.81	18.56	-97.470	39.584	G	A0047050005S01W3003 NWSWSE
54	1955	49.00	6.08	22.74	-97.392	39.566	G	A0047140006S01W0201 48501370
55	1955	48.00	5.56	13.06	-97.573	39.573	G	A0045570005S02W3201 NWNWSW
56	1955	175.00	8.27	29.56	-97.265	39.535	G	A0038030006S01E1301 38402340
57	1955	180.00	5.94	19.19	-97.459	39.568	G	A0045940005S01W3201 SESWSW
58	1955	128.00	6.31	28.56	-97.283	39.562	G	A0044430006S01E0202 NWSWNE
59	1955	165.00	4.94	17.06	-97.498	39.582	G	A0046360005S02W2503 SWSWSW
60	1955	7.00	4.31	18.56	-97.470	39.591	G	A0044630005S01W3001 NWSWNE
61	1955	120.00	3.73	5.04	-97.724	39.599	G	A0048190005S04W2401 14505080
62	1955	40.00	2.69	2.19	-97.778	39.615	G	A0044480005S04W1604 SENWSW
63	1955	7.00	4.50	18.50	-97.471	39.588	G	A0044630005S01W3002 CEW2NE

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
64	1955	65.00	4.56	17.06	-97.498	39.587	G	A0033900005S02W2501 NWNWSW
65	1955	81.00	5.06	10.56	-97.620	39.580	G	A0045180005S03W3501 NWNWNE
66	1955	165.00	4.56	17.06	-97.498	39.587	G	A0046360005S02W2501 NWNWSW
67	1955	228.00	4.50	17.50	-97.490	39.588	G	A0041870005S02W2505 NCSWNW
68	1955	130.00	6.58	28.16	-97.290	39.559	G	A0046090006S01E0203 22004450
69	1955	195.00	9.31	29.06	-97.274	39.519	G	A0040230006S01E2402 NWSWNW
70	1956	131.00	2.22	4.77	-97.729	39.621	G	A0056340005S04W1401 41251221
71	1956	90.00	5.15	20.38	-97.437	39.579	G	A0063990005S01W3301 44653300
72	1956	34.00	6.81	29.19	-97.271	39.556	G	A0064180006S01E0108 NESWSW
73	1956	55.00	10.50	29.50	-97.266	39.502	G	A0060110006S01E2501 CWSE
74	1956	160.00	6.50	26.75	-97.317	39.560	G	A0052130006S01E0406 26401320
75	1956	177.00	6.50	27.61	-97.301	39.560	G	A0049750006S01E0301 26402040
76	1956	141.00	10.31	30.44	-97.249	39.505	G	A0054750006S02E3002 NESENW
77	1956	131.00	2.67	4.76	-97.729	39.615	G	A0056340005S04W1403 17671247
78	1956	159.00	3.69	7.56	-97.677	39.600	G	A0060250005S03W2001 SWNWSE
79	1956	120.00	11.50	32.50	-97.211	39.488	G	A0063340006S02E3302 NCNE
80	1956	67.50	2.69	5.94	-97.707	39.615	G	A0060710005S04W1301 SENESE
81	1956	70.00	16.76	33.02	-97.201	39.412	G	A0057200007S02E2703 12805200
82	1956	75.00	5.81	18.31	-97.474	39.569	G	A0062590005S01W3102 NWSWSE
83	1956	189.00	5.44	19.06	-97.461	39.575	G	A0060720005S01W3203 SWSWNW
84	1956	163.00	18.19	36.44	-97.138	39.391	G	A0059550008S03E0602 SENENW
85	1956	240.00	5.06	15.81	-97.521	39.580	G	A0049910005S02W3401 NWNENE
86	1956	51.00	5.31	19.56	-97.452	39.577	G	A0056580005S01W3202 NWSWNE
87	1956	96.00	2.51	3.99	-97.744	39.617	G	A0063020005S04W1502 26100060
88	1956	254.00	5.06	11.19	-97.608	39.580	G	A0059850005S03W3602 NENWNW
89	1956	155.00	16.81	34.31	-97.177	39.411	G	A0060590007S02E2601 NWSWSE
90	1956	60.00	5.06	8.81	-97.653	39.580	G	A0060200005S03W3302 NWNENE
91	1956	100.00	4.25	20.77	-97.429	39.592	G	A0064150005S01W2802 39601188
92	1956	83.00	2.50	3.50	-97.753	39.617	G	A0063260005S04W1503 CENESW
93	1956	91.00	10.13	30.02	-97.256	39.508	G	A0064460006S02E3003 46055170
94	1956	100.00	5.31	16.56	-97.507	39.576	G	A0065830005S02W3501 NWSWNE
95	1956	56.00	3.80	11.51	-97.603	39.598	G	A0057880005S03W2401 10502600
96	1956	59.52	3.56	15.31	-97.531	39.602	G	A0065250005S02W2201 NWNESW
97	1956	103.50	18.56	36.56	-97.136	39.386	G	A0059430008S03E0601 NWNWSE
98	1956	111.00	4.50	16.50	-97.508	39.588	G	A0051200005S02W2603 CWE2SE
99	1957	111.00	3.47	14.75	-97.541	39.603	G	A0070170005S02W2108 28001300
100	1957	110.00	6.50	24.50	-97.359	39.560	G	A0070410006S01E0601 NCNE
101	1957	107.00	14.69	33.81	-97.186	39.442	G	A0069230007S02E1501 SWNESE
102	1957	40.00	2.06	1.94	-97.782	39.624	G	A0070570005S04W1701 NENENE
103	1957	63.00	5.56	25.06	-97.349	39.573	G	A0075610005S01E3202 NWNWSW
104	1957	60.00	5.19	17.69	-97.486	39.578	G	A0066230005S02W3603 SENWNE
105	1957	175.00	5.50	19.50	-97.453	39.574	G	A0070430005S01W3204 NCSWSE
106	1957	17.00	3.69	8.31	-97.663	39.600	G	A0069560005S03W2102 SWNESW
107	1957	159.00	5.31	18.63	-97.469	39.576	G	A0070420005S01W3103 NCN2SWNE
108	1957	34.00	12.50	33.50	-97.192	39.474	G	A0066770007S02E0302 CWNWNE
109	1957	126.00	5.44	17.56	-97.488	39.575	G	A0070150005S02W3604 SWSWNE
110	1957	45.00	1.06	3.44	-97.754	39.638	G	A0066710005S04W1002 NENENW
111	1957	44.00	6.50	26.75	-97.317	39.560	G	A0068400006S01E0406 26401320
112	1957	83.00	2.19	7.56	-97.677	39.622	G	A0067060005S03W1701 SWNWNE
113	1958	165.00	14.50	34.50	-97.173	39.445	G	A0077060007S02E1401 CWNW
114	1958	152.00	7.44	25.00	-97.350	39.547	G	A0077860006S01E0801 CWSWSWNW
115	1959	41.00	5.69	12.19	-97.590	39.571	G	A0081530005S02W3101 SENWSW
116	1959	112.00	8.56	29.69	-97.262	39.530	G	A0081050006S01E1302 NENWSE
117	1959	34.58	6.39	20.02	-97.443	39.562	G	A0081940006S01W0406 32205200
118	1959	70.00	5.06	15.81	-97.521	39.580	G	A0080020005S02W3401 NWNENE
119	1959	39.00	5.69	25.56	-97.339	39.571	G	A0081950005S01E3203 SWNWSE
120	1961	29.00	3.44	19.31	-97.456	39.604	G	A0086880005S01W2003 SWSENW
121	1962	94.00	4.27	18.27	-97.475	39.592	G	A0090080005S01W3004 38503850
122	1963	84.00	5.50	11.50	-97.602	39.574	G	A0091050005S03W3604 N2SWSE
123	1963	65.98	6.42	29.06	-97.274	39.561	G	A0092030006S01E0104 30504980
124	1963	44.00	5.69	11.94	-97.594	39.571	G	A0091050005S03W3605 SENESE
125	1963	102.00	4.62	23.02	-97.387	39.587	G	A0091210005S01W2501 20105165
126	1963	157.00	9.44	28.19	-97.290	39.518	G	A0094920006S01E2301 SESWNW
127	1964	62.00	6.25	20.40	-97.436	39.563	G	A0105850006S01W0405 39353155
128	1964	120.00	12.50	33.50	-97.192	39.474	G	A0104340007S02E0303 CWNWNW
129	1964	187.00	3.44	12.19	-97.590	39.604	G	A0098890005S02W1901 SESWNW
130	1964	244.00	8.69	28.56	-97.283	39.529	G	A0100440006S01E1401 SWNWSE
131	1964	110.00	7.56	25.56	-97.340	39.545	G	A0099730006S01E0802 NWNWSE
132	1965	165.00	7.31	27.56	-97.302	39.549	G	A0111240006S01E1001 NWSWNE
133	1965	202.00	6.50	21.52	-97.415	39.560	G	A0111650006S01W0301 26352540
134	1965	171.00	6.31	21.31	-97.419	39.562	G	A0113520006S01W0302 NWSENW
135	1965	152.00	8.50	29.50	-97.266	39.531	G	A0106860006S01E1303 NCW2
136	1965	30.20	11.06	32.94	-97.202	39.494	G	A0108690006S02E3301 NENENE

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
137	1965	75.00	1.44	4.94	-97.726	39.633	G	A0107400005S04W1102 SESENE
138	1965	133.00	15.56	34.56	-97.172	39.429	G	A0114430007S02E2301 NWNWSE
139	1965	129.00	6.69	29.19	-97.271	39.557	G	A0110180006S01E0109 SENWSW
140	1965	155.00	10.29	29.40	-97.268	39.505	G	A0109720006S01E2504 37503170
141	1965	102.00	3.69	22.19	-97.402	39.600	G	A0109690005S01W2301 SENWSW
142	1965	162.00	9.69	28.44	-97.285	39.514	G	A0114620006S01E2302 SENESW
143	1965	112.00	4.69	24.06	-97.367	39.586	G	A0114750005S01E3001 SWNWSW
144	1965	75.00	1.44	4.94	-97.726	39.633	G	A0107400005S04W1101 SESENE
145	1966	77.00	2.81	7.31	-97.682	39.612	G	A0119900005S03W1702 NWSSEW
146	1966	190.00	6.69	24.56	-97.358	39.557	G	A0122690006S01E0603 SWNWSW
147	1966	95.00	6.69	24.94	-97.351	39.557	G	A0122690006S01E0602 SESENE
148	1966	60.50	4.31	24.06	-97.367	39.591	G	A0124980005S01E3002 NWSWNW
149	1966	90.00	6.50	27.50	-97.303	39.560	G	A0118470006S01E0302 NCW2NE
150	1966	116.00	6.14	20.50	-97.434	39.565	G	A0118320006S01W0403 45352630
151	1966	114.00	15.50	33.50	-97.192	39.430	G	A0125070007S02E2202 CWE2SE
152	1966	108.00	4.06	20.19	-97.440	39.594	G	A0119760005S01W2803 NENWNW
153	1966	60.00	3.65	14.01	-97.556	39.600	G	A0124990005S02W2103 18355240
154	1966	173.00	5.90	21.50	-97.415	39.568	G	A0119750005S01W3401 05352620
155	1966	60.50	4.69	24.06	-97.367	39.586	G	A0124980005S01E3001 SWNWSW
156	1966	94.00	4.06	23.06	-97.386	39.595	G	A0115980005S01W2503 NWNWNW
157	1967	160.00	2.62	5.50	-97.716	39.616	G	A0130110005S04W1303 19902650
158	1967	0.00	5.44	17.19	-97.495	39.575	G	A0129610005S02W3602 SESWNW
159	1967	14.00	4.43	22.87	-97.390	39.590	G	A0142540005S01W2601 30350710
160	1967	105.00	3.40	14.43	-97.547	39.604	G	A0130910005S02W2104 31703000
161	1967	108.00	3.06	21.69	-97.412	39.610	G	A0142550005S01W2202 NENWNE
162	1967	51.00	6.25	28.19	-97.290	39.563	G	A0131770006S01E0204 39404290
163	1967	204.00	3.88	13.88	-97.558	39.597	G	A0141500005S02W2003 06500660
164	1967	135.00	16.89	33.99	-97.183	39.410	G	A0130090007S02E2709 06000051
165	1967	100.00	3.67	15.51	-97.527	39.600	G	A0128230005S02W2202 17502600
166	1967	142.00	3.69	21.69	-97.412	39.600	G	A0136310005S01W2201 SENWSE
167	1967	103.00	9.53	28.51	-97.284	39.516	G	A0126040006S01E2303 24802600
168	1967	103.00	3.97	6.79	-97.691	39.596	G	A0133840005S03W1906 01501130
169	1967	116.00	2.08	5.69	-97.712	39.624	G	A0133850005S04W1304 48501624
170	1967	98.00	5.50	16.50	-97.508	39.574	G	A0132280005S02W3502 NCN2NW
171	1968	120.00	7.06	24.06	-97.367	39.552	G	A0157230006S01E0701 NWNWNW
172	1968	32.00	3.32	10.26	-97.626	39.605	G	A0148350005S03W2301 36003895
173	1968	115.00	15.56	31.99	-97.219	39.429	G	A0157950007S02E2001 23200030
174	1968	0.00	19.56	35.31	-97.159	39.372	G	A0150170008S02E1202 NWNWSE
175	1968	51.00	15.81	34.56	-97.172	39.426	G	A0157910007S02E2302 NWSWSE
176	1968	40.00	16.46	33.76	-97.187	39.416	G	A0146310007S02E2705 28401260
177	1968	75.00	16.50	35.50	-97.155	39.416	G	A0149450007S02E2501 CNS2NW
178	1968	26.00	16.23	33.76	-97.187	39.420	G	A0146310007S02E2706 40801260
179	1968	57.00	15.31	32.94	-97.203	39.433	G	A0146630007S02E2102 NESENE
180	1968	107.00	2.31	3.19	-97.759	39.620	G	A0153520005S04W1504 NESWNW
181	1968	90.00	17.06	35.81	-97.149	39.407	G	A0151500007S02E3601 NWNWNE
182	1968	72.30	9.31	30.69	-97.244	39.520	G	A0158890006S02E1901 NESWNE
183	1968	92.00	8.28	29.31	-97.269	39.534	G	A0143010006S01E1306 37853635
184	1969	133.00	13.31	32.69	-97.207	39.462	G	A0162150007S02E0901 NESWNE
185	1969	131.00	12.31	33.06	-97.200	39.476	G	A0166110007S02E0304 NWSWNW
186	1969	139.00	12.25	32.75	-97.206	39.477	G	A0164530007S02E0402 39601320
187	1969	30.00	5.88	18.72	-97.467	39.568	G	A0164220005S01W3104 06301485
188	1969	129.00	18.72	35.50	-97.155	39.383	G	A0164010008S02E0102 14802630
189	1969	63.00	7.44	27.69	-97.300	39.547	G	A0161970006S01E1002 SESWNE
190	1970	140.00	12.56	33.06	-97.200	39.473	G	A0170970007S02E0305 NWNWSW
191	1970	210.00	19.06	35.56	-97.154	39.379	G	A0172460008S02E1203 NWNWNE
192	1970	99.00	17.81	35.19	-97.161	39.397	G	A0170980007S02E3602 NESWSW
193	1970	80.00	16.31	34.69	-97.170	39.418	G	A0169970007S02E2602 NESWNE
194	1970	51.00	13.38	32.89	-97.203	39.461	G	A0176600007S02E0902 32600600
195	1970	64.00	14.69	33.81	-97.186	39.442	G	A0170290007S02E1501 SWNESE
196	1970	220.00	11.69	30.06	-97.255	39.485	G	A0170060006S02E3101 SWNWSW
197	1970	130.00	10.02	28.52	-97.284	39.509	G	A0171600006S01E2601 51802560
198	1970	81.00	1.88	3.73	-97.749	39.626	G	A0171360005S04W1003 06201408
199	1970	194.00	11.44	29.56	-97.265	39.489	G	A0170050006S01E3601 SWSWNE
200	1971	69.00	16.49	34.01	-97.183	39.416	G	A0185430007S02E2603 26805240
201	1971	98.10	5.85	17.52	-97.489	39.569	G	A0182360005S02W3605 08002510
202	1971	125.00	12.72	32.38	-97.213	39.470	G	A0184160007S02E0403 14803280
203	1971	81.00	12.52	32.98	-97.202	39.473	G	A0184160007S02E0404 25200100
204	1972	100.00	2.06	1.94	-97.782	39.624	G	A0188230005S04W1701 NENENE
205	1972	31.42	1.71	2.16	-97.778	39.629	G	A0198120005S04W0905 15304430
206	1972	453.00	15.02	34.18	-97.179	39.437	G	A0196030007S02E2303 51804350
207	1972	143.00	2.19	7.31	-97.682	39.622	G	A0193840005S03W1704 SWNENW
208	1972	80.00	10.02	28.52	-97.284	39.509	G	A0198300006S01E2601 51802560
209	1973	65.00	6.74	22.01	-97.406	39.557	G	A0216520006S01W0203 13505240

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrld,subsection
210	1973	93.00	17.77	33.89	-97.185	39.397	G	A0215250007S02E3408 12000605
211	1973	93.00	17.77	33.99	-97.184	39.397	G	A0215250007S02E3402 12000050
212	1973	94.00	17.25	34.25	-97.178	39.405	G	A0208540007S02E3501 39603960
213	1973	147.00	16.88	32.50	-97.211	39.410	G	A0211940007S02E2801 06602640
214	1973	67.00	3.88	14.38	-97.548	39.597	G	A0211410005S02W2105 06603250
215	1973	135.00	15.25	32.25	-97.215	39.434	G	A0207320007S02E2103 39603960
216	1973	282.00	5.92	24.53	-97.359	39.568	G	A0211790005S01E3102 04402500
217	1973	66.40	10.75	32.50	-97.210	39.499	G	A0208550006S02E2801 13402660
218	1973	114.00	8.72	30.23	-97.252	39.528	G	A0207430006S02E1801 14804040
219	1974	22.00	17.79	33.78	-97.187	39.397	G	A0227970007S02E3411 11201150
220	1974	90.00	17.28	33.98	-97.184	39.404	G	A0227960007S02E3403 38000100
221	1974	110.00	16.56	34.69	-97.170	39.415	G	A0229830007S02E2604 NENWSE
222	1974	80.00	15.23	33.22	-97.197	39.434	G	A0229850007S02E2203 40604120
223	1974	87.00	2.87	3.24	-97.758	39.612	G	A0222910005S04W1505 07103990
224	1974	29.00	4.95	12.01	-97.593	39.581	G	A0232280005S02W3001 02505250
225	1974	105.00	4.94	12.25	-97.589	39.582	G	A0232280005S02W3002 03003960
226	1974	160.00	9.69	29.06	-97.274	39.514	G	A0222100006S01E2403 SWNWSW
227	1975	180.00	10.68	29.18	-97.272	39.500	G	A0233810006S01E2503 16804340
228	1975	29.00	3.25	11.26	-97.608	39.606	G	A0243360005S03W2402 39703930
229	1975	141.00	4.25	20.25	-97.439	39.592	G	A0237300005S01W2804 39603950
230	1975	19.00	3.25	11.28	-97.607	39.606	G	A0243360005S03W2403 39703795
231	1975	91.00	17.85	34.76	-97.169	39.396	G	A0239050007S02E3502 08001260
232	1975	70.00	15.50	33.50	-97.192	39.430	G	A0234150007S02E2204 NCN2NE
233	1975	90.00	3.02	3.76	-97.748	39.610	G	A0238200005S04W2201 52001280
234	1975	219.00	14.02	33.40	-97.194	39.452	G	A0239060007S02E1502 52003150
235	1975	75.00	14.50	34.50	-97.173	39.445	G	A0233940007S02E1403 CNNW
236	1975	135.00	5.13	14.76	-97.541	39.579	G	A0244290005S02W3301 46201250
237	1975	82.50	2.85	5.63	-97.713	39.612	G	A0236900005S04W1305 08151980
238	1975	96.00	4.85	24.02	-97.368	39.584	G	A0252680005S01E3003 08005180
239	1975	189.00	3.49	14.53	-97.546	39.603	G	A0253360005S02W2106 26802500
240	1975	109.00	5.25	16.01	-97.517	39.577	G	A0244070005S02W3503 39505250
241	1976	56.00	4.40	7.13	-97.685	39.589	G	A0275490005S03W2905 31824573
242	1976	85.00	3.35	5.00	-97.725	39.605	G	A0265710005S04W2402 34525260
243	1976	105.00	6.90	22.41	-97.398	39.554	G	A0259570006S01W0204 05303100
244	1976	103.00	6.31	19.50	-97.453	39.563	G	A0259560006S01W0502 36602650
245	1976	105.00	6.27	19.78	-97.448	39.563	G	A0259550006S01W0501 38301185
246	1976	180.00	5.81	25.81	-97.335	39.570	G	A0281330005S01E3204 NWSESE
247	1976	180.00	5.81	26.31	-97.325	39.570	G	A0281330005S01E3301 NWSESW
248	1976	65.00	5.53	11.04	-97.611	39.573	G	A0277680005S03W3607 24755080
249	1976	107.00	16.13	32.75	-97.206	39.421	G	A0271200007S02E2802 46201340
250	1976	11.00	3.01	8.25	-97.664	39.609	G	A0267340005S03W2103 52153955
251	1976	147.00	5.46	13.54	-97.564	39.574	G	A0254900005S02W3204 28702440
252	1976	74.60	15.72	34.27	-97.178	39.427	G	A0268550007S02E2304 15003850
253	1976	79.62	11.76	32.29	-97.215	39.484	G	A0279980006S02E3305 12603750
254	1976	83.00	2.84	6.57	-97.696	39.612	G	A0275890005S03W1803 08502280
255	1976	103.06	11.09	31.67	-97.226	39.494	G	A0279400006S02E3201 48201720
256	1976	45.00	3.56	10.77	-97.617	39.602	G	A0258790005S03W2302 23101220
257	1976	252.00	5.00	9.28	-97.644	39.581	G	A0277710005S03W3402 52603800
258	1976	114.00	8.20	28.29	-97.289	39.536	G	A0278120006S01E1403 42203740
259	1976	94.00	8.20	28.75	-97.280	39.536	G	A0278110006S01E1402 42201330
260	1977	184.00	7.35	28.22	-97.289	39.548	G	A0300760006S01E1102 34104130
261	1977	75.00	6.88	20.26	-97.439	39.555	G	A0285430006S01W0404 06303930
262	1977	39.00	4.50	19.28	-97.457	39.588	G	A0298520005S01W2902 26503820
263	1977	118.50	4.44	17.56	-97.488	39.589	G	A0303120005S02W2507 SWSWNE
264	1977	102.00	6.49	21.02	-97.425	39.560	G	A0308460006S01W0303 26755150
265	1977	132.00	6.39	19.25	-97.458	39.562	G	A0309850006S01W0503 32203970
266	1977	181.00	3.50	6.50	-97.697	39.603	G	A0292130005S03W1904 NCW2NW
267	1977	0.00	2.51	3.99	-97.744	39.617	G	A0305480005S04W1502 26100060
268	1977	144.00	6.33	27.24	-97.308	39.562	G	A0299340006S01E0303 35404020
269	1977	118.50	4.50	17.50	-97.490	39.588	G	A0303120005S02W2506 CWNWNE
270	1977	77.00	3.06	6.36	-97.699	39.609	G	A029080005S03W1903 49503370
271	1977	95.00	18.24	35.20	-97.161	39.390	G	A0300770008S02E0103 40004250
272	1977	52.00	1.01	1.83	-97.784	39.639	G	A0295870005S04W0803 52500890
273	1977	21.00	5.59	12.76	-97.579	39.572	G	A0298480005S02W3103 21621257
274	1977	132.00	2.99	6.20	-97.703	39.610	G	A0305690005S03W1805 00404250
275	1977	27.00	1.98	4.02	-97.743	39.625	G	A0303600005S04W1103 01305150
276	1977	114.00	2.98	6.77	-97.692	39.610	G	A0310980005S03W1806 01001230
277	1977	46.00	5.31	12.76	-97.579	39.576	G	A0298480005S02W3102 36211254
278	1977	23.00	15.00	32.43	-97.212	39.438	G	A0308470007S02E2104 52602990
279	1977	36.00	5.38	21.38	-97.418	39.576	G	A0302710005S01W3402 33003300
280	1977	101.00	14.02	34.65	-97.171	39.452	G	A0300780007S02E1402 51801860
281	1977	84.00	13.69	33.78	-97.187	39.456	G	A0289230007S02E1001 16501180
282	1977	162.00	13.35	33.75	-97.187	39.461	G	A0289240007S02E1002 34321346

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
283	1977	171.00	12.61	33.34	-97.195	39.472	G	A0301590007S02E0306 20803490
284	1977	9.00	11.49	32.76	-97.206	39.488	G	A0288380006S02E3304 26801250
285	1977	165.00	11.43	30.05	-97.256	39.489	G	A0300790006S02E3102 30004990
286	1977	94.00	11.25	32.49	-97.211	39.492	G	A0288650006S02E3309 39602680
287	1977	90.00	5.50	16.50	-97.508	39.574	G	A0311080005S02W3505 NCN2NE
288	1977	70.00	3.55	10.26	-97.626	39.602	G	A0307690005S03W2303 23753895
289	1977	29.32	10.56	31.69	-97.226	39.502	G	A0301580006S02E2906 NENWSE
290	1977	29.32	9.94	31.06	-97.237	39.511	G	A0301580006S02E2002 SWSWSW
291	1977	29.32	9.81	31.06	-97.237	39.512	G	A0301580006S02E2001 NWSWSW
292	1977	97.00	18.65	35.20	-97.161	39.385	G	A0300770008S02E0104 18504250
293	1977	306.80	4.78	9.02	-97.650	39.584	G	A0305260005S03W2703 11505180
294	1977	55.00	9.02	29.02	-97.275	39.524	G	A0295990006S01E2404 52005180
295	1977	210.00	8.52	28.26	-97.289	39.531	G	A0295980006S01E1404 25403920
296	1977	158.00	8.37	29.55	-97.265	39.533	G	A0294980006S01E1305 33102400
297	1977	68.00	2.38	6.75	-97.692	39.619	G	A0291240005S03W1804 32541298
298	1978	4.60	4.48	16.99	-97.499	39.589	G	A0316480005S02W2604 27400034
299	1978	120.00	2.57	2.55	-97.771	39.616	G	A0317810005S04W1606 22952400
300	1978	52.00	3.41	14.50	-97.546	39.604	G	A0311820005S02W2107 31352650
301	1978	135.00	6.25	26.25	-97.326	39.563	G	A0325080006S01E0405 39603935
302	1978	73.50	19.44	35.56	-97.154	39.374	G	A0313370008S02E1205 SWSWNE
303	1978	73.50	19.38	35.19	-97.161	39.375	G	A0313370008S02E1206 NCE2SWNW
304	1978	73.50	19.50	35.50	-97.156	39.373	G	A0313370008S02E1204 CWSWNE
305	1978	120.00	2.37	2.37	-97.774	39.619	G	A0317780005S04W1601 33503340
306	1978	120.00	2.25	3.76	-97.748	39.621	G	A0317800005S04W1506 39501250
307	1978	72.00	5.25	22.25	-97.401	39.578	G	A0319000005S01W3501 39603960
308	1978	98.00	2.01	2.89	-97.765	39.625	G	A0317790005S04W1605 52500600
309	1978	180.00	9.38	30.11	-97.254	39.519	G	A0322320006S02E1902 32904700
310	1978	147.00	8.50	30.50	-97.247	39.531	G	A0323270006S02E1802 NCSESW
311	1978	94.00	7.40	24.70	-97.356	39.547	G	A0314590006S01E0702 31501580
312	1979	87.00	7.25	28.75	-97.280	39.550	G	A0336420006S01E1103 39401300
313	1979	97.00	4.56	24.31	-97.363	39.588	G	A0327690005S01E3004 NWNESW
314	1979	5.60	5.74	22.22	-97.402	39.571	G	A0326270005S01W3502 13504100
315	1979	117.00	15.31	34.52	-97.173	39.433	G	A0331360007S02E2306 36202550
316	1979	92.00	13.73	33.51	-97.192	39.456	G	A0334280007S02E1003 14302590
317	1979	183.00	13.57	33.08	-97.200	39.458	G	A0336400007S02E1004 22694856
318	1979	152.00	5.84	20.64	-97.432	39.569	G	A0329220005S01W3303 08601920
319	1979	69.00	8.21	30.25	-97.252	39.536	G	A0334270006S02E1803 41803960
320	1980	128.00	5.93	21.19	-97.421	39.568	G	A0346990005S01W3403 03604300
321	1980	56.00	5.26	9.67	-97.637	39.577	G	A0347490005S03W3406 39301755
322	1980	56.00	5.23	9.63	-97.638	39.578	G	A0347490005S03W3405 40451950
323	1980	19.00	2.85	5.63	-97.713	39.612	G	A0340130005S04W1305 08151980
324	1981	255.00	6.99	26.72	-97.318	39.553	G	A0357930006S01E0402 00701500
325	1981	65.00	2.50	6.02	-97.706	39.617	G	A0352610005S03W1807 26605200
326	1981	143.00	6.31	29.19	-97.271	39.562	G	A0352880006S01E0111 NESWNW
327	1981	76.00	3.25	9.61	-97.638	39.606	G	A0351140005S03W2201 39602050
328	1981	180.00	16.81	33.56	-97.191	39.411	G	A0349640007S02E2707 NWSWSE
329	1981	10.00	13.20	31.41	-97.231	39.464	G	A0355260007S02E0801 42503090
330	1981	109.00	12.32	32.28	-97.215	39.476	G	A0357890007S02E0405 36003800
331	1981	201.00	11.25	30.99	-97.239	39.492	G	A0357900006S02E3103 39600050
332	1981	131.50	9.00	28.54	-97.284	39.524	G	A0356610006S01E1405 00202440
333	1981	48.00	8.77	27.99	-97.294	39.527	G	A0356990006S01E1501 12000050
334	1981	170.00	7.45	26.98	-97.313	39.547	G	A0357940006S01E0901 29000080
335	1982	50.00	3.33	4.43	-97.736	39.605	G	A0359440005S04W2302 35643036
336	1982	368.20	19.17	36.28	-97.141	39.377	G	A0360600008S03E0708 44003800
337	1982	86.00	3.01	3.17	-97.759	39.610	G	A0361120005S04W2202 52504373
338	1983	45.00	6.88	20.26	-97.439	39.555	G	A0367320006S01W0404 06303930
339	1983	49.96	4.33	22.68	-97.393	39.591	G	A0364940005S01W2603 35201700
340	1983	0.00	4.33	22.68	-97.393	39.591	G	A0364950005S01W2602 35351700
341	1983	151.00	4.12	11.01	-97.612	39.594	G	A0365700005S03W2501 46405210
342	1983	160.00	16.50	33.32	-97.196	39.416	G	A0365930007S02E2708 26603590
343	1983	221.00	14.17	32.47	-97.211	39.450	G	A0368630007S02E1601 44002800
344	1983	99.00	9.53	28.75	-97.280	39.516	G	A0366890006S01E2304 25001300
345	1984	90.00	16.25	34.50	-97.174	39.419	G	A0371470007S02E2605 39602660
346	1984	0.00	12.99	33.10	-97.199	39.467	G	A0371800007S02E0308 00504760
347	1985	105.00	3.18	7.01	-97.687	39.607	G	A0380070005S03W2002 43235230
348	1986	103.00	6.14	25.02	-97.349	39.565	G	A0381230006S01E0501 45505150
349	1986	40.00	5.26	9.67	-97.637	39.577	G	A0381600005S03W3406 39301755
350	1986	68.00	14.25	33.87	-97.185	39.448	G	A0383030007S02E1503 39800700
351	1986	40.00	5.23	9.63	-97.638	39.578	G	A0381600005S03W3405 40451950
352	1986	108.00	3.65	14.01	-97.556	39.600	G	A0382440005S02W2103 18355240
353	1987	225.00	3.24	6.72	-97.693	39.606	G	A0385150005S03W1905 40001500
354	1987	102.00	18.25	34.77	-97.169	39.390	G	A0385370008S02E0203 39501200
355	1987	113.00	18.12	34.98	-97.165	39.392	G	A0385350008S02E0202 46500100

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
356	1987	110.00	18.01	35.72	-97.151	39.394	G	A0385340008S02E0105 52501470
357	1987	109.00	15.25	32.75	-97.206	39.434	G	A0386800007S02E2105 39601320
358	1987	100.00	14.66	32.99	-97.202	39.442	G	A0386370007S02E1602 17950059
359	1987	192.00	9.76	29.81	-97.260	39.513	G	A0385250006S01E2405 12501000
360	1988	198.00	6.75	19.75	-97.448	39.557	G	A0391460006S01W0504 13201320
361	1988	17.00	6.33	27.24	-97.308	39.562	G	A0388180006S01E0303 35404020
362	1988	320.00	19.29	34.96	-97.166	39.376	G	A0389240008S02E1106 37400205
363	1988	127.00	6.01	24.06	-97.367	39.567	G	A0391060006S01E0604 52404950
364	1988	335.00	18.55	34.10	-97.181	39.386	G	A8891150008S02E0204 24004750
365	1988	557.40	18.55	34.10	-97.181	39.386	G	A889117HD08S02E0206 24004750
366	1988	25.60	18.55	34.10	-97.181	39.386	G	A889117IN08S02E0206 24004750
367	1988	180.00	15.82	33.25	-97.197	39.426	G	A0387240007S02E2205 09603940
368	1988	95.00	15.56	31.99	-97.219	39.429	G	A0390310007S02E2001 23200030
369	1988	120.00	15.48	33.25	-97.197	39.430	G	A0390900007S02E2208 27383965
370	1988	152.00	14.68	33.50	-97.192	39.442	G	A0390370007S02E1504 17002640
371	1988	158.00	5.25	22.25	-97.401	39.578	G	A0387540005S01W3501 39603960
372	1988	413.50	4.86	10.32	-97.625	39.583	G	A889116HD05S03W2602 07263564
373	1988	67.50	4.86	10.32	-97.625	39.583	G	A889116IN05S03W2602 07263564
374	1989	0.00	5.98	10.69	-97.618	39.567	G	A0397200005S03W3502 01001640
375	1989	0.00	19.05	36.38	-97.139	39.379	G	A0395770008S03E0710 50003300
376	1989	165.00	4.05	11.25	-97.608	39.595	G	A0398130005S03W2502 50003980
377	1989	68.00	18.68	34.59	-97.172	39.385	G	A0393420008S02E0205 17002150
378	1989	120.00	3.93	10.75	-97.617	39.596	G	A0392040005S03W2304 03501330
379	1989	61.40	17.02	33.76	-97.188	39.408	G	A0393060007S02E3406 51501250
380	1989	0.00	3.99	17.98	-97.481	39.596	G	A0395000005S02W2405 00400100
381	1989	0.00	3.98	17.98	-97.481	39.596	G	A0395000005S02W2408 00800100
382	1989	0.00	3.98	17.98	-97.481	39.596	G	A0395000005S02W2409 01200100
383	1989	85.00	16.13	32.75	-97.206	39.421	G	A0393540007S02E2802 46201340
384	1989	0.00	3.97	17.98	-97.481	39.596	G	A0395000005S02W2410 01600100
385	1989	92.00	15.72	34.27	-97.178	39.427	G	A0394480007S02E2304 15003850
386	1989	102.00	14.25	33.01	-97.201	39.448	G	A0395090007S02E1505 39705230
387	1989	156.00	3.68	11.05	-97.612	39.600	G	A0393840005S03W2405 17005000
388	1990	47.50	3.42	13.50	-97.565	39.604	G	A0399530005S02W2004 30822658
389	1990	110.00	4.12	11.01	-97.612	39.594	G	A0399520005S03W2501 46405210
390	1990	128.00	2.38	6.75	-97.692	39.619	G	A0398630005S03W1804 32541298
391	1990	0.00	18.33	35.73	-97.151	39.389	G	A0400640008S02E0106 35401450
392	1990	212.00	17.25	33.12	-97.199	39.405	G	A0401610007S02E3407 39604630
393	1990	189.00	16.99	33.01	-97.201	39.408	G	A0400970007S02E2710 00305240
394	1990	148.50	3.93	13.24	-97.570	39.596	G	A0400850005S02W2006 03504000
395	1990	45.00	3.81	11.25	-97.608	39.598	G	A0399320005S03W2408 10103960
396	1990	42.50	3.67	9.79	-97.635	39.600	G	A0398720005S03W2207 17401110
397	1990	42.50	3.66	9.80	-97.635	39.600	G	A0398720005S03W2206 18101040
398	1990	42.50	3.64	9.82	-97.634	39.601	G	A0398720005S03W2205 18800970
399	1990	42.50	3.63	9.83	-97.634	39.601	G	A0398720005S03W2204 19500900
400	1990	135.00	10.72	31.89	-97.222	39.499	G	A0401470006S02E2902 15000600
401	1990	80.00	10.07	31.69	-97.226	39.509	G	A0401500006S02E2909 49001650
402	1990	47.50	3.50	13.42	-97.567	39.603	G	A0399530005S02W2010 26583082
403	1990	0.00	9.29	29.34	-97.269	39.520	G	A0398270006S01E2406 37593496
404	1990	47.50	3.50	13.50	-97.565	39.603	G	A0399530005S02W2009 26582658
405	1990	43.00	9.01	29.35	-97.269	39.524	G	A0398410006S01E2407 52403455
406	1990	72.00	3.43	9.99	-97.631	39.604	G	A0399050005S03W2203 30150035
407	1990	407.00	4.45	8.22	-97.664	39.589	G	A0400910005S03W2813 29004100
408	1990	47.50	3.42	13.42	-97.567	39.604	G	A0399530005S02W2005 30823082
409	1991	111.00	7.25	28.75	-97.280	39.550	G	A0403160006S01E1103 39401300
410	1991	95.00	4.37	21.79	-97.410	39.591	G	A0404490005S01W2702 33501100
411	1991	27.00	5.87	11.61	-97.600	39.568	G	A0404090005S03W3609 06752050
412	1991	0.00	5.61	5.35	-97.718	39.572	G	A0404270005S04W3605 20553410
413	1991	150.00	14.99	30.88	-97.240	39.437	G	A0405290007S02E1805 00500650
414	1992	100.00	4.50	19.28	-97.457	39.588	G	A0406590005S01W2902 26503820
415	1992	50.00	5.16	11.51	-97.602	39.579	G	A0406480005S03W3601 44502600
416	1992	18.00	12.81	32.62	-97.208	39.469	G	A0406540007S02E0406 10002000
417	1992	0.00	10.29	29.40	-97.268	39.505	G	A0407500006S01E2504 37503170
418	1992	80.00	4.94	12.25	-97.589	39.582	G	A0406520005S02W3002 03003960
419	1992	37.50	4.91	10.43	-97.623	39.582	G	A0406780005S03W2603 04703000
420	1992	19.50	4.63	10.19	-97.627	39.586	G	A0406790005S03W2604 19804290
421	1993	3.71	12.76	32.84	-97.204	39.470	G	A0411740007S02E0407 12500850
422	1994	161.00	19.09	36.76	-97.132	39.378	G	A9491920008S03E0711 48001250
423	1995	322.00	19.33	36.93	-97.129	39.375	G	A9590180008S03E0713 35500350

Surface water rights:

index	appyr	qnew (acft/yr)	row	col	long	lat	src	fileid,legloc,dwrid,subsection
1	1941	129.00	4.13	13.19	-97.571	39.594	S	VCD00090005S02W2901 46004260
2	1941	129.00	4.48	13.13	-97.572	39.588	S	VCD00090005S02W2902 27254600
3	1953	30.00	20.69	34.31	-97.178	39.355	S	A0020410008S02E1401 SWNESW
4	1954	11.86	4.50	8.03	-97.668	39.588	S	A0026680005S03W2812 26405100
5	1954	11.86	4.73	7.79	-97.672	39.585	S	A0026680005S03W2906 14001120
6	1954	11.86	4.63	8.08	-97.667	39.586	S	A0026680005S03W2801 19804850
7	1954	11.86	4.53	7.24	-97.683	39.588	S	A0026680005S03W2908 25004000
8	1954	11.86	4.39	8.03	-97.668	39.589	S	A0026680005S03W2810 32005100
9	1954	11.86	4.66	7.65	-97.675	39.586	S	A0026680005S03W2907 18001850
10	1954	11.86	4.53	7.02	-97.687	39.588	S	A0026680005S03W2909 25005150
11	1955	45.00	3.19	17.44	-97.491	39.607	S	A0045720005S02W2401 SENENW
12	1955	45.00	3.50	16.50	-97.509	39.603	S	A0045720005S02W2301 NCSWNW
13	1956	24.00	1.94	3.06	-97.761	39.625	S	A0063250005S04W1001 SWSWSW
14	1956	41.50	19.92	35.93	-97.148	39.367	S	A0056790008S02E1210 04000350
15	1956	30.50	20.32	35.69	-97.152	39.361	S	A0059610008S02E1306 36001650
16	1956	30.50	20.30	35.80	-97.150	39.361	S	A0059610008S02E1303 37001050
17	1956	144.00	4.50	6.50	-97.697	39.588	S	A0050240005S03W3001 NCSW
18	1956	41.50	19.83	35.98	-97.147	39.368	S	A0056790008S02E1209 09000100
19	1956	30.50	20.34	35.44	-97.157	39.361	S	A0059610008S02E1308 34802940
20	1956	30.50	20.22	35.92	-97.148	39.362	S	A0059610008S02E1305 41000400
21	1964	76.00	10.44	31.44	-97.230	39.503	S	A0099280006S02E2904 SESENW
22	1964	76.00	10.06	31.19	-97.235	39.509	S	A0099280006S02E2903 NENWNW
23	1966	75.50	4.53	13.14	-97.572	39.588	S	A0124250005S02W2903 25004554
24	1966	75.50	5.19	13.59	-97.563	39.578	S	A0124250005S02W3203 42902180
25	1970	29.33	20.49	34.95	-97.165	39.358	S	A0171090008S02E1404 26800250
26	1970	29.33	20.50	34.91	-97.166	39.358	S	A0171090008S02E1408 26400500
27	1970	29.33	20.49	34.68	-97.171	39.358	S	A0171090008S02E1405 27001700
28	1970	28.00	4.01	3.01	-97.762	39.595	S	A0176860005S04W2701 52505210
29	1976	25.50	4.34	8.89	-97.652	39.590	S	A0263810005S03W2807 34650595
30	1976	25.75	20.34	35.44	-97.157	39.361	S	A0259830008S02E1308 34802940
31	1976	25.75	20.32	35.69	-97.152	39.361	S	A0259830008S02E1306 36001650
32	1976	25.75	20.30	35.80	-97.150	39.361	S	A0259830008S02E1303 37001050
33	1976	25.75	20.22	35.92	-97.148	39.362	S	A0259830008S02E1305 41000400
34	1976	25.50	4.43	8.67	-97.656	39.589	S	A0263810005S03W2808 30351750
35	1977	5.00	20.34	35.44	-97.157	39.361	S	A0303940008S02E1308 34802940
36	1977	5.00	20.32	35.69	-97.152	39.361	S	A0303940008S02E1306 36001650
37	1977	5.00	20.30	35.80	-97.150	39.361	S	A0303940008S02E1303 37001050
38	1977	5.00	20.22	35.92	-97.148	39.362	S	A0303940008S02E1305 41000400
39	1981	90.00	16.21	32.07	-97.218	39.420	S	A0357490007S02E2803 41804900
40	1984	98.00	17.41	32.48	-97.211	39.403	S	A0371480007S02E3301 31002750
41	1988	116.00	19.92	35.93	-97.148	39.367	S	A0391690008S02E1210 04000350
42	1988	116.00	19.83	35.98	-97.147	39.368	S	A0391690008S02E1209 09000100
43	1989	180.00	3.25	17.56	-97.489	39.606	S	A0394990005S02W2404 39602340
44	1989	102.00	5.66	5.66	-97.712	39.572	S	A0392640005S04W3604 18001800
45	1989	102.00	5.48	5.73	-97.711	39.574	S	A0392640005S04W3603 27401450
46	1989	102.00	5.48	5.90	-97.708	39.574	S	A0392640005S04W3602 27500550
47	1989	60.00	4.89	6.58	-97.695	39.583	S	A0392990005S03W3003 06002225
48	1989	335.00	19.98	36.39	-97.139	39.365	S	A0395490008S03E0709 01003200
49	1990	150.00	17.98	32.82	-97.205	39.394	S	A0398580007S02E3303 00860972
50	1990	120.00	17.26	32.39	-97.212	39.405	S	A0398590007S02E3302 39303225
51	1992	75.00	18.02	32.74	-97.207	39.394	S	A0408420008S02E0402 52001350
52	1993	0.00	5.35	11.07	-97.611	39.576	S	A0411510005S03W3610 34404910
53	1993	0.00	5.28	11.42	-97.604	39.577	S	A0411510005S03W3611 38103070

Conversion: 723.97 =(acre-ft/yr)/cfs

Grid domain:

longitude

west: -97.784

east -97.129

latitude

south: 39.371

north: 39.639

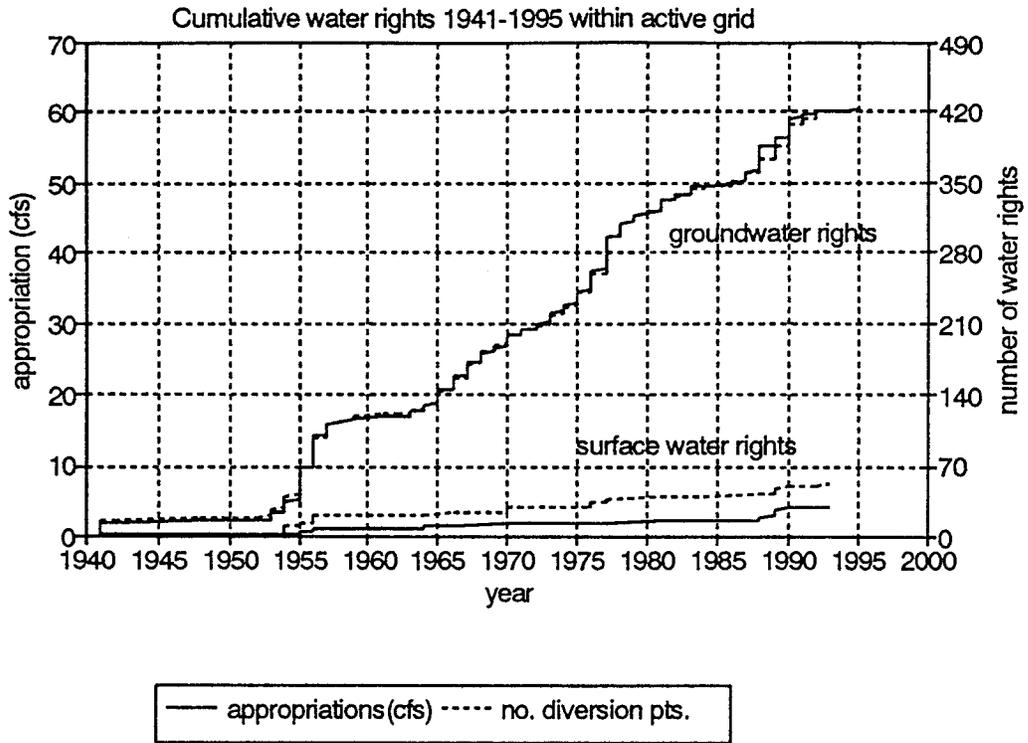


Figure B1

Water rights through 1995 within active grid

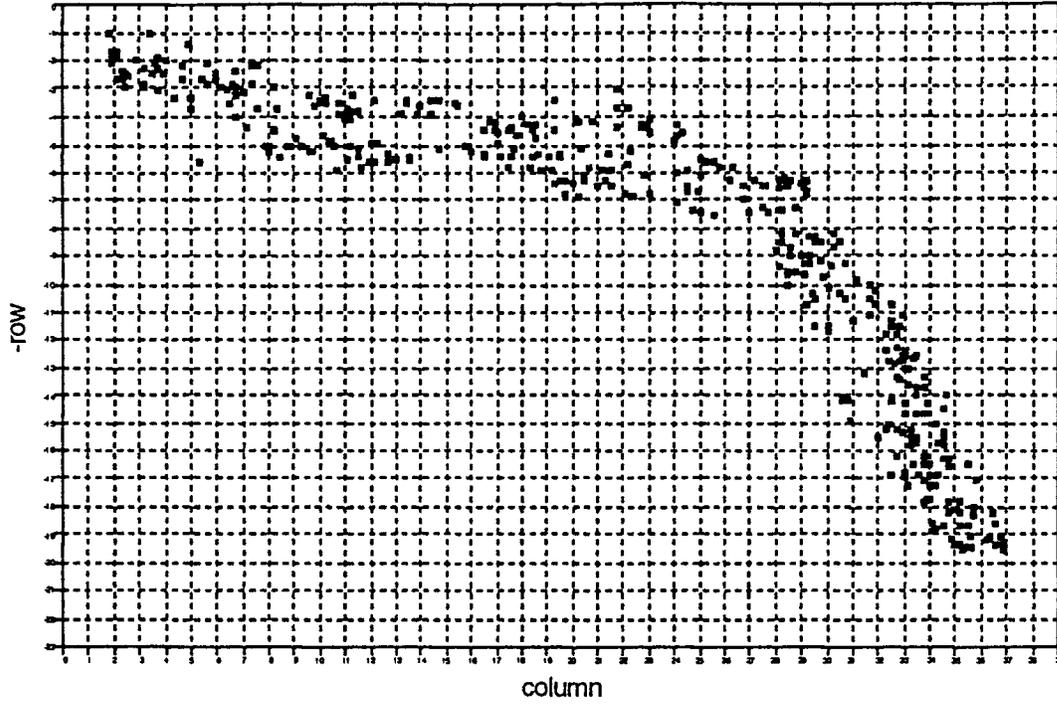


Figure B2

Surface water rights through 1995 within active grid

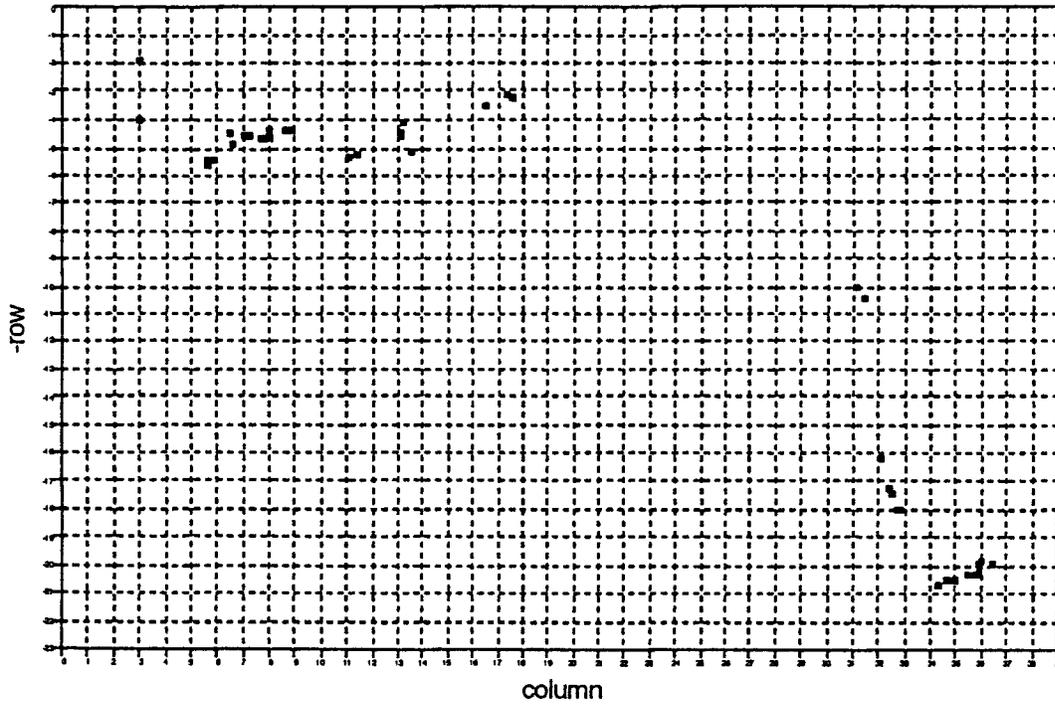


Figure B3

Appendix B2

Reported water use data for the MODFLOW—simulated area

Reported Water Use File (1980-86)																				Swelected newq for nonzero reported use:								418 = no. wells with qnew							
Lower Republican River Valley																																			
combined	qualifiers	P_yr	sc	row	col	Pc	netq	newq	afu_8c	afu_81	afu_82	afu_83	afu_84	afu_85	afu_86	sel_80	sel_81	sel_82	sel_83	sel_84	sel_85	sel_86	rpt_80	rpt_81	rpt_82	rpt_83	rpt_84	rpt_85	rpt_86						
'A0003990005S04W1501'	'NENWNE'	1948	'G'	3	4		80	80	0	29	44	131	133	57	20			80	80	80	80	80	80			1	1	1	1	1	1				
'A0009050008S02E1107'	'43501150'	1952	'G'	20	35		89	89	0	0	0	0	0	0	0																				
'A0011520005S02W2502'	'SWNESE'	1953	'G'	5	18		110	110	0	14	22	111	94	49	28			110	110	110	110	110	110			1	1	1	1	1	1				
'A0012990006S01E0102'	'34005230'	1953	'G'	7	30		79.8	79.79	0	0	0	0	0	0	0																				
'A0015050005S02W2201'	'NWNESW'	1953	'G'	4	16	*	78	78	0	0	0	44	35	53	71					78	78	78	78					1	1	1	1				
'A0015450005S03W3601'	'44502600'	1953	'G'	6	12	*	98	98	0	21	14	0	57	0	0			98	98							1	1								
'A0017090005S02W2601'	'SENESE'	1953	'G'	5	18		97	48.5	0	0	0	0	46	0	0																				
'A0017090005S02W2602'	'SENESE'	1953	'G'	5	17		97	48.5	0	13	0	0	75	0	0			48.5								1									
'A0017130005S04W1601'	'33503340'	1953	'G'	3	3	*	146	146	0	227	89	0	0	0	78			146	146			146				1	1								
'A0019820008S02E0201'	'NESWSW'	1953	'G'	19	35		130	130	0	0	8	0	0	0	0				130																
'A0022070005S04W0901'	'NESWSW'	1954	'G'	2	3	*	53	53	0	0	0	0	0	0	0																				
'A0023010005S04W1601'	'33503340'	1954	'G'	3	3	*	86	43	0	0	0	0	0	0	0																				
'A0023010005S04W1602'	'SWNESW'	1954	'G'	3	3		86	43	0	0	0	0	0	0	15																				
'A0023180005S04W2101'	'NECRNENW'	1954	'G'	4	3		88	88	0	13	16	70	59	46	27			88	88	88	88	88	88			1	1	1	1	1	1	1			
'A0027900008S02E0105'	'52501470'	1954	'G'	18	36	*	85	85	0	0	0	0	0	0	0																				
'A0029830006S01W0406'	'32205200'	1954	'G'	7	21	*	75	75	0	0	0	0	0	0	0																				
'A0031360007S02E1801'	'SWNENE'	1954	'G'	15	31		218	54.5	0	31	82	105	14	9	13			54.5	54.5	54.5	54.5	54.5	54.5			1	1	1	1	1	1	1			
'A0031360007S02E1802'	'SWNENE'	1954	'G'	15	31		218	54.5	0	21	77	104	15	14	14			54.5	54.5	54.5	54.5	54.5	54.5			1	1	1	1	1	1	1			
'A0031360007S02E1803'	'SWNENE'	1954	'G'	15	31		218	54.5	0	24	81	106	25	30	30			54.5	54.5	54.5	54.5	54.5	54.5			1	1	1	1	1	1	1			
'A0031360007S02E1804'	'NWNWNE'	1954	'G'	14	31		218	54.5	0	21	82	102	28	28	28			54.5	54.5	54.5	54.5	54.5	54.5			1	1	1	1	1	1	1			
'A0032090005S04W0801'	'SENESE'	1954	'G'	2	2		330	165	0	0	0	55	39	14	11					165	165	165	165					1	1	1	1	1			
'A0032090005S04W0802'	'NESESE'	1954	'G'	2	2		330	165	0	0	0	55	77	23	34					165	165	165	165					1	1	1	1	1			
'A0032260006S02E3310'	'12501700'	1954	'G'	12	33		268	268	0	0	0	0	0	0	0																				
'A0033890005S02W2503'	'SWSWSW'	1955	'G'	5	18	*	120	120	0	9	11	177	161	29	118			120	120	120	120	120	120			1	1	1	1	1	1	1			
'A0033900005S02W2501'	'NWNWWSW'	1955	'G'	5	18	*	65	65	0	0	0	0	0	0	0																				
'A0034670006S01E2401'	'SENESE'	1955	'G'	10	30		120	120	0	11	0	86	90	55	0			120		120	120	120					1		1	1	1	1			
'A0035410005S02W3602'	'SESWSW'	1955	'G'	6	18	*	67.5	67.5	0	0	0	18	23	9	14					67.5	67.5	67.5	67.5					1	1	1	1	1			
'A0038030006S01E1301'	'38402340'	1955	'G'	9	30		175	175	582	51	116	143	124	77	48			175	175	175	175	175	175			1	1	1	1	1	1	1			
'A0039110005S03W3501'	'NWNWNE'	1955	'G'	6	11	*	111	111	0	0	0	0	64	46	61																				
'A0040230006S01E2402'	'NWSWSW'	1955	'G'	10	30		195	195	552	7	158	134	0	0	0			195	195	195	195					1	1	1	1	1	1	1			
'A0041870005S02W2505'	'NCSWSW'	1955	'G'	5	18		228	228	96	0	16	265	243	88	232			228		228	228	228	228			1		1	1	1	1	1			
'A0042020006S01E0201'	'CNWSE'	1955	'G'	7	29		144	144	0	19	26	30	61	49	21			144	144	144	144	144	144			1	1	1	1	1	1	1			
'A0043880005S04W1603'	'NCS2SE'	1955	'G'	3	3		82	82	0	0	0	4	42	28	0					82	82	82					1	1	1	1	1	1			
'A0044430006S01E0202'	'NWSWSW'	1955	'G'	7	29		128	128	152	15	57	133	201	53	81			128	128	128	128	128	128			1	1	1	1	1	1	1			
'A0044480005S04W1604'	'SENESE'	1955	'G'	3	3		40	40	0	14	11	79	64	39	9			40	40	40	40	40	40			1	1	1	1	1	1	1			
'A0044630005S01W3001'	'NWSWSW'	1955	'G'	5	19		14	7	0	0	0	0	0	0	0																				
'A0044630005S01W3002'	'CEW2NE'	1955	'G'	5	19		14	7	0	4	0	0	0	0	0			7								1									
'A0045180005S03W3501'	'NWNWNE'	1955	'G'	6	11	*	81	81	0	0	0	0	0	0	0																				
'A0045570005S02W3201'	'NWNWWSW'	1955	'G'	6	14		48	48	0	0	0	0	0	0	0																				
'A0045750005S01W3101'	'CESENE'	1955	'G'	6	19		107	107	0	33	35	118	123	46	44			107	107	107	107	107	107			1	1	1	1	1	1	1			
'A0045860006S02E3001'	'NENWSE'	1955	'G'	11	31		220	220	253	0	80	166	188	66	66			220		220	220	220	220			1		1	1	1	1	1			
'A0045940005S01W3201'	'SESWSW'	1955	'G'	6	20		180	180	0	40	43	167	172	0	55			180	180	180	180	180	180					1	1	1	1	1			
'A0046090006S01E0203'	'22004450'	1955	'G'	7	29		130	130	0	38	53	53	72	53	32			130	130	130	130	130	130			1	1	1	1	1	1	1			
'A0046110005S02W3202'	'NWNWSE'	1955	'G'	6	14		212	212	0	0	0	0	0	88	28																				
'A0046360005S02W2501'	'NWNWWSW'	1955	'G'	5	18	*	330	165	0	0	0	0	0	0	0																				
'A0046360005S02W2503'	'SWSWSW'	1955	'G'	5	18	*	330	165	0	0	0	0	0	0	0																				
'A0046550007S02E2207'	'13202610'	1955	'G'	16	34		120	120	0	0	0	0	0	0	0																				
'A0047040006S01W0101'	'NWSWSW'	1955	'G'																																

Reported Water Use File (1987-93)
 Lower Republican River Valley
 file created on 10-09-95

Ccombined	Qualifiers	P_yr	Row	Col	Sr	Netq	Newq	Pafu_87	afu_88	afu_89	afu_90	afu_91	afu_92	afu_93	sel_87	sel_88	sel_89	sel_90	sel_91	sel_92	sel_93	rpt_87	rpt_88	rpt_89	rpt_90	rpt_91	rpt_92	rpt_93	newq_nz
A0295870005S04W080	52500890	1977	2	2	G	52	52	26.68	74.41	52.7	46.73	71.66	0	0	52	52	52	52	52			1	1	1	1	1			1
A0066710005S04W100	NENENW	1957	2	4	G	45	45	20.62	6.81	62.24	47.51	46.4	3.75	0	45	45	45	45	45	45		1	1	1	1	1	1		1
A0107400005S04W110	SESENE	1965	2	5	G	150	75	0	0	44.21	106.71	150.25	0	0			75	75	75					1	1	1		1	
A0107400005S04W110	SESENE	1965	2	5	G	150	75	0	0	44.21	44.93	0	0	0			75	75						1	1			1	
A0032090005S04W080	SESENE	1954	2	2	G	330	165	22.23	41.43	35.45	56.71	113.43	0	0	165	165	165	165	165			1	1	1	1	1		1	
A0198120005S04W090	15304430	1972	2	3	G	31.42	31.42	22.13	31.42	20.39	19.64	22.48	14.41	18.72	31.42	31.42	31.42	31.42	31.42	31.42	31.42		1	1	1	1	1	1	1
A0032090005S04W080	NESESE	1954	2	2	G	330	165	49.35	73.65	75.13	70.71	74.39	7.37	0	165	165	165	165	165			1	1	1	1	1	1		1
VCD00080005S04W090	NESWSW	1941	2	3	G	60	60	56.9	92.43	73.1	49.16	88.49	5.6	0	60	60	60	60	60	60		1	1	1	1	1	1		1
A0022070005S04W090	NESWSW	1954	2	3	G	53	53	0	0	0	0	0	0	0															1
A0171360005S04W100	6201408	1970	2	4	G	81	81	11.6	37.78	71.02	38.67	116	0	18.41	81	81	81	81	81		81	1	1	1	1	1	1		1
A0303600005S04W110	1305150	1977	2	5	G	27	27	8.84	12.89	15.4	9.57	40.33	2.21	0	27	27	27	27	27	27		1	1	1	1	1	1		1
A0317790005S04W160	52500600	1978	3	3	G	98	98	0	89.49	93.22	87	97.36	0	0			98	98	98	98			1	1	1	1	1		1
A0188230005S04W170	NENENE	1972	3	2	G	100	100	0	0	0	0	0	0	0															1
A0070570005S04W170	NENENE	1967	3	2	G	40	40	42.53	131.3	74.74	67.65	138.33	19.65	0	40	40	40	40	40	40		1	1	1	1	1	1		1
A0003990005S04W150	NENWNE	1948	3	4	G	80	80	41.52	56.71	83.04	76.97	72.92	22.28	0	80	80	80	80	80	80		1	1	1	1	1	1		1
A0133850005S04W130	48501624	1967	3	6	G	116	116	19.74	5.99	80.63	35.39	95.33	2.06	0	116	116	116	116	116	116		1	1	1	1	1	1		1
A0193840005S03W170	SWNENW	1972	3	8	G	143	143	24.86	101.1	58	58.92	75.13	0	0	143	143	143	143	143			1	1	1	1	1		1	
A0067060005S03W170	SWNWNNE	1957	3	8	G	83	83	5.16	32.22	10.61	21.65	29	0	0	83	83	83	83	83			1	1	1	1	1		1	
A0056340005S04W140	41251221	1956	3	5	G	262	131	22.28	141.8	86.08	0	101.27	0	0	131	131	131					1	1	1	1	1		1	
A0317800005S04W150	39501250	1978	3	4	G	120	120	0	80.04	80.79	70.38	79.71	0	0			120	120	120	120				1	1	1	1		1
A0153520005S04W150	NESWNW	1968	3	4	G	107	107	46.54	84.46	67.5	45.62	86	3.66	0	107	107	107	107	107	107		1	1	1	1	1	1		1
A0017130005S04W160	33503340	1953	3	3	G	146	146	0	146.7	161.58	138.71	204.33	0	0			146	146	146	146			1	1	1	1	1		1
A0023010005S04W160	33503340	1954	3	3	G	86	43	0	0	0	0	0	0	0															1
A0317780005S04W160	33503340	1978	3	3	G	0	0	0	0	0	0	0	0	0															1
A0291240005S03W180	32541298	1977	3	7	G	68	68	9.21	34.99	38.67	55.77	86.31	0	0	68	68	68	68	68			1	1	1	1	1		1	
A0398630005S03W180	32541298	1990	3	7	G	128	128	0	0	0	0	0	0	0															1
A0043880005S04W160	NCS2SE	1955	3	3	G	82	82	18.91	77.78	24.86	55.24	29.28	1.1	0	82	82	82	82	82	82		1	1	1	1	1	1		1
A0063260005S04W150	CENESW	1956	3	4	G	83	83	16.57	53.03	87.83	87.83	56.34	20.55	0	83	83	83	83	83	83		1	1	1	1	1	1		1
A0305480005S04W150	26100060	1977	3	4	G	0	0	0	0	0	0	0	0	0															1
A0063020005S04W150	26100060	1956	3	4	G	96	96	58.92	115.7	60.32	66.95	124.29	5.14	0	96	96	96	96	96	96		1	1	1	1	1	1		1
A0352610005S03W180	26605200	1981	3	7	G	65	65	63.71	70.43	36.64	20.71	72.18	0	0	65	65	65	65	65			1	1	1	1	1		1	
A0317810005S04W160	22952400	1978	3	3	G	0	0	0	0	0	0	0	0	0															1
A0130110005S04W130	19902650	1967	3	6	G	160	160	30.87	34.06	65.92	30.2	94.28	0	0	160	160	160	160	160			1	1	1	1	1	1		1
A0056340005S04W140	17671247	1958	3	5	G	0	0	0	0	0	0	0	0	0															1
A0044480005S04W160	SENWSW	1955	3	3	G	40	40	20.44	28.72	25.96	39.99	39.28	2.71	0	40	40	40	40	40	40		1	1	1	1	1	1		1
A0023010005S04W160	SWNESW	1954	3	3	G	86	43	0	0	110.21	96.44	180.76	0	0			43	43	43					1	1	1		1	
A0060710005S04W130	SESENE	1956	3	6	G	67.5	67.5	41.1	105.6	78.13	56.34	137.11	3.94	0	67.5	67.5	67.5	67.5	67.5	67.5		1	1	1	1	1	1		1
A0340130005S04W130	8151980	1980	3	6	G	19	19	0	0	0	0	0	0	0															1
A0236900005S04W130	8151980	1975	3	6	G	82.5	82.5	32.95	90.73	85.5	41.18	107.46	13.33	0	82.5	82.5	82.5	82.5	82.5	82.5		1	1	1	1	1	1		1
A0119900005S03W170	NWSESW	1968	3	8	G	77	77	12.57	13.76	5.34	4	18.02	1.07	0.67	77	77	77	77	77	77		1	1	1	1	1	1		1
A0275890005S03W180	8502280	1976	3	7	G	83	83	18.41	63.05	43.46	49.5	78.81	12.52	0	83	83	83	83	83	83		1	1	1	1	1	1		1
A0222910005S04W150	7103990	1974	3	4	G	87	87	14.58	15.32	50.82	44.19	77.34	2.54	0	87	87	87	87	87			1	1	1	1	1	1		1
A0023180005S04W210	NECRNEN	1954	4	3	G	88	88	51.56	100.5	59.48	53.03	83.09	7.73	0	88	88	88	88	88			1	1	1	1	1	1		1
A0361120005S04W220	52504373	1982	4	4	G	86	86	24	97.48	58.49	61.99	88.99	4.81	0	86	86	86	86	86	86		1	1	1	1	1	1		1
A0310980005S03W180	1001230	1977	4	7	G	114	114	39.94	58	49.16	82.49	117.55	0	0	114	114	114	114	114			1	1	1	1	1		1	
A0238200005S04W220	52001280	1975	4	4	G	90	90	60.76	84.26	60.36	59.35	82.49	6.48	0	90	90	90	90	90	90		1	1	1	1	1	1		1
A0305690005S03W180	404250	1977	4	7	G	132	132	12.8	19.67	48.17	26.07	146.28	5.97	0	132	132	132	132	132	132		1	1	1	1	1	1		1
A0142550005S01W220	NENWNE	1967	4	22	G	108	108	27.62	37.98	57.45	56.34	75.86	7.95	0	108	108	108	108	108	108		1	1	1	1	1	1		1

5

Ccombined	Qualifiers	P_yr	Rol	Col	Sr	Netq	Newq	afu_87	afu_88	afu_89	afu_90	afu_91	afu_92	afu_93	sel_87	sel_88	sel_89	sel_90	sel_91	sel_92	sel_93	rpt_87	rpt_88	rpt_89	rpt_90	rpt_91	rpt_92	rpt_93	newq_nz			
						SUM	41147	15892	26114	23636	23525	34623	8809	5199	26736	28585	32915	34309	35361	28299	19110	244	268	298	310	318	240	161	380			
									= use fraction=(sum water use / sum qnew)						0.594	0.914	0.718	0.686	0.979	0.311	0.272											
									= qnew fraction = (sum qnew / qnew total)						0.65	0.695	0.8	0.834	0.859	0.688	0.464											
									= newq fraction = (sum numq / numq total)						0.642	0.705	0.784	0.816	0.837	0.632	0.424											
									qnew total = 41147 ac-ft																							
									numq total = 422																							
									numq = rpt_yr																							

USE_S_80

Surface Water Use (1980 - 86)
File created on 10-16-95

Combined	Qualifier	p_yr	Row	Col	Pc	netq	newq	afu_80	afu_81	afu_82	afu_83	afu_84	afu_85	afu_86	sel_80	sel_81	sel_82	sel_83	sel_84	sel_85	sel_86	rpt_80	rpt_81	rpt_82	rpt_83	rpt_84	rpt_85	rpt_86	
A0020410008S02E1401	SWNESW	1953	21	35		30.00	30	0	20.55	8.68	35.8	25.85	26.52	8.35	0	30	30	30	30	30	30		1	1	1	1	1	1	
A0026680005S03W2801	19804850	1954	5	9		83.00	11.86	0	17.03	0	0	66.29	42.81	0	0	11.86	0	0	11.86	11.86	0		1			1	1		
A0026680005S03W2810	32005100	1954	5	9		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0026680005S03W2812	26405100	1954	5	9		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0026680005S03W2906	14001120	1954	5	8		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0026680005S03W2907	18001850	1954	5	8		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0026680005S03W2908	25004000	1954	5	8		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0026680005S03W2909	25005150	1954	5	8		83.00	11.86	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0045720005S02W2301	NCSWNW	1955	4	17		90.00	45	0	0	0	132.6	66.29	57.45	0	0	0	0	45	45	45	0				1	1	1		
A0045720005S02W2401	SEENW	1955	4	18		90.00	45	0	0	0	0	0	0	58.92	0	0	0	0	0	0	45								1
A0050240005S03W3001	NCSW	1956	5	7		144.00	144	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0056790008S02E1209	9000100	1956	20	36	*	83.00	41.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0056790008S02E1210	4000350	1956	20	36	*	83.00	41.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0059610008S02E1305	41000400	1956	21	36	*	122.00	30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0059610008S02E1306	36001650	1956	21	36	*	122.00	30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0059610008S02E1308	34802940	1956	21	36	*	122.00	30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0059610008S02E1303	37001050	1956	21	36	*	122.00	30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0063250005S04W1001	SWSWSW	1956	2	4		24.00	24	0	0	0	0	0	12.15	7.95	0	0	0	0	0	24	24							1	1
A0099280006S02E2903	NENWNW	1964	10	32		152.00	76	0	0	0	0	0	105.9	0	0	0	0	0	0	76	0							1	
A0099280006S02E2904	SESENW	1964	11	32		152.00	76	0	0	84.7	0	128.9	0	0	0	0	76	0	76	0	0		1			1			
A0124250005S02W2903	25004554	1966	5	14		151.00	75.5	0	111.2	0	0	0	91.15	59.66	0	75.5	0	0	75.5	75.5		1					1	1	
A0124250005S02W3203	42902180	1966	6	14		151.00	75.5	0	0	58.92	294.6	415.4	0	0	0	0	75.5	75.5	75.5	0	0		1	1	1				
A0171090008S02E1404	26800250	1970	21	35		88.00	29.33	36	27.18	27.4	82.2	114.6	23.72	9.28	29.33	29.33	29.33	29.33	29.33	29.33	29.33	1	1	1	1	1	1	1	
A0171090008S02E1405	27001700	1970	21	35		88.00	29.33	0	0	0	0	0	25.04	9.41	0	0	0	0	29.33	29.33							1	1	
A0171090008S02E1408	26400500	1970	21	35		88.00	29.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0176860005S04W2701	52505210	1970	5	4		28.00	28	30.38	0	6.63	27.62	12.15	8.1	6.08	28	0	28	28	28	28	28	1		1	1	1	1	1	1
A0259830008S02E1303	37001050	1976	21	36	*	103.00	25.75	0	5.89	11.22	116.9	119.7	19.64	0	0	25.75	25.75	25.75	25.75	25.75	0		1	1	1	1	1		
A0259830008S02E1305	41000400	1976	21	36	*	103.00	25.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0259830008S02E1306	36001650	1976	21	36	*	103.00	25.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0259830008S02E1308	34802940	1976	21	36	*	103.00	25.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
A0263810005S03W2807	34650595	1976	5	9		51.00	25.5	99.43	0	23.48	51.56	38.67	0	7.73	25.5	0	25.5	25.5	25.5	0	25.5	1		1	1	1			1

Surface Water Rights(1987-93)																													
File created on 10-17-95																													
combined	Qualifier	p_yr	pd	row	col	netQ	newQ	afu_87	afu_88	afu_89	afu_90	afu_91	afu_92	afu_93	sel_87	sel_88	sel_89	sel_90	sel_91	sel_92	sel_93	rpt_87	rpt_88	rpt_89	rpt_90	rpt_91	rpt_92	rpt_93	
A0020410008S02E1401	SWNESW	1953		21	35	30	30	31.82	31.82	0	0	26.52	10.68	0	30	30			30	30		1	1			1	1		
A0026680005S03W2801	19804850	1954		5	9	83	12	24.91	92.8	54.8	50.93	47.73	0	0	12	12	12	12	12			1	1	1	1	1			
A0026680005S03W2810	32005100	1954		5	9	83	12	0	0	0	46.4	0	0	0				12							1				
A0026680005S03W2812	26405100	1954		5	9	83	12	0	0	0	0	68.61	1.25	0					12	12						1	1		
A0026680005S03W2906	14001120	1954		5	8	83	12	0	0	0	0	25.63	0	0					12							1			
A0026680005S03W2907	18001850	1954		5	8	83	12	0	0	0	0	157.8	4.51	5.46					12	12	12					1	1	1	
A0026680005S03W2908	25004000	1954		5	8	83	12	0	0	0	0	0	0	0															
A0026680005S03W2909	25005150	1954		5	8	83	12	0	0	0	0	0	0	0															
A0045720005S02W2301	NCSWNW	1955		4	17	90	45	0	88.38	95.01	119.3	126	15.91	0		45	45	45	45	45			1	1	1	1	1		
A0045720005S02W2401	SEENENW	1955		4	18	90	45	0	0	0	0	0	0	0															
A0050240005S03W3001	NCSW	1956		5	7	144	144	0	0	62.84	63.53	55.7	0	0			144	144	144						1	1	1		
A0056790008S02E1209	09000100	1956	*	20	36	83	42	0	0	77.23	51.37	53.03	16.57	0			42	42	42	42					1	1	1	1	
A0056790008S02E1210	04000350	1956	*	20	36	83	42	0	0	0	0	0	0	0															
A0059610008S02E1305	41000400	1956	*	21	36	122	31	0	0	0	0	0	14.73	0						31							1		
A0059610008S02E1306	36001650	1956	*	21	36	122	31	0	0	0	0	0	0	0															
A0059610008S02E1308	34802940	1956	*	21	36	122	31	0	0	0	0	0	40.92	0						31							1		
A0059610008S02E1303	37001050	1956	*	21	36	122	31	0	0	0	0	0	31.49	11.3						31	31						1	1	
A0063250005S04W1001	SWSWSW	1956		2	4	24	24	13.26	0	0	0	18.27	16.5	0	24					24	24					1	1		
A0099280006S02E2903	NENWNW	1964		10	32	152	76	2.95	0	0	0	0	0	0	76								1						
A0099280006S02E2904	SESENW	1964		11	32	152	76	0	0	0	0	0	0	0															
A0124250005S02W2903	25004554	1966		5	14	151	76	57.08	0	238.6	243.1	268.8	16.57	0	76		76	76	76	76			1		1	1	1	1	
A0124250005S02W3203	42902180	1966		6	14	151	76	0	198.9	238.6	0	0	0	0		76	76								1	1			
A0171090008S02E1404	26800250	1970		21	35	88	29	42.42	39.77	0	34.25	33.14	4.46	0	29	29			29	29	29			1	1		1	1	1
A0171090008S02E1405	27001700	1970		21	35	88	29	21.21	36.02	39.77	0	0	3.39	0	29	29	29			29			1	1	1			1	
A0171090008S02E1408	26400500	1970		21	35	88	29	0	0	0	0	68.5	3.76	0						29	29					1	1		
A0176860005S04W2701	52505210	1970		5	4	28	28	7.8	15.32	9.34	8.38	18.93	0	0	28	28	28	28	28						1	1	1	1	1
A0259830008S02E1303	37001050	1976	*	21	36	103	26	56.12	74.25	102.2	85.94	78.92	0	0	26	26	26	26	26						1	1	1	1	1

Appendix C

Testing the combined model with simplified test cases

Appendix C: Testing the combined model with simplified test cases.

We tested our combined SWAT-MODFLOW model on a small watershed (1.23 km²) for which results from example model runs are described in the SWAT manual (Arnold, et al., 1994). The test case, designated as Y7, and located at Riesel, TX, is part of a basin that is gaged and operated by USDA-ARS. This watershed is subdivided into seven subbasins. Data files for this watershed accompanied the SWAT program installation disks, and are described in Ch. 5 of the SWAT manual, which also provides maps coded with gray scales showing elevation contours, stream network, and domains for subbasins, soils and land use.

In order to use this example as a test case for the combined SWAT-MODFLOW model, we assumed that the watershed is underlain by a shallow aquifer of the same areal domain. We used an aquifer hydraulic conductivity of 20 m/day and a streambed hydraulic conductivity of 1 m/day. We superimposed on the watershed a regular grid of 45 rows by 32 columns, or 1440 cells, chosen to approximately match the resolution of cells apparent in the digitized subbasin boundary maps shown in the SWAT manual. Of these, 766 grid cells lie mostly within the watershed domain. Grid cells are square with sides of approximately 40 m. A grid map was scaled to be superimposed on the watershed maps in the SWAT manual in order to transfer subbasin domains, the stream network and ground surface elevations onto the grid. Fig. C1 displays the watershed Y7 subbasins and their exit points, the superimposed MODFLOW grid, as well as the stream network. Fig. C2 displays the elevation contours, the stream network and the model grid; and for each cell, an estimated direction of overland flow is also shown.

In order to obtain elevations for the watershed domain, the following procedure was used. Elevation contours were digitized in terms of grid coordinates, producing a data file of piecewise-linear approximations to the contours, from which a mesh-centered grid of interpolated elevations for all active cells was produced using SURFER. Program MSH2BLK, written specifically for this case, was then used to convert the mesh-centered grid of interpolated elevations into a block-centered grid, consistent with MODFLOW's convention.

Based on the block-centered grid of ground surface elevations, the depth to water table was assumed to be 1 m below land surface at the lowest land surface elevation (155.5 m) and 3 m below land surface at the highest land surface elevation (170.7 m), and was linearly interpolated between these extremes using MSH2BLK. Given that the aquifer base was assumed impervious and horizontal at 150 m elevation, the water table configuration resulted in an initial saturated thickness ranging from 5.5 to 20.7 m.

Program MSH2BLK also produced a routing map, i.e. a designated overland flow route for each grid cell based on neighboring elevations and the stream network, and identified the resulting exit routes from each subbasin. From these exit routes, one each was chosen to

represent the location of subbasin outflow calculated by SWAT; these exits are identified as circled cells in fig. C1.

Superimposing a grid on the Y7 watershed as described above served as a basis for constructing input file Y7.SWB for MODSWB, the soil water balance module in MODFLOW, which associates the watershed with the aquifer as follows. First, the outlets of each subbasin are listed; each outlet is identified as a tributary to the main stream channel network for the basin. In the case of watershed Y7, each subbasin is associated with only one exit. Second, each of these exit points is associated with a particular stream segment and reach of the stream network. Third, an array of 45 rows by 32 columns associates each grid cell with a subbasin, numbered 1-7. These associations are shown in fig. C2. Finally, the average annual water fluxes written by SWAT are appended to input file Y7.SWB to be distributed according to these connections as previously described (Section IIa.). Appendix C1 lists the MODSWB input file Y7.SWB for the Y7 watershed.

Summary of test results

Three cases, identified as Y70C, Y7SSC and Y7IRRC were used to test the watershed-aquifer connections in MODSWB. All cases to be compared were run under steady state conditions, so that change in aquifer storage does not play a role in the mass balances. At the boundary of the watershed, water table elevations were specified as constant heads, given by the interpolation scheme described previously. The first case uses the average annual fluxes computed by SWAT for input to the MODSWB package in MODFLOW; in Y7IRRC, some of the fluxes are artificially changed, so that irrigation pumping and irrigation return fluxes are included in testing the watershed-aquifer interface.

Case Y70C was run with initial heads given by the interpolation scheme described above, and without the soil water balance module (MODSWB), in order to verify that a mass balance is achieved. The following budget summary for this case shows a negligible mass balance discrepancy, achieved with 16 solution iterations and a solution tolerance of 0.001 m for the strongly implicit (SIP) solver in MODFLOW.

Case Y70C
 VOLUMETRIC BUDGET FOR ENTIRE MODEL

 RATES FOR THIS TIME STEP L**3/T

 IN:
 STORAGE 0.00000
 CONSTANT HEAD 0.97268E-01
 WELLS 0.00000
 RECHARGE 0.00000
 STREAM LEAKAGE 0.00000
 TOTAL IN 0.97268E-01
 OUT:
 STORAGE 0.00000
 CONSTANT HEAD 0.40660E-01
 WELLS 0.00000
 RECHARGE 0.00000
 STREAM LEAKAGE 0.56581E-01
 TOTAL OUT 0.97242E-01
 IN - OUT 0.25749E-04
 PERCENT DISCREPANCY = 0.03

Cases Y7SSC and Y7IRRC both take as initial heads the steady state solution calculated for case Y70C, and both include the soil water balance module (MODSWB) with the average annual fluxes calculated by SWAT. Case Y7IRRC is distinguished from Y7SSC by artificially changing some of the average annual fluxes in the soil water balance module input file, in order to test the watershed-aquifer connections.

Appendix C2 displays an excerpt from SWAT standard output file for the Y7 watershed case summarizing subbasin and basin hydrologic fluxes. Appendix C2 also displays summary results from MODFLOW (MODSWB) for cases Y7SSC and Y7IRRC. The summary results for these two cases include the following.

- (1). Fluxes, mm/yr (SWAT's units) for each subbasin and average basin fluxes, weighted by subbasin areas.
- (2). Corresponding flow rates, m³/s (MODFLOW's units) for each subbasin and basin totals.
- (3). Subbasin weighting factors.
- (4). For each well, irrigation pumping rate and irrigation return flow as recharge.
- (5). For each subbasin outlet, total surface and subsurface outflow into stream network as lateral inflow.
- (6). Summary of watershed flux connection to aquifer, showing total basin flow rates, m³/s (MODFLOW's units) and average basin fluxes, mm/yr (SWAT's units).
- (7). Hydrologic budget summary for MODFLOW simulation.

The first six items were written by subroutine SWBHYD in the MODSWB package; the last is MODFLOW's standard budget summary.

Average annual fluxes for each subbasin were written by SWAT for the Y7 case and read by MODSWB for case Y7SSC as shown below; the areally weighted basin averages were calculated in MODSWB.

Average annual fluxes for case Y7SSC (Swat units, mm/yr):

sub	Area (fract)	PREC MM	SURQ MM	LATQ MM	PERC MM	ET MM	WYLD MM	IRR MM
1	0.058	867.93	47.50	0.33	9.39	827.79	84.80	0.00
2	0.149	867.93	80.97	0.17	0.28	809.79	111.00	0.00
3	0.050	867.93	96.17	0.18	2.66	785.90	126.95	0.00
4	0.068	867.93	64.69	0.66	0.00	824.34	95.85	0.00
5	0.101	867.93	67.49	0.08	0.00	822.81	97.64	0.00
6	0.125	867.93	63.85	0.77	0.00	825.39	94.17	0.00
7	0.449	867.93	65.63	0.19	0.00	823.61	96.80	0.00
Areally weighted avg basin fluxes (Area=1230000 m ²)								
		867.93	68.29	0.29	0.72	820.10	99.42	0.00

The average basin fluxes can be compared with results from both SWAT and MODFLOW:

- i. The basin fluxes (1) appear in SWAT's basin summary on output file Y7.STD, an excerpt from which is shown on file Y7.OUT in Appendix C2; all fluxes (for case Y7SSC) are the same to the displayed precision.
- ii. The MODSWB summary (6), shown below can be compared in terms of fluxes with the average basin fluxes (1), and in terms of flow rates with MODFLOW's hydrologic budget summary (7). For case Y7SSC, recharge from precipitation, 0.72 mm/yr, matches in both comparisons. The sum of surface and subsurface flow to streams, 68.58 mm/yr, matches SWAT's flux data, but cannot be compared directly with MODFLOW's budget summary, since only vertical exchange via streambed leakage is directly involved in the aquifer hydrologic balance. However, the surface and subsurface (lateral) flows from subbasins into the stream network contribute additional streamflow, which affects stream depth (via Manning's equation) and consequently the stream-aquifer hydraulic gradient that drives streambed leakage.

MODSWB (soil water balance module) summary for Y7SSC:

Transfer from watershed to aquifer	flow rate (Modflow units)	flux (Swat units)
Conversion=	25639.025	
Recharge due to precipitation	0.2805649E-04	0.719
Irrigation pumping=	0.0000000E+00	0.000
Surface & subsurface flow to streams	0.2674850E-02	68.581

In case Y7IRRC, the following changes were made to the watershed fluxes: irrigation was set to 100 mm/yr, and precipitation was decreased by a corresponding 100 mm/yr. Percolation from the root zone was calculated at 50.8 mm/yr. Of this percolation, 30.8 mm was attributed to precipitation and distributed evenly over the basin; the remainder was attributed to irrigation return, and distributed as recharge at the pumping well locations. (A procedure was added to SWAT's mainline to estimate these components of percolation).

Briefly, both the summary from MODSWB (below) and MODFLOW's budget summary reflect all of these fluxes correctly. In the case of recharge, the inflow in the MODFLOW budget summary equals the sum of recharge due to precipitation and irrigation return shown in MODSWB's summary.

MODSWB (soil water balance module) summary for Y7IRRC:

Transfer from watershed to aquifer	flow rate (Modflow units)	flux (Swat units)
Conversion=	25639.025	
Recharge due to precipitation	0.1201303E-02	30.800
Recharge due to irrigation return	0.7800608E-03	20.000
Irrigation pumping=	-0.3900304E-02	-100.000
Surface & subsurface flow to streams	0.2674850E-02	68.581

SWAT example: Y7 watershed

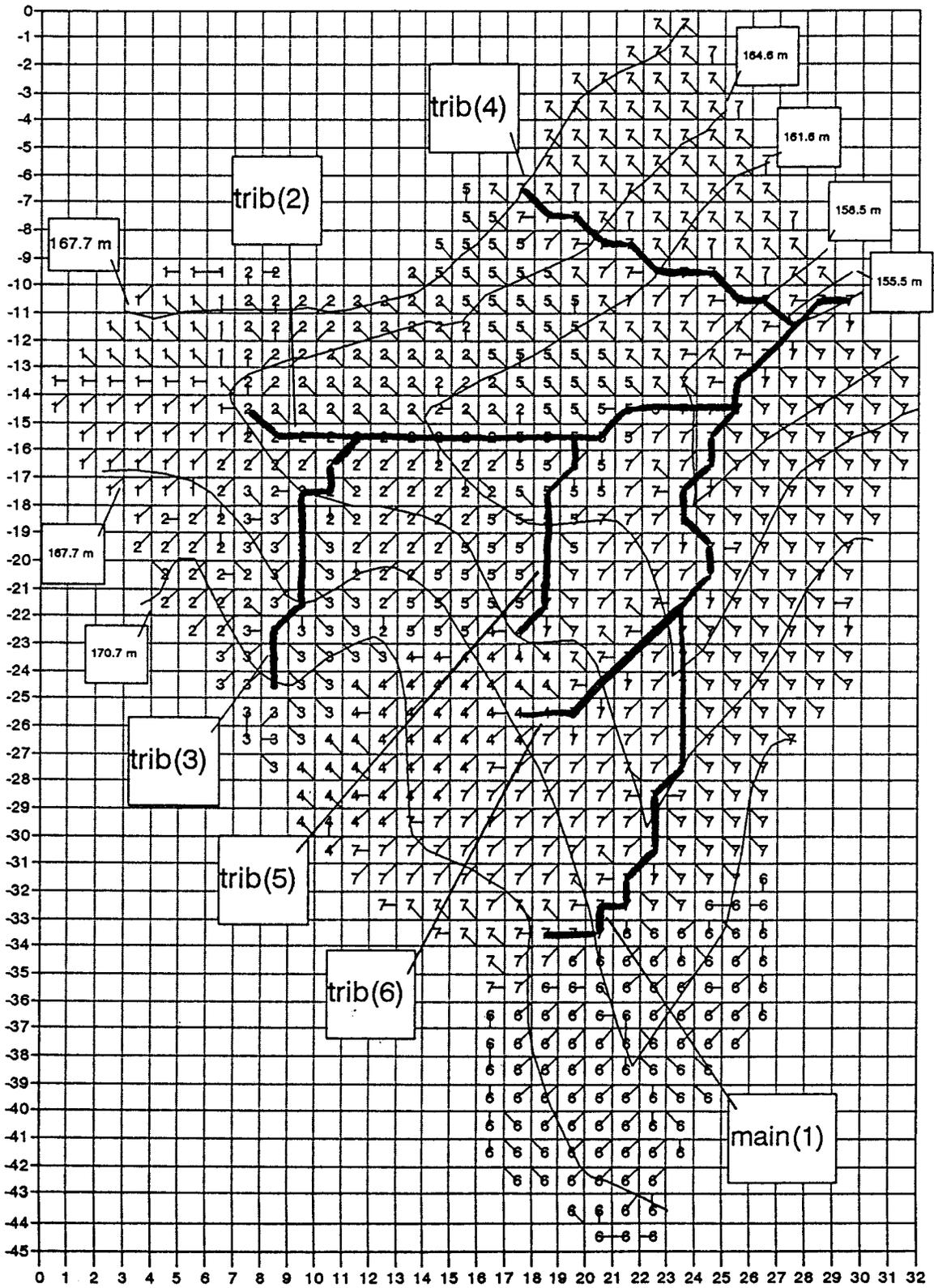


Figure C2

Appendix C1

MODSWB input file for the Y7 watershed case

Appendix C2

Summary output for Y7 watershed test cases using the combined
SWAT-MODFLOW model

Y7.out: summary of Swat standard output for Y7 test case

SUB-BASIN STATISTICS

AVE ANNUAL VALUES					
SUB-BASIN NO	RAIN (MM)	SUR Q (MM)	SUR Q (MM)	Y (T/HA)	
1	867.9	47.5	0.3	1.3	2089.7
2	867.9	81.0	0.2	2.5	2118.1
3	867.9	96.2	0.2	2.8	2122.2
4	867.9	64.7	0.7	2.1	2104.0
5	867.9	67.5	0.1	1.9	2115.0
6	867.9	63.9	0.8	2.1	2097.7
7	867.9	65.6	0.2	2.4	2103.1

AVE MONTHLY BASIN VALUES								
MO	R (MM)	SNOW FALL (MM)	SUR Q (MM)	SUR Q (MM)	WATER YIELD (MM)	ET (MM)	Y (T/HA)	EO (MM)
1	37.83	0.00	0.39	0.01	5.97	32.67	0.01	227.62
2	74.92	0.00	11.69	0.03	15.88	35.20	0.30	285.65
3	62.57	0.00	3.28	0.02	7.42	40.44	0.12	447.86
4	135.50	0.00	19.16	0.09	22.25	63.09	0.66	549.48
5	108.13	0.00	8.10	0.05	10.88	121.18	0.21	699.27
6	84.70	0.00	7.64	0.01	10.12	237.37	0.37	825.45
7	70.10	0.00	3.67	0.00	5.91	108.92	0.14	806.64
8	17.27	0.00	0.00	0.00	2.04	22.87	0.00	813.55
9	90.87	0.00	4.73	0.00	6.19	49.11	0.17	628.02
10	81.07	0.00	5.52	0.03	6.76	41.05	0.16	487.36
11	63.03	0.00	2.56	0.01	3.66	37.99	0.08	313.37
12	43.67	0.00	1.80	0.03	2.70	31.03	0.04	234.04

BASIN STATISTICS

Curve number (CN): MEAN = 71.978 MAX = 94.488 MIN = 58.857
 PRED MO WATER YLD: MEAN = 8.28 MM ST DEV = 9.84 MM

AVE ANNUAL BASIN STRESS DAYS

WATER STRESS DAYS = 15.23
 TEMPERATURE STRESS DAYS = 4.55
 NITROGEN STRESS DAYS = 0.00
 PHOSPHORUS STRESS DAYS = 0.00

AVE ANNUAL BASIN VALUES

PRECIP = 867.9 MM
 SNOW FALL = 0.00 MM
 SNOW MELT = 0.00 MM
 PRED SURFACE Q = 68.29 MM
 SUB-SUR Q = 0.29 MM
 GROUNDWATER Q = 33.81 MM
 REVAP = 0.00 MM
 GW PERC = 0.00 MM
 GW RECHARGE = 33.64 MM
 PRED H2O YLD = 99.42 MM
 DEEP PERC = 0.72 MM
 ET = 820.1 MM
 PET = 2106.1MM
 TRANS LOSSES = 2.97 MM
 TOTAL SUB-BASIN SED YLD = 2.247 T/HA
 BASIN SED YLD = 2.247 T/HA

File avgann.1: average annual sub-basin fluxes written by modified Swat mainline and appended to Modswb input file Y7.swb for base case Y7SSC:

```

3 1990 7 1 file avgann.1
(8x,2i4,20f10.2)
1 avgann format
day mon yr sub PREC MM SURQ MM LATQ MM PERC MM ET MM WYLD MM IRR MM ETPOT MM PREPCP MM PRIIRR MM
3 1 867.93 47.50 0.33 9.39 827.79 84.80 0.00 2089.68 9.39 0.00
3 2 867.93 80.97 0.17 0.28 809.79 111.00 0.00 2118.08 0.28 0.00
3 3 867.93 96.17 0.18 2.66 785.90 126.95 0.00 2122.23 2.66 0.00
3 4 867.93 64.69 0.66 0.00 824.34 95.85 0.00 2104.02 0.00 0.00
3 5 867.93 67.49 0.08 0.00 822.81 97.64 0.00 2114.96 0.00 0.00
3 6 867.93 63.85 0.77 0.00 825.39 94.17 0.00 2097.65 0.00 0.00
3 7 867.93 65.63 0.19 0.00 823.61 96.80 0.00 2103.14 0.00 0.00
    
```

Case Y7SSC:

1 U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER MODEL
 OSWAT test case Y7: 1 LAY, 15 ROWS, 32 COLS, 40m x 40m cells; Steady state '94 const heads boundary; SIP .01m; w/ SWB module

To convert from flow (Modflow units) to flux (Swat units), multiply by cnvrsn:
 cnvrsn=cnvrt/bsarea= 25639.03
 cnvrt=cnvlen*daystp*timstp= 0.3153600E+11 total basin area= 1230000.
 length cnvlen= 1000. daystp=days/step: 365.0 timstp= 0.8640E+05

sub Fluxes for time step 1

day	mon	yr	sub	PREC MM	SURQ MM	LATQ MM	PERC MM	ET MM	WYLD MM	IRR MM
3	1		1	867.93	47.50	0.33	9.39	827.79	84.80	0.00
3	2		2	867.93	80.97	0.17	0.28	809.79	111.00	0.00
3	3		3	867.93	96.17	0.18	2.66	785.90	126.95	0.00
3	4		4	867.93	64.69	0.66	0.00	824.34	95.85	0.00
3	5		5	867.93	67.49	0.08	0.00	822.81	97.64	0.00
3	6		6	867.93	63.85	0.77	0.00	825.39	94.17	0.00
3	7		7	867.93	65.63	0.19	0.00	823.61	96.80	0.00

Areally weighted avg basin fluxes (Swat units):
 867.93 68.29 0.29 0.72 820.10 99.42 0.00

Flow rates by subbasin (Modflow units):

day	mon	yr	sub	Precip	Surface Q	Subsurf Q	Percolation	Evapotransp	Water yield	Irrigation
1			1	0.1963E-02	0.1075E-03	0.7465E-06	0.2124E-04	0.1873E-02	0.1918E-03	0.0000E+00
2			2	0.5044E-02	0.4706E-03	0.9879E-06	0.1627E-05	0.4706E-02	0.6451E-03	0.0000E+00
3			3	0.1693E-02	0.1875E-03	0.3510E-06	0.5187E-05	0.1533E-02	0.2476E-03	0.0000E+00
4			4	0.2302E-02	0.1716E-03	0.1750E-05	0.0000E+00	0.2186E-02	0.2542E-03	0.0000E+00
5			5	0.3419E-02	0.2659E-03	0.3151E-06	0.0000E+00	0.3241E-02	0.3846E-03	0.0000E+00
6			6	0.4231E-02	0.3113E-03	0.3754E-05	0.0000E+00	0.4024E-02	0.4591E-03	0.0000E+00
7			7	0.1520E-01	0.1149E-02	0.3327E-05	0.0000E+00	0.1442E-01	0.1695E-02	0.0000E+00

Areally weighted total basin flow rates (flux*area, Modflo. units):
 0.3385E-01 0.2664E-02 0.1123E-04 0.2806E-04 0.3199E-01 0.3878E-02 0.0000E+00

day	mon	yr	sub	areal fract	area m^2	area/grid	phi=Wells,M	psi_irr/phi	psi_ret/phi
1			1	0.5800E-01	0.7134E+05	0.9257E+00	0.0000E+00	0.0000E+00	0.0000E+00
2			2	0.1490E+00	0.1833E+06	0.1010E+01	0.0000E+00	0.0000E+00	0.0000E+00
3			3	0.5000E-01	0.6150E+05	0.9576E+00	0.0000E+00	0.0000E+00	0.0000E+00
4			4	0.6800E-01	0.8364E+05	0.1042E+01	0.0000E+00	0.0000E+00	0.0000E+00
5			5	0.1010E+00	0.1242E+06	0.1090E+01	0.0000E+00	0.0000E+00	0.0000E+00
6			6	0.1250E+00	0.1537E+06	0.1008E+01	0.0000E+00	0.0000E+00	0.0000E+00
7			7	0.4490E+00	0.5523E+06	0.9856E+00	0.0000E+00	0.0000E+00	0.0000E+00

Lateral inflow to stream from subbasin outflow:

sub idx	lay	row	col	seg	rch lat.	inflow
1	29	1	15	8	2	1 0.1082E-03
2	38	1	16	17	2	10 0.4715E-03
3	53	1	20	10	3	6 0.1879E-03
4	79	1	26	19	6	2 0.1733E-03
5	44	1	15	23	2	16 0.2662E-03
6	3	1	34	21	1	3 0.3150E-03
7	26	1	12	28	1	26 0.1153E-02

MODSWB (soil water balance module) summary:
 Transfer from watershed to aquifer flow rate flux (Modflow units) (Swat units)
 Conversion= 25639.025
 Recharge due to precipitation 0.2805649E-04 0.719
 Irrigation pumping= 0.0000000E+00 0.000
 Surface & subsurface flow to streams 0.2674850E-02 68.581

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

0	CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
	IN:		IN:	
	---		---	
	STORAGE =	0.00000	STORAGE =	0.00000
	CONSTANT HEAD =	0.84011E+06	CONSTANT HEAD =	0.97235E-01
	WELLS =	0.00000	WELLS =	0.00000
	RECHARGE =	189.55	RECHARGE =	0.21939E-04
	STREAM LEAKAGE =	5842.9	STREAM LEAKAGE =	0.67627E-03
0	TOTAL IN =	0.84614E+06	TOTAL IN =	0.97933E-01
0	OUT:		OUT:	
	---		---	
	STORAGE =	0.00000	STORAGE =	0.00000
	CONSTANT HEAD =	0.35513E+06	CONSTANT HEAD =	0.41103E-01
	WELLS =	0.00000	WELLS =	0.00000
	RECHARGE =	0.00000	RECHARGE =	0.00000
	STREAM LEAKAGE =	0.49086E+06	STREAM LEAKAGE =	0.56812E-01
0	TOTAL OUT =	0.84599E+06	TOTAL OUT =	0.97915E-01
0	IN - OUT =	157.63	IN - OUT =	0.18239E-04
0	PERCENT DISCREPANCY =	0.02	PERCENT DISCREPANCY =	0.02

Case Y7IRRC:

1 U.S. GEOLOGICAL SURVEY MODULAR FINITE-DIFFERENCE GROUND-WATER MODEL
 OSWAT test case Y7: 1 LAY,45 ROWS, 32 COLS, 40m x 40m cells; Steady state '94 const heads boundary;SIP .001m

sub Fluxes for time step 1

day	mon	yr	sub	PREC MM	SURQ MM	LATQ MM	PERC MM	ET MM	WYLD MM	IRR MM	ETPOT MM
3	1			767.93	47.50	0.33	50.80	827.79	84.80	100.00	2089.68
3	2			767.93	80.97	0.17	50.80	809.79	111.00	100.00	2118.08
3	3			767.93	96.17	0.18	50.80	785.90	126.95	100.00	2122.23
3	4			767.93	64.69	0.66	50.80	824.34	95.85	100.00	2104.02
3	5			767.93	67.49	0.08	50.80	822.81	97.64	100.00	2114.96
3	6			767.93	63.85	0.77	50.80	825.39	94.17	100.00	2097.65
3	7			767.93	65.63	0.19	50.80	823.61	96.80	100.00	2103.14
Areally weighted avg basin fluxes (Swat units):				767.93	68.29	0.29	50.80	820.10	99.42	100.00	2106.11

Flow rates by subbasin (Modflow units):

day	mon	yr	sub	Precip	Surface Q	Subsurf Q	Percolation	Evapotransp	Water yield	Irrigation
1				0.1737E-02	0.1075E-03	0.7465E-06	0.1149E-03	0.1873E-02	0.1918E-03	0.2262E-03
2				0.4463E-02	0.4706E-03	0.9879E-06	0.2952E-03	0.4706E-02	0.6451E-03	0.5811E-03
3				0.1498E-02	0.1875E-03	0.3510E-06	0.9907E-04	0.1533E-02	0.2476E-03	0.1950E-03
4				0.2037E-02	0.1716E-03	0.1750E-05	0.1347E-03	0.2186E-02	0.2542E-03	0.2652E-03
5				0.3025E-02	0.2659E-03	0.3151E-06	0.2001E-03	0.3241E-02	0.3846E-03	0.3939E-03
6				0.3744E-02	0.3113E-03	0.3754E-05	0.2477E-03	0.4024E-02	0.4591E-03	0.4875E-03
7				0.1345E-01	0.1149E-02	0.3327E-05	0.8896E-03	0.1442E-01	0.1695E-02	0.1751E-02
Areally weighted total basin flow rates (flux*area, Modflo units):				0.2995E-01	0.2664E-02	0.1123E-04	0.1981E-02	0.3199E-01	0.3878E-02	0.3900E-02

day	mon	yr	sub	areal fract	area m^2	area/grid	phi=Wells,M	psi irr/phi	psi ret/phi
1				0.5800E-01	0.7134E+05	0.9257E+00	0.1611E-08	0.1968E+01	0.3937E+00
2				0.1490E+00	0.1833E+06	0.1010E+01	0.1611E-08	0.1969E+01	0.3937E+00
3				0.5000E-01	0.6150E+05	0.9576E+00	0.1611E-08	0.1968E+01	0.3937E+00
4				0.6800E-01	0.8364E+05	0.1042E+01	0.1611E-08	0.1968E+01	0.3937E+00
5				0.1010E+00	0.1242E+06	0.1090E+01	0.1611E-08	0.1968E+01	0.3937E+00
6				0.1250E+00	0.1537E+06	0.1008E+01	0.1610E-08	0.1969E+01	0.3938E+00
7				0.4490E+00	0.5523E+06	0.9856E+00	0.1611E-08	0.1969E+01	0.3938E+00

Adjust pumping rates and recharge based on irrigation return flow:

L	sub	row	col	pumping	rechrg	irr
1	1	13	5	-0.113E-03	0.226E-04	
2	1	17	5	-0.113E-03	0.226E-04	
3	2	13	12	-0.291E-03	0.581E-04	
4	2	19	12	-0.291E-03	0.581E-04	
5	3	23	11	-0.195E-03	0.390E-04	
6	4	25	17	-0.133E-03	0.265E-04	
7	4	27	13	-0.133E-03	0.265E-04	
8	5	12	19	-0.197E-03	0.394E-04	
9	5	20	17	-0.197E-03	0.394E-04	
10	6	36	24	-0.244E-03	0.488E-04	
11	6	38	19	-0.244E-03	0.488E-04	
12	7	6	23	-0.584E-03	0.117E-03	
13	7	18	28	-0.584E-03	0.117E-03	
14	7	27	21	-0.584E-03	0.117E-03	

Lateral inflow to stream from subbasin outflow:

sub idx	lay	row	col	seg	rch lat.	inflow
1	29	1	15	8	2	1 0.1082E-03
2	38	1	16	17	2	10 0.4715E-03
3	53	1	20	10	3	6 0.1879E-03
4	79	1	26	19	6	2 0.1733E-03
5	44	1	15	23	2	16 0.2662E-03
6	3	1	34	21	1	3 0.3150E-03
7	26	1	12	28	1	26 0.1153E-02

MODSWB (soil water balance module) summary:

Transfer from watershed to aquifer	flow rate (Modflow units)	flux (Swat units)
Conversion=	25639.025	
Recharge due to precipitation	0.1201303E-02	30.800
Recharge due to irrigation return	0.7800608E-03	20.000
Irrigation pumping=	-0.3900304E-02	-100.000
Surface & subsurface flow to streams	0.2674850E-02	68.581

VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

IN:	CUMULATIVE VOLUMES	L**3	IN:	RATES FOR THIS TIME STEP	L**3/T
	---			---	
	STORAGE =	0.00000		STORAGE =	0.00000
	CONSTANT HEAD =	0.85029E+06		CONSTANT HEAD =	0.98413E-01
	WELLS =	0.00000		WELLS =	0.00000
	RECHARGE =	15711.		RECHARGE =	0.18184E-02
	STREAM LEAKAGE =	5842.9		STREAM LEAKAGE =	0.67627E-03
0	TOTAL IN =	0.87185E+06		TOTAL IN =	0.10091
0	OUT:			OUT:	
	---			---	
	STORAGE =	0.00000		STORAGE =	0.00000
	CONSTANT HEAD =	0.35153E+06		CONSTANT HEAD =	0.40686E-01
	WELLS =	31699.		WELLS =	0.39003E-02
	RECHARGE =	0.00000		RECHARGE =	0.00000
	STREAM LEAKAGE =	0.48613E+06		STREAM LEAKAGE =	0.562E5E-01
0	TOTAL OUT =	0.87136E+06		TOTAL OUT =	0.10085
0	IN - OUT =	487.88		IN - OUT =	0.56468E-04
0	PERCENT DISCREPANCY =		0.06	PERCENT DISCREPANCY =	0.06