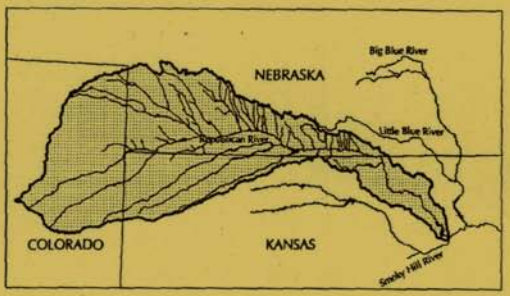
REPUBLICAN RIVER COMPACT ADMINISTRATION

THIRTY-SIXTH ANNUAL REPORT



FOR THE YEAR 1995

Cambridge, Nebraska

June 6, 1996

REPUBLICAN RIVER COMPACT ADMINISTRATION

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TABLE OF CONTENTS

MINUTES
37th Annual Meeting
REPUBLICAN RIVER COMPACT ADMINISTRATION

The meeting was called to order by Chairman Jess at 8:30 a.m., June 6, 1996, in the City Office/Community Center in Cambridge, Nebraska.

Those in attendance were:

NAME	REPRESENTING
J. Michael Jess	Nebraska Commissioner, Chairman
Hal Simpson	Colorado Commissioner
David Pope	Kansas Commissioner
Ann Bleed	Nebraska Dept. of Water Resources/Eng. Committee
Richard Stenzel	Colorado State Engineer's Office/Eng. Committee
David Barfield	Kansas Division of Water Resources/Eng. Committee
Mike Thompson	Nebraska Dept. of Water Resources/Eng. Committee
Russell Oaklund	Nebraska Dept. of Water Resources/Eng. Committee
Bill McIntyre	Colorado State Engineer's Office/Eng. Committee
Leif Holliday	Kansas Division of Water Resources/Eng. Committee
Don Blankenau	Nebraska Department of Water Resources/Legal Committee
Cliff Seigneur	Colorado Attorney General's Office/Legal Committee
DeAnn Hupe Seib	Kansas Division of Water Resources/Legal Committee
Kenneth Albert	Frenchman Valley Irrigation District
Dennis Allacher	Bureau of Reclamation
Robert Andrews	Frenchman-Cambridge Irrigation District, Nebraska
Michael Bart	Corps of Engineers
Willis Barth	Frenchman Valley Irrigation District, Nebraska
Jari Beek	Bureau of Reclamation
Ralph Best	Frenchman-Cambridge Irrigation District, Nebraska
Beverly Bogle Louthan	Tri-Basin Natural Resources District, Nebraska
Dan Bose	Lower Republican Natural Resources District, Nebraska
Jerry Buehre	Corps of Engineers
Stan Clark	Kansas State Senator
Jim Cook	Nebraska Natural Resources Commission
Raymond Durner	Land Owner, Bartley, Nebraska
Brad Edgerton	Nebraska Department of Water Resources
Bill Fuller	Kansas Farm Bureau
Gil Gyllenborg	Bureau of Reclamation
Del Harsh	Middle Republican Natural Resources District, Nebraska
Wayne Heathers	Middle Republican Natural Resources District, Nebraska
Ginger Jensen	Kearney Hub, Nebraska
Sara Kay	Nebraska Water Resources Association
Tom Knutson	Loup Basin Reclamation District, Nebraska
Diana Lambson	Hastings Tribune, Nebraska
Bryan Lubek	Lower Republican Natural Resources District, Nebraska
Clayton Lukow	Farmer, Holstein, Nebraska
Jim Lundgren	Nebraska Water Users
Wayne Madsen	Middle Republican Natural Resources District, Nebraska
Jill Manring	Bureau of Reclamation

NAME	REPRESENTING
Ron Milner	Upper Republican Natural Resources District, Nebraska
Darin Nelson	Almena Irrigation District #5, Kansas
Kenneth Nelson	Irrigation Projects Reauthorization Council
Joyce Newport	Cambridge Clarion, Nebraska
Lee Orton	Irrigation Projects Reauthorization Council, Nebraska
Roy Patterson	Frenchman-Cambridge Irrigation District, Nebraska
Scott Ross	Kansas Division of Water Resources
Thad Schemper	Almena Irrigation District #5, Kansas
Ed Schrock	Nebraska State Senator
Paul Schroeder	Lower Republican Natural Resources District, Nebraska
Tom Shoemaker	Cambridge, Nebraska
Norma Sitzman	Frenchman Valley/Hitchcock & Red Willow Irrigation District, Nebraska
Marvin Swanda	Bureau of Reclamation
Larry Swanson	Hitchcock & Red Willow Irrigation District, Nebraska
John Thorburn	Tri-Basin Natural Resources District, Nebraska
Paul Trenchard	Nebraska Landowner
Robert Uerling	Hitchcock & Red Willow Irrigation District, Nebraska
Robert Wallen	Frenchman-Cambridge Irrigation District, Nebraska
Linda Weiss	U.S. Geological Survey
Shane Wright	Nebraska Department of Water Resources
Ron Wunibald	Lower Republican Natural Resources District, Nebraska
Joe Hall	Consultant, Denver
Jim Hinrichs	
Gloria Hinrichs	

APPROVAL OF MINUTES

The minutes of the 36th Annual Meeting of June 8, 1995, as published in the 35th Annual Report, stood as previously approved and signed.

REPORT OF THE CHAIRMAN

Commissioner Jess

Commissioner Jess stated Nebraska has been meeting with Kansas to try to resolve issues of dispute between the two states. CDR Associates has been hired to serve as facilitator. Three member teams from the two states have been meeting approximately once a month, since late 1995, to explore alternatives to resolve the issues of dispute. Commissioner Jess reported Colorado and the federal agencies had been briefed the day before on the status of these efforts.

Jess also reported the Upper Republican Natural Resources District (NRD) extended the moratorium in critical townships, limiting the pumpage of ground water from wells within its Ground Water Control Area. The data on measuring and metering of withdrawals can be found in the central files of the NRD. District Manager, Ron Milner, added that the Board recently imposed a moratorium on construction of new wells within critical townships of the Control Area. In Nebraska, Jess

mentioned management of ground water is a shared responsibility between NRDs and the State.

Water year 1996 started out with little moisture throughout the fall and winter. It wasn't until mid to late spring that enough precipitation occurred to cause runoff events, Jess said. Since then, there has been considerable rainfall. Jess then requested the following Nebraskans to report:

Wayne Heathers

Heathers reported on the 450 square mile Special Protection Area (SPA) found primarily along the Republican River from Stratton to Bartley and a short section of Beaver Creek. He stated that the purpose of the SPA, within the Middle Republican NRD, is to improve water quality by reducing nitrates in the ground water. Training was offered, and 380 operators have been certified in the application of fertilizers. An additional benefit of improved handling of chemicals has been the reduction of ground water usage, thus cutting down on leaching.

Ron Wunibald

Wunibald reported on his Board's SPA composed of 32 square miles within the Lower Republican NRD. Nitrate contamination initiated designation of the SPA in 1990. Since then, slight improvement has been seen in water quality. Water efficiency is also promoted.

John Thorburn

Thorburn reported on the Ground Water Quality Management Area within the Tri-Basin NRD. Nitrate levels have stabilized or declined since 1989. The water table has also remained stable, he reported.

Don Blankenau

Legislative Bill 108, recommended by the Governor's Water Council, was the only water legislation passed in Nebraska during the 1996 session, Blankenau reported. The Legislature sought to create a process whereby conjunctive management could occur only in situations where conflicts between ground water and surface water users are clearly evident. The Legislature preferred regulation be handled by the local Natural Resources Districts. In cases where the NRDs are unable or unwilling to proceed, the Department of Water Resources is empowered to step in. In areas where there is an interstate compact, decree, or formal agreement, the Department can act independently. The Department is authorized to initiate appropriate authorities at such time as clear cause-and-effect relationships can be conclusively determined. Don noted the bill limits the Department's authority to the Republican River basin for the next three years, after which it would go state wide.

Russ Oaklund

Calendar year 1995 was wet through June. The need for regulatory water administration was delayed until July. On July 5, 38 junior permits on Frenchman Creek were closed above Frenchman Canal. These permits were closed until the Frenchman Valley and H & RW Irrigation Districts completed the irrigation season on September 6. On July 17, the following occurred: 14 senior permits were regulated and 42 junior permits were closed on Medicine Creek; 10 senior permits were regulated and 23 junior permits were closed on Red Willow Creek; 1 senior permit was regulated and 14 junior permits were closed on the Republican River from the mouth of Medicine Creek to the Cambridge Diversion Dam. These restrictions were lifted September 15 when the Frenchman-Cambridge Irrigation District completed its season. On July 31, seven permits on Frenchman Creek below the Culbertson Canal headgate were regulated and nine main stem Republican River permits from Trenton Dam to Bartley Diversion Dam were closed. Diversions by the Bartley Canal were restricted to the maximum limit of its natural flow appropriation. All of the restrictions were lifted September 15. On July 28, 112 permits on the Republican River from Harlan County Dam to Guide Rock Diversion Dam were regulated for the benefit of the Nebraska and Kansas Bostwick Irrigation Districts.

Some 104 water appropriations, from the Republican River, between Haigler and Culbertson were investigated and subsequently adjudicated last year, Oakland said. Included were the sub-basins of Arikaree River, Buffalo Creek, Rock Creek, South Fork of the Republican River, and Frenchman Creek. Of the total , 39 permits were cancelled in full and 12 permits were cancelled in part. Rights to irrigate about 3,200 acres were cancelled, he said.

REPORT OF THE COMMISSIONER FROM COLORADO

Commissioner Simpson encouraged Kansas and Nebraska to continue negotiating. He stated in the Kansas v Colorado case, over the Arkansas River Compact, Colorado and Kansas spent $18-20 million in legal fees and still have two more years of litigation. In addition, Colorado must take a number of regulatory steps to reduce depletions to comply with the Court order and must pay Kansas for past damages.

Commissioner Simpson stated that several water bills were passed during the past Legislative session, one being Senate Bill 124 which was introduced as a response to the outcome of the Kansas v Colorado dispute Compact. The Bill authorized a low interest (3%), 40-year loan for up to $3 million to enable the purchase of senior water rights. This will make augmentation water available in the Arkansas River basin. A $50,000 grant to Augmentation Associations was also provided to purchase computers and software to communicate electronically with power companies. Statutes were changed requiring power companies to provide monthly reports on demand to Simpson's office. Fines were set at $500 a day for well owners who refused to cooperate with the rules; 9½ new staff positions were created to enforce these rules.

Senate Bill 74, although dealing with non-tributary ground water, resulted in a one-year study of the South Platte River basin, including issues related to the federal Endangered Species Act.

Regarding the Republican River Basin, it is anticipated that a new rule for a water conservation reserve program, allowing farmers to set aside and not use their allotted water without being penalized, will be adopted in August, 1996.

REPORT OF THE COMMISSIONER FROM KANSAS

Commissioner Pope agreed with Simpson, stating the Kansas v Colorado litigation was a long and difficult endeavor costing lots of time and money. Negotiating a settlement is a better way. He stated he is encouraged with the negotiations under way with Nebraska and hopeful that the two states could find resolution of Kansas' concerns through them.

Legislation passed during the past session included House Bill 2613 which establishes two special funds: the Interstate Water Litigation Fund and the Water Conservation Projects Fund. These funds provide a special mechanism for the receipt and distribution of monies made available for several water-related issues. The Interstate Water Litigation Fund provides a source of funding for Kansas to protect and enforce its rights under various water compacts. The Water Conservation Projects Fund provides a funding mechanism in the event that monetary settlement is made in the Kansas v Colorado litigation. It will provide a place for monies to be deposited outside of the general State coffers, Pope said.

Kansas Governor, Bill Graves, started a water quality initiative a year ago to develop a program to deal with water contamination. Governor Graves asked various State agencies to work cooperatively toward this goal. The first target area identified is the Lower Republican and Kansas River basin.

The Sub-Basin Water Resources Management Program was initiated several years ago to target areas of the state that have special water problems. It uses a systematic approach to address problems and develop solutions through local input and partnerships. The effort is intended to achieve a comprehensive water management strategy.

All surface water right holders and owners of alluvial wells and wells hydrologically connected to tributary streams in northwest Kansas are now required to install measuring devices on their pumps and diversions. Full compliance is anticipated within three years.

Climatologically, Kansas had extremely dry conditions during summer and fall 1995. Drought conditions continued until the end of April when significant rainfall occurred.

REPORT FROM BUREAU OF RECLAMATION

Gil Gyllenborg

Gyllenborg reported the following restructuring and reorganization: Jari Beek was hired as deputy to Gyllenborg; Dennis Allacher and Jill Manring are team leaders of the contract renewal effort; Marv Swanda is in charge of operations; and Gene Harms handles facilities maintenance.

The Ord, Nebraska, construction office was closed in 1995. Transfer of the Twin Loups Project is in progress. Construction activities are nearly complete.

A study funded through Fiscal Year 1998 evaluates potential ground water supplies and problems related to water quality in the state of Nebraska. Part of that study is to assess long-term rural domestic and small community water supply needs. Alternatives will also be explored. A second, three-year study, the Nebraska Rainwater Basin Assessment, which deals with wetlands activities, is proposed to begin in 1998.

Jill Manring

Manring reported that federal contracts for three irrigation districts in the Republican River basin are due for renewal December 31, 1996. Another district's contract expires December 31, 1997.

As part of its required analysis for contract renewal, the Bureau initially developed 44 "what if" scenarios based on public input. The Number has been screened down to 12. Ultimately, the 12 scenarios will be reduced to 4 or 5, she said. Hydrology modeling of the Resource Management Assessment (RMA) has been completed; a draft RMA is scheduled for completion during June and will be sent out for public comment. Environmental Impact Statement and RMA scoping meetings are planned for August.

The Bureau conducted a water quality sampling program as another component of the contract renewal effort within the Republican River basin, Manring reported. Based on laboratory findings, elevated selenium levels are evident in the lower end of the basin. The Bureau is currently working with the U.S. Fish and Wildlife Service to sample aquatic biota to determine if they are absorbing and accumulating selenium. The additional sampling is scheduled for the third week of June, 1996, she said.

Manring said interim contract extension is another initiative being pursued by the Bureau. Interim contracts will allow irrigation districts to continue receiving project water while negotiating long-term contracts. Interim contracts will be issued on a year-to-year basis up to a maximum of three years, she said. It is expected the interim contracts would contain most of the same provisions as the existing contracts. The chief exception is a 25-year term. Finally, it was reported, Legislation introduced by Senator Kerrey and Congressman Barrett of Nebraska (Senate Bill 1649 and House Bill 3350) would extend water service contracts for an additional four years.

Barfield asked if the RMA document would provide details on how the computer modeling was done. Manring responded by saying a detailed appendix would be part of the RMA. Raw data will be available to the MOA cooperating agencies and upon request to others. It was said the general public will receive a document containing a description of the modeling effort.

Marvin Swanda

Swanda provided the following data for 1995 operations at reservoirs in the Republican River basin: The precipitation ranged from 62% of normal at Enders to 244% at Keith Sebelius. Keith Sebelius reached the highest reservoir level since 1967. There was record precipitation in May 1995 of 14.3 inches at the dam. Irrigation deliveries ranged from 4.2 inches at Almena to 14.2 inches for the Frenchman-Cambridge Irrigation District.

Harlan County Reservoir's high elevation was 1,951 feet; about 5.2 feet into the flood pool. The 1995 irrigation season ended with an elevation of 1,940 feet.

Swanson, Hugh Butler, and Harry Strunk Reservoirs started the 1996 irrigation season in the flood pool. Available data for the day previous to the meeting showed Bonny Reservoir was one foot from full; Swanson Reservoir was about half a foot from full; Enders Reservoir was 9.2 feet below full; Hugh Butler Reservoir was about 1 foot from full; Harry Strunk Reservoir was 0.7 feet into the flood pool; Keith Sebelius Reservoir was about 4.3 feet below full; Harlan County Reservoir was about 0.8 feet into the flood pool; and Lovewell Reservoir was about 2.9 feet into the flood pool. Swanda said, "We expect full, base water supplies for Frenchman-Cambridge and the Bostwick Irrigation districts, which will probably have additional water available. Almena would have about 11 inches available; they expect to take 3 inches. H&RW and Frenchman Valley can expect to receive 4½ inches of irrigation water."

For each federal dam, the Bureau has been working with local and State emergency management officials to assist in developing emergency plans. Each will contain specific warning and evacuation plans for communities downstream. Swanda said, the Bureau will be scheduling meetings to provide assistance to each county.

Finally, Swanda reported seepage concerns at Enders Dam. It was said the Bureau expects to construct an additional toe drain by 1997. Uplift pressure and seepage concerns at Hugh Butler dam also were discussed.

REPORT FROM CORPS OF ENGINEERS

Michael Bart

Bart reported repair of the Milford Lake outlet channel will begin in the fall of 1996. The anticipated construction time is one year. Upon completion, the outlet channel will again be able to convey a full outlet release.

Efforts are underway to re-establish wetland areas at the upper end of Milford Lake. The Corps is working with the Kansas Department of Wildlife and Parks to re-establish up to as much as two thousand acres of wetlands, he said.

Bart reported that their Corps' study of Harlan County is being held in abeyance pending completion of the Bureau's Republican River basin studies.

REPORT FROM U.S. GEOLOGICAL SURVEY

Linda Weiss

Weiss reported on stream flow gaging stations in the Republican River basin. The Geological Survey (USGS) operates, reviews and publishes flow records for 14 stations in the basin and publishes records for three other stations. Cooperators include the Corps of Engineers and the Nebraska Department of Water Resources, Weiss said.

ENGINEERING COMMITTEE REPORT

Ann Bleed gave the report of the Engineering Committee, stating it had four assignments from last year. One was to calculate the virgin water supply and consumptive use within the basin, the second was to review the Bureau of Reclamation's equations for modeling Harlan County Reservoir as published in the Republican River Basin Flows report to which Jill Manring referred. The third was to review ground water studies of the Republican River basin. The fourth was to review and recommend options for maintaining gaging stations used by the Republican River Compact.

Three additional items were added to the Engineering Committee agenda at the request of Kansas' representative David Barfield. The first was to review and discuss the methodology used by Nebraska to determine ground water consumptive uses. Kansas' request was precipitated by changes in Nebraska's methodology to estimate its consumptive use of water in the basin. The second was to determine whether the Committee should include known flood flows in determining the virgin water supply. The last was to determine whether the virgin water supply and allocations should be adjusted every year.

Virgin Water Supply and Consumptive Use

The calculation of virgin water supply and consumptive use was included in the Engineering Committee's report in the form of three tables. Concerns were raised by both Kansas and Colorado about both changes in methods used by Nebraska to compute its 1995 estimates, as well as a portion of the methodology it has historically employed. Bleed briefly overviewed changes in Nebraska's methods to estimate 1995 water use. These included an extensive review of the wells considered alluvial, the use of metered data of the Upper Republican NRD, and the use of the results of survey questionnaires in the Middle and Lower Republican NRDs to refine estimates of irrigated acres.

Kansas Committee member, Barfield, stated that Kansas was not aware of the changes in Nebraska's methods until the May 7, 1996, Engineering Committee meeting. He sated he had inadequate time to review all of the changes and underlying data, but his review to date reveals concerns with Nebraska's method to estimate diversion requirements for each irrigated acre. He believed Nebraska's method significantly underestimates the quantity of water required for irrigation, as compared to other commonly accepted methods, such as the Blaney-Criddle method. He also stated that he wanted time to review the data of the Middle and Lower Republican River NRDs used to determine irrigated acres. As a result, Barfield state the Nebraska method must be rectified before he would sign the Engineering Committee report.

The Commissioners and members of the Engineering Committee discussed differences in alluvial definitions among the respective states.

Colorado Committee member, Stenzel, voiced objection to Nebraska's treatment of precipitation. As opposed to being 100 percent effective, many rainfall events produce run-off. Nebraska's methodology underestimates consumptive use and is therefore unreliable, he claimed.

After again indicating the methodology for reporting ground water usage in Nebraska was not acceptable, Barfield said he would not sign the Engineering Committee report. Stenzel was more reticent. He indicated a willingness to sign the report but insisted this wording be made part of the record: "The numbers presented in Tables 1, 2 and 3 do not reflect any changes in methodology using Blaney-Criddle or corrections for credit given to total precipitation taken by Nebraska. Any future changes in methodology should be applied to this year's report." The tables were later removed from the report.

Review of Bureau of Reclamation Equations for Modeling Harlan County Reservoir

Upon return to other aspects of the Committee report, Bleed indicated Committee members had reviewed the Bureau of Reclamation regression equations used for modeling operations of the Harlan County Reservoir. It was said for the Bureau's purposes the regression equations are an acceptable means to adjust historical runoff to reflect current levels of development. However, the Committee concluded the equations should not be used to extrapolate flows into the future.

Review of Ground Water Studies

The Engineering Committee also undertook the review of ground water studies of the Republican basin. One focus was to determine the linkage between the Ogallala formation and Republican River flows. The Engineering Committee work focused on the three most recent studies in the Upper and Middle NRDs of Nebraska. The reports indicate the perennial reaches of some tributary streams in the basin have been shortened as a result of pumping. All three reports predict ground water levels and stream flows in the area will decline in the future with continued or increased pumping. However, the Engineering Committee

concluded the reports do not provide sufficient information to determine what the impacts of Ogallala pumping are on the flows of the Republican River. Should this information be necessary, the Engineering Committee suggested another modeling effort be developed.

Compact Gaging Stations

Two gaging stations used in Compact administration are currently being run by the Cambridge office of the Nebraska Department of Water Resources. Monthly measurements are published in the State Hydrographic Report. As the USGS has no involvement in these two gages, the Engineering Committee was asked to review options for USGS operation and/or oversight. After much dialog, the Engineering Committee provided four options for review and publication of Compact gage records. The Commissioners agreed to the following: "The USGS data could be published along with the State of Nebraska's stream flow data in the annually published Nebraska Hydrographic Report. These data are currently available in electronic form through the State of Nebraska's Natural Resources Commission Data Bank. The Nebraska Department of Water Resources is currently developing its own stream flow data bank. The USGS would continue to publish the records for the stations they operate."

Additional Issues Raised by Kansas

Kansas raised questions relating to whether adjustments to virgin water supply should be made annually or every five to ten years. Kansas also questioned whether flood flows should be included in calculating the annual virgin water supply. The Committee decided these were issues that should be discussed by the Compact Commissioners, not the Engineering Committee. In view of the on-going efforts to resolve Kansas' concerns regarding the Compact which might render these issues moot, the Compact Commissioners decided to defer on these issues until a later date.

As a means to resolve the debate surrounding the Engineering Committee members' report, Pope moved the Committee be directed to develop a technical definition which would address which ground water sources should be included in the Committee's computations. In addition to inclusion of alluvial aquifer systems, other hydraulically-connected aquifers such as the Ogallala formation were mentioned. Pope also proposed the Committee be directed to review the methodology employed by each state in preparing estimates of consumption from ground water sources. Both motions were properly seconded and carried unanimously.

The Engineering Committee met during the noon-time recess. Committee members later reported they had reached agreement on the final Engineering Committee Report. It was decided to strike the entire last paragraph on the first page ("Computations of 1995 Virgin Water Supply and Consumptive Use") along with Tables 1, 2 and 3. In their place it was agreed to substitute, "Due to concerns raised during the course of the Engineering Committee meeting as well as subsequent to it, the numbers prepared were not endorsed by the full committee and are therefore not attached." With these modifications, Pope moved to receive

the report; Simpson seconded. Motion carried.

After extensive discussion of Kansas' and Colorado's concerns with Nebraska's methods, the Commissioners assigned the Engineering Committee to review the various methodologies to determine alluvial wells and to recommend an operational definition for the alluvium. In addition, the Commissioners requested the Engineering Committee review the methodologies employed by each state to estimate consumptive use and to make a recommendation for a methodology which could be used to produce 1995 estimates which could be agreed upon by the end of October so they could meet and give the Engineering Committee additional guidance prior to the end of the year. On questioning by Nebraska, Kansas stated it was not specifically concerned with the use of meter information in the Upper Republican NRD.

LEGAL COMMITTEE REPORT

Representatives of the Legal Committee offered no report.

OPEN FORUM

Nebraska State Legislator Ed Schrock

Senator Schrock commended the Kansas and Nebraska individuals involved with Compact negotiations for trying to resolve differences of opinion. To that end, he pledged support as a member of the State Legislature.

Wayne Heathers

Heathers spoke as the co-chairman of the Nebraska Republican River Basin Water Management Districts Coalition referred to as the Basin Coalition. The Coalition has been in existence for two years. During this time, members have educated themselves on various issues of the basin. Three issues are of greatest concern: implementation of LB 108, renewal of water service contracts between the Bureau of Reclamation and the irrigation districts, and issues involving the Republican River Compact.

With the passage of LB 108, the Coalition recommends NRDs apply for an integrated water management area from the Department of Water Resources. The process would become a partnership or cooperator approach to resolve issue where everyone is involved.

Lee Orton

Attorney Orton represents the Irrigation Projects Reauthorization Council, a group of 10 irrigation projects located in Kansas and Nebraska. Most of Orton's clients are irrigation projects located in the Republican River Basin of Kansas and Nebraska. The Council was created as an entity to aid member districts in renewing contracts with the Bureau of Reclamation.

OLD BUSINESS

Jess renewed a previous request for reports of historical document research. Specifically, he requested Kansas share reports of research conducted by Doug Littlefield. It was said the research might be useful to Compact commissioners in resolving disputes.

Pope responded by saying Kansas is willing to share the documents in question, but only if others would share expenses.

NEW BUSINESS

As the only element of new business, Jess proposed the following resolution:

WHEREAS the Administration of the Republican River Compact Commission gathered to meet in Cambridge, Nebraska, on June 5 and 6;
WHEREAS the administration was hosted to a reception and dinner by a number of local representatives;
IT IS HEREBY RESOLVED that the following be recognized and commended for a fine evening that promoted the spirit of cooperation and an interstate comity that is central to the Republican River Compact:
Cambridge Telephone Company
Frenchman Cambridge Irrigation District
First National Bank of Cambridge
First Central Bank
City of Cambridge
Cambridge Lyons Club
Jim Tenopir family
Roy Patterson

Pope seconded the motion, and it was passed unanimously.

COMMITTEE ASSIGNMENTS

Legal Committee

The Legal Committee members assigned by the Commissioners are: Don Blankenau for Nebraska, DeAnn Hupe Seib for Kansas, and Cliff Seigneur for Colorado.

Engineering Committee

The Engineering Committee members assigned by the Commissioners are:

Nebraska	Colorado	Kansas
Ann Bleed	Dick Stenzel	David Barfield
Mike Thompson	Bill McIntyre	Leif Holliday
Russ Oaklund		Scott Ross

SETTING OF 1997 ANNUAL COMPACT MEETING

The Compact Administration selected June 5, 1997, for its next Annual Meeting to be held in Colorado.

ADJOURNMENT

No response was given when Jess asked if there was further business to discuss. The meeting was adjourned at 1:52 p.m.

J. Michael Jess
Nebraska Commissioner (Chairman)

Hal D. Simpson
Colorado Commissioner

David L. Pope
Kansas Commissioner

REPORT OF THE ENGINEERING COMMITTEE TO THE REPUBLICAN RIVER COMPACT COMMISSION FOR THE 1995 WATER YEAR

The Engineering Committee for the Republican River Compact Commission met May 7, 1996 in Lincoln, Nebraska. Attending the meeting were David Barfield from Kansas; Richard Stenzel and William McIntyre from Colorado; and Michael Thompson, Russell Oaklund and Ann Bleed from Nebraska.

Agenda

At the annual meeting on June 8, 1995 the Engineering Committee was requested to: 1) Calculate the virgin water supply and consumptive use in accordance with the compact formulae; 2) Review the Bureau of Reclamation's Regression Equations for Modeling Harlan County Reservoir as published in "Republican River Basin Flows, Flows Adjusted to 1993 Level of Basin Development" by Lane, Norval and Weghorst, U. S. Department of Interior Bureau of Reclamation, October 1995; 3) Review the ground water studies of the Republican River Basin; and 4) Review and recommend options for maintaining gaging stations used by the Republican River Compact but not operated by the U. S. Geological Survey. In addition to the four above committee assignments, three additional items were added to the agenda by Barfield: 5) Review and discuss the methodology used by each state to determine ground water consumptive use; 6) Determine whether the virgin water supply and allocations needed to be adjusted every year; and 7) a Determine whether flood flows should be included in the calculation of the virgin water supply. A review of how each state calculated consumptive use was added because Nebraska has more precisely delineated the boundaries of the alluvial aquifer in Nebraska, has revised its methodology of determining the number of acres irrigated by ground water wells and, for the area in the Upper Republican Natural Resources District, has started using actual pumpage data instead of estimates based on irrigation requirements.

Computation of the 1995 Virgin Water Supply and Consumptive Use

Due to concerns raised during the course of the Engineering Committee meeting, as well as subsequent to it, the numbers prepared were not endorsed by the full committee and are therefore not included in this report.

Review the Bureau of Reclamation's Regression Equations for Modeling Harlan County Reservoir as published in "Republican River Basin flows, Flows Adjusted to 1993 Level of Basin Development" by Lane, Norval and Weghorst, U. S. Department of Interior Bureau of Reclamation, October 1995

The Engineering Committee members reviewed this Bureau report, which was prepared as background for contract renewal with the basin's irrigation districts. The purpose of the report was to estimate inflows to Harlan County Reservoir under 1993 development conditions and historic climatic conditions. The data are to be used as input to computer models, which will be used to assess management alternatives. Given the nature of the data available for analysis, the committee concluded the Bureau did the a reasonably good job of developing a method to adjust historical inflow data to reflect current development conditions.

Essentially the study developed a basin factor that could be used to adjust the historical data. The basin factor is simply an index which allows the adjustments of the flow data to fit historical development patterns. There was no attempt to separate or analyze the interrelationship of the causal components of the basin factor or to project how these separate components might impact flows in the future. Thus, the basin factor is merely an index for development.

The Engineering Committee cautions that the basin factor cannot be used to extrapolate flows into the future. The only condition under which extrapolation into the future would be accurate would be if future development trends occurred just as they had in the past. If however, the rate of development of conservation activities or well usage changes, there would be no way of knowing how to change the basin factor to accommodate the differences. The Bureau report itself recognizes this limitation. The report states "Further, a strong caution is expressed against using the basin factors and their flow relationships established in this study to predict future water supply." p. 13 The Engineering Committee feels this statement needs to be emphasized.

Review of Ground Water Studies of the Republican River Basin

The Engineering Committee focused on the three most recent modeling studies of the basin. We looked at the studies to see what they could tell us about the stream flows and the impact of pumping from the Ogallala formations on the renewable water supplies in the Republican River. The studies described ground water models that were calibrated to mimic the changes in ground water levels and stream flows for the area between the Platte River basin on the north and the Republican River basin on the south (Figure 1). A brief summary of each study is presented in Appendix A.

All studies used the calibrated models to predict the impacts of continued ground water development. The results indicated there were and would continue to be water level declines in the ground water formations between the Platte River and the Republican River and declines in the outflows to the surface water system of the Republican River basin. Other useful information in these reports included geological descriptions of the area and documentation of historical water level increases and declines. Most of the increases occurred in the Platte River basin. Ground water levels and stream flows were shown to have declined in many areas in the Republican River Basin. Perennial reaches of tributary stream have also shortened in the western part of the basin.

The committee concluded that the studies and models were useful for looking at ground water level and stream flow changes that have or could occur in the area.

It should be noted however that the predicted declines in the oldest of the studies, on the middle Republican area, have not occurred. Barfield also observed that in the past the Compact Commissioners have excluded the Ogallala because its impact on the virgin water supply could not be quantified. These studies do not give a quantification of the impact of the Ogallala, but the models do have node points that indicate the present day level of depletions to stream flows caused by the pumping of the regional aquifers.

In all the studies the Republican River is treated as a boundary for the model. Because the models are constrained along the boundaries, the accuracy of the model in predicting water levels along the Republican River is a function of the modeling assumptions. In addition all the studies describe the Ogallala aquifer in the region as very heterogeneous. The degree to which the Ogallala is cemented varies greatly from place to place and this significantly affects the rate of water movement to the saturated zone. Furthermore, its saturated thickness differs greatly because of the incision of streams tributary to the Republican River. Therefore, it will be difficult to generalize about impacts of pumping in the Ogallala formations on the renewable water supplies of the basin. The Committee concluded that to improve understanding the impact of pumping in the Ogallala formations on the main stem Republican River, a model that extended the model boundary further to the south and did not treat the Republican River as a model boundary condition could be developed.

Barfield also reported that the Kansas' Sub-basin Water Resources Management Team is considering the construction of models on Prairie Dog, Sappa and Beaver Creeks in the near future.

Gaging Stations

Article IX of the Republican River Compact states the United States Geological Survey shall collaborate with the officials of the States administering the Compact in the collection, correlation, and publication of water facts necessary for the proper administration of this Compact. Until 1994 the stations used by the Compact administration were operated cooperatively by the U. S. Geological Survey and the State of Nebraska as part of the U. S. Geological Survey's Cooperative Program. Under this program Nebraska maintained the gages and provided monthly stream flow measurements to the USGS. The USGS provided oversight to the State's work, analyzed the data and provided and published the final stream flow record. In 1993 the USGS discontinued the policy of allowing participants in the Cooperative Program to provide their share of the station costs by direct services. As a result, the State of Nebraska discontinued its participation in the Cooperative Program on all stations in the Republican basin except for Frenchman Creek at Palisade, the Republican River at Cambridge and the Republican River near Guide Rock. Nebraska does provide cash contributions to the USGS to help fund these stations. The USGS has continued to fund and operate ten of the twelve stations used by the Republican River Compact. However, two stations, Beaver Creek near Beaver City and Medicine Creek below Harry Strunk Lake are now being operated solely by the State of Nebraska.

The two Nebraska stations are maintained and operated by the Cambridge Division of the Nebraska Department of Water Resources. The Cambridge Division measures stream flow at these stations with a current meter at least monthly to maintain an accurate gage-discharge rating curve. All measurement notes are checked by the person doing the measurement and by a second person in the division office. More frequent stream flow measurements are made if water administration, gaging equipment problems, or flow events that might change the current rating curve occur. Every year the gage records are analyzed and a flow record is developed by one person in the Cambridge office. This record is checked by a second person in the division office. The final record is reviewed by another hydrographer outside of the Cambridge office. If at any point in this process, the record is

questioned, the record is sent back to the person who worked the original record for possible correction. The final discharges are published in the Nebraska Hydrographic Report and are available electronically from the Nebraska Natural Resources Commission Data Bank. The Nebraska Department of Water Resources is in the process of developing its own stream flow data bank. All initial gaging records and stream flow measurement notes are kept by the Department Division office for at least five years and are then archived in the State of Nebraska's depository.

The Engineering Committee was asked to explore with the USGS options that would enable the USGS to operating these two stations along with the ten other Compact stations currently being operated by the USGS. Bleed consulted with Glenn Engel of the USGS and reported that Engel offered the Compact the following options:

1) Operate the gages as part of the USGS Cooperative Program. Under this option the Compact Commission would pay an annual fee of around $4100 per gage. The USGS would fund the other half of the cost of operating the gage and would be solely responsible for operating the gage and providing the flow data in electronic and book form. Stream flow measurements would be made on a six week schedule. The fee per gage is approximate because the USGS is uncertain of what the fee will be in the future. A 4% increase in fees is a probability. Under this scenario all stream flow data for the Compact would be available through the USGS.

2) The Compact would pay the USGS approximately $800 per gage per year to review the gage records and produce electronically and publish the final stream record. All data would be available through the USGS. The State of Nebraska would continue to maintain and operate the gages, provide monthly stream flow measurements, and analyze the data.

3) The State of Nebraska would continue to be solely responsible for operating the gages, provide monthly streamflow measurements, analyze and publish the data. Representatives from Colorado and Kansas would have the opportunity to review gaging station operation and maintenance procedures is they so desired. Under this option there would be three ways the data could be disseminated:

A) The USGS would publish the states record but would note that it had not been reviewed by the USGS. Engel indicated that the USGS would prefer not to publish data they had not reviewed.

B) The USGS data could be published along with the State of Nebraska's stream flow data in the annually published Nebraska Hydrographic Report. These data are currently available in electronic form through the State of Nebraska's Natural Resources Commission Data Bank. The Nebraska Department of Water Resources is currently developing its own stream flow data bank. The USGS would continue to publish the records for the stations they operate.

C) The data could be published by both the USGS and the Nebraska Department of Water Resource.

4) Option three could be implemented as stated above with the exception that every year the final records produced by Nebraska would be sent for final review to the states of Colorado and Kansas.

In options 1 and 2 above, the data would be reviewed by the USGS. In option 3 the data would be reviewed only the Nebraska. In option 4 the data would be reviewed annually by all three compact states. In all cases the data used by the Compact would be available from one source, but in option 3B, the source would be the State of Nebraska. For all other options the data will be published by the USGS.

The Engineering Committee concluded that from a technical perspective, any of the four options would provide equally accurate data. All states indicated a willingness to review the gaging data produced by Nebraska if the Commissioners felt this was necessary to assure comfort with the level of accuracy of the data. The real question is whether the Compact Commissioners see sufficient value in having the USGS operate the gaging stations to justify paying the cost of cooperating with the USGS .

Review and Discussion the Methodology Used by Each State to Determine Ground Water Consumptive Use

Nebraska's Methodology

Bleed explained that in order to increase the accuracy of the ground water pumpage reported by Nebraska, the state contracted Vince Dreeszen, Professor Emeritus from the Conservation and Survey Division of the University of Nebraska, to review well logs and determine, based on the geology, the extent of the Republican River alluvium. Dreeszen was also asked to identify which of the wells previously considered to be alluvial by Nebraska were in fact pumping from the alluvium. Before 1991 all wells within a mile of the thread of the stream were considered to be alluvial wells. In 1991 Nebraska changed their list to include all wells along the mainstem within the alluvial valley as determined by a 1981 map from the USGS publication Hydrological Reconnaissance of the Republican River Basin, Nebraska by Mike Ellis. On the tributaries, all wells within a mile of the stream were listed as alluvial unless the wells were clearly developed in the uplands. If there was any doubt, the well was considered to be alluvial. Thompson reported that a brief review of the wells along the mainstem convinced Dreeszen that the boundaries as noted on maps from the USGS publication Ground Water in the Republican River Basin in Nebraska by H. A. Waite, E.C. Reed and D. S. Jones, Nebraska Water Resources Survey Water Supply Paper 1, 1944. were accurate. Therefore Dreeszen focused on defining the extent of the alluvium along the tributaries. Based on well logs Dreeszen defined four general types formations in which wells could be developed. The alluvium; the Ogallala formations; Ogallala formations capable of producing flowing wells; and Pleistocene formations with a lithology similar to the Ogallala but not associated with either the Ogallala or the current alluvial valley. Dreeszen then examined and categorized the wells based on the formation(s) from which it derived water. Many wells were pumping from both the alluvium and one or more of the other four types of formations. If there was any water at all produced from the alluvium, the well was considered to be alluvial. For wells pumping from both the alluvium and some other formation, Dreeszen tried to determine how much of the water for the well was produced from the alluvium. Otherwise, if the well was not alluvial or was

drilled through the alluvium, it was dropped from the list. Of the roughly 2700 wells previously listed by Nebraska as alluvial, 358 wells were defined by Dreeszen as wells pumping from Pleistocene or Ogallala formations. One hundred and fifty-seven of these wells were dropped from the list of alluvial wells. The remaining 201 wells are still being examined and therefore have been maintained on the list as alluvial wells. A number of the wells dropped from the alluvial list were on Frenchman Creek, on Stinking Water Creek and along the mainstem. Most of the wells above Enders were Ogallala. For the 157 dropped wells: 96 on the Frenchman were Ogallala wells; 48 on the mainstem were Ogallala and Pleistocene; 12 on Medicine Creek were Pleistocene and Ogallala and one on Red Willow was Ogallala. Nebraska emphasized that this list was still preliminary and would be further refined next year. Barfield requested an up-to-date listing of all wells within the Republican River basin and an indication of changes in the listing due to their review. Nebraska agreed to provide an updated list of the wells used for this year's calculations as soon as it is finalized.

In addition to reviewing the list of wells considered to be in the alluvium, Nebraska made other efforts to improve the accuracy of the ground water pumpage. In the past Nebraska has calculated the amount of water pumped per acre and multiplied the pumpage by the number of acres served by each well as listed on the well registration. All registered wells were assumed to be in use every year. In cases where more than one well was used to serve the same field, acres were double counted. Additionally, this methodology assumed all registered wells were used every year. A new methodology is currently being developed which Nebraska hopes will eliminate these problems. Mike Thompson explained these changes.

Within the Upper Republican Natural Resources District (URNRD) there is a ground water control area. All wells in the area are metered and the meters are monitored by the URNRD. The Upper Republican NRD has a periodic check of meters and a maintenance program. For 1995 Nebraska used the actual metered pumpage as reported by the URNRD for wells in this area. Additionally, the URNRD also measured pumpage for wells outside the control area but within the Republican Basin. These numbers were also used.

In the balance of the Republican River Basin in Nebraska meters are not required on wells. However, the Middle and Lower Republican Natural Resources Districts undertook the task of sending out questionnaires for all registered wells. Among other data, each respondent was asked to list the number of actual acres served by these wells and whether the wells were used in 1995. With the survey the state hoped to get a more accurate assessment of how many acres were actually irrigated in 1995. Forty and sixty percent of the questionnaires for Middle and Lower Republican respectively were returned. The NRD's interpreted the surveys and provided the state with a summary table of the results. If a questionnaire was returned, the state used the acreage reported on the questionnaire in the Compact calculations. If there was no return, the well was assumed to have been used in 1995 to irrigate the number of acres listed as irrigated on the well registration. The NRD's have agreed to continue sending out questionnaires every year. The results of the survey indicate that for wells for which a questionnaire was returned, roughly half of the registered acres were being irrigated in 1995. Barfield requested sample surveys sent out by each of the Districts.

Other than the use of actual pumpage data from the Upper Republican Natural

Resources District, Nebraska did not change the methodology used to compute the consumptive use and pumpage per acre. As in the past the pumpage per acre was determined by subtracting April through August precipitation from 26". Precipitation was determined using Thiessen polygons and weather stations.

Stenzel stated that Nebraska should not deduct the entire precipitation amount from the 26" as this overstates the efficiency of rain to meet the needs of the crops. He stated that the efficiency for precipitation should be more in the range of 60% to 70%. He also asked how the 26" was originally derived. Bleed stated that it was determined to be the average need for the type of crops grown in that portion of the Republican River basin, which is primarily assumed to be corn. It was stated by Barfield and Stenzel that Nebraska should consider using Blaney Criddle to calculate the potential consumptive use for the crops grown. Stenzel believes this methodology would better reflect the type of crops grown each year and the variation in crop needs due to temperatures and precipitation. Stenzel asked how Nebraska calculated return flows from the values as determined above. It was stated by Bleed that, as in the past, the 26" minus April to August precipitation number was multiplied by the number of acres irrigated and divided by 12" to get acre feet pumped. This was the number that was input to the Compact's computer program. Stenzel pointed out that the results should have originally been divided by 75% to reflect the irrigation application efficiency and the result reported as the amount of ground water pumped. That number would then be multiplied by the Compact program to reflect return flows. Barfield and Stenzel stated they felt that the methodology used by Nebraska underestimates the pumpage per acre.

Colorado's Methodology

McIntyre and Stenzel reviewed Colorado's method of defining the alluvium and calculating ground water pumpage. In the 1980's Colorado hired John Romero, a geologist,, to look at well logs and other information on geological deposits to define the extent of the alluvial aquifer. Previously Colorado included all wells within one mile of stream. As a result of Romero's work, a number of wells were dropped from Colorado's list.

Well usage is based on information on questionnaire sent to 133 wells. The questionnaire asks for information on crops grown, the number of acres irrigated, or, if the well is a municipal or industrial well, the number of gallons pumped. The questionnaire response rate is 60%. A spreadsheet is used to compile the data from questionnaires.

For wells without a response Colorado calculates pumpage. Using weather stations data from four stations, Thiessen polygons are used to estimate precipitation for each irrigated area. Consumptive use per acres is then estimated using a TR-21 Blaney Criddle methodology. The crop distribution used, to come up with crop use by type includes corn, alfalfa, small grain and other (beans, and pasture grass). From these calculations Colorado determined the average crop irrigation requirement was 1.4 feet per acre. The consumptive use figures are divided by an efficiency factor of 75% to calculated the amount of water pumped. New studies indicate that the majority of farmers not getting 75% efficiency, however Colorado decided continue to use the 75% figure since this is what is used in the compact calculations.

Kansas' Methodology

Barfield reported that ground water pumpage numbers are based on a water use reporting system. Both surface and ground water pumps are included. Beginning in the late 80's Kansas imposed fines for not providing the state with a water use report indicating the amount of water pumped for the water year. At the time of the preparation of engineering committee numbers, reports for 93% of the points of diversions had been received. Water use could be inferred on an additional 5% of the points of diversions which had overlapping water appropriation permits, bringing total reporting compliance to the 98% range. Information provided on the water use reports are either with a totalizing flow meter or by multiplying the number of hours pumped times the rate of pumpage. Kansas officials visit every water right at least once when it is perfected and do a rate test. Kansas officials do not check the meters or pumpage every year but compliance checks are also sometimes made. Different things can trigger a compliance check, including the use of a program which checks to see if the reported pumpage fits with the amount expected to be pumped for that crop that year.

During a general discussion of the consumptive use computations for the Compact, Barfield observed that in some cases the methods used require a conversion of a CU to pumpage and then the Compact calculations reconvert the pumpage to CU. Actual pumpage is used in other cases. The mixture of methods was considered to be undesirable. Additionally, questions were raised about the use of the 75% efficiency factor. McIntrye felt 65% to 75% is about right for Colorado. Although the pumpage calculations are not comparable and there are questions regarding the validity of the 75% efficiency factor used by the compact, the Engineering Committee did not feel the resulting error was worth further investigation at this point in time.

Determination of Whether the Virgin Water Supply Needs To Be Adjusted Every Year and Whether Flood Flows Should Be Included in the Calculation of the Virgin Water Supply.

Barfield raised the issue of whether the Compact required the virgin water supply and allocations to be adjusted in response to climatic variations every year. He suggested that the compact would allow adjustments to the virgin water supply and allocation to be done every five or ten years. Barfield also questioned whether flood flows should be included when calculating the annual virgin water supply. The Committee decided these were issues that should be discussed by the Compact Commissioners rather than by the Engineering Committee.

David Barfield, Kansas

Ann Salomon Bleed, Nebraska

Richard Stenzel, Colorado

Michael Thompson, Nebraska

William McIntyre, Colorado

Russell Oaklund, Nebraska

APPENDIX A

Hydrogeology of the Tri-Basin and Parts of the Lower Republican and Central Platte Natural Resources Districts, Nebraska

by J. M Peckenpaugh, J. T. Dugan, R. A. Kern and W. J. Schroeder
U.S. Geological Survey Water-Resources Investigations Report 87-4176

Prepared in cooperation with the Nebraska Natural Resources Commission Lower Republican Natural Resources District, 1987.

Study Area

The study area covered 5600 square miles in south central Nebraska between the Platte and Republican Rivers. Counties included in the area are: Gosper, Phelps, Kearney, Furnas, Harlan, Franklin , Webster, Dawson, Buffalo, Hall, Lincoln, Frontier, Red Willow and Adams.

Purpose

The hydrogeologic system in south-central Nebraska was described and modeled to evaluate the quantitative effects of management practices on water levels, streamflow, and surface-water seepage.

General Method of Investigation

Computer programs were developed to represent the hydrologic regime of four components of the system: the surface-water system, soil zone, unsaturated zone, and saturated zone. A digital finite-element, ground-water-flow model, RAQSIM (Regional Aquifer Simulation Model by Cady and Peckenpaugh, 1985) was used to represent the hydrogeolgoic conditions. Data for the model was obtained from logs of test holes from published reports and unpublished data. New field data included: 23 test holes, mass water-level measurements in the spring of 1981 and fall of 1981 and spring 1982; water samples in 68 locations; 1980 land use map; and 18 water use sites studied for 2 to 3 years to collect data on the amount of water pumped for different crops, soils, and climatic conditions.

Computer programs for Potential Evapotranspiration (PET) and the soil Moisture Program were developed and used to represent the movement of water in and through the soil zone. The programs require climatic, soil and crop data to calculate both the amount of water that will pass through the soil zone to become recharge to the aquifer and the Crop Irrigation Requirement (CIR) of the crops. PET computes the monthly potential ET using the Jensen-Haise method (Jensen et. al 1969). The Soil Moisture Program simulates infiltration, storage and removal of water from the soil on a monthly basis in order to compute the recharge to the underlying saturated zone. The Soil Moisture Program requires values for (1) monthly PET, 2) crop coefficients, which are the monthly ratios of consumptive water requirements to PET for row crops, sorghum, alfalfa, small grain, pasture and range; 3) precipitation, and infiltration-curve coefficients and infiltration curve numbers that are dependent on soils, topography and land use; 4) available water capacity for eight soil groups, and (5) crop root-zone depths.

Recharge and Discharge Programs were used to compute the net recharge and discharge to and from the saturated zone for each finite element in the ground water flow model for each period of time. The ACRES Program calculates the number of acres of each land use type in each finite element for both irrigated and dryland. The inputs to this program included the 1980 land use inventory developed from remote sensing data and aerial photography and the distribution of irrigated acres throughout the study period. Current land use map and registered well records through time were used to linearly interpret back through time the number of irrigated acres in the area.

The PUMP Program used the results of ACRES and other data to compute recharge to the aquifer and CIR values for each element in the model for the nonirrigation period and for the irrigation period. The data used by the program include: historical land use data (ACRES), recharge and CIR for irrigated land and dryland for nonirrigation and irrigation pumping periods (Soil-Moisture); 3) distribution of soil groups within each finite element; 4) weighting factors for each element which are used for distribution recharge and CIR values; 5) location of surface water irrigated lands in finite elements; 6) location of reservoirs and seepage from reservoirs within the finite elements; 7) municipal pumpage estimated from communities greater than 500 people by using an estimate of 300 gpdpc and 8) surface water seepage from canals.

In the ground water flow model streams were represented by reaches with nodes on each end. Nodes where water levels are not allowed to change are referred to as known heads. There are 117 known head nodes in the model. Most of the known head nodes are on the boundary of the study area; however, a few occur at reservoir sites. At the known head nodes water levels are linearly interpolated between measured water levels in 1940, 1965, and 1981. RAQSIM adds or removes water from nodes so head is constant.

Calibration

The calibration period was from 1940 to 1981.

Results

The underflow into the study area was determined to be 116,700 a.f. in 1940 and 82,800 a.f. in 1981. The underflow to areas along the southern border of study area is negligible. Underflow of ground water along the eastern border is 42,100 a.f. in 1940 and 45,000 a.f. in 1981. Sensitivity analyses indicated that water levels rose sharply as recharge increased from 1 to 1.25 times initial recharge value; transmissivity increases of 1 to 2 times the initial value decreased water levels moderately; Specific yield increases up to 1.75 times the initial value caused water levels to decline slightly and decreasing specific yield to .75 caused water levels to rise slightly. The model is most sensitive to changes in recharge.

The difference between the computed and measured 1981 water levels ranged from less than 10 feet to 15 to 20 feet. Maximum computed water level declines of 50 feet occur in northeastern Webster County and declines of 40 feet in area the area west of Harlan County. When the model was run with a scenario of no additional irrigation development, the model showed that by the year 2000 in

areas along the Platte water levels rose to levels exceeding 10 feet with a maximum rise of 40 feet in northern Gosper County. In a much larger area to the east of the area with higher water levels, water level declines in excess of 10 feet were common. The maximum decline was 30 feet.

Other Useful Information

Loess plains cover the area in the north, loess hills, canyons and Republican breaks border the section along Republican River. The divide between the Platte River and the Republican River basins is not distinct. The silty, eolian deposits of loess sloping west to east from 2600 feet in Gosper to 1900 feet in Webster County lack external drainage and are dotted with numerous small basins and depressions (Rainwater Basins). The loess hills and canyons at the edge where the Ogallala formation is present but discontinuous, creates small tablelands. Where the Ogallala is absent in the south, the hills are more rounded. The Platte River has very little valley incision by tributary development; the Republican and its tributaries are well entrenched and occupy a position 200-300 feet lower than the Platte River.

The surface of the area is unconsolidated Quaternary deposits except where they have been eroded by streams, mostly along Republican River and its tributaries. The Quaternary deposits are sands, gravels, silts, and clays of fluvial origin and sands, silts, and clays of eolian origin. The deposits thin toward the south and to the east. The Ogallala Formation of Tertiary age occurs below the Quaternary over much of area except where eroded in central and southern Franklin County north of the Republican River and in Webster County along the Republican River valley and tributaries. The Ogallala formations are up to 300 feet thick in south west Dawson County. The Ogallala formations consist of calcareous silt, silty or sandy clay, and fine to medium grained sand. Undifferentiated silt, clay and sand predominates; quartzite and mortar beds, lenses of sand and silt that were cemented by secondary accumulations of silica are common.

Hydrogeology of Parts of the Twin Platte and Middle Republican Natural Resources Districts, Southwestern Nebraska

by J. W. Goeke, J. M. Peckenpaugh, R.E. Cady and J.T. Dugan
Nebraska Water Survey Paper No. 70 Conservation and Survey Division, IANR. UNL 1992.

Study Area

Between South Platte and Platte Rivers and Republican River in Lincoln, Hayes, Frontier, Dawson and Gosper County: 3,970 square miles.

Purpose

The purpose of the study was to describe the hydrogeologic system and identify changes in that system from 1935 to 1978. The model could then be used to evaluate quantitatively the effects of management practices on seepage losses.

General Method of Investigation

The study analyzed four water system components: the surface water system, the soil zone, the unsaturated zone and the saturated zone. The geology of area was defined by drilling 58 test holes. Soils were grouped according to existing county soil surveys. Soil-zone and recharge-discharge models were used to estimate fluxes. RAQSIM, a finite element groundwater flow model of the saturated zone was used to analyze ground water interactions. Discharge from wells was set to zero where the simulated water level fell below the base of the aquifer. The southern boundary, the south side of the Republican River was simulated as a no-flow boundary. The aquifer south of the Republican is very limited. Since the river is included in the stream network, flow from the aquifer or to the aquifer along this boundary is simulated as flow from or to the river. Throughout the simulation, the northern boundary at the North Platte and Platte Rivers was considered a known-head boundary with the water level fixed at the water surface. Treatment of the east and west boundaries depended on the simulation.

Evaporation and transpiration from groundwater was not simulated. The largest area of shallow groundwater exists between the North Platte and South Platte rivers, which were modeled as known-head boundaries, thus forcing the nodes between the two rivers to maintain a fairly constant head regardless of fluxes. A similar situation exists with nodes along the Platte and Republican rivers, where these steams are also simulated as known-head nodes.

The model was calibrated to the 1935 through 1978 period by decreasing the differences between the measured and computed water levels and stream flows to acceptable levels. The model was then used to simulate three development scenarios: 1) minimum development with no additional acres irrigated after 1980, 2) a moderate development of 2.5 percent increase; and 3) a maximum development of 10 percent increase. All three scenarios were evaluated for ground water application rates of 6, 9, 12, 15, and 18 inches per year.

Results

Given moderate development by year 2020 and 12 inch application rates, recoverable groundwater in storage would decrease by 11.3 percent from the 1980 base line and stream flow in Red Willow and Medicine Creeks would decrease approximately 80 percent from the average simulated flow on Sept 1 and December 1, 1981. Water-level declines of 20 to 40 feet would occur overmuch of the study area by the year 2020.

Other Useful Information

Geological cross-sections and water table and soils maps trace the hydrogeology between the Platte and Republican Rivers. Seepage measurements of streams, canals and reservoirs are also included. The report contains two water table maps, one predevelopment in 1935 and the other 1977-1978, after most of the development, along with a map showing the difference between the two. These maps indicate that the water table rises associated with seepage from Swanson, Hugh Butler, and Harry Strunk lakes generally are as much as 30 ft to 40 ft. Seepage from Culbertson Extension Canal north of McCook has raised the water table 10 - 20 ft in an east-west trending area about 8 miles long. In northeastern Hitchcock County the water table declined < 10 ft. In eastern Frontier County the Orafino (Medicine Creek Area) well shows progressive water level declines since 1975. All other observation wells showed declines during pumping but no decline in spring water levels.

Bureau records were used to estimate seepage for six Republican River canals: Culbertson, Culbertson Extension, Red Willow, Cambridge, Meeker-Driftwood, and Bartley.

Seepage losses in the Republican Basin are much smaller than those along the Platte River. The seepage losses, however, do have an effect on local ground water conditions. Seepage from the reservoirs is also provided. Lake Maloney, in the Platte River basin, has a loss from seepage two - four times larger than seepage losses from Hugh Butler and Harry Strunk lakes, even though all are similar size. Swanson Lake has higher losses than Butler and Strunk.

The saturated zone consists of Holocene to Pleistocene alluvial deposits and the Ogallala Group of Miocene age. The more recent alluvial deposits are in the North and South Platte and Platte and Republican valleys. The Ogallala group underlies the upland area between the Platte and Republican Rivers. The composition differs greatly in short distances. Absent in the Republican Valley, the Ogallala thickens steadily northward to a maximum of about 500 feet in the Platte valley. As the water table slopes toward the Republican Valley in Frontier and Hayes counties, greater thicknesses of the Ogallala sediments cemented with calcium carbonate are also included in the unsaturated zone. The degree to which the Ogallala is cemented varies greatly from place to place and this significantly affects the rate of water movement to the saturated zone. Although the Ogallala is continuous across Hayes and Frontier Counties, its thickness and saturated thickness differ greatly because of the incision of streams tributary to the Republican River (Red Willow, Medicine, Muddy Creeks).

In the Republican valley, the Pleistocene sand and gravels are the principal

source of groundwater because the river removed the Ogallala and the Pleistocene unit is underlain by impermeable shale. (Note: The cross sections in the report indicate that a ridge of Pierre Shale rises to pinch off the Ogallala near the Republican River mainstem in the western area. Also, looking at the cross sections, there appears to be about 100 feet saturated Ogallala in the township north of Stratton and north of McCook , Arapaho, and east of Cambridge.)

A conspicuous feature of the bedrock surface is the buried valley that underlies the present Republican River valley. This trough probably was carved into Cretaceous bedrock in the late Tertiary or early Pleistocene time and then was filled with sediment before it was reexcavated by erosion during the late Pleistocene time. The Republican River may have deepened the valley somewhat before it deposited the alluvium on which it now flows.

Simulated Response of the High Plains Aquifer to Ground-Water Withdrawals in the Upper Republican Natural Resources District, Nebraska

by John M. Peckenpaugh, Rich A. Kern, Jack T. Dugan and John M. Kilpatrick

U. S. Geological Survey Water-Resources Investigations Report 95-4014. Lincoln, Nebraska 1995.

Study Area

The area modeled extends from the South Platte River on the north to the North Fork of the Republican River and the Republican River on the South. The east and west boundaries extended a few miles into Colorado on the west and about a mile east of the eastern boundaries of Perkins, Chase, and Dundy Counties on the east.

Purpose

In the mid-1970's Lappala (1978) developed a digital ground-water flow model to assess the impacts of ground-water withdrawals on water levels in the aquifer and stream flows of the Upper Republican NRD north of the Republican River for the years 1952-1975. The 1995 study is an update of the Lappala study

General Method of Investigation

The impacts of ground-water withdrawals were assessed by a three-dimensional, finite-difference, ground-water-flow model, MODFLOW by McDonald and Harbaugh, 1988. The South Platte River and the Republican River and Enders Reservoir served as constant head boundaries in the model and thus their stream flows were not simulated. However, interior streams were modeled using a stream-routing package. The streams that were modeled included Western and Sutherland Canals; Stinking Water, Spring, and Frenchman Creeks in Chase County and Buffalo, Rock, Horse, Spring, Indian and Muddy Creeks in Dundy County. The model itself was calibrated under steady-state conditions to simulate the flow system in the aquifer before extensive pumping began. The model was calibrated under transient conditions by simulating the period between 1952 and 1989. The calibrated model was used to simulate two different pumping scenarios: one using a calculated Crop Irrigation Requirement (CIR) to estimate pumpage and a scenario pumping 13 inches per year.

Results

The calibrated steady state condition exhibited a root mean square error or water level between modeled and actual water levels was 30 feet. The mean absolute error was 23.5 feet with a maximum absolute error of 80 feet. The transient condition calibration produced simulated water levels within 10 feet of actual conditions for much of the study area with maximum differences of around 40 feet in Dundy County and near the Republican River. A figure showing the differences between actual and simulated water table elevations indicated that many of the differences occurred along the Republican River, with the model showing water table elevations as much as 30 feet below the actual. The root-mean-square error was only 8.8 feet. The comparison of actual and simulated stream flows for the interior streams compared reasonably well.

When the calibrated model was used to simulate the CIR scenario, projected water level changes in 2030 declined from 0 to 30 feet along the Republican river and as much as 50 feet in northern Chase County. Stream flows also declined: Frenchman Creek near Imperial declined from 32.6 cfs in May of 1989 to 10.2 cfs in May of 2030; Rock Creek near Parks declined from 11.4 cfs to 5.4 cfs. The 13 inch scenario projected water level declines in year 2030 of 80 - 90 feet in northern Chase County and a stream flow of 1.6 cfs and 4.2 cfs at Frenchman Creek and Rock Creek, respectively.

Other Useful Information

The report includes data on stream flow and data and maps of well development and water levels in 1952 and 1989. Seepage measurements made in the fall of 1952, the spring and fall of 1975, the fall of 1983, and the spring of 1989 indicate decreased seepage from the aquifer to streams. Base flow dropped from 53 to 26.4 cfs on Frenchman Creek near Imperial and from 14 cfs to 11.2 cfs at Rock Creek at Parks between 1975 and 1989. The perennial reaches of Frenchman, Stinking Water and Spring Creek were also shortened two to three miles between 1975 and 1989.

The first irrigation well was drilled in 1913; by 1950's more than 90 additional wells were drilled. By 1975 there were more than 1,700 registered irrigation wells with only 400 more by 1989. A map of water level changes between 1952 and 1989 showed changes ranging from an increase of 20 feet near the South Platte River to a decrease of 40 feet along the Republican River. Some of the greatest water level declines occur in areas with few registered irrigation wells. Flow into the aquifer along the western boundary was calculated to be 42,430 acre feet in 1952 and 32,800 acre feet in 1989, a decrease of 9,630 acre-feet. Flow out of the area along the eastern edge was calculated to be 52,750 acre-feet in 1952 and 50,130 acre-feet in 1989. There was a calculated net decrease in ground-water storage between 1952 and 1989 of 6.25 million acre feet. Pumpage from the aquifer removed 7.51 million acre feet during this same period.

Digital Model of the Ogallala Aquifer of the Northern High Plains Colorado

by R. Luckey and W. Hofstra
Colorado Water Resources Circular No. 24

Study Area

The study area includes parts of Sedgwick and Yuma counties and all of Phillips County (see attached Figure 2).

Purpose

A finite difference model of a 1,400 square mile area in the northern high plains of Colorado was developed and used to make predictions for the 1971-1980 period and for the 1964-2000 period assuming a) no new development and b) the addition of 610 new wells during the period 1971-1980.

General Method of Investigation

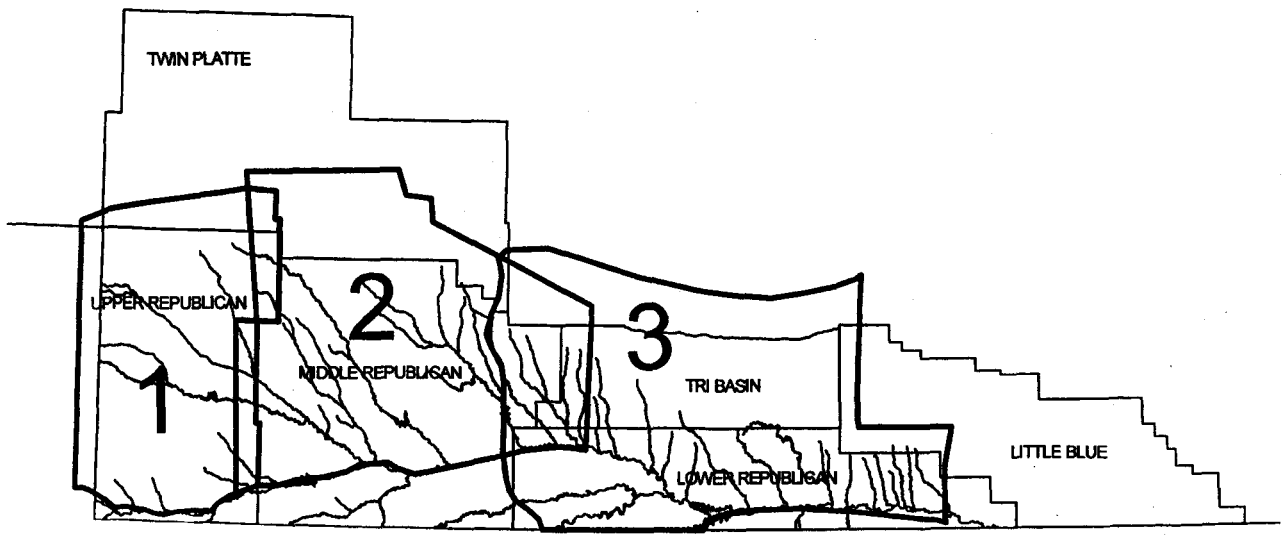
The model was based on the information presented by Hofstra, Major, and Luckey (1972). The model used software developed by Pinder (1970), a finite-difference technique. The model appears to be similar to, or the predecessor of, the U.S.G.S. MODFLOW model. The model was verified by comparing predicted and observed water level changes between 1964 and 1970.

Results and Other Useful Information

The model was most sensitive to changes in pumpage which were only estimated within broad limits. The model was almost as sensitive to specific yield. The model was less sensitive to recharge and least sensitive to hydraulic conductivity. The model predicted ground water declines, with the most significant declines in the southeast part of the modeled area. Under the assumption of no new development, assumption a) declines greater than 50 feet were predicted in the southeast and south central part of the modeled area by the year 2000. A large part of the modeled area shows a predicted declines of between 40 and 50 feet by the year 2000.

The continued development assumption, assumption b, predicts declines ranging from 10 feet to more than 120 feet by the year 2000. The greatest declines predicted under the continued development assumption occur in the extreme southeast corner of the model area.

Republican River Basin Ground Water Models With Natural Resources District Boundaries



1 Upper Republican Natural Resources District (NRD) by Peckenpaugh et al

2 Twin Platte and Middle Republican NRD's by Goeke et al

3 Tri-Basin and Lower Republican NRD's by Peckenpaugh et al

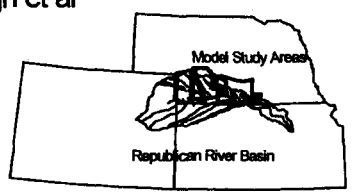


Figure 1

REPUBLICAN RIVER COMPACT MEETING
June 6, 1996
Cambridge, Nebraska

1995 Operations

As shown on the attached Table 1, the precipitation in the Republican River Basin varied from 62 percent of normal at Enders reservoir to 244 percent of normal at Keith Sebelius Reservoir. Total precipitation was near normal at the other reservoirs ranging from 15.52 inches at Red willow Dam to 25.59 inches at Norton Dam.

Inflows varied from 62 percent of the most probable forecast at Enders Reservoir to 244 percent of the most probable forecast at Keith Sebelius Lake. Inflows into Harlan County Lake were 201,800 AF and Lovewell Reservoir 67,465 AF. Inflows into Keith Sebelius were 11,214 AF which is over 2 times the expected most probable amount.

Farm delivery values are as follows:

District	Farm Delivery
Frenchman Valley	5.4 inches
H&RW	5.6 inches
Frenchman-Cambridge	14.2 inches
Almena	4.2 inches
Bostwick in NE	12.6 inches
Kansas-Bostwick	12.2 inches

Operation Notes

Bonny Reservoir--normal operations.

Enders Reservoir--normal operations.

Swanson, Hugh Butler and Harry Strunk Lakes--Swanson started the irrigation season 2.86 feet into the flood pool; Hugh Butler 1.2 feet into the flood pool; and Harry Strunk 2.0 feet into the flood pool. All these reservoirs were full by the end of May.

Keith Sebelius Lake--Reservoir was at its highest level since 1967. There was record precipitation (14.33 inches) and inflow in the month of May.

Harlan County Lake--Last year's high was El. 1951.18 which is 5.2 feet into the flood pool. The lake finished the season at elevation 1940.56 (5.42 feet from full). Inflow for the year was 201,800 AF.

Exhibit #1

Current Operations

Table 2 shows a summary of data for the first five months.

Bonny Reservoir--The outlet pipe has been replaced. An Early Warning System (EWS) has been setup. Bonny is presently .9 feet from full.

Swanson Lake--Presently .5 feet from full.

Enders Reservoir--A toe drain is scheduled to be installed this fall or next year. A reservoir operating restriction may be put in place subject to the completion of the toe drain.

Hugh Butler Lake--Presently 1.0 feet from full. Corrective action studies have been initiated.

Harry Strunk Lake--Target elevation of 2 feet into flood pool. Presently .7 feet into flood pool.

Keith Sebelius Lake--Presently 4.3 feet from full.

Harlan County Lake--Presently .8 feet into flood pool. Since water supply was expected to be sufficient, no specific operation criteria was negotiated for 1996.

Lovewell Reservoir--Presently 2.9 feet into flood pool. Target elevation of 2 feet into flood pool.

Other Items:

Inspections--
All of the dams will be inspected in 1997.

Emergency Management Operations--
Meetings are being held with the local Emergency Management personnel below Reclamation facilities to set up notification procedures.

Water Availability--
Full supplies are available for Frenchman-Cambridge and the Bostwick Irrigation Districts. Almena will have 11 inches available (the District will use 3 inches) and H&RW and Frenchman Valley are expected to deliver 4.5 inches.

Other Reservoirs--
Kirwin reservoir is 2.2 feet into the flood pool and Webster Reservoir is 2.5 feet into the flood pool.

TABLE 1
NEBRASKA-KANSAS AREA OFFICE
Summary of Precipitation, Reservoir Storage and Inflows

CALENDAR YEAR 1995

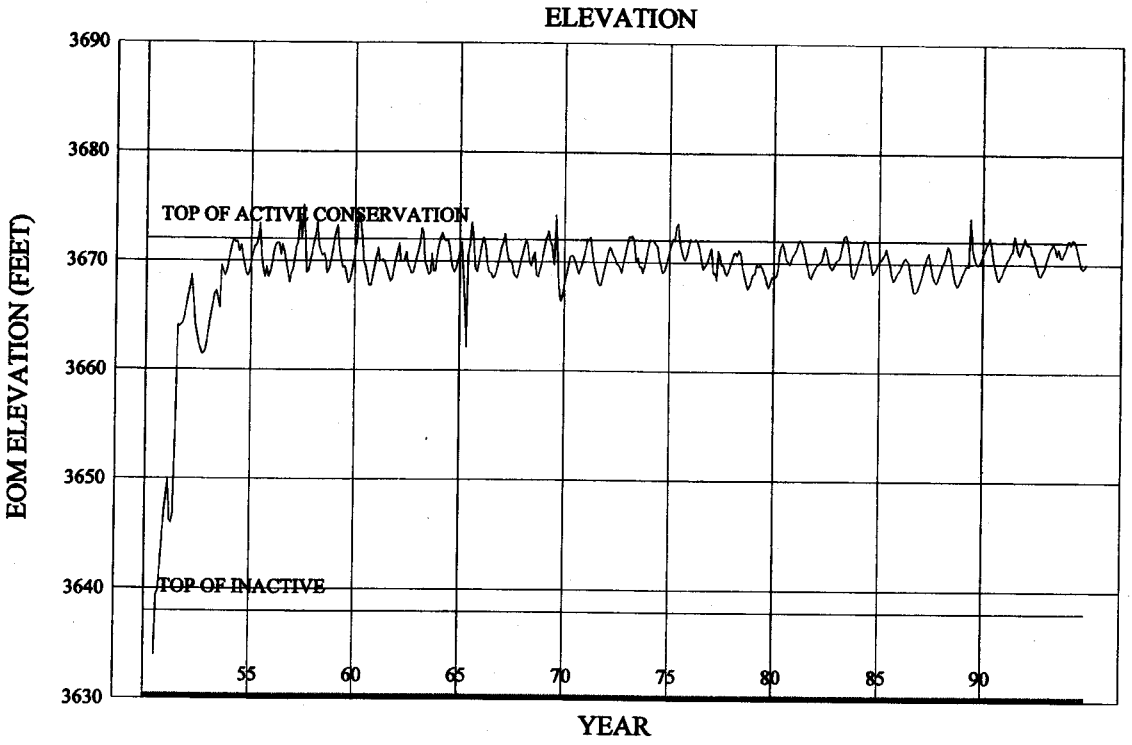
Reservoir	Total Precip. Inches	Percent Of Average %	Storage 12-31-94 AF	Storage 12-31-95 AF	Gain or Loss AF	Maximum Storage Content AF	Maximum Storage Date	Minimum Storage Content AF	Minimum Storage Date	Total Inflow AF	Percent Of Most Probable %
Box Butte	22.32	141	10,813	12,608	1,795	21,743	JUL 4	6,242	SEP 15	20,825	114
Merritt	27.27	141	68,831	68,831	0	76,549	MAY 31	35,714	SEP 13	197,923	112
Sherman	25.23	114	52,722	51,531	(1,191)	69,653	JUN 1	28,546	SEP 11	107,943	96
Calamus	32.12	142	94,714	108,566	13,852	131,437	MAY 30	66,386	SEP 29	318,106	128
Davis Creek	25.26	109	8,385	18,285	9,900	31,535	JUL 3	7,432	APR 16	57,453	168
Bonny	21.18	127	37,485	36,460	(1,025)	45,121	JUN 14	36,213	DEC 16	18,133	107
Enders	18.02	98	24,660	23,334	(1,326)	32,482	JUL 3	18,344	AUG 29	18,911	62
Swanson	21.55	109	85,117	81,238	(3,879)	126,918	JUN 20	73,841	OCT 22	69,414	107
Hugh Butler	15.52	79	32,804	31,465	(1,339)	39,788	JUN 15	29,705	SEP 22	16,813	91
Harry Strunk	19.23	94	28,054	21,613	(6,441)	39,779	MAY 27	13,005	SEP 8	38,366	93
Keith Sebelius	25.59	107	25,216	24,513	(703)	31,957	JUN 16	24,363	NOV 8	11,214	244
Harlan County	22.11	99	285,301	263,580	(21,721)	388,925	JUN 7	248,553	SEP 18	201,800	146
Lovewell	23.15	84	30,970	37,320	6,350	57,380	JUN 5	27,860	SEP 11	67,465	106
Kirwin	28.31	123	98,680	104,330	5,650	144,675	JUN 2	98,120	SEP 11	91,083	542
Webster	28.83	125	82,405	82,482	77	144,654	JUN 5	75,653	SEP 10	157,434	1,249
Waconda	25.80	103	221,194	242,339	21,145	416,682	JUN 10	215,694	SEP 11	538,278	549
Cedar Bluff	24.16	118	69,244	91,680	22,436	98,610	AUG 8	69,244	JAN 1	38,773	467

TABLE 2
NEBRASKA-KANSAS AREA OFFICE
Summary of Precipitation, Reservoir Storage and Inflows

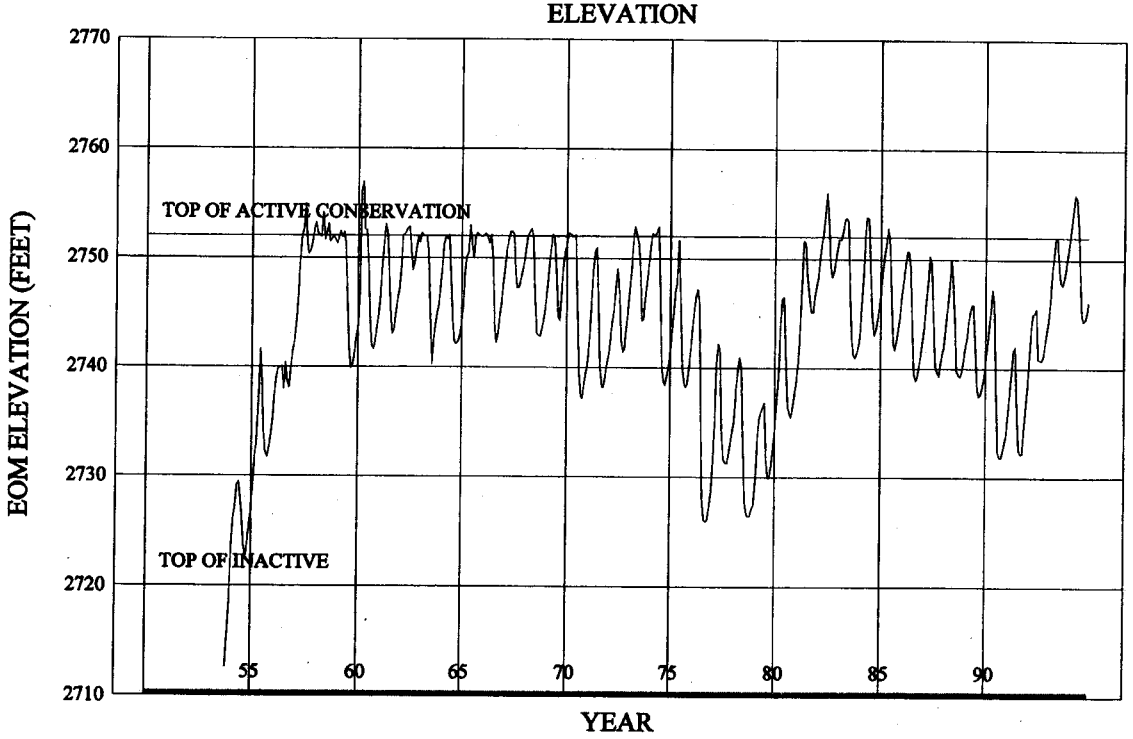
JANUARY - MAY 1996

Reservoir	Precip. Inches	Percent Of Average %	Storage 05-31-95 AF	Storage 05-31-96 AF	Gain or Loss AF	Inflow AF	Percent Of Most Probable %
Box Butte	7.17	118	20,156	20,004	(152)	8,794	88
Merritt	9.45	136	76,549	75,665	(884)	80,490	108
Sherman	8.56	103	69,365	69,076	(289)	26,860	98
Calamus	10.49	125	130,967	129,150	(1,817)	116,957	109
Davis Creek	8.44	102	22,530	27,545	5,015	16,468	88
Bonny	7.16	109	42,161	39,491	(2,670)	7,428	76
Enders	8.88	120	31,507	30,000	(1,507)	8,175	66
Swanson	8.00	114	120,441	107,596	(12,845)	31,247	75
Hugh Butler	6.78	97	39,109	35,426	(3,683)	6,703	78
Harry Strunk	6.83	92	39,499	36,168	(3,331)	16,543	87
Keith Sebelius	9.84	109	31,392	27,097	(4,295)	4,605	200
Harlan County	8.12	102	382,110	321,448	(60,662)	66,874	85
Lovewell	8.68	90	56,300	50,930	(5,370)	16,389	116
Kirwin	6.75	76	143,895	110,680	(33,215)	18,990	200
Webster	6.72	76	143,550	87,060	(56,490)	19,996	244
Waconda	7.70	85	403,255	226,758	(176,497)	95,212	212
Cedar Bluff	8.34	114	91,760	93,200	1,440	6,895	164

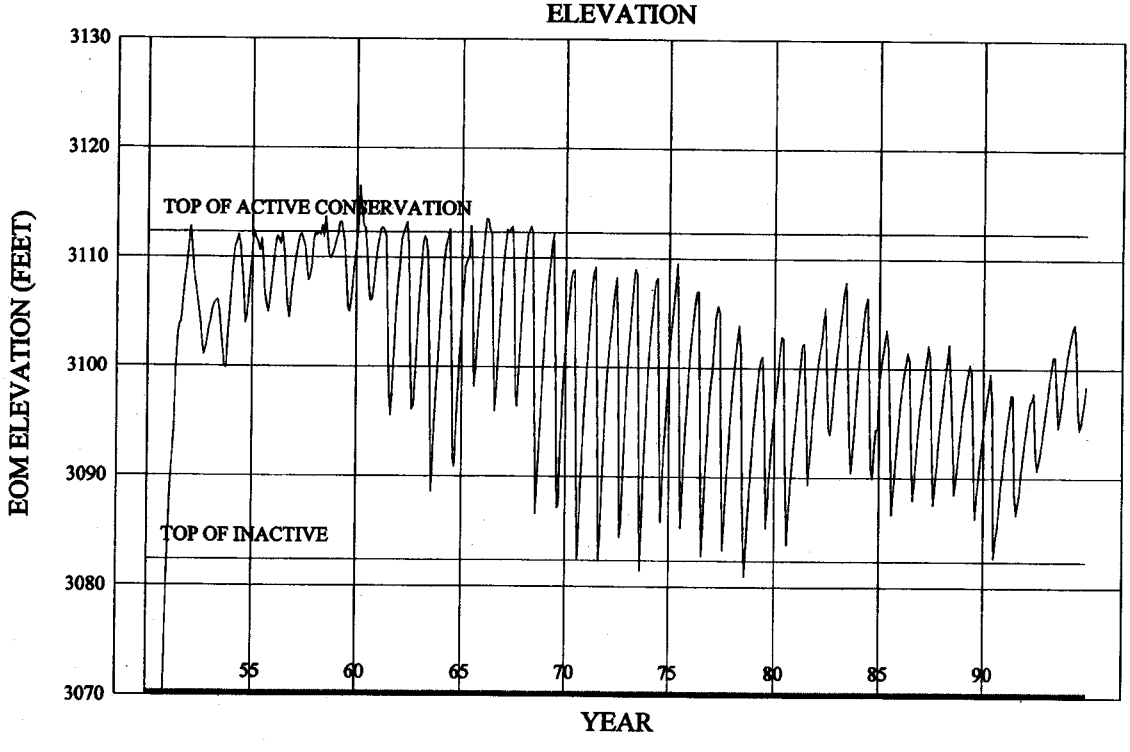
BONNY RESERVOIR



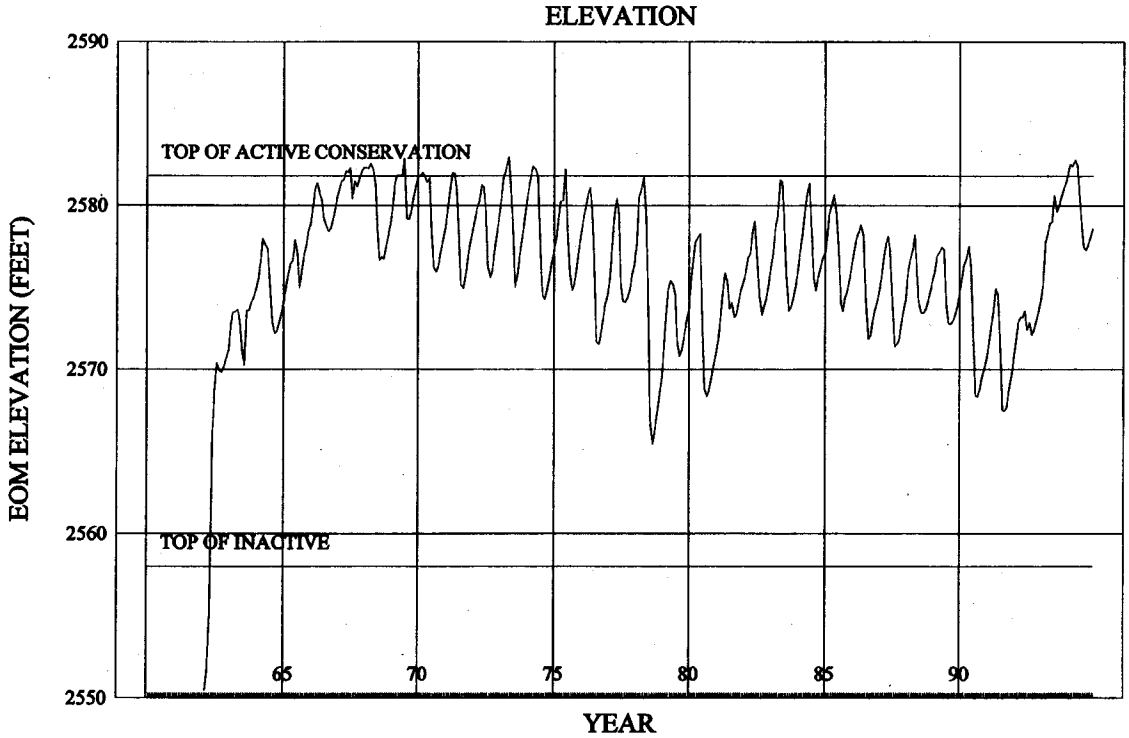
SWANSON LAKE



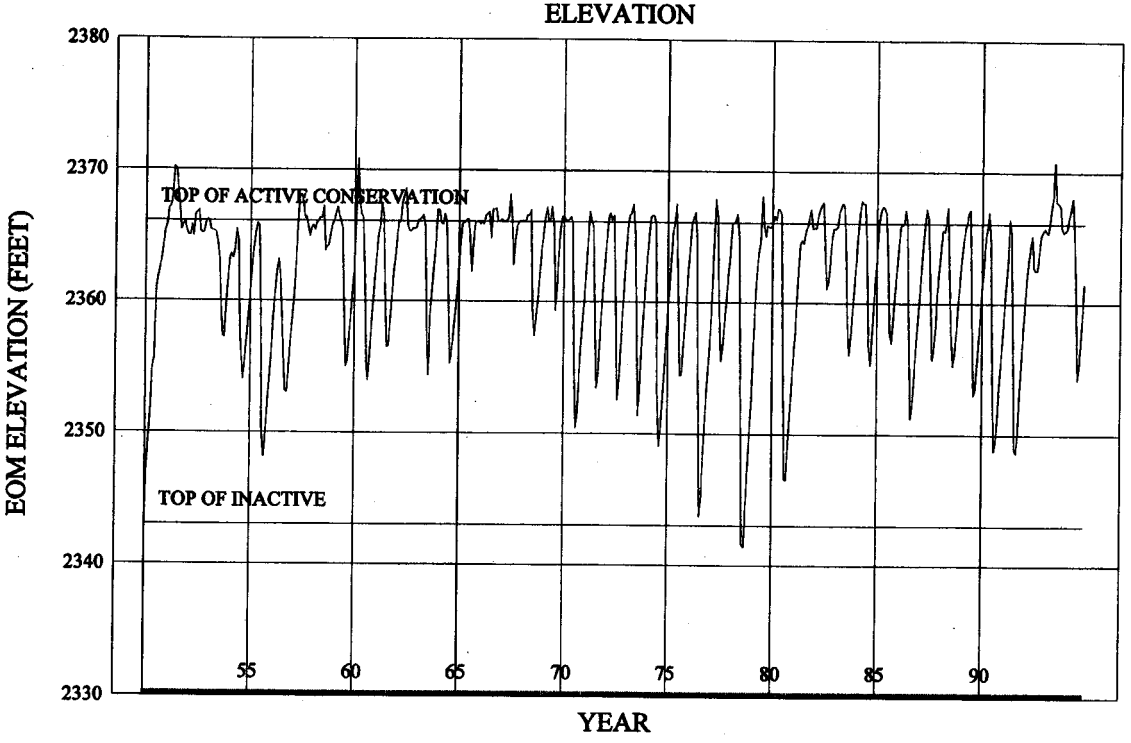
ENDERS RESERVOIR



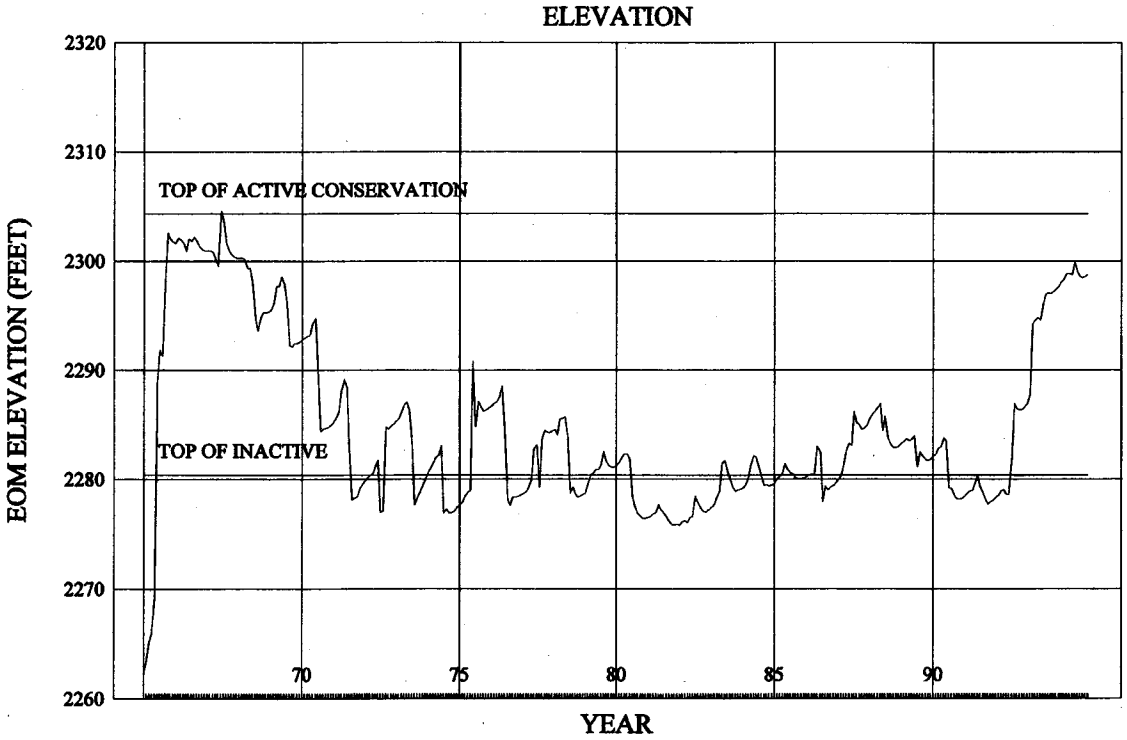
HUGH BUTLER LAKE



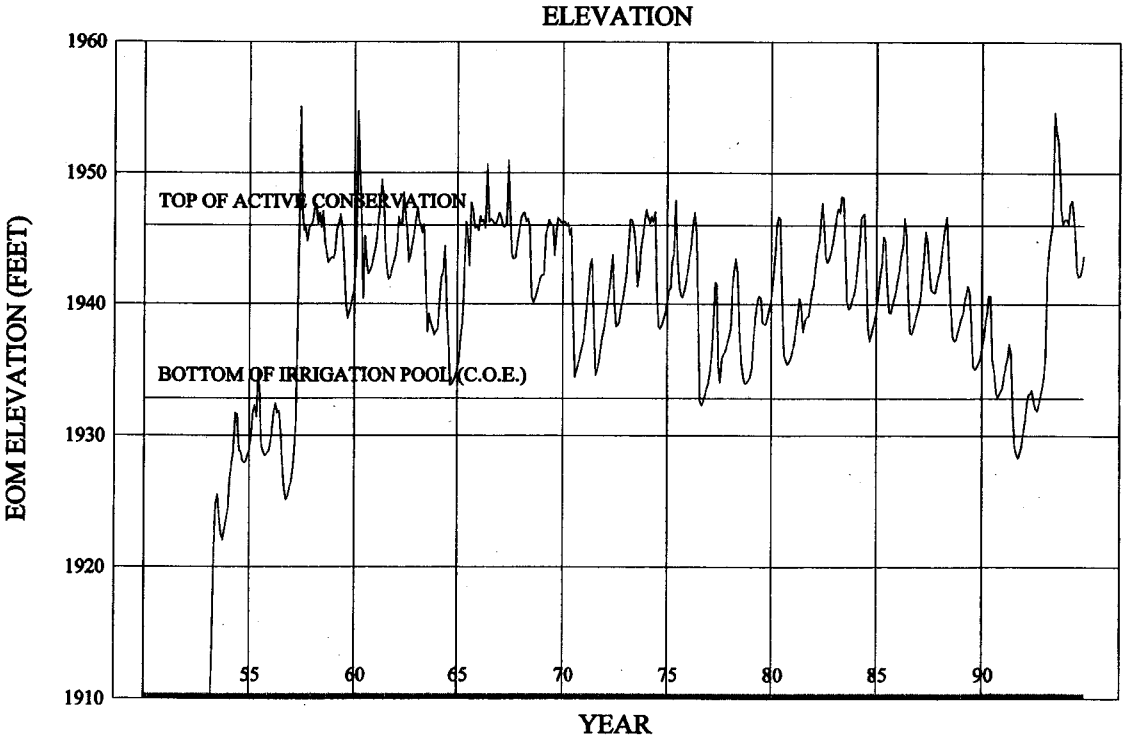
HARRY STRUNK LAKE



KEITH SEBELIUS LAKE



HARLAN COUNTY LAKE



LOVEWELL RESERVOIR