REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
April 2, 2001

Modeling

Calibration of the predevelopment (prior to extensive ground-water development for irrigation, not pre-settlement) ground-water flow model is proceeding. The model is being calibrated with: (1) pre-1964 ground-water levels, (2) pre-1964 long-term average base flows (ground-water discharge to streams) determined from base flow separation analysis at gaging stations, (3) base-flow gain/loss measurements during the 1970s, 1980s, and 1998 indicating relative proportions of tributary inflow and main stem base-flow gain, (4) the location of the headwaters of perennial streams. Substantial improvements have been made in the match between simulated and observed ground-water levels and base flows and the model is close to being satisfactorily calibrated. However, there are still some areas in which simulated ground-water levels and/or base flows are higher or lower than observed values. Model simulations are being made to improve the model fit in these areas. The principal model parameters that have been adjusted to improve model calibration have been: recharge (long-term average prior to extensive irrigation), aquifer hydraulic conductivity, ground-water evapotranspiration in riparian areas along streams (adjusted to account for historical changes in woodland area), and streambed conductance (a term that describes how much water can be transmitted through streambeds, depends on streambed hydraulic conductivity and area), and the connection between the upland and alluvial aquifer along the alluvial valley boundary. Adjustments to these parameters have helped the simulation results to more closely approximate observed data.

The ground-water model for the development period (1950-1997) has been constructed and trial simulations have been conducted. More extensive development period simulations will not be conducted until the predevelopment model calibration is completed. The development period model has two stress periods per year, a summer (irrigation season) stress period from May – September and a winter (non-irrigation) stress period from October – April. There are a total of 95 stress periods during the development simulation period beginning in May 1950 and ending in September 1997. All of the model input data for these stress periods have been generated. During the last quarter, processing of recharge and pumping data sets was completed and values were assigned to areas on maps for each stress period using Geographic Information System (GIS) procedures.

Additional base-flow separation analysis was completed to improve characterization of predevelopment base flow and to fix errors identified in some the data analyzed earlier. The base-flow estimates are being used for model calibration. A report entitled "Base flow and runoff components of streamflow and base-flow gain/loss in part of the Republican River Basin Nebraska, Kansas, and Colorado" is being written and figures and tables are being prepared.

The 1997 water-table elevation map has been refined and was used to generate refined maps of aquifer saturated thickness and depth to water. These figures are in the

process of being finalized for publication in the modeling report and will be released as digital data sets when the reports are published.

A report entitled "Description of hydrogeologic system and simulation of ground-water flow and ground-water/surface-water interaction in part of the Republican River Basin Nebraska, Kansas, and Colorado" is being written and figures and tables are being prepared.

In the next quarter, additional model simulations will be conducted to improve the calibration of the predevelopment ground-water model. After completing this calibration, the development period model will be calibrated to changes in ground-water level and base flow during 1950-97. The calibrated simulation results will be analyzed to evaluate the effects of ground-water pumping on ground-water flow and base flow, and the sensitivity of model results to model parameters. The effects of selected hypothetical future scenarios on ground-water flow and base flow will be simulated using the calibrated model. Writing of the reports documenting the methods and results of the study will continue.

The study is behind schedule due to difficulty with model calibration and the technical complexity of the effort. It is expected that drafts of reports will be ready for review in June or July. With an expedited review schedule, it is expected that reports should be approved for publication by USGS in August and printed copies available by September.

Ground-Water/Surface-Water Interaction

The component of the study involving field investigations of ground-water/surface-water interactions has been completed. The results of the study were published in USGS Water-Resources Investigations Report 99-4200, "Interaction of streams and ground water in selected tributaries of the Republican River, Nebraska, 1998-99," by Gregory V. Steele.

Ground-Water Quality

The component of the study involving investigations of areal ground-water quality in the Nebraska part of the Republican River Basin has been completed. The results of the study were published in USGS Water Resources Investigations Report 00-4056, "Distribution of nitrate in ground water in the Republican River Basin, Southwest Nebraska, 1996-98" by Jennifer S. Stanton.

For additional information, please contact Matt Landon (Hydrologist), Bob Joseph (Hydrologic Investigations Chief), or Mike Slifer (District Chief) at the USGS Lincoln, Nebraska office (Tele: 402-437-5082).

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
May 1998

Model Preparation

Data from many sources continue to be inventoried, evaluated, and assembled into digital spatial (GIS) data coverages. A digital map of the elevation of the base of the aquifer for the entire study area was completed (see attached).

Digital maps of the hydraulic conductivity (K) and specific yield (S_y) of the High Plains aquifer compiled by the USGS-Oklahoma District from maps generated by the USGS Regional Aquifer-System Analysis of the High Plains aquifer in the 1980's are being reviewed by USGS-Nebraska District personnel. After review, the digital coverages will be clipped to the boundaries of the study area and used for model input.

A digital coverage of major streams, canals, and reservoirs, and gaging stations was completed (see attached). Work is proceeding on coverages of river elevation and land surface elevation from Digital Elevation Models (DEMs). Historical ground-water-level data in Kansas and Colorado were retrieved from the USGS database and checked for anomalies. Water-table maps of the study area for different time periods are being generated.

Historical streamflow data for about 70 sites in the study area have been retrieved from databases and are being analyzed to determine baseflow (streamflow derived from ground-water discharge) using a computerized baseflow separation method. Historical low-flow seepage data have been compiled and are being evaluated to estimate ground-water/surface-water exchanges and gaining and losing river reaches. Preliminary compilation of surface-water diversion and reservoir storage data has begun. Preliminary review of estimation methods and compilation of data to determine evapotranspiration (ET), recharge, and pumping has begun.

In the next quarter, GIS coverages of most of the data needed for steady-state simulations of the pre-development period will be completed and loaded into the model. Aquifer stresses (ET, recharge, interaction with surface water (SW)) for the pre-development period will be estimated. Preliminary steady-state model simulations will begin. Estimation of aquifer stresses (pumping, ET, recharge, interaction with SW) for the transient model of the development period (1950-97) will proceed.

Ground-Water/Surface-Water Interaction

Drilling and well installation at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects was completed. At each site, two transects of wells were installed, with each transect consisting of 3 well nests with each nest containing 3 wells at differing depths. At each site, pressure transducers with built-in data loggers for automatically recording water levels were installed in the shallowest 3 wells of one transect and in the stream. Water levels are being measured monthly in all observation wells. All wells and stream monitoring sites were surveyed so that accurate water-level elevations can be compared between wells and streams. Water samples were collected

from the tributary streams and one transect (9 wells) at each site in April. The water samples were analyzed for pH, specific conductance, dissolved oxygen, temperature, and nitrate-nitrogen concentrations. Samples to be analyzed for oxygen- and hydrogen-isotopes were collected for Ed Harvey, Conservation and Survey Division. Thirty samples also were collected for tritium analyses. Ed Harvey arranged to have the tritium samples analyzed at the University of Waterloo. The tritium and other sampling results from April will be used to plan collection of samples for ground-water age dating using chlorofluorocarbons (CFC's) in July.

Ground-Water Quality

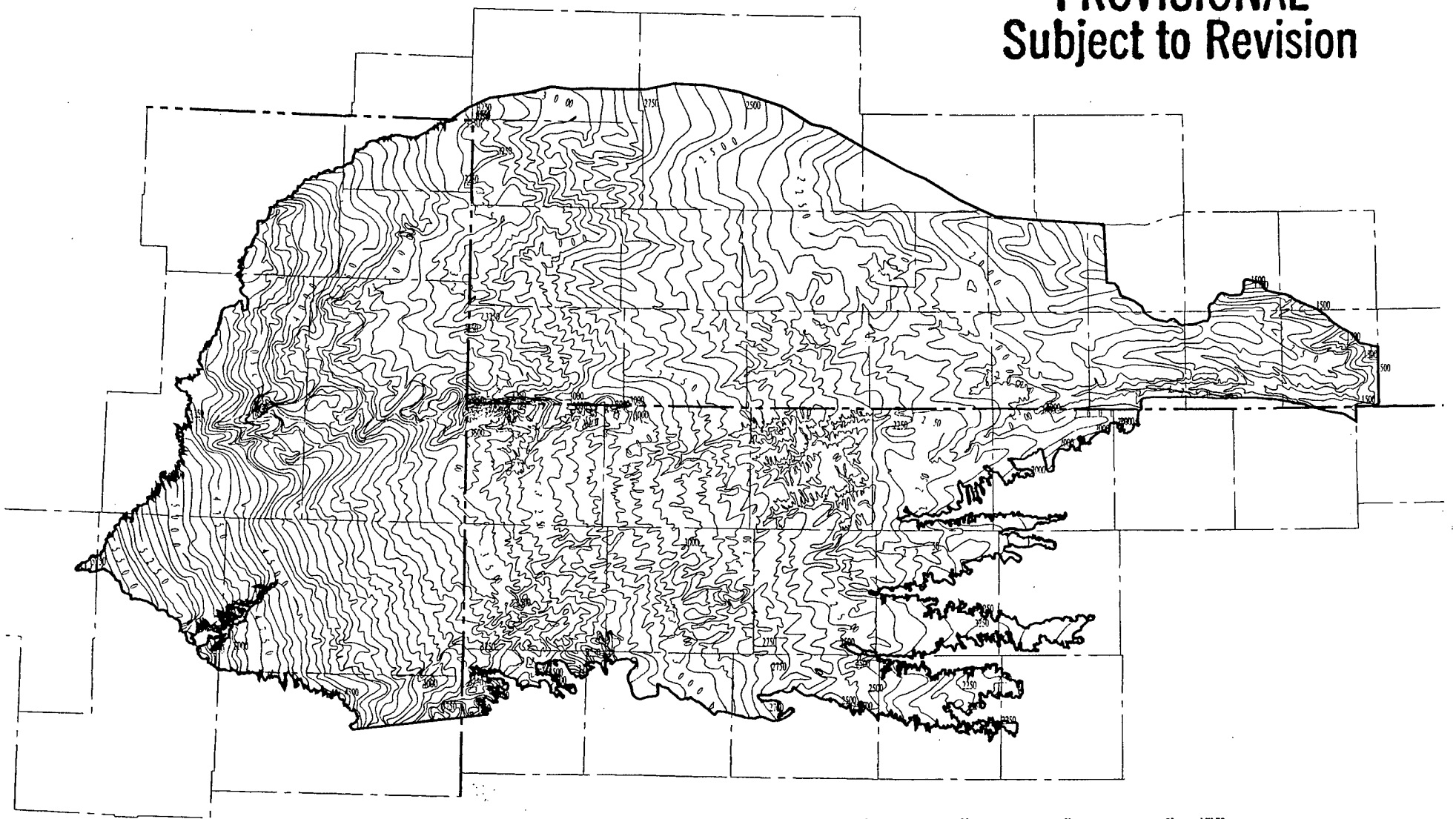
Preparations are continuing for collection of 214 ground-water samples in the Nebraska part of the Republican River basin for this study this summer. Target wells for sampling were selected using a stratified random approach based on areal distribution. Letters with enclosed response forms were sent to well owners requesting permission to sample. Sampling is scheduled to occur beginning in June; the exact timing of sample collection is dependent on the start of irrigation season. The sampling is being coordinated with collection of about 400 samples in the Upper Republican NRD this summer.

General

Discussions were held with Kansas regarding the possibility of having Kansas be a cooperator in the study. Matt Landon (project chief) and Mike Slifer (USGS Nebraska District Chief) made a presentation on the study at a meeting on April 23 in Santa Fe, New Mexico, between federal agencies (Justice Department, Bureau of Reclamation, Corps of Engineers, USGS) and representatives of the Kansas Water Office and Kansas Attorney General's Office. Kansas officials said that they would have further internal discussions to consider their involvement in the study.

A liaison meeting will be held on June 8 to coordinate Republican Basin activities in Nebraska among investigators from the USGS, CSD, and NDWR.

PROVISIONAL
Subject to Revision



Preliminary Map of Elevation of Base of
High Plains Aquifer
5.19.98
Republican River Basin Ground-water Model
U.S. Geological Survey
Lincoln, Ne

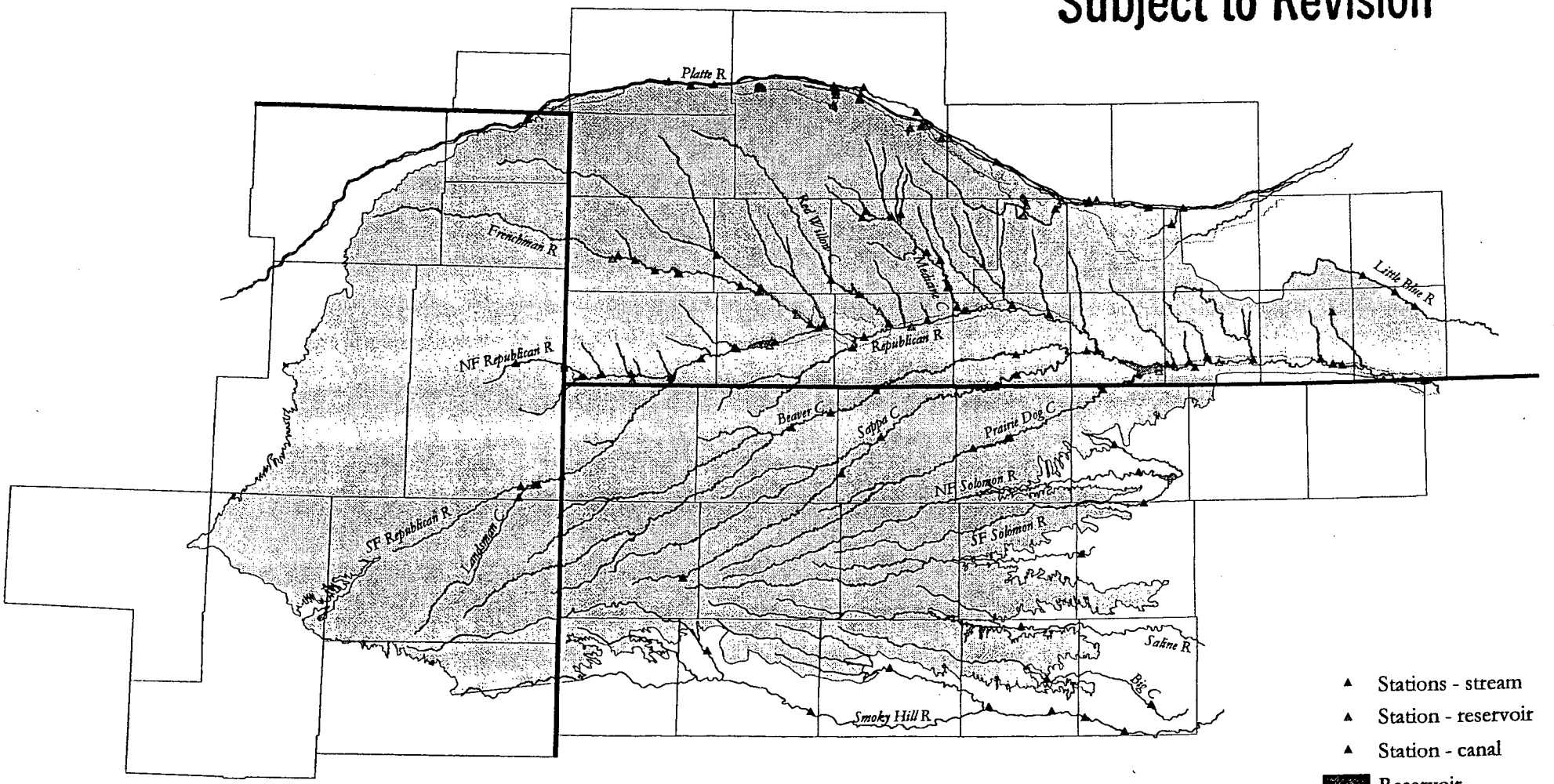
0 25 50 75 MILES

0 25 50 75 KILOMETERS

Study Area

Post-Development

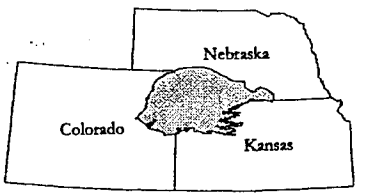
PROVISIONAL
Subject to Revision



- Stations - stream
- Station - reservoir
- Station - canal
- Reservoir
- Canal
- Hydrology
- County
- State Boundary
- Study Border

Preliminary Basemap 5/12/98
Republic River Basin Ground-Water Model
U.S. Geological Survey
Lincoln, NE

0 50 100 Miles
0 50 100 Kilometers



REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
June 1, 2000

Modeling

Simulations of long-term average conditions prior to extensive development of ground-water irrigation are proceeding and adjustments to the ground-water flow model are being made to calibrate the model to predevelopment ground-water levels and base flows (streamflow derived from ground-water discharge to streams). The calibration process has thus far involved making some changes to values of aquifer hydraulic conductivity, streambed conductance, drain conductance, and aquifer bottom elevation in the model. A preliminary model for simulating the development period of 1950-97 has also been partially constructed and simulations of the development period will proceed once estimation of recharge and pumping for the development period has been completed. Plans for scenarios to simulate in the future projections were refined.

A soil-water balance model called the Deep Percolation and Irrigation Requirement Model (DPIRM) is being used to estimate ground-water recharge, irrigation requirement (to estimate ground-water pumping), and ground-water evapotranspiration (ET) losses to riparian trees. Simulations for the development period of 1950-97 are proceeding. The simulated pumping values are being compared to metered pumping data compiled from various sources. The ground-water recharge, pumping, and ET values estimated for unique combinations of soils, climate, and land use using the DPIRM are being loaded into a Geographic Information System (GIS) database to assign recharge and pumping values to areas on maps. Construction of the GIS database for the development period of 1950-97 has been completed. Composite land use coverages for each county for every fifth year between 1950 and 1995 have been constructed using existing land use and surface-water irrigation coverages, state well registrations, county land use data, and distributions of sprinkler and gravity irrigation systems extrapolated from times when the numbers or distribution of these systems were known.

Writing of the final interpretative report is proceeding. Portions of the background and methods sections of the report have been written and figures and tables are being prepared.

Work to identify changes in riparian tree area from aerial photos at 16 locations in the study area for three time periods between the late 1930s and the mid 1990s is progressing. The aerial photos have been scanned and are being registered and digitized to determine riparian tree area during each time period. The effort will be used to estimate how much ground-water use by riparian trees has changed during the study period in response to changes in riparian tree area.

In the next quarter, calibration of the steady-state predevelopment ground-water flow model will be completed. Estimation of ground-water pumping, recharge, and ET for the development period will be completed. The transient ground-water flow model of the 1950-97-development period will then be calibrated. The effects of selected hypothetical future scenarios on ground-water flow and streamflow will be simulated using the model. Writing of the final report documenting the methods and results of the modeling study will continue. The first draft of the report should be completed late summer to early fall and the final reports published in the winter of 2000/2001.

Ground-Water/Surface-Water Interaction

The component of the study involving field investigations of ground-water/surface-water interactions has been completed. The following report summarizing the results of the study was published in January: USGS Water-Resources Investigations Report 99-4200, "Interaction of streams and ground water in selected tributaries of the Republican River, Nebraska, 1998-99," by Gregory V. Steele.

Ground-Water Quality

For the areal ground-water quality component of the project, the report "Distribution of nitrate in ground water in the Republican River Basin, Southwest Nebraska, 1996-98" by Jennifer S. Stanton has been approved for publication by USGS and is currently being printed. The report should be released within 1 to 2 months.

RCP Ann

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Room 406 Federal Building
100 Centennial Mall North
Lincoln, Nebraska 68508
(402) 437-5082

May 4, 2000

To: Nebraska Republican Basin Management Districts Meeting Participants

From: Matthew K. Landon, Hydrologist, U.S. Geological Survey (USGS), Lincoln, Nebraska

Subject: Seeking input on possible scenarios for simulations of future conditions

In cooperation with the Nebraska Republican River Basin Management Districts, the USGS is constructing a ground-water flow model to simulate ground-water flow and ground-water/surface-water interaction in the Republican River Basin. A component of this project is to use the ground-water flow model to simulate the effects of possible future scenarios on ground-water flow and ground-water/surface-water interaction. These simulations of future conditions inherently require that assumptions be made regarding future climate and water use. These simulations are sometimes referred to as predictive simulations. However, because we cannot know exactly how key variables like the climate or irrigation will change in the future, these simulations are not really designed to predict what ground-water levels and streamflows will be at specific times in the future. Rather, these simulations of possible future scenarios are most useful for comparison to other scenarios and to understand the effects of certain management policies relative to other policies.

We need to get input from the members and participants in the Nebraska Republican River Basin Management Districts regarding what future simulation scenarios would be of greatest use for future planning and management purposes. As we had discussed at the last meeting in Cambridge on February 29, at the next meeting we would like to discuss future scenarios that you would find most useful. Because these future simulations need to be run this summer, it is my hope that we can finalize a priority list of three or four future scenarios at the meeting on June 1. While there may be a large number of future simulations that would potentially be of interest, all these simulations require time and money to setup the simulations, run them, and interpret and write-up the results. Therefore, practical limitations of project resources require that the number of future scenarios be restricted to no more than three or four scenarios.

Based upon some preliminary discussions with managers and others, I have compiled a preliminary list of possible future simulation scenarios below for your consideration

(over)

Possible Priority Scenarios for simulating hydrologic effects of water management scenarios during 2000-2040:

I. **Continued irrigation well development at 1990s rates in the future up to an upper limit defined by irrigable land, continuation of present allocation policies (limits in some areas, no limits in others), and average 1950-97 climate.** This scenario represents a continuation of present conditions into the future and could serve as the standard to which other scenarios will be compared.

II. **Irrigation well development frozen at late 1990s levels, continuation of present allocation policies (limits in some areas, no limits in others), and average 1950-97 climate.** An alternative scenario compared to scenario I.

III. **Irrigation well development frozen at late 1990s levels, allocation limits in those areas that do not currently have allocations, and average 1950-97 climate.** An alternative scenario compared to Scenario I.

Other scenarios to consider could include simulations of the effects of: droughts more severe than observed in the last 50 years such as a 1930s drought, continued implementation of conservation practices that decrease runoff and increase soil-water storage and ground-water recharge, continued increases in irrigation efficiency, and increased utilization of the Tri-County ground-water mound to increase flow in the Platte River.

It would be very helpful to the study if we could discuss these or alternative scenarios at the meeting on June 1. For those who cannot attend the meeting on June 1, please notify me regarding your thoughts on the issue. Thank you very much for your consideration of these issues. I look forward to continuing to work with you on this project.

Sincerely,

Matthew K. Landon

Matthew K. Landon

May 8, 2000

MEMO

To: Member Districts and other interested parties

From: Virgil Norton

Re: Agenda for the next Nebraska Republican Basin Water Management Districts meeting and minutes of the February 29, 2000 meeting.

Enclosed is the Agenda for the next meeting of the NRBWMD, which will be held June 1, 2000, at the Cambridge Community Hall at 10:30 a.m. CST.

Also enclosed are the minutes of the February 29, 2000 meeting.

If you have questions regarding the minutes or would like to add items to the agenda, please contact Dave Eigenberg (308-928 2182) or Roy Patterson (800-841 0419).

Included with this mailing is a letter from Matt Landon with a request for input on determining alternatives to be evaluated with the model that is being developed by USGS.

Thank you.

****

Please note that the agenda for the next meeting is copied on the back of this memo.

****

NE Republican Basin Management Districts
June 1, 2000 10:30 a.m. CDT
Cambridge Community Hall
MEETING AGENDA

1. Call meeting to order

2. Roll call of member districts

3. Approve minutes of February 29, 2000 meeting

4. Review agenda

5. Republican Basin hydrology research
   USGS study up-date & discussion of alternative hypothetical situations to be used in model simulations - Matt Landon

6. Republican River Compact
   Status of litigation with Kansas - Dave Cookson
   Surface Water metering - Russell Oakland

7. Irrigation district re-contracting negotiations

8. Proposed NE Republican River Management Districts Association

9. District reports

10. Other business

11. Date, location and topics for next meeting

Nebraska Republican Basin Management Districts

VISION STATEMENT

To enhance the management of groundwater and surface water for the benefit of the citizens of the Republican River Basin and for future generations.

MISSION STATEMENT

The mission of the Nebraska Republican Basin Water Management Districts is to educate and inform the people of the Republican River Basin on water issues and to act as a general coordination group for LB 108, Republican River Compact issues, and related matters.

MEMBER DISTRICTS

Nebraska Bostwick ID
Mike Delka, Manager
POB 446
Red Cloud NE 68970
(402) 746-3424

Frenchman-Cambridge ID
Roy Patterson, Manager
(NRBMD co-chair)
POB 116
Cambridge NE 69022
(308) 697-4535

Frenchman Valley/Hitchcock-Red Willow IDs
Norma Sitzman, Manager
POB 297
Culbertson NE 69024
(308) 278-2125

Lower Republican NRD
Dave Eigenberg, Manager
(NRBMD co-chair)
POB 618
Alma NE 68920
(308) 928-2182

Middle Republican NRD
Dan Smith, Manager
(NRBMD Secretary)
POB 81
Curtis NE 69025
(308) 367-4281

Tri-Basin NRD
John Thorburn, Manager
1308 2nd St.
Holdrege NE 68949
(308) 995-6688

Upper Republican NRD
Virgil Norton, Manager
POB 1140
Imperial NE 69033
(308) 882-5173

NEBRASKA REPUBLICAN BASIN MANAGEMENT DISTRICTS
Minutes of Regular Meeting - - February 29, 2000
Cambridge Community Hall, Cambridge, NE

The regular meeting of the Nebraska Republican Basin Water Management Districts was called to order by co-chair John Thorburn at 10:35 a.m. CST. Norton called the roll. All eight Basin water management districts were present. A copy of the attendance sheet showing names of individuals who signed is attached to these minutes.

Minutes of the November 5, 1999 regular meeting were mailed February 18, 2000.

Roy Patterson moved to approve the November 5, 1999 minutes; seconded by Dave Eigenberg. The motion carried.

Thorburn reviewed the agenda and asked for additions or deletions. "District reports" was added between Items #8 and #9.

Item #5 - Republican Basin hydrology research

Matt Landon, Greg Steele and Jennifer Stanton, USGS, Lincoln, provided up-dates on the Basin study being conducted by USGS. Components of the study include: construction of a deep percolation and irrigation requirement model (DPIRM); development of a model through which groundwater/surface water interactions can be investigated; and groundwater quality sampling. Information on changes in land use during the past several decades is also being collected. A copy of the progress report on the overall study is attached to these minutes.

Landon discussed the DPIRM modeling component. He indicated that he expects the final report on the DPIRM model to be completed by the end of 2000. Landon suggested that at the next meeting of the Coalition it would be useful to discuss alternatives that USGS should consider for simulations through the DPIRM model. He will distribute a letter prior to the next meeting with specifics about the request for alternatives.

Steele distributed and discussed a published report on the groundwater/surface water interaction component. The report, "Interaction of Streams and Ground Water in Selected Tributaries of the Republican River, Nebraska, 1998-99", is designated as U.S. Geological Survey Water-Resources Investigations Report 99-4200. It can be ordered from: U.S. Geological Survey, 406 Federal Building, 100 Centennial Mall North, Lincoln, NE 68508.

Stanton presented preliminary data from the groundwater quality component of the study. She indicated that 283 wells were sampled throughout the Basin. The objectives of the sampling activity are to determine nitrate levels in the groundwater, and to examine the relationship between nitrate levels and hydro-geologic characteristics of the areas sampled. A fact sheet prepared by Stanton has been reviewed by USGS personnel and should be published by about June 1, 2000.

The meeting was recessed at 11:50 a.m. for lunch, and reconvened at 12:55 p.m.

Item #6 - Republican River Compact

6.A - Status of litigation with Kansas

Dave Cookson, Assistant Attorney General, summarized the history of the Republican River Compact; issues involved in the KS v NE & CO litigation before the U.S. Supreme Court; and the status of the case.

6.B - LB 1161 (flowmeter cost-share) up-date

There was a discussion of LB 1161, which proposes to provide cost share funds for meters or other measuring devices for holders of individual surface water rights whose water use is not recorded by the irrigation districts. Russell Oakland, NDWR, indicated that approximately 400 surface water rights are included under LB 1161. Cost share funds will be provided by the state, through the Basin NRDs.

Thorburn -- All alluvial wells in the Tri-Basin NRD are metered.

Smith -- The MRNRD has 1100 alluvial wells that must be metered. So far, 380 are metered, about 120 are in a wavered status, 250 are signed up for metering, and the remaining have been notified that meters must be installed during the next year. The MRNRD is now also moving into the upland well metering phase. A number of meters have been installed on upland wells through a District local cost-share program.

Eigenberg -- The LRNRD is on a three-year schedule for installation of meters on alluvial wells (sections 1-12 last year, sections 13-24 this year, & sections 25-36 by the program deadline next year). Response and cooperation from farmers has been good. The LRNRD is working with the NDWR to clear up well registration data.

Norton -- No requests for cost share have been received in the URNRD. Some irrigators will take advantage of the availability of cost share funds for replacement meters. Also, some irrigators who had the option under the URNRD program of using alternative measuring methods have indicated interest in installing meters. It is likely that 30 to 50 meters may be installed under the program during the next year.

Item #7 - Update on BuRec contract negotiations & BuRec draft EIS for alternative contract agreements

Sitzman - FV and H & RW IDs-- Progress is still being made on the contract negotiations. They have been working on lake-levels, which is a complex issue. A technical meeting was held February 23rd. The term of the new contracts will be 25 to 40 years.

Patterson - FCID-- Much progress has been made. He reiterated the complexity of the lake-level issue. The BuRec is now talking about signing the contracts by July.

Delka - NBID -- While there are still issues to be settled, there is a potential for getting contracts signed this summer.

Item #8- Water banking, leasing proposals

Thorburn provided an up-date on the status of legislation, indicating that all banking and leasing legislation has been put aside for this session.

Item Unnumbered - Reports from member districts and cooperating agencies

Norton -- The URNRD held a special meeting last week and voted unanimously to have the Chair of the Board testify in favor of LB 1041, which proposed to extend the fertilizer fee. Groundwater level measurements will start in the next few days.

Smith -- The MRNRD is working with the FV and H&RW irrigation districts to provide both local and state cost share funds for surge valves for surface irrigators. The MRNRD has cost-shared on the purchase of six surge valves. They will be doing the same with the FC irrigation district. Groundwater level measurements will start soon.

Eigenberg -- The LRNRD is in the process of analyzing the water use data from the meters that were installed for the 1999 irrigation season. The NRD is working with the irrigators to use the data for enhanced farm management. The district expects to have a district-wide groundwater management plan in effect later this spring.

Thorburn -- The Tri-Basin NRD has a district-wide water quality program and recently added another township to the Phase II component of their water quality program.

Sitzman -- The FV/H & RW IDs are assisting irrigators in burying pipe. If the irrigator buys the pipe, the districts will bury the pipe. The good winter weather helped to get caught up on ditch repair and maintenance.

Patterson -- The FCID has also had a good winter in terms of outside work.

Delka -- The NBID has been involved in maintenance. The District will be cooperating with the LRNRD to participate in the BuRec surge valve program. The Bureau may allow use of the valves beyond the boundaries of the irrigation district. NRCS will provide technical assistance. Delka thanked the LRNRD for agreeing to read the observation wells for the NB District.

Power Districts -- Claude Capple and Clayton Lukow, in behalf of the Mid West Electric Co-op, McCook PPD, South Central PPD, Southern Nebraska RPPD, Southwest PPD, and Twin Valleys PPD, presented and discussed a memo to the water districts outlining concerns of the Republican Basin PPDs relative to the Kansas lawsuit. The memo emphasizes the willingness and desire of the PPDs to work cooperatively with the water management districts on this issue. A copy of that memo is attached to these minutes. Dick Neil and Jack Maddux commented on the importance of everyone in the Basin working together.

Item #9 - Election of Officers

Norton nominated Dave Eigenberg and Roy Patterson as Co-Chairs; and Dan Smith as Secretary. Seconded by Delka. There were no other nominations. The above individuals were elected by voice vote.

Item #10 - Other Business

Ron Daniel requested that Thorburn remain as the Coalition contact for administration of the Environmental Trust grant. The group agreed his request.

Item #11 - The next meeting was scheduled for June 1, 2000, at 10:30 a.m., at the Cambridge Community Hall.

The meeting was adjourned at 2:10 p.m.

2-29-00

NRBMD

Name	Organization	
John Hogburn	Tri Basin NRD	Holdrege
Regina Hoffman	Frenchman Valley NRD	Culbertson
Virgil Norton	Upper Republican NRD	Imperial, NE
MATT LANDIN	U.S. GEOLOGICAL SURVEY	LINCOLN
Jennifer Stanton	USGS	Lincoln
Greg Steele	USGS	Lincoln
Mike Dekka	Bostwick Irr. Distr.	in Nebr.
Ray D. Wenz	Tri Basin	Holdrege
Wayne Madsen	Middle Rep. NRD	Trenton
Duane Easton	Middle Rep. NRD	Maywood
Kevin Fornoff	Middle Rep. NRD SWPD	Hayes Center
Tony Anderson	UNL Cooperative Extension (Harlan County)	Alma
Dan Smith	Middle Republican NRD	
KELLY WERTZ	MRNRD	
Bob Merrigan	MKNRD	
Roger Kolbet	H.R.W IRR	Culbertson
Kenneth Albert	Frenchman valley Irr. Dist.	Culbertson
RICH HOLLOWAY	TRI-BASIN NRD	HOLDREGE
Rhys Johnson	TRI-BASIN NRD.	
Bryan Lubeck	Lower Republican NRD	Alma
DAVE EISENBERG	LOWER REPUBLICAN NRD	ALMA
Kerry Woollen	LR NRD	Alma
	Jim Stroch KRVN	Lexington
	S.C.P.P.D.	Nelson
MAX VAN SKIVER	Sand Canyon PPD	
Bill Umberger		Elwood
JACK MADDUX	WAUNETA	

NAME	ORGANIZATION
Joyce Newport	Cambridge Claim
Dixie Jensen	Kearney Hub
Diana J. Lamberson	Hastings Tribune
Russell Oakland	DWR, Cambridge
David Cookson	NE Atty General's Ofc.
Clayton Luhr	Southern Power Dist.
Erick Keel	Notre Dame Bureau
Gail McNeil	Twin Valleys PPD
Paul J. Liess	" "
Ron Darvel	Southwest NE R C&D
Ray Balderson	S.W. Neb. R.C.+D
CLAUDE CAPPEL	McCOOK PUBLIC POWER DIST.
Don Suda	Southwest PPD
Jim Phinney	McCook Public Power Dist.
ANGUS GAREY	McCook Nat'l Bank
Kevin Nienhueser	McCook National Bank
Robert F. Rose	Culbertson Village Board member
Roy Jackson	C. Cambridge

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
February 29, 2000

Modeling

Assembly and estimation of input and calibration data for the ground-water flow model is nearly complete and ground-water model simulations are proceeding. Modification of the Deep Percolation and Irrigation Requirement Model (DPIRM), a soil-water balance model that is being used to estimate irrigation requirement and ground-water recharge, was completed. The DPIRM was modified to change how soil evaporation and plant transpiration are calculated. New crop coefficients more suitable for the High Plains region were inserted into DPIRM. The relationships between soil water content and the ratio of actual to potential soil evaporation also were modified based upon literature review. Testing of the revised code was completed. Simulations to estimate ground-water recharge during the period prior to extensive development of ground-water supplies for irrigation (referred to as "predevelopment") have been completed. Simulations to estimate ground-water recharge and irrigation requirement (to estimate ground-water pumping) for the development period of 1950-97 are proceeding. Data on pumping for domestic, municipal, industrial, and livestock purposes was compiled from historical water use reports and these quantities were estimated for the development period.

The ground-water recharge and pumping values estimated for unique combinations of soils, climate, and land use using the DPIRM are being loaded into a Geographic Information System (GIS) database to assign recharge and pumping values to areas on maps. The GIS database has been constructed for the predevelopment period and is nearly complete for the development period of 1950-97. Composite land use coverages for each county for every fifth year between 1950 and 1997 are being constructed using existing land use and surface-water irrigation coverages, state well registrations, county land use data, and distributions of sprinkler and gravity irrigation systems extrapolated from times when the numbers or distribution of these systems were known.

An extensive literature review on tree water use and ground-water losses to evapotranspiration (ET) was done to validate the approach being used to estimate ground-water ET losses to riparian trees in this study. A composite riparian tree coverage of the study area for use in estimating ground-water ET loss in the model was completed. The DPIRM is being used to estimate potential tree water consumption and actual tree water use from soil water. The maximum riparian tree water consumption rate from ground water is being estimated as the difference between the potential and actual soil water use rate for trees. Simulations of tree water use for the pre-development period have been completed and are being loaded into the ground-water model. Simulations of tree water use during the development period are proceeding. Work to identify changes in riparian tree area from aerial photos at 16 locations in the study area for three time periods between the late 1930s and the mid 1990s is progressing. Many of the aerial photos have been scanned and the electronic photos are being analyzed to determine riparian tree area during each time period. The effort will be used to estimate how much ground-water use by riparian trees has changed during the study period in response to changes in riparian tree area.

Geologic maps were digitized and the boundaries of the Ogallala formation and paleo-alluvial deposits (older alluvial deposits in buried alluvial valleys outside of modern alluvial valleys) were added to electronic maps of modern alluvial deposits to form a composite geologic map of the study area. These geologic boundaries were used with maps and other sources of information on aquifer hydraulic conductivity and storativity to create initial aquifer property zones in the ground-water flow model.

The steady-state (long-term average) ground-water flow model of the predevelopment period, with a one-mile grid and 30,224 active model cells, was updated with revised input and calibration data. Simulations of long-term average conditions prior to extensive development of ground-water irrigation are proceeding and adjustments to the model are being made to calibrate the model to predevelopment ground-water levels and base flows.

A report is being prepared that documents the results of base-flow separations and statistical tests to identify historical trends and significance of changes in streamflow, base flow, runoff, and precipitation in the Republican River Basin. Work on this report was made a lower priority to focus on progress on the soil-water balance and ground-water modeling. It is expected that the base-flow report will be published slightly before or concurrently with the final modeling report in the winter of 2000/2001. Results of historical streamflow gain/loss measurements, including data collected by this study in October 1998, are being reviewed and reinterpreted to identify regional patterns of ground-water/surface-water interaction and better understand factors causing these patterns.

In the next quarter, estimation of ground-water pumping, recharge, and ET for the development period will be completed. Calculations of ground-water recharge from canal leakage will be completed. Calibration of the steady-state predevelopment ground-water flow model will be completed. The transient ground-water flow model of the 1950-97-development period will be constructed and calibration will begin. Detailed plans of the scenarios to simulate in the future projections will be developed and discussed with the cooperators. The DPMIRM will be modified as necessary to simulate these future scenarios and recharge and pumping arrays for the future projection simulations will be developed. Writing of the final report documenting the methods and results of the modeling study will continue. The first draft of the report should be completed next summer and published by the end of 2000.

Ground-Water/Surface-Water (GW/SW) Interaction

The component of the study involving field investigations of ground-water/surface-water interactions has been completed. The following report summarizing the results of the study was published in January: USGS Water-Resources Investigations Report 99-4200, "Interaction of streams and ground water in selected tributaries of the Republican River, Nebraska, 1998-99," by G.V. Steele.

Ground-Water Quality

For the areal ground-water quality component of the project, the fact sheet written by Jennifer Stanton has been through USGS colleague review and has been submitted for regional approval. The fact sheet should be published in the next 3 months.

TO: The Nebraska Republican Basin Management Districts

FROM: Mid West Electric Co-op
McCook PPD
South Central PPD
Southern Nebraska RPPD
Southwest PPD
Twin Valleys PPD

The report to the U. S. Supreme Court by the Special Master, Vincent L. McKusick, on Nebraska's motion to dismiss Kansas' action against Nebraska is indeed sobering. Kansas has alleged that the use of groundwater wells pumping in the Republican River Basin has deprived Kansas of its full amount of water allocated to it by the Republican River Compact. The Compact, approved by the Federal Government on March 26, 1943, allocated the waters of the Republican River Basin by a formula agreed to by Colorado, Nebraska, and Kansas.

Nebraska argued that groundwater pumped was not addressed in the Compact. Mr. McKusick framed the issue very succinctly in his denial of Nebraska's motion to dismiss. On page 18 of his report he stated, "Thus the issue is more narrowly stated: Does the Compact restrict groundwater pumping that depletes the stream flow in the Republican River Basin?" He referred to Article II of the Compact that "virgin water supply" as "the water supply within the Basin undepleted by the activities of man." He continued on page 20: "Based on the plain language defining these terms, I find that the Compact unambiguously governs the entire natural stream flow of the Basin, which includes all groundwater that would be part of the stream flow in the Basin except for depletion by activities of man such as pumping." Mr. McKusick continues on Page 20 of his report, "To be noted first is the unqualified inclusiveness of the language defining what the Compact regulates: the 'water supply within the Basin,' not some of it, but all of it. And the water supply that is regulated is the 'virgin' supply; that is, the full quantity of water in its natural state, 'undepleted by the activities of man."

Mr. McKusick's report is written in a very clear manner that permits no misinterpretation. For the purpose of this communication it should be noted that the Supreme Court rarely finds contrary to a Water Master's recommendations.

We who represent the six rural public power districts in the Republican Basin are alarmed about the seriousness of this report and we are persuaded that all economic interests in the Basin are threatened. We have an unquestioned interest in the outcome of this issue. We cannot, nor shall we, ignore the serious financial stress of our customers if irrigated agriculture, as we know it, is seriously disrupted.

We believe that everyone in the Basin must subvert very narrow parochial interests as we consider how to best address this threat. At a meeting of the Nebraska Republican Basin Management Districts held on June 7, 1999, all six of the power districts in the Basin were represented. At that meeting as at others at an earlier time, the representation of the districts has consistently stated that we were stakeholders in the Basin, that we did have considerable political and financial muscle, and yet we were in attendance only to ask the question, "How can we help?"

We were convinced then, as we are now, that the Attorney Generals of both States and to a great degree an irrigation organization, Nebraskans First, has rendered a disservice to the citizens in the Basin. On several occasions at public forums, the people were told that Kansas had no case that Nebraska would prevail and the irrigators in the Basin could continue with business as usual. We believe that this was an example of irresponsible leadership. Based on these comments, the groundwater irrigators through their NRD's were very resistant to change any irrigation practices that might have allowed Nebraska to present a stronger case to the Water Master.

We are appalled the political agenda would sacrifice the economic vitality of the Republican River Basin farmers of both States. Nebraska has repeatedly asked of Kansas, "How have you been harmed? What is your proposal for redressing the injury that you claim?" We ask that you present to Nebraska how you believe this controversy can be resolved. To date Nebraska has had no response and we ask why?

We are aware of the brief filed by the Attorney General of Nebraska in support of Nebraska's motion to dismiss. We think the arguments were sound, the issues raised were relevant and we wonder why the special water master seemed to ignore those arguments.

There are several serious issues that have not been addressed by the special water master. How does Kansas justify "a beneficial consumptive use" of water that they send on to the Gulf of Mexico? When Kansas has received its full allocation in all except one year, how do they calculate damage? What science in being used to prove conclusively that all or most of the groundwater pumpers in the basin has harmed Kansas? Finally, we ask, "Why can't people of good will and reason resolve this issue?" This issue will absorb so much time and treasure from the citizens of each State.

Those of you who attended the June 7th meeting in Cambridge will recall the very candid discussion among the participants on what the role should be for the power districts, if any. There was concern expressed by some that they were fearful of active involvement by the power districts. The fear expressed was that the power districts would inject themselves in the management of water resources and there was a not too subtle inference that because power district revenue was dependent on the sale of kilowatts, the power districts would encourage irresponsible pumping excesses. It was suggested that we would have no concern about water conservation and would, in fact, exacerbate the existing water resource deficiencies in the Republican Basin. The power districts representatives categorically rejected those views on June 7, 1999. We categorically reject them today. Our only interest is to assist the residents in the Basin in any manner possible. We have no hidden agenda. We do believe that the economic vitality of the entire Republican River Basin is being confronted with a potentially catastrophic change in its irrigated agriculture.

Only a unified effort from all the stakeholders in the Basin will have a chance for a successful solution. The six power districts that serve the Basin ask again today, "How can we help?" We are determined to protect the interest of all our customers in the Basin. The four irrigation districts and the four NRD's in the Basin must provide the leadership in the search for a solution. We know we need your guidance. We think you will have a desperate need for what help we can provide. We close this communication with this

comment. Please remember that the quarrel is not with each other, nor is it with many of the farmers and ranchers in Kansas. Our quarrel is with the Kansas Attorney General and with the Administrator of Water Resources in Kansas.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
January 2000

Modeling

Input and calibration data for the ground-water flow model are continuing to be assembled or estimated and loaded into the model. Modification of the Deep Percolation Model (DPM), a soil-water balance model that is being used to estimate irrigation requirement and ground-water recharge, was completed. The DPM was modified to change how soil evaporation and plant transpiration are calculated. New crop coefficients more suitable for the High Plains region were inserted into DPM. The relationships between soil water content and the ratio of actual to potential soil evaporation also were modified based upon literature review. The testing and debugging of the revised code has been completed. Simulations to estimate ground-water recharge during the predevelopment period are currently being run. Data on pumping for domestic, municipal, industrial, and livestock purposes was compiled from historical water use reports.

The ground-water recharge and pumping values estimated for unique combinations of soils, climate, and land use using the DPM are being loaded into a Geographic Information System (GIS) database to assign recharge and pumping values to areas on maps. The GIS database has been constructed for the predevelopment period and is continuing to be constructed for the development period of 1950-97. The procedures have been developed for the Nebraska part of the study area and work is continuing on developing the composite land use coverages to spatially distribute recharge and pumping values in Kansas. Slightly different procedures have to be used in the different states because of differences in available information on the location and type of water use. Composite land use coverages for each county for every fifth year between 1950 and 1997 are being constructed using existing land use and surface-water irrigation coverages, state well registrations, county land use data, and distributions of sprinkler and gravity irrigation systems extrapolated from times when the numbers or distribution of these systems were known. A preliminary draft of the procedures used in estimating and distributing recharge and pumping was completed. A shortened version of this text will be included in the final modeling report. The first draft of the report should be completed next summer and published by the end of 2000.

Writing of a report documenting the results of the base-flow separations and statistical tests to identify historical monotonic trends and significance of changes in streamflow, base flow, runoff, and precipitation in the Republican River Basin continued. Work on this report was made a lower priority in order to focus on progress on the soil-water balance and ground-water modeling. It is expected that the base flow report will be published slightly before or concurrently with the final modeling report in late 2000.

An extensive literature review on tree water use and ground-water losses to evapotranspiration was done to validate the approach being used to estimate ground-water ET losses to trees in this study. A composite riparian tree coverage of the study area for use in estimating ground-water ET loss in the model is complete. Geologic maps were digitized so that boundaries of the Ogallala formation and paleo-alluvial deposits

can be added to electronic maps of modern alluvial deposits. These geologic boundaries are being used with maps of aquifer hydraulic conductivity and storativity to create hydraulic property zones in the ground-water flow model. The steady-state ground-water flow model of the predevelopment period was updated. The project review team met on November 9-10 in Lincoln.

In the next quarter, data compilation and estimation of ground-water pumping, recharge, and ground-water ET will be completed. The DPM will be used to estimate areal recharge and ground-water pumping for irrigation. Calculations of ground-water recharge from canal leakage will be completed and included in the recharge maps generated. Estimates of pumping for domestic, municipal, industrial, and livestock purposes will be completed and included in the ground-water pumping maps generated. Electronic maps of recharge and pumping will be generated and loaded into the ground-water flow model (MODFLOW). Once estimates of pre-development long-term average recharge are completed, the steady-state predevelopment ground-water flow model will be calibrated. The transient MODFLOW model of the 1950-97 development period will be constructed and calibration will begin. Detailed plans of the scenarios to simulate in the future projections will be developed and discussed with the cooperators. The DPM will be modified as necessary to simulate these future scenarios and recharge and pumping arrays for the future projection simulations will be developed.

Ground-Water/Surface-Water (GW/SW) Interaction

For the GW/SW interaction component of the project, the fact sheet written by Greg Steele is in the process of being printed and should be released in late January.

Ground-Water Quality

For the areal water-quality component of the project, the fact sheet written by Jennifer Stanton has been through USGS colleague review is currently being revised and prepared for submission for regional approval. The fact sheet should be published in the next 3 months.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
November 1999

Modeling

Input and calibration data for the ground-water flow model are continuing to be assembled or estimated. The major focus of activity has been estimation of recharge and ground-water pumping, which are being estimated using a soil-water balance model called the Deep Percolation Model (DPM). The DPM was modified so that irrigation requirement and efficiency are calculated, and the algorithms for simulating runoff, interception, and soil evaporation were revised to adapt the model for use in the High Plains. The revised model was tested and debugged. Trial simulations to test the model under a wide variety of conditions are nearly complete. Irrigation and runoff data used for calibrating the DPM simulations were assembled. Data on seasonal irrigation applications were assembled from a variety of sources, organized into electronic files, and analyzed to determine average seasonal irrigation rates by year, county, soil, and irrigation type. Data also were compiled on irrigation efficiency, irrigation runoff proportion, soil-water content at which irrigation water is applied, and daily irrigation application rate for sprinkler and gravity irrigation systems. Annual values for the percent of precipitation that becomes runoff were calculated for all gaging stations at which base-flow separations have been done and will be used in calibrating the DPM. Soils data from the USDA-NRCS STATSGO database were analyzed and soils having similar properties were combined in order to reduce the number of soil units in the study area which need to be simulated. Precipitation, temperature, and solar radiation data were analyzed and prepared for loading into DPM. A method of estimating solar radiation based upon the difference between maximum and minimum daily temperature was identified, tested, and used to estimate daily solar radiation during 1950-81, prior to the existence of solar radiation measurement stations in the study area.

A trial Geographic Information System (GIS) database was constructed for Dundy County and used to successfully test and modify the procedures for spatially distributing recharge and pumping estimated using DPM. Soils, climatic, and land use information are overlain in the database and used to delineate areas having unique combinations of these variables. The GIS database is being constructed for other counties in the study area following the same procedures. Composite land use coverages for each county for each year (1950-97) of the simulation period are being constructed using existing land use and surface-water irrigation coverages, state well registrations, county land use data, and distributions of sprinkler and gravity irrigation systems extrapolated from times when the numbers or distribution of these systems were known. Mass balance calculations were made for major canals and reservoirs in the Republican surface-watershed to estimate water leakage (recharge) from canals and reservoirs. Sections of the final report are being written. The first draft of the report should be completed next summer and published by the end of 2000.

Analyses to separate base flow and runoff components of streamflow were completed for about 60 stations. Procedures were developed and followed for selecting optimal input parameters to the base-flow separation program for each station. Statistical

tests were run for identifying trends and significance of changes in streamflow, base flow, runoff, and precipitation. A report documenting the results of these analyses is being written and a draft should be complete by the end of 1999.

Literature was reviewed concerning ground-water losses to evapotranspiration (ET) and preparations were made for analysis of aerial photographs of 16 areas in the Republican River Basin for the late 1930's, 1970's, and mid-1990's to determine changes in riparian tree area. It was more difficult than originally expected to locate and obtain all of the aerial photographs required, especially the photographs from the 1930's. Nearly all of these photographs have been obtained. Preparations were made for constructing a composite riparian tree coverage of the study area for use in estimating ground-water ET loss in the model.

In the next quarter, data compilation and estimation of ground-water pumping, recharge, and ground-water ET will continue. The DPM will be used to estimate areal recharge and ground-water pumping for irrigation and the results will be spatially distributed using GIS. Calculations of ground-water recharge from canal and reservoir leakage will be completed for irrigation projects on the south side of the Platte. Pumping for domestic, municipal, industrial, and livestock purposes will be estimated from historical water use reports. Recharge and pumping estimates will be loaded into the ground-water flow model. Interpretation of base-flow separation analyses and statistical testing for trends in streamflow, runoff, base flow, and precipitation will be completed and a report documenting the results will be completed. A composite riparian tree coverage of the study area for use in estimating ground-water ET loss will be completed. Once estimates of pre-development long-term average recharge are completed, the ground-water flow model for the pre-development period will be calibrated. The ground-water flow model of the development period (1950-97) will be constructed and simulations will begin.

Ground-Water/Surface-Water (GW/SW) Interaction

For the GW/SW interaction component of the project, the fact sheet written by Greg Steele went through USGS review and was approved. The fact sheet is being prepared for printing and should be published by the end of 1999.

Ground-Water Quality

For the areal water-quality component of the project, the fact sheet written by Jennifer Stanton has been through USGS colleague review and is currently being revised and prepared for submission for regional approval. The fact sheet should be published by January.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
February 29, 2000

Modeling

Assembly and estimation of input and calibration data for the ground-water flow model is nearly complete and ground-water model simulations are proceeding. Modification of the Deep Percolation and Irrigation Requirement Model (DPIRM), a soil-water balance model that is being used to estimate irrigation requirement and ground-water recharge, was completed. The DPIRM was modified to change how soil evaporation and plant transpiration are calculated. New crop coefficients more suitable for the High Plains region were inserted into DPIRM. The relationships between soil water content and the ratio of actual to potential soil evaporation also were modified based upon literature review. Testing of the revised code was completed. Simulations to estimate ground-water recharge during the period prior to extensive development of ground-water supplies for irrigation (referred to as "predevelopment") have been completed. Simulations to estimate ground-water recharge and irrigation requirement (to estimate ground-water pumping) for the development period of 1950-97 are proceeding. Data on pumping for domestic, municipal, industrial, and livestock purposes was compiled from historical water use reports and these quantities were estimated for the development period.

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An extensive literature review on tree water use and ground-water losses to evapotranspiration (ET) was done to validate the approach being used to estimate ground-water ET losses to riparian trees in this study. A composite riparian tree coverage of the study area for use in estimating ground-water ET loss in the model was completed. The DPIRM is being used to estimate potential tree water consumption and actual tree water use from soil water. The maximum riparian tree water consumption rate from ground water is being estimated as the difference between the potential and actual soil water use rate for trees. Simulations of tree water use for the pre-development period have been completed and are being loaded into the ground-water model. Simulations of tree water use during the development period are proceeding. Work to identify changes in riparian tree area from aerial photos at 16 locations in the study area for three time periods between the late 1930s and the mid 1990s is progressing. Many of the aerial photos have been scanned and the electronic photos are being analyzed to determine riparian tree area during each time period. The effort will be used to estimate how much ground-water use by riparian trees has changed during the study period in response to changes in riparian tree area.

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The steady-state (long-term average) ground-water flow model of the predevelopment period, with a one-mile grid and 30,224 active model cells, was updated with revised input and calibration data. Simulations of long-term average conditions prior to extensive development of ground-water irrigation are proceeding and adjustments to the model are being made to calibrate the model to predevelopment ground-water levels and base flows.

A report is being prepared that documents the results of base-flow separations and statistical tests to identify historical trends and significance of changes in streamflow, base flow, runoff, and precipitation in the Republican River Basin. Work on this report was made a lower priority to focus on progress on the soil-water balance and ground-water modeling. It is expected that the base-flow report will be published slightly before or concurrently with the final modeling report in the winter of 2000/2001. Results of historical streamflow gain/loss measurements, including data collected by this study in October 1998, are being reviewed and reinterpreted to identify regional patterns of ground-water/surface-water interaction and better understand factors causing these patterns.

In the next quarter, estimation of ground-water pumping, recharge, and ET for the development period will be completed. Calculations of ground-water recharge from canal leakage will be completed. Calibration of the steady-state predevelopment ground-water flow model will be completed. The transient ground-water flow model of the 1950-97-development period will be constructed and calibration will begin. Detailed plans of the scenarios to simulate in the future projections will be developed and discussed with the cooperators. The DPMIRM will be modified as necessary to simulate these future scenarios and recharge and pumping arrays for the future projection simulations will be developed. Writing of the final report documenting the methods and results of the modeling study will continue. The first draft of the report should be completed next summer and published by the end of 2000.

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WATER-LEVEL CHANGES, 1980 TO 1997, AND SATURATED THICKNESS, 1996–97, IN THE HIGH PLAINS AQUIFER

The High Plains aquifer underlies one of the major agricultural regions in the world, including parts of eight States—Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. In the area underlain by the High Plains aquifer (called the High Plains region in this report), the total number of acres irrigated with ground water expanded rapidly after 1940: 1949—2.1 million acres; 1959—6.1 million acres; 1969—9.0 million acres; and 1980—13.7 million acres (Gutentag and others, 1984; Thelin and Heimes, 1987). In 1990, about 95 percent of the water withdrawn from the High Plains aquifer (about 15.7 million acre-feet) was used for irrigation (Marilee Horn, U.S. Geological Survey, written commun., 1996).

Water-level declines began to occur in the High Plains aquifer soon after extensive ground-water irrigation development began. By 1980, water levels in the High Plains aquifer in parts of Texas, New Mexico, and southwestern Kansas had declined more than 100 feet (Luckey and others, 1981). In response to these declines, the U.S. Geological Survey, in cooperation with numerous Federal, State, and local water-resource agencies, began a ground-water monitoring program in 1988 to assess annual water-level change in the aquifer using water-level measurements from more than 7,000 wells. The purpose of this report is to present (1) water-level changes in the High Plains aquifer from 1980 to 1997 and from 1996 to 1997, (2) the precipitation pattern in the High Plains region during 1996, and (3) estimated saturated thickness of the High Plains aquifer in 1996–97. The water-level measurements used in this report were collected in winter or early spring when irrigation wells were not pumping. Map scale and density of water-level elevation data preclude showing small areas in the maps of water-level change and saturated thickness where the value may be more or less than indicated.

Water-Level Changes, 1980 to 1997

The water-level changes in the High Plains aquifer result from an imbalance between discharge, the largest component of which is ground-water withdrawals for irrigation, and recharge, which is primarily from precipitation. This imbalance began with large-scale development of the aquifer for irrigation. Ground-water withdrawals for irrigation in a given year can be affected by climatic conditions, particularly precipitation, which can cause large variations in the amount of irrigation water needed to satisfy the water requirements for crops.

Water levels declined 2.7 feet from 1980 to 1997

The pattern of water-level changes in the High Plains aquifer from 1980 to 1997 (fig. 1) is based on water-level measurements from 5,233 wells (table 1). A large area in the northern part of the southern High Plains in New Mexico and Texas with greater than 100 feet of water-level declines from predevelopment to 1980 (Luckey and others, 1981) has continued to decline, but at slower rates. The average area-weighted rate of decline in this area from predevelopment to 1980 was 3.7 feet per year; the rate of decline in this area from 1980 to 1997 was 1.6 feet per year. Areas with substantial water-level declines from predevelopment to 1980 in the southern part of the southern High Plains in Texas and in the southeastern part of the northern High Plains in Nebraska (Luckey and others, 1981) had considerably slower rates of decline, or rising water levels, from 1980 to 1997.

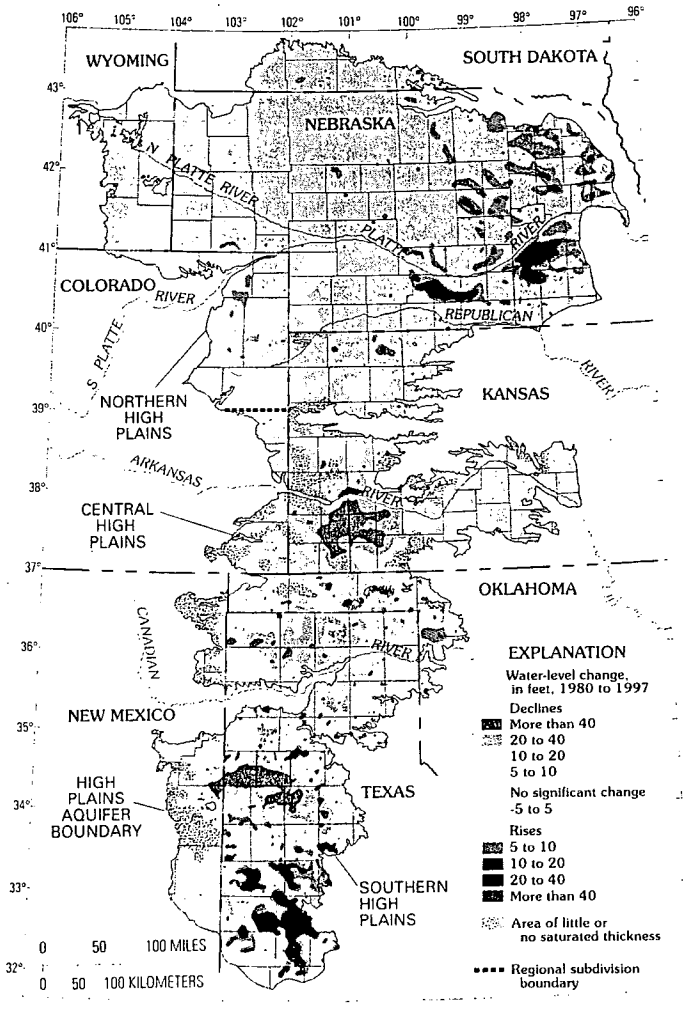

Figure 1. Water-level changes in the High Plains aquifer, 1980 to 1997.

U.S. Department of the Interior
U.S. Geological Survey

USGS Fact Sheet 124–99
December 1999

Table 1. Number of High Plains aquifer wells measured for 1996 and 1997 and used for the water-level comparison periods—1980 to 1997 and 1996 to 1997

State	Wells measured for:		Wells used for water-level comparison periods	
	1996	1997	1980 to 1997	1996 to 1997
Colorado	604	604	502	579
Kansas	1,174	1,298	755	889
Nebraska	3,490	3,617	1,937	3,401
New Mexico	751	547	168	104
Oklahoma	298	268	171	256
South Dakota	114	105	70	100
Texas	2,903	2,581	1,617	2,364
Wyoming	83	63	13	62
High Plains	**9,417**	**9,083**	**5,233**	**7,755**

Ninety-nine percent of all water-level changes from 1980 to 1997 are within a rise of 32 feet and a decline of 60 feet. The average area-weighted water level in the High Plains aquifer declined 2.7 feet from 1980 to 1997 compared to a decline of 9.9 feet from predevelopment to 1980 (table 2). Assuming 1950 as the beginning of irrigation development in the High Plains region, the rate of water-level decline decreased from 0.33 foot per year (1950 to 1980) to 0.16 foot per year (1980 to 1997).

Factors that contributed to the smaller rate of water-level decline from 1980 to 1997 as compared to predevelopment to 1980 are: (1) a decrease in ground-water withdrawals from the High Plains aquifer for irrigation, and (2) greater than normal precipitation from 1980 to 1996. Ground-water withdrawals for irrigation were 18.0 million acre-feet in 1980 and 15.7 million acre-feet in 1990 (Thelin and Heimes, 1987; Marilee Horn, U.S. Geological Survey, written commun., 1996). Precipitation from 1981 to 1996 in the High Plains region averaged 21.2 inches per year, 1.4 inches per year more than normal (table 3).

Factors that may have caused a decrease in ground-water withdrawals, in addition to increased precipitation, include: (1) a decrease in irrigated acreage in areas with water-level declines and in areas with large potential rates of aquifer depletion; (2) use of more efficient irrigation technology, such as low-pressure nozzles and drop tubes on center pivots; (3) improved farm-management practices, including irrigation scheduling, reuse of irrigation return flow, the conversion to alternative crops or crop varieties with smaller consumptive irrigation requirements, and methods to retain soil moisture; (4) local regulation of ground-water withdrawals for irrigation and development of irrigated land; and (5) economic considerations, including declining or stable commodity prices, increased production costs (including energy and fertilizer costs), and various agricultural programs of the Federal government that encourage the transfer of marginal land out of irrigated production.

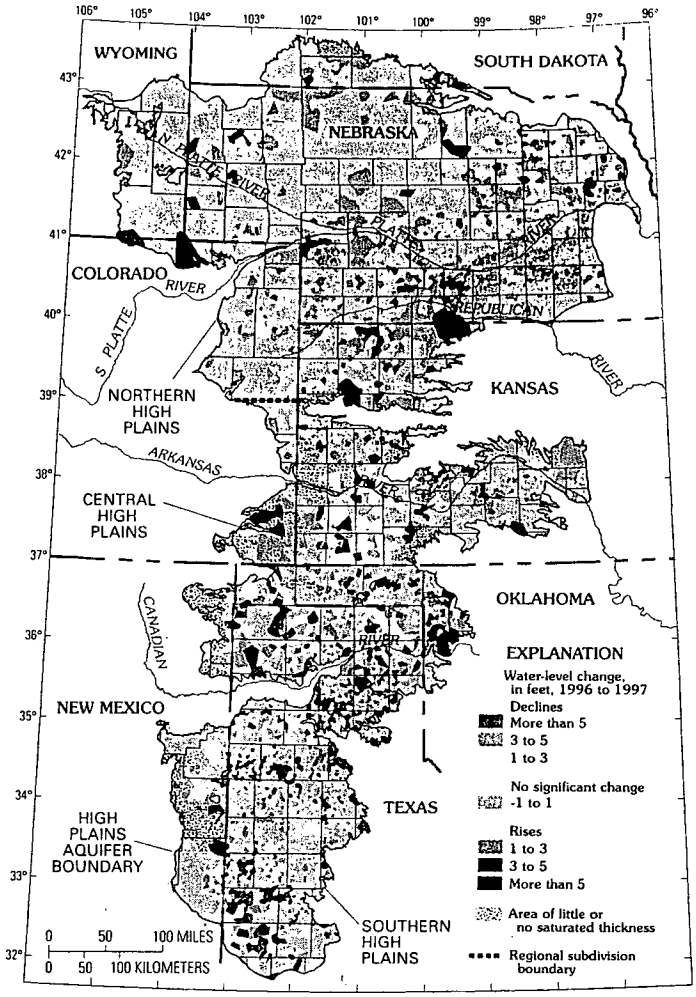

Figure 2. *Generalized water-level changes in the High Plains aquifer, 1996 to 1997.*

Table 2. Characteristics of the High Plains aquifer in 1980 and water-level changes in the High Plains aquifer, predevelopment to 1980, 1980 to 1997, and 1996 to 1997

[ft, foot; ft/yr, foot per year]

State	Percentage of total aquifer area[1]	Percentage of total volume of drainable water in storage in 1980[2]	Average area-weighted water-level change				
			Predevelopment (1950 to 1980)		1980 to 1997		1996 to 1997
			Water-level change[3] (ft)	Rate of change (ft/yr)	Water-level change (ft)	Rate of change (ft/yr)	Water-level change (ft)
Colorado	8.2	3.7	−4.2	−0.14	−5.9	−0.35	+0.15
Kansas	16.2	9.9	−9.9	−0.33	−8.0	−0.47	+0.23
Nebraska	38.6	65.5	0	0	+2.3	+0.13	+0.58
New Mexico	3.6	1.5	−9.8	−0.33	−4.0	−0.23	−0.65
Oklahoma	4.2	3.4	−11.3	−0.38	−2.7	−0.16	+0.70
South Dakota	2.9	1.8	0	0	+3.1	+0.18	+0.82
Texas	21.5	12.0	−33.7	−1.12	−7.4	−0.43	−0.98
Wyoming	4.8	2.2	0	0	−1.5	−0.09	−0.24
High Plains	**100**	**100**	**−9.9**	**−0.33**	**−2.7**	**−0.16**	**+0.08**

[1]Does not include areas of little or no saturated thickness.
[2]Modified from Gutentag and others (1984).
[3]Luckey and others (1981).

Table 3. Average area-weighted precipitation and comparison to 30-year normal precipitation (1961–90) in the High Plains region, 1981 to 1996, and 1996

[Data from National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina; data values are in inches per year]

State	1981 to 1996		1996	
	Average precipitation	Departure from 30-year normal	Average precipitation	Departure from 30-year normal
Colorado	17.5	+1.3	19.0	+2.8
Kansas	22.6	+1.3	26.7	+5.4
Nebraska	23.3	+1.5	24.1	+2.3
New Mexico	17.6	+1.3	15.4	−1.0
Oklahoma	21.3	+1.3	25.3	+5.3
South Dakota	20.3	+2.0	22.4	+4.0
Texas	20.1	+1.2	18.6	−0.3
Wyoming	15.6	+1.1	13.6	−0.9
High Plains	**21.2**	**+1.4**	**22.0**	**+2.2**

Water-Level Changes, 1996 to 1997, and Precipitation, 1996

Ninety-nine percent of all water-level changes from 1996 to 1997 (fig. 2) are within a rise of 11.1 feet and a decline of 11.1 feet. The average area-weighted water level in the High Plains aquifer rose 0.08 foot from 1996 to 1997 (table 2) based on measurements from 7,755 wells (table 1). The average area-weighted water-level change in the High Plains aquifer from 1996 to 1997 by State ranged from a rise of 0.82 foot in South Dakota to a decline of 0.98 foot in Texas (table 2).

Water levels rose 0.08 foot from 1996 to 1997

The average area-weighted precipitation during 1996 in the High Plains region was 22.0 inches, or 2.2 inches greater than the 30-year normal (table 3). The precipitation pattern ranged from more than 10 inches greater than normal to more than 5 inches less than normal (fig. 3).

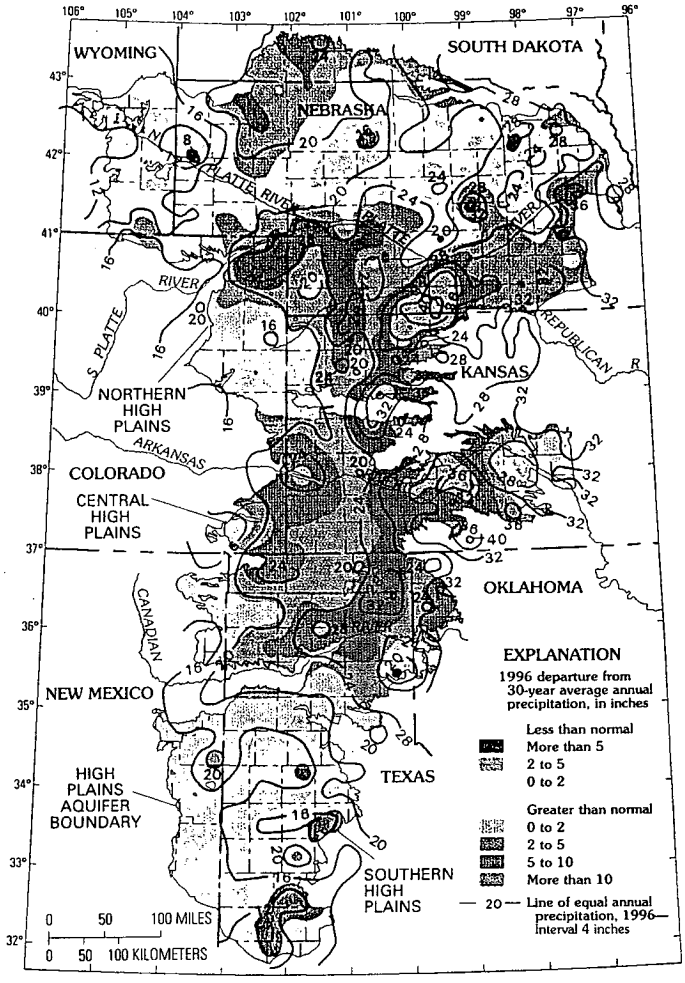

Figure 3. *Annual precipitation, 1996, and departure from 30-year normal precipitation (1961–90) (precipitation data from the National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, North Carolina).*

Saturated Thickness, 1996–97

A saturated-thickness map of the High Plains aquifer (fig. 4) was prepared by superimposing a 1996–97 water-table map over a map of the elevation of the base of the aquifer and contouring the elevation difference. The 1996–97 water-table map was based on 10,085 measurements—49 stream elevations (March 1997) and 10,036 water-level elevations in wells (1,370 from 1996 and 8,666 from 1997). A water level was used only if the land-surface elevation of the well had been determined; a 1996 water level was used only if the 1997 water level was not available for a given well. Within aquifer areas where there were no 1996 or 1997 measurements, such as in the northern High Plains in northeastern Wyoming, parts of western Nebraska, and north of the South Platte River in northeastern Colorado, the 1980 saturated-thickness contours were used (Weeks and Gutentag, 1981). Around the boundary of the aquifer, the contours were approximated.

Saturated thickness in 1996–97 ranged from generally 0 at the boundary of the aquifer to more than 1,000 feet in west-central Nebraska. The percentage of the area of the High Plains aquifer within each saturated thickness interval in 1980 (Gutentag and others, 1984) and in 1996–97 is summarized by State in table 4. The tabulated results show that the area of the High Plains aquifer with less than 100 feet of saturated thickness increased from 46 percent in 1980 to 49 percent in 1996–97.

Table 4. Saturated-thickness distribution in the High Plains aquifer, 1980 and 1996–97

[ft, feet; <, less than]

State	Area of High Plains aquifer within State[1] (square miles)	Year[2]	Percentage of area within each saturated thickness interval						
			0 to 100 ft		100 to 200 ft	200 to 400 ft	400 to 600 ft	600 to 800 ft	800 to 1,200 ft
			0 to 50 ft	50 to 100 ft					
Colorado	14,900	1980	76		18	6	--	--	--
		1996–97	58	23	15	4	--	--	--
Kansas	30,500	1980	66		21	12	1	--	--
		1996–97	51	19	18	11	1	--	--
Nebraska	63,650	1980	14		21	29	22	10	4
		1996–97	9	8	20	28	22	9	4
New Mexico	9,450	1980	85		15	--	--	--	--
		1996–97	72	17	11	--	--	--	--
Oklahoma	7,350	1980	58		25	11	6	--	--
		1996–97	35	21	28	12	4	--	--
South Dakota	4,750	1980	44		13	25	18	--	--
		1996–97	26	12	15	32	15	--	--
Texas	35,450	1980	61		25	14	--	--	--
		1996–97	33	32	<23	12	<1	--	--
Wyoming	8,000	1980	46		26	18	4	4	2
		1996–97	41	7	28	16	<5	<4	<1
High Plains	**174,050**	**1980**	**46**		**22**	**18**	**9**	**4**	**1**
		1996–97	**32**	**17**	**20**	**17**	**9**	**4**	**1**

[1]Luckey and others (1981), includes areas of little or no saturated thickness.

[2]All 1980 values are from Gutentag and others (1984).

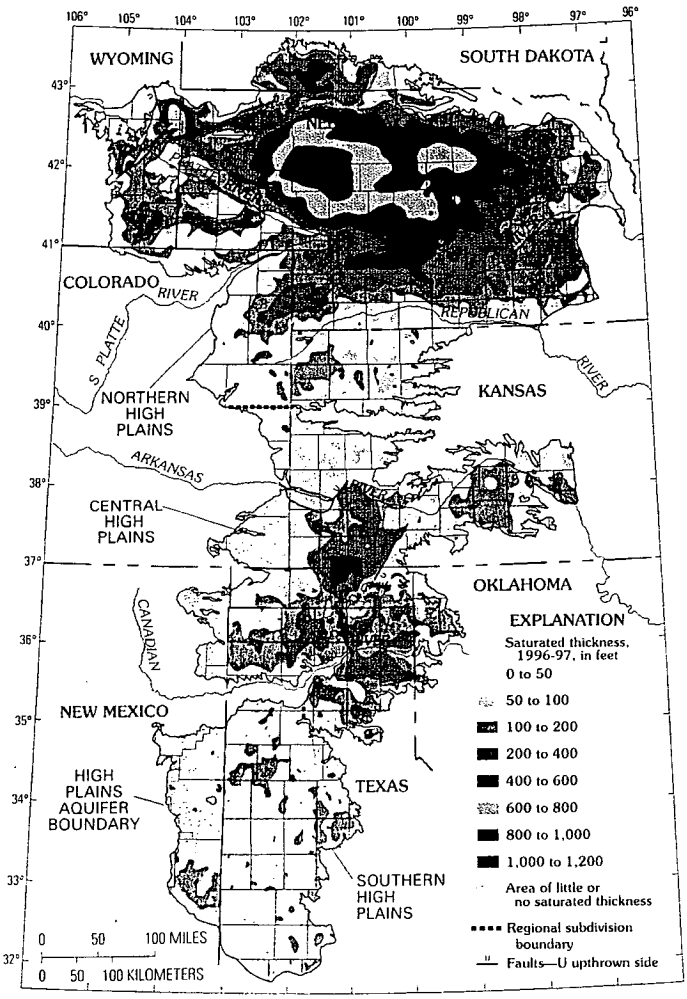

Figure 4. Saturated thickness of the High Plains aquifer, 1996–97 (modified from Weeks and Gutentag, 1981).

References

Gutentag, E.D., Heimes, F.J., Krothe, N.C., Luckey, R.R., and Weeks, J.B., 1984, Geohydrology of the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400–B, 63 p.

Luckey, R.R., Gutentag, E.D., and Weeks, J.B., 1981, Water-level and saturated-thickness changes, predevelopment to 1980, in the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA–652, 2 sheets, scale 1:2,500,000.

National Oceanic and Atmospheric Administration, 1951–96, Climatological data set TD–3220: Asheville, N.C., National Climatic Center.

Thelin, G.P., and Heimes, F.J., 1987, Mapping irrigated cropland from Landsat data for determination of water use from the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Professional Paper 1400–C, 38 p.

Weeks, J.B., and Gutentag, E.D., 1981, Bedrock geology, altitude of base, and 1980 saturated thickness of the High Plains aquifer in parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA–648, 2 sheets, scale 1:2,500,000.

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REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
June 1999

Modeling

Input and calibration data for the ground-water flow model are continuing to be assembled or estimated. The major focus of activity in the last two months has been estimation of recharge and ground-water pumping. A daily soil-water balance model called the Deep Percolation Model (DPM), which calculates the amount of deep percolation out of the bottom of the soil profile, is being modified to also estimate irrigation requirement. Most of the climatic, soils, and land use input data for the model have been assembled and are being analyzed. Electronic maps of climate, soils, and land use data were overlain and used to plan the DPM simulations. Historical land use data by county from the National Agricultural Statistics Service (NASS) are being analyzed to identify changes in crops during 1950-97. Data from the Census of Agriculture are being used to fill in gaps in the NASS data. Metered pumping data from Kansas for 1990-97 and the Upper Republican NRD for 1980-97 are being analyzed and will be compared to irrigation requirements estimated using the DPM for different crops, soils, and types of irrigation application. Historical data on surface-water diversions, farm deliveries, number and location of irrigated acres, and canal losses were organized into a database and used to calculate average annual rates of irrigation application for Republican River surface-water irrigation projects. Refinement of the ground-water flow model continued. The grid size of the model was modified to 1-mile square grid cells. Literature review concerning ground-water losses to evapotranspiration and preparations for analysis of aerial photographs to determine changes in riparian tree area continued.

In the next quarter, simulations using the DPM will begin and be used to estimate recharge and ground-water pumping. Ground-water recharge from canal and reservoir leakage will be estimated. Analyses of streamflow records to refine the base-flow estimates and analyze historical trends in base flow and runoff will continue; preparation of a report concerning these analyses will begin. Analyses of aerial photographs of 16 areas will begin and will be used to determine the change in land area covered by riparian trees in the last 50 years. The goal is to complete generation of input data sets for the ground-water model by about October. Refinement of the ground-water flow model and preliminary simulations will continue.

Ground-Water/Surface-Water (GW/SW) Interaction

Monitoring of water levels at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects continued. Agreements were signed with the Upper, Middle, and Lower Republican NRD's to continue water-level monitoring along the transects through September.

Analysis and interpretation of the water-level and water-quality data collected through April was completed. A draft of a report was completed by Greg Steele and has been submitted for USGS technical and editorial review.

In the next quarter, GW/SW-level monitoring on the transects will continue. USGS review of the report will continue. The report will be published by Fall 1999.

Ground-Water Quality

Interpretation of the water-quality data and preparation of a report is continuing. A draft of the report will be completed by the end of June and submitted for USGS technical and editorial review. The report will be published by Fall 1999.

Republican River Basin Ground-Water Modeling, Ground-Water/Surface-Water Interaction, and Ground-Water Quality Study

U.S. Geological Survey, Lincoln, Nebraska

- **Timeline: April 1997 – March 2001**
- **Funding:**
  - ***Nebraska Republican River Basin Management Districts (Environmental Trust Fund)*** ***$ 790,000***
  - ***U.S. Geological Survey*** ***$ 246,000***
  - ***Total:*** ***$1,036,000***
- **Study Components**
  - ***Ground-water (GW) flow model of the entire Republican River basin upstream of the Hardy, NE streamflow station***
  - ***Ground-water / surface-water (GW/SW) interaction along selected major tributaries of the Republican River***
  - ***GW quality in the Nebraska portion of the Republican River basin***

GW Modeling

- **Objectives**
  - ***Quantify GW/SW interaction throughout the Republican River basin upstream of the Hardy, NE streamflow station***
  - ***Evaluate the effects of various GW pumpage scenarios on future streamflow***
- **Approach**
  - ***Compiling & evaluating data from many sources***
  - ***Constructing digital spatial data coverages (GIS) that will be used to generate model input***
    - Aquifer geometry
    - Aquifer properties
    - Aquifer stresses (pumping, evapotranspiration, interaction with SW, recharge)
  - ***Model will simulate water flow in the High-Plains aquifer (Ogallala + alluvium) and GW/SW exchange***
  - ***Model will be adjusted to match measured water levels & GW/SW exchanges (Calibration):***
    - Pre-development (pre-1950)
    - Changes during development (1950-97)
  - ***Calibrated model will be used to simulate the effects of hypothetical pumping scenarios on streamflow***
- **Benefits**
  - ***Will provide a GW model capable of simulating the effects of GW pumpage on streamflow, enabling better management of limited GW and SW resources by the basin's water managers***

- **Products (GW Modeling)**
  - *Interpretative technical report describing model development and results of simulations (published fall 2000)*
  - *Fact sheet summarizing modeling results in layman's terms (published fall 2000)*
  - *Interactive Web site that will describe study progress and will serve as a repository for the data assembled*

GW/SW Interaction

- **Objective**
  - *Evaluate GW/SW interaction at three sites on selected principal tributaries of the Republican River*
- **Approach**
  - *Install arrays of nested wells at each site: Sappa Cr. Nr Stamford, Frenchman Cr. Nr Palisade, Frenchman Cr. Nr Champion*
  - *Water levels in wells & streams will be used to determine water movement between GW & SW and GW flow directions*
  - *Water-quality & GW age distribution (using chlorofluorocarbons) will be used to better understand GW/SW interaction*
- **Benefit**
  - *Will provide an understanding of how the GW & SW systems interact along principal tributaries to the Republican River*
- **Product**
  - *Fact sheet describing GW/SW interaction at the investigated sites using the water-level & water-quality data (Summer 1999)*

GW Quality

- **Objectives**
  - *Determine the areal extent of nitrate concentrations in GW in the Nebraska portion of the Republican River basin*
  - *Determine the association of nitrate concentrations in GW with hydrogeological & land-use variables*
- **Approach**
  - *Collect water-quality samples from 300 wells during 1997-98*
  - *Compare GW nitrate concentrations with local hydrogeologic & land-use conditions*
- **Benefits**
  - *Provide GW quality data in an area of Nebraska in which little data has been available*
  - *Provide associations between GW nitrate concentrations & hydrogeologic & land-use factors to help water managers focus management plans on areas of greatest concern*
- **Product**
  - *Hydrologic atlas describing GW quality & associations with hydrogeologic & land-use characteristics (Fall 1999)*

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
March 1999

Modeling

Input and calibration data for the ground-water flow model are continuing to be assembled or estimated. Preliminary modeling of the pre-ground-water irrigation development period (pre-1950) was suspended until refined estimates of recharge are obtained. The major focus of activity in the last two months has been assembly of data and estimation of ground-water pumping, irrigation applications from surface-water sources, and recharge. Metered pumping data from Kansas and the Upper Republican NRD are being analyzed. Metered pumping data from other sources have been requested. Information on surface-water diversions, farm deliveries, number and location of irrigated acres, and canal and reservoir losses was requested from the Bureau of Reclamation, Irrigation Districts, and Nebraska Natural Resources Commission. The data received to date is being analyzed to estimate surface-water irrigation applications and ground-water recharge from canal and reservoir seepage. A daily soil-water balance model is being used to estimate areal recharge from precipitation and irrigation. Input data for the soil-water balance model (called Deep Percolation Model) is being assembled and includes daily climate station data, soil properties, and land use data. The soil-water-balance model is being modified to calculate the amount of irrigation water that would need to be applied to meet crop consumptive use requirements for those areas and periods for which metered pumping data are unavailable.

Analysis of the October 1998 and other historical streamflow gain/loss data sets was completed and ground-water/surface-water (GW/SW) exchanges were calculated and organized into digital maps. Analyses of streamflow records to separate base flow from runoff at about 50 gaging stations are continuing; additional analyses were done in the last quarter to refine the base-flow estimates and analyze historical trends in base flow and runoff to determine if they are statistically significant. Aerial photographs of 16 areas in the Republican River Basin for the late 1940's, late 1970's, and mid-1990's were ordered. The aerial photos will be analyzed to determine if the area covered by trees has changed in the last 50 years. The results will be used to evaluate whether the amount of ground water removed from the aquifer by evapotranspiration from riparian trees has increased in the last 50 years.

In the next quarter, data compilation and estimation of ground-water pumping, recharge, ground-water ET, and GW/SW exchange will continue with a goal of completing generation of these input data sets for incorporation into the model by the end of the summer.

Ground-Water/Surface-Water (GW/SW) Interaction

Monitoring of water levels at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects continued. Water samples were collected for the final time from transect wells in February and analyzed for field parameters and nitrate concentrations. Samples for oxygen- and hydrogen-isotopes were also collected for Ed

Harvey (UNL-Conservation and Survey Division). Analysis and interpretation of the water-level and water-quality data continued.

In the next quarter, GW/SW-level monitoring on the transects will continue through April. Interpretation of water-level and water-quality data and report writing will continue. A draft of the fact sheet reporting the results will be completed this spring and submitted for USGS technical and editorial review. The fact sheet will be published by next fall.

Ground-Water Quality

For the areal water-quality component of the project, all water-quality and supporting data has been entered into the USGS database and quality-assurance data analysis is nearly complete. The water-quality data has been sent to landowners. Interpretation of the water-quality data and preparation of the fact sheet reporting the results is continuing. A draft of the fact sheet reporting the results will be completed this spring and submitted for USGS technical and editorial review. The fact sheet will be published by next fall.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
January 1999

Modeling

Data from many sources continue to be inventoried, evaluated, and assembled into digital spatial (GIS) data coverages or files for use as input or calibration data for the ground-water model. Preliminary steady-state modeling of the pre-development (pre-1950) period began. Data on perennial stream reaches and how they have changed through time was compiled and plotted on maps and a GIS coverage of perennial streams was revised. The revised stream coverage and river elevations were loaded into the model. Digital land surface, 1997 water table elevation, and 1997 saturated thickness data were compared to published maps and refinements were made. Streamflow was measured at about 375 sites in the Nebraska part of the Republican River Basin during the week of October 26, 1998 to evaluate streamflow gain/loss under 1998 baseflow conditions. The October 1998 and other historical streamflow gain/loss data sets are being analyzed and GW/SW fluxes determined. Review of estimation methods, compilation of data on climate, land use, and soils, and preliminary work to calculate ground-water evapotranspiration (ET), recharge, and pumping continued. The first meeting of the technical review team for the modeling component of the study occurred on Nov. 10 in Lincoln. Technical issues and the report outline were discussed at the meeting. The report outline was revised.

In the next quarter, data compilation and construction of model input and calibration data will continue. Steady-state simulations of the pre-development (pre-1950) period will continue. Analysis of streamflow gain/loss data sets will be completed. Baseflow separations made at about 35 sites in the basin will be refined by adjusting the input parameters to the separation routine. Revision of the pre-development and 1997 water level and saturated thickness maps will be completed. Estimation of ground-water ET, recharge, and pumping for the pre-development and development periods will continue with a goal of completing generation of these input data sets by early summer.

Ground-Water/Surface-Water (GW/SW) Interaction

Monitoring of water levels at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects continued. Water samples were collected from transect wells in October and analyzed for field parameters and nitrate concentrations. Analysis and interpretation of the water-level and water-quality data continued. The tritium data collected in September was received.

In the next quarter, GW/SW-level monitoring on the transects will continue through April. Water samples will be collected from the transects in February and analyzed for field parameters and nitrate. Analysis and interpretation of water-level and water-quality data and report writing will continue. A draft of the fact sheet reporting the results will be completed this spring and submitted for USGS technical and editorial review. The fact sheet will be published by next fall.

Ground-Water Quality

For the areal water-quality component of the project, compilation and quality-assurance of well location, construction, and other supporting information was nearly completed and the water-quality and supporting data was entered into the USGS database. The water-quality data was sent to landowners. In the next quarter, analysis and interpretation of the water-quality data and report writing will proceed. A draft of the fact sheet reporting the results will be completed this spring and submitted for USGS technical and editorial review. The fact sheet will be published by next fall.

Outline for Presentation of Project Preliminary Results and Status to Nebraska Republican Basin Management Districts January 21, 1999

Study Overview

Modeling of Ground-Water Flow and Ground-Water/Surface-Water Interaction in Basin (Matt Landon)

- Overview of Basin Ground-Water System
- Historical Ground-Water Development
- Changes in Ground-Water Levels and Streamflow
- Status of Modeling and other analysis
- Discussion of Hypothetical Modeling Scenarios

Ground-Water/Surface-Water Interaction Field Studies (Greg Steele)

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
November 1998

Modeling

Data from many sources continue to be compiled, evaluated, and assembled into digital spatial data (GIS) coverages. Data sets for model input and calibration are being constructed. Input data sets for base of aquifer, land surface, rivers, and boundary conditions have been loaded into the model. A preliminary model is partially set-up. Preliminary simulations of the pre-development period will begin shortly.

Historical ground-water-level data from continuous recorder wells was retrieved and analyzed. Previously published maps of water-level change were analyzed and a water-level change map of pre-development to 1997 is being constructed. Maps of the pre-development and 1997 water table elevation and 1997 saturated thickness were refined.

Maps showing locations and dates of installation of irrigation wells were made using well registration data obtained from Nebraska, Kansas, and Colorado. Preliminary analysis of water use records in Kansas and Colorado began.

Streamflow data for about 35 sites in the study area were analyzed to determine historical trends in base flow (streamflow derived from ground-water discharge) and runoff (streamflow derived from overland flow of precipitation) using a computerized base-flow separation method. The streamflow data were compared to historical precipitation data. Preliminary interpretations regarding factors influencing streamflow in different parts of the study area were made.

Streamflow gains and losses were calculated and plotted for historical low-flow streamflow measurement sets on the lower and middle Republican River and tributaries. Gain/loss data sets in the upper Republican River basin are currently being analyzed. USGS-Nebraska District personnel made streamflow measurements at or visited about 380 sites during a streamflow gain/loss investigation on the Republican River during the week of Oct. 26. Measurements were made on the Republican River and all tributaries above Harlan County Reservoir. Major tributary streams were followed upstream to the point of zero flow (to the nearest bridge crossing). In addition, hydraulic potentiometer measurements to investigate ground-water/surface-water interaction and streambed properties also were made at selected sites. Conditions were generally good for the gain/loss measurements and the quality of the data set should be good. The data is presently being analyzed and compared to historical gain/loss data. A map of perennial stream reaches in the basin is being assembled using the results of previous investigations, previous streamflow gain/loss studies, and land-surface and river elevation data.

A graduate student working on the project began her thesis work to quantify historical changes in the area covered by trees in selected parts of the basin and to calculate historical changes in losses of water from the aquifer by evapotranspiration (ET) from riparian zones. Climate, soils, and land use data is being assembled in preparation for determining estimates of recharge, ET, and pumping in the study area. Methods of estimating these inflows and outflows continued to be reviewed. In the next

quarter, construction of additional model data sets will continue and steady-state model simulations will proceed. Estimation of aquifer inflows and outflows (pumping, ET, recharge, interaction with SW) will continue with a goal of completing generation of these data sets by next spring.

Ground-Water/Surface-Water (GW/SW) Interaction

Monitoring of water levels at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects continued. Water levels continue to be automatically recorded in three wells and the stream at the two Frenchman Creek sites and in five wells and the stream at the Sappa Creek site. Water levels are being measured monthly in the other wells. During Sept. 8-12, samples were collected from 9 wells, the stream, and the streambed at the Sappa Creek site (12 samples), and 4 wells and the stream at both the Palisade and Champion sites (5 samples at each site). The samples are being analyzed to determine ground-water recharge age using concentrations of chlorofluorocarbons (CFCs), tritium, and dissolved gases. The water samples were also analyzed for pH, specific conductance, dissolved oxygen, temperature, and nitrate-nitrogen concentrations. Samples to be analyzed for oxygen- and hydrogen-isotopes were collected for Ed Harvey, UNL, Conservation and Survey Division. Preliminary analysis of water-level and water-quality data continued. In the next quarter analysis and interpretation of the data will continue. GW/SW-level monitoring will continue. Water samples will be collected in November and analyzed for field parameters and nitrate concentrations.

Ground-Water Quality

Compilation and quality-assurance of well location, construction, and other supporting information for the water-quality samples collected last summer is continuing. The water-quality data is being quality-assured and entered into the USGS database. The data will be sent to landowners by mid-December. Interpretation of the data will continue in the next quarter.

General

A liaison meeting was held September 22 to coordinate Republican Basin activities in Nebraska among investigators from the USGS, CSD, and NDWR. The next coordination meeting will occur in early December. Matt Landon presented a poster describing the modeling study, the hydrogeology of the basin, and the preliminary results of base-flow separations at the Midwest Ground Water Conference in Lawrence, Kansas, October 13-14, and gave a talk on the same material at the Ground Water Management Districts Association meeting in Ft. Worth on November 2. Greg Steele gave a talk on the preliminary results of the water-level measurements at the GW/SW interaction study sites at the Midwest Ground Water Conference.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
August 1998

Modeling

Data from many sources continue to be inventoried, evaluated, and assembled into digital spatial (GIS) data coverages. Most of the physical information concerning aquifer geometry and characteristics has been assembled and is being loaded into the model in preparation for steady-state simulations of the pre-1950 period ("pre-development" in most parts of the study area).

Coverages of river elevation and land surface elevation from Digital Elevation Models (DEMs) were completed and loaded into the model. Measured river elevations at gaging stations were compared to elevations estimated from digital topographic maps and generally found to compare very well. Historical ground-water-level data for the study area was analyzed and selected long-term hydrographs plotted. Preliminary water-table maps of the pre-development period and March 1997 were completed (see attached).

A preliminary map of March 1997 saturated thickness was developed. Areas of Cretaceous bedrock outcrop (areas of no aquifer) were digitized. A digital map of areas of little or no saturated thickness was compiled from various sources and compared to the March 1997 saturated thickness map. Metadata for a digital coverage of elevation of base of aquifer was prepared in preparation for releasing the coverage for review. Digital geologic maps of the study area are being prepared using information compiled from several sources.

Digital data sets of hydraulic conductivity and specific yield put together for the whole High Plains aquifer by the USGS-Oklahoma district were reviewed and a decision was made not to use the coverages explicitly because the accuracy of the coverages was not sufficient for the scale of this project. Initial hydraulic conductivity and specific yield values will be assigned to stream-valley alluvial deposits and the Ogallala Formation based upon the patterns indicated by the High Plains aquifer maps. Historical aquifer-test data were compiled into tables and will be compared to regional maps of estimated properties.

Historical streamflow data for about 70 sites in the study area are being analyzed to determine baseflow (streamflow derived from ground-water discharge) using a computerized baseflow separation method. Historical low-flow seepage measurements were compiled and the data were plotted on maps and entered into databases. The seepage data are being digitized and analyzed to estimate ground-water/surface-water exchanges and gaining and losing river reaches. Review of estimation methods and compilation of data to determine evapotranspiration (ET), recharge, and pumping has begun.

In the next quarter, preliminary steady-state model simulations will begin. Estimation of aquifer stresses (pumping, ET, recharge, interaction with SW) for the transient model of the development period (1950-97) will proceed with a goal of completing generation of these input data sets by next spring.

Ground-Water/Surface-Water (GW/SW) Interaction

Monitoring of water levels at the three sites (Sappa Creek near Stamford, Frenchman Creek near Palisade, Frenchman Creek near Champion) for the paired-observation well transects continued. Surveying of the transect wells was completed. Two additional pressure transducers with built-in data loggers were installed in June; water levels are now being automatically recorded in three wells and the tributary stream at the two Frenchman Creek sites and in five wells and Sappa Creek at the Sappa Creek site. Water levels are being measured monthly in the other wells. Water samples were collected from the tributary streams and one transect (9 wells) at each site during August 11-14. The water samples were analyzed for pH, specific conductance, dissolved oxygen, temperature, and nitrate-nitrogen concentrations. Samples to be analyzed for oxygen- and hydrogen-isotopes were collected for Ed Harvey, Conservation and Survey Division. Sampling to determine ground-water recharge age using concentrations of chlorofluorocarbons (CFCs) was rescheduled and will begin September 8. Analyses of tritium samples collected from the transects in April (data supplied by Ed Harvey) were used to plan the CFC sample collection. Preliminary analysis of water-level and water-quality data began and will continue in the next quarter. Interpretation of the data and writing of the report will occur over the winter of 1998-99 with publication of a fact sheet reporting the results in Fall 1999.

Ground-Water Quality

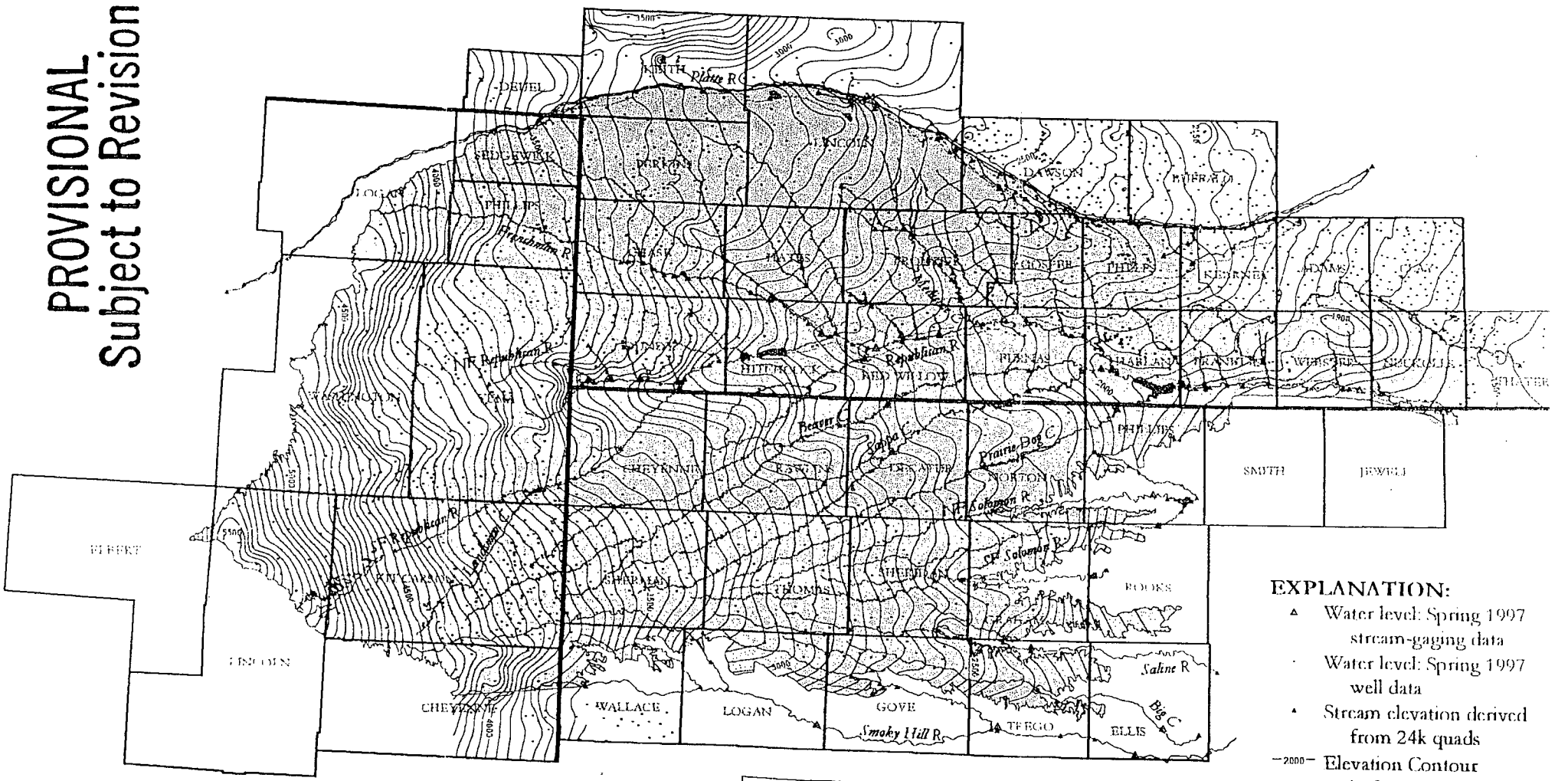
Two hundred and fourteen ground-water samples in the Nebraska part of the Republican River basin were collected during June, July, and August, completing the sampling for this component of the project. The samples collected this summer were mostly collected from the Middle and Upper Republican NRDs since sampling in the Lower Republican and Tri-Basin NRDs was mostly completed in the summer of 1997. All wells were sampled for nitrate (analyzed at Olsen's Lab in McCook) and 25% of the wells were sampled for major ions (analyzed at the USGS National Water Quality Lab in Arvada, Colorado). Replicate samples were collected at 10% of wells, reference samples at 3% of wells, and blanks at 1% of wells as quality assurance/quality control samples. Samples to be analyzed for oxygen- and hydrogen-isotopes were collected for Ed Harvey, Conservation and Survey Division. The sampling was closely coordinated with collection of about 400 samples in the Upper Republican NRD. In the next quarter, compilation and quality-assurance of well location, construction, and other supporting information will be completed and the information will be entered into the USGS database. The water-quality data will be quality-assured, entered into the database, and these results will be sent to landowners. Interpretation of the data and writing of the report will mainly occur over the winter of 1998-99 with publication of a fact sheet reporting the results in Fall 1999.

General

A web site for the project was developed and is now online at the following address: *http://www-ne.cr.usgs.gov/repub/home.html*. Abstracts on the modeling and GW/SW interaction components of the study were submitted to the Midwest Ground Water Conference, occurring Oct. 12-14 in Lawrence, Kansas (see attached abstracts). Posters or oral presentations describing the study and results to date will be presented at this meeting. A liaison meeting was held June 8 to coordinate Republican Basin activities in Nebraska among investigators from the USGS, CSD, and NDWR. The next coordination meeting will occur September 22.

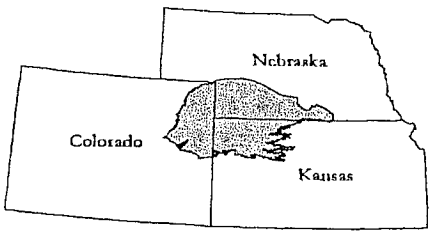
Preliminary Spring 1997 Water Table

PROVISIONAL
Subject to Revision



Preliminary 1997 Water Table
Prepared on 8/17/98
Republican River Basin Ground-Water Model
U.S. Geological Survey
Lincoln, NE

0 50 100 Miles
0 50 100 Kilometers

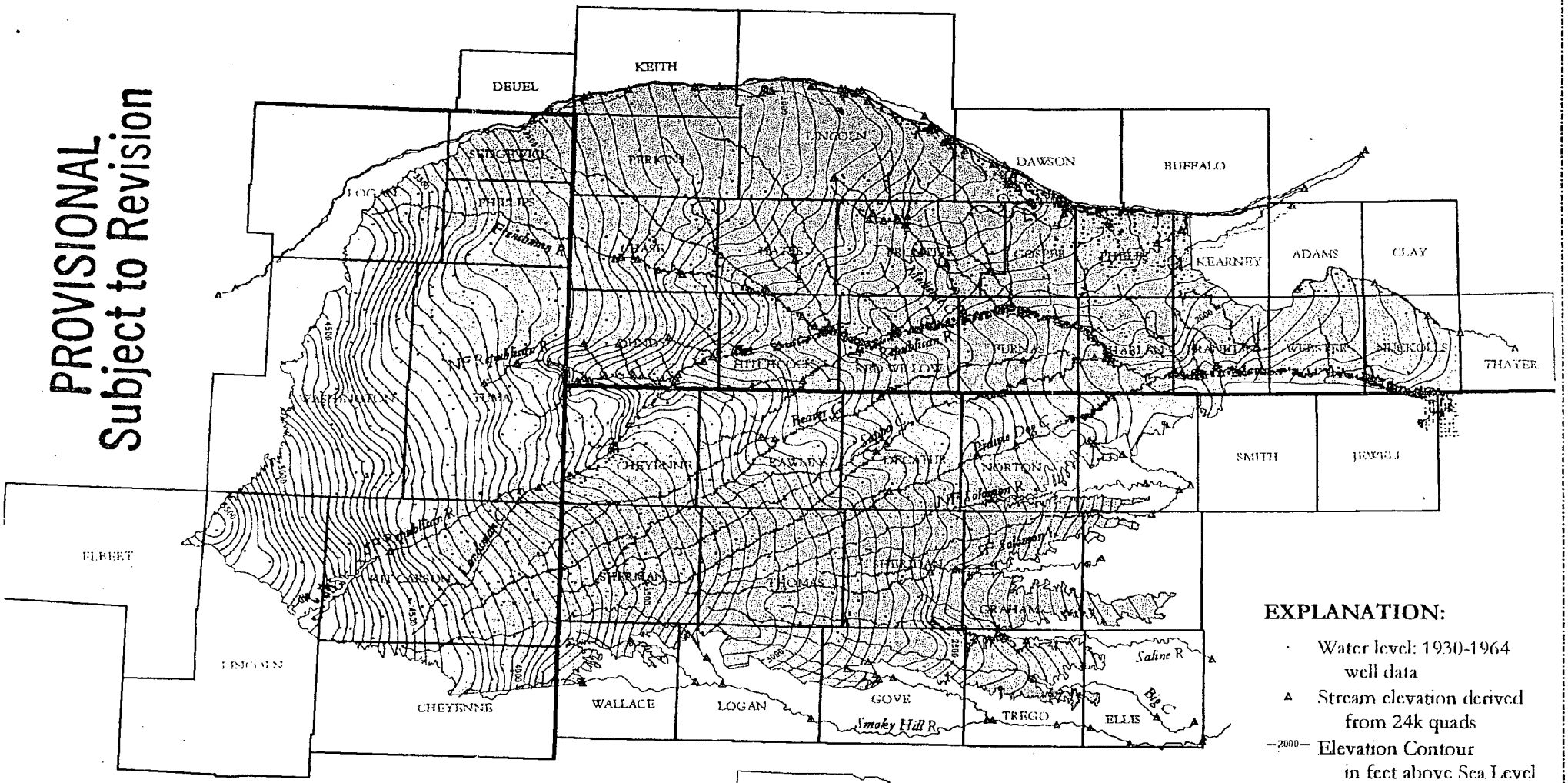


EXPLANATION:

- Water level: Spring 1997 stream-gaging data
- Water level: Spring 1997 well data
- Stream elevation derived from 24k quads
- 2000 Elevation Contour in feet above Sea Level
- Reservoir
- Canal
- Stream
- State
- County
- Study area

Preliminary "Pre-development" Water Table: 1930-1964

PROVISIONAL
Subject to Revision



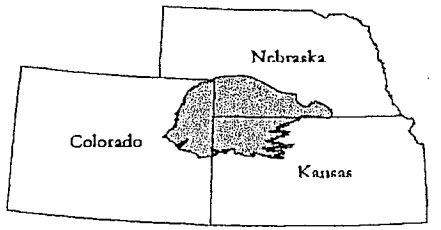
EXPLANATION:

- Water level: 1930-1964 well data
- Stream elevation derived from 24k quads
- —2000— Elevation Contour in feet above Sea Level
- Reservoir
- Canal
- Stream
- State
- County
- Study area

Preliminary "Pre-development" Water Table: 1930-1964
Prepared on 8/19/98
Republican River Basin Ground-Water Model
U.S. Geological Survey
Lincoln, NE

0 50 100 Miles

0 50 100 Kilometers



Abstract submitted to 43rd Midwest Ground Water Conference, Lawrence, Kansas, Oct. 12-14, 1998

A Study of Ground-Water Flow and Ground-Water/Surface-Water Interaction in the Republican River Basin, Southwest Nebraska, Northwest Kansas, and Northeast Colorado

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Development of ground-water supplies in the High Plains aquifer for irrigation in the Republican River Basin has led to concerns about diminishing streamflow in the basin. A cooperative study between the U.S. Geological Survey and the Southwest Nebraska Resource Conservation and Development Area is being conducted to evaluate ground-water flow and ground-water/surface-water interaction using a digital, finite-difference, ground-water flow model (MODFLOW) of the entire basin upstream of the gaging station on the Republican River near Hardy, Nebraska, at the Kansas-Nebraska border. The objectives of the modeling component of the study are to: (1) quantify ground-water/surface-water interaction throughout the basin, and (2) simulate the effects of future pumpage scenarios on streamflow. Digital spatial data coverages of aquifer geometry, properties, and stresses are being constructed using available information to generate model-input data for the study area of about 30,000 mi^2. The model boundaries are the Platte River on the north, the Little Blue River on the northeast, and the edge of the High Plains aquifer in northeast Colorado and northwest Kansas on the west and south, respectively. The model will be calibrated under both steady-state (pre-1950) and transient (1950-97) conditions. The study will provide a ground-water model capable of quantifying the effects of ground-water pumping on streamflow in the basin, enabling better management of limited ground- and surface-water resources.

Abstract submitted to 43rd Midwest Ground Water Conference, Lawrence, Kansas, Oct. 12-14, 1998

Characterizing Stream-Aquifer Relations in the Tributaries of the Republican River, Southwest Nebraska

By Gregory V. Steele, U.S. Geological Survey, Room 406 Federal Building, 100 Centennial mall North, Lincoln, NE 68508, (402) 437-5509, gvsteele@usgs.gov

In 1997 the U.S. Geological Survey, in cooperation with the Southwest Nebraska Resource Conservation and Development Area, began a 4-year study to quantify the stream-aquifer relations in the Republican River Valley. As part of this study, 18 well nests were installed in 1998 at three sites along tributaries of the Republican River in Nebraska— Frenchman Creek near Champion, Frenchman Creek near Palisade, and Sappa Creek near Stamford. These three sites were selected to characterize the ground-water flow in the alluvial valleys of the Republican River tributaries. On Frenchman Creek, the Champion site represents areas downstream of surface-water impoundments; the Palisade site represents rangeland to irrigated farmland; and the Sappa Creek site represents areas of predominately irrigated farmland. At each site there are two transects of wells; each transect consists of three well nests—one near the stream, one near the tributaries alluvial valley wall, and a third midway between the other two. Each well nest is comprised of one shallow well screened at the water table, one deep well screened at the bottom of the aquifer, and one well screened about midway between the other two.

Review of preliminary data indicates that a strong stream-aquifer relation exists at the Frenchman Creek sites. At the Champion and Palisade sites, ground-water levels rose abruptly in wells adjacent to and nearly 800 feet from Frenchman Creek following rapid changes in stream stage. In addition, bank storage, following rises in stream stage, appears to be an important component of stream flow in Frenchman Creek. Preliminary data show that the stream-aquifer relation at the Sappa Creek site is not as strong as at the Frenchman Creek sites. The stream stage of Sappa Creek did not correlate well with large changes in ground-water levels recorded at nearby observation wells.

REPUBLICAN RIVER BASIN MODELING, GROUND-WATER/SURFACE-WATER INTERACTION AND WATER-QUALITY PROJECT
March 1998

Model Preparation

Data from many sources continue to be inventoried and evaluated. Digital spatial (GIS) data coverages are being constructed from the data assembled and are being used for input data for the ground-water flow model (MODFLOW). A digital map of the elevation of the base of the aquifer for the entire study area is nearly complete. Maps of the base of the aquifer in Nebraska and Colorado were digitized and will be combined with a digital map of the base of the aquifer in Kansas. The base of aquifer maps will be carefully checked against existing hydrogeologic cross-sections to ensure that the coverage adequately represents aquifer geometry along the river valleys. A working-group of investigators from USGS, CSD, NDWR, and NDEQ have completed a preliminary inventory of existing hydrogeologic cross-sections in the Nebraska portion of the Republican River Basin. Cross-sections in Kansas and Colorado are also being gathered and evaluated by the USGS.

Maps of the hydraulic conductivity (K) and specific yield (S_y) of the High Plains aquifer digitized by the USGS-Oklahoma District from maps generated by the USGS Regional Aquifer-System Analysis of the High Plains aquifer in the 1980's were evaluated. These maps were found to have the same level of detail as state-by-state maps of these parameters and will be used for input to the model. The coverages will be clipped to the boundaries of the study area.

Work is proceeding on assembling a coverage of land surface elevation from Digital Elevation Models (DEMs). Historical ground-water-level data in Nebraska were retrieved from the USGS database, checked for anomalies, and corrected when necessary. These data will be used to calibrate the model. Preliminary work began on assembling a digital coverage of river elevation.

In the next quarter, water-level data from Kansas and Colorado will be retrieved and evaluated. Digital water-table maps of the study area will be assembled either by digitizing existing maps or constructing new maps using the water-level data. Streamflow data for the study area will be retrieved from databases and will be analyzed to determine baseflow. The results of historical low-flow measurements will be evaluated to estimate ground-water/surface-water exchanges. Digital data sets will be imported into the model to generate model input values as they are obtained.

Ground-Water/Surface-Water Interaction

Drilling and well installation at the three sites for the paired-observation well transects began February 23 and is proceeding. The drilling was delayed for two weeks because of wet conditions at the sites. All wells have been installed at the sites along Sappa Creek near Stamford and Frenchman Creek near Palisade. Eighteen wells (6 well nests with wells at 3 depths) were installed at each site. Drilling will shortly be completed at the site along Frenchman Creek near Champion. Lithologic descriptions and geophysical logs (resistivity and conductance, using a logger borrowed from CSD) have

been used to determine the stratigraphy at each well nest location and to determine optimal well placement.

In the next quarter, pressure transducers with built-in data loggers will be installed in selected wells along the transects and in the tributary streams. Water levels will be measured monthly in other wells along the transects. All wells and stream monitoring sites will be surveyed so that accurate water-level elevations can be determined. Water samples will be collected from the tributary streams and one transect of wells at each site in April. Water samples will be analyzed for field parameters (pH, specific conductance, dissolved oxygen, and temperature) and nitrate-nitrogen concentrations; selected wells will also be analyzed for tritium concentrations. The results of the sampling in April will be used to help plan collection of samples for ground-water age dating using chlorofluorocarbons (CFC's) in July.

Ground-Water Quality

Preparations are underway for collection of about 214 ground-water samples in the Nebraska part of the Republican River basin in the summer of 1998. Wells are being selected using a stratified random approach based on areal distribution, well depth, and availability for sampling. Well owners are being contacted by phone to obtain permission for sample collection. Sampling will occur in June, July, or August; the exact timing of sample collection is dependent on the start of irrigation season.

General

A liaison meeting was held on March 2 to coordinate Republican Basin activities in Nebraska among investigators from the USGS, CSD, and NDWR. The next meeting is scheduled for June 8.

Presentations on the Republican River water-quality, SW/GW interaction, and modeling study were made at the Middle Republican NRD annual water conference on March 4 and the 1998 NRD Water Programs Conference on March 6.