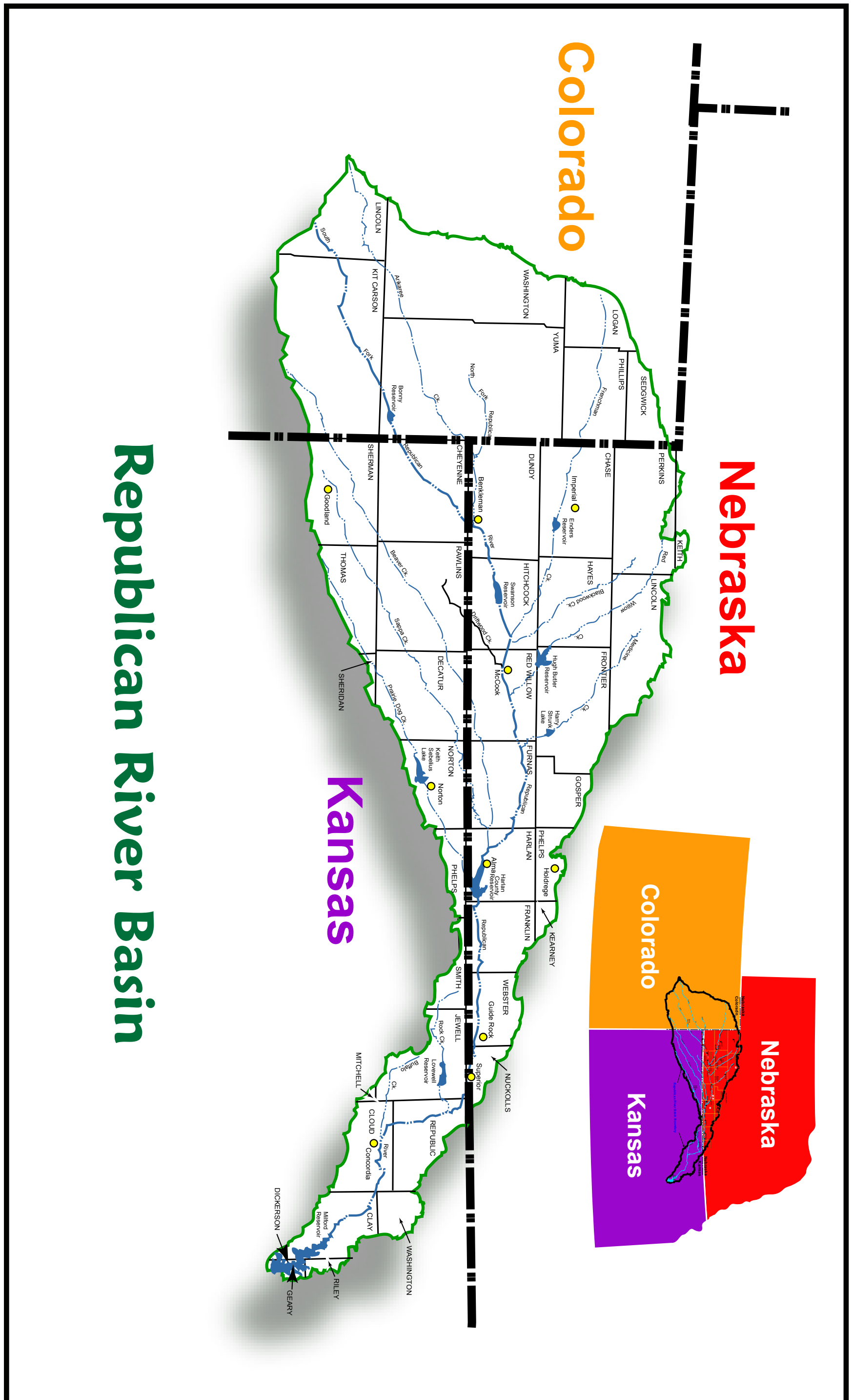


# Republican River

## 48th Annual Report for the year 2008


Special Meeting - Teleconference - April 28, 2009
Annual Meeting - Lincoln, Nebraska - August 12, 2009

# Compact Administration

MINUTES OF THE SPECIAL MEETING
OF THE
REPUBLICAN RIVER COMPACT ADMINISTRATION
April 28, 2009

Conducted by Telephone from the following locations:
Burlington, Denver, and Wray, Colorado
Colby, Courtland, Stockton, and Topeka, Kansas
Grand Island, Lincoln, and McCook, Nebraska

## Agenda and Transcript

The meeting agenda is included as Attachment A and the transcript of this meeting is included as Attachment B.

## Introductions

The meeting was called to order by Chairman Brian Dunnigan at 9:05 a.m. on April 28, 2009. Commissioners from each state introduced key members of their staff that were on the call. Attendees included:

| Name | Representing |
|---|---|
| Brian P. Dunnigan | Nebraska Commissioner, Chairman |
| Dick Wolfe | Colorado Commissioner |
| David W. Barfield | Kansas Commissioner |
| Peter J. Ampe | Colorado Attorney General's Office |
| Alex Davis | Colorado Department of Natural Resources |
| Megan A. Sullivan | Colorado Division of Water Resources |
| Mike Sullivan | Colorado Division of Water Resources |
| Chuck Beaver | Kansas Department of Wildlife and Parks |
| Chris Beightel | Kansas Division of Water Resources |
| Dale Book | Consultant for Kansas |
| Hongsheng Cao | Kansas Division of Water Resources |
| John Draper | Outside Counsel for Kansas |
| Hank Ernst | Kansas Division of Water Resources |
| Burke Griggs | Attorney, Kansas Department of Agriculture |
| Leland Rolfs | State of Kansas |
| Scott Ross | Kansas Division of Water Resources |
| Sam Speed | Kansas Attorney General's Office |
| Katie Tietsort | Kansas Division of Water Resources |
| Justin D. Lavene | Nebraska Attorney General's Office |
| James Schneider | Nebraska Department of Natural Resources |
| James R. Williams | Nebraska Department of Natural Resources |

**<u>Colorado Compact Compliance Pipeline</u>**

Commissioner Wolfe thanked a number of individuals that had assisted with Colorado's project, including Keith Vander Horst, Chris Grimes, Dave Keeler, Devan Ridnor, and Katie Radke. Mr. Wolfe also thanked the Republican River Conservation District, CAPA, the Bureau of Reclamation, the Division of Wildlife, the Division of Parks, and the Colorado Water Conservation Board. Mr. Wolfe also thanked Kansas and Nebraska for their cooperation and feedback, and stated that Colorado was committed to taking the appropriate steps to achieve Compact compliance as soon as possible.

Mr. Wolfe provided some history and background regarding the proposed Compact Compliance Pipeline. The Republican River Conservation District has instituted a water use fee (currently $14.50 per acre). The purpose of the fee is to generate the revenue for CREP and EQIP land retirement programs (since 2007 approximately 30,000 acres have been taken out of production). The district has worked with the Yuma County Public Improvement District to lease purchase senior water rights on the North Fork of the Republican River. Lastly, the district has developed and proposed the construction of the Compact Compliance Pipeline, a $71 million project. Combined, these efforts represent over $90 million committed to compliance efforts.

The state of Colorado has moved forward in promulgating rules in 2008, requiring all wells to have meters or approved power conversion coefficients in order to operate in 2009. The State began drafting Compact compliance rules beginning in 2006. These rules give the state the authority to administer wells in the basin. The State has also released water from Bonny Reservoir for out-of-priority storage.

The proposal for the Compact Compliance Pipeline was initially submitted to the RRCA in March 2008. Additional meetings on the matter were held during April, May, August, and November 2008. While Colorado recognizes that the three states are continuing to have productive negotiations towards resolution of the issues for approval of the Compact Compliance Pipeline, the state also believes that time is of the essence and that it is necessary to proceed along the parallel track of the dispute resolution process.

Mr. Wolfe stated that Colorado was seeking action by the RRCA in order to facilitate a number of transactions that needed to occur prior to the Republican River Water Conservation District assuming the water rights for the project. The transaction would be worth about $50 million, primarily funded by a loan from the Colorado Water Conservation Board.

Mr. Wolfe listed key points in the resolution proposed by Colorado, titled *Resolution by the Republican River Compact Administration Regarding Approval of Colorado's Augmentation Plan and Related Accounting Procedures Submitted under Subsection III.B.1.k of the Final Settlement Stipulation,* and dated April 2009. The resolution is included in Attachment C followed by exhibits one through four. The exhibits are:

- Exhibit 1—*Application for Approval of an Augmentation Plan and Related Accounting Procedures under Subsection III.B.I.K. of the Final Settlement Stipulation in Kansas v. Nebraska and Colorado, No. 126, Original, The Republican River Compact Compliance Pipeline,* submitted by the State of Colorado and the

Republican River Water Conservation District, acting by and through its Water Activity Enterprise, March 2008.

- Exhibit 2—Proposed Changes to the *Republican River Compact Administration Accounting Procedures and Reporting Requirements*, Revised July 27, 2005, Updated November 7, 2008, Colorado Proposal, Updated January 26, 2009.
- Exhibit 3—*Rights to Designated Groundwater,* Revised March 2009.
- Exhibit 4—*Hypothetical Calculations of the Projected Delivery and the Limit on Augmentation Water Supply Credit*, Revised February 13, 2009.

The approval of the augmentation plan would be subject to terms and conditions listed by Mr. Wolfe:

1. Consumptive use of groundwater would not exceed historical consumptive use shown in Column 7 of Exhibit 3,
2. The net depletions from Colorado's Compact Compliance Wells shall be computed by the RRCA Groundwater Model and included in Colorado's Computed Beneficial Consumptive Use of groundwater,
3. The diversions from any individual Compact Compliance Well shall be limited to no more than 2,500 acre-feet per year, and
4. Limitations on the Augmentation Water Supply Credit are spelled out on pages three and four of the proposed resolution and an example is provided in Exhibit 4.

Mr. Wolfe listed individuals and entities that have provided letters of support for the proposed project, including:

- Arikaree Groundwater Management District,
- Central Yuma Groundwater Management District,
- the City of Burlington,
- the City of Holyoke,
- the City of Wray,
- the City of Yuma,
- Colorado Agricultural Preservation Association (CAPA)
- Colorado Corn Growers Association,
- Farm Credit of Southern Colorado,
- Frenchman Groundwater Management District,
- Highline Electric Association,
- Kit Carson County,
- Logan County,
- Marks Butte Groundwater Management District,
- Phillips County,
- Plains Groundwater Management District,
- Quality Irrigation,
- Republican River Water Conservation District through its Water Activity Enterprise,

- Sandhills Groundwater Management District,
- Sedgwick County,
- South Platte Basin Roundtable,
- Stratton Equity Group,
- the Town of Julesburg, and lastly,
- W-Y Groundwater Management District.

Mr. Wolfe asked if there any comments from the public. Those that spoke in favor of the Compact Compliance Pipeline included:

- Dennis Corryell, President of the Republican River Water Conservation District,
- Tim Pautler from Stratton, Secretary of the Plains Groundwater Management District in the RRWCD,
- Deb Daniel, Manager of the Plains and East Cheyenne Groundwater District,
- Robin Wiley, expressed support from Yuma County and the Yuma County Water Authority,
- Byron Weathers, producer in Yuma County, and President of the Colorado Corn Growers Association, and
- Terry Hall, Manager of Y-W Electric Association.

The final public comment was from Brad Edgerton, Manager of Frenchman-Cambridge Irrigation District, who stated that if the plan was not adopted by the RRCA then Colorado should adopt rules to administer wells.

**Nebraska Response**

Following the public comments, Commissioner Dunnigan made a statement regarding the pipeline proposal. He affirmed that the Nebraska Department of Natural Resources (NDNR) believes that streamflow augmentation may be a useful tool for achieving compact compliance, and that Nebraska continues to support Colorado's efforts to achieve approval within the RRCA.

Mr. Dunnigan stated that the Colorado proposal did not adequately address the protection for Nebraska's surface water users on the North Fork Republican River or set effective limits on the water volumes pumped into the North Fork Republican River.

**Kansas Response**

Commissioner Barfield acknowledged Colorado's significant efforts in developing the plan, and stated that Kansas has no desire to delay Colorado's efforts to achieve compliance with the Compact.

Mr. Barfield stated that Kansas continued to have significant concerns regarding Colorado's interpretation of its requirements for complying with the Compact, especially on the South Fork tributary. Kansas is also concerned regarding details of Colorado's proposed accounting and the operational limits proposed by Colorado.

Mr. Barfield added that it is Kansas' view that this issue is not appropriate for submission to the dispute resolution process described in the Final Settlement Stipulation.

## Vote on Resolution

Colorado moved to approve the Colorado Compact Compliance Pipeline Resolution as introduced. Kansas seconded the motion. Colorado voted in favor of the resolution with Kansas and Nebraska voting against it. The motion failed.

## Continuation of the Special Meeting

Mr. Wolfe asked for a continuation of the Special Meeting, to take place in two to three weeks, in order to provide time for additional negotiations between the three states to take place prior to the continuation. The Commission agreed that the meeting would continue in two to three weeks, with the date and time to be determined. The meeting was not adjourned.

MINUTES OF THE
CONTINUATION OF THE APRIL 28, 2009, SPECIAL MEETING
OF THE
REPUBLICAN RIVER COMPACT ADMINISTRATION
August 12, 2009
Lincoln, Nebraska

## Agenda and Transcript

The meeting agenda is included as Attachment D and a transcript of this meeting is included as Attachment E. Attendees included:

| Name | Representing |
|---|---|
| Brian P. Dunnigan | Nebraska Commissioner, Chairman |
| Dick Wolfe | Colorado Commissioner |
| David W. Barfield | Kansas Commissioner |
| Peter J. Ampe | Colorado Attorney General's Office |
| Alexandra Davis | Colorado Department of Natural Resources |
| Willem Schreuder | Principia Mathematica, Consultant for Colorado |
| Megan A. Sullivan | Colorado Division of Water Resources |
| Mike Sullivan | Colorado Division of Water Resources |
| Chris Beightel | Kansas Division of Water Resources |
| Dale Book | Spronk Water Engineers, Consultant for Kansas |
| Burke Griggs | Attorney, Kansas Department of Agriculture |
| Chelsea Juricek | Kansas Department of Agriculture |
| Sam Perkins | Kansas Department of Agriculture |
| Sam Speed | Kansas Attorney General's Office |
| Scott Ross | Kansas Division of Water Resources |
| Jason Kepler | Nebraska Department of Natural Resources |
| Paul Koester | Nebraska Department of Natural Resources |
| Justin D. Lavene | Nebraska Attorney General's Office |
| Tom O'Connor | Attorney, Nebraska Department of Natural Resources |
| James Schneider | Nebraska Department of Natural Resources |
| James R. Williams | Nebraska Department of Natural Resources |

## Call to Order and Adjournment

The continuation of the April 28, 2009, Special Meeting of the Republican River Compact Administration (RRCA) was called to order by Chairman Brian Dunnigan at 8:07 a.m. on August 12, 2009, at the Cornhusker Hotel in Lincoln, Nebraska. Mr. Dunnigan stated that any remaining business would be addressed during the Annual Meeting. Mr. Dunnigan asked for a motion to adjourn the continuation of the Special Meeting. Commissioner Barfield moved to adjourn the meeting; Commissioner Wolfe seconded the motion. The meeting was adjourned.

# MINUTES OF THE
# 48th ANNUAL MEETING
# OF THE
# REPUBLICAN RIVER COMPACT ADMINISTRATION
August 12, 2009
Lincoln, Nebraska

## Agenda and Transcript

The meeting agenda is included as Attachment D and a transcript of this meeting is included as Attachment E.

## Call to Order and Introductions

The meeting was called to order by Chairman Brian P. Dunnigan at approximately 8:12 a.m. on August 12, 2009, at the Cornhusker Hotel in Lincoln, Nebraska. Mr. Dunnigan welcomed everyone in attendance. Each Commissioner introduced key staff and representatives of various districts. Attendees included:

| Name | Representing |
|---|---|
| Brian P. Dunnigan | Nebraska Commissioner, Chairman |
| Dick Wolfe | Colorado Commissioner |
| David W. Barfield | Kansas Commissioner |
| Peter J. Ampe | Colorado Attorney General’s Office |
| Alexandra Davis | Colorado Department of Natural Resources |
| Willem Schreuder | Principia Mathematica, Consultant for Colorado |
| Megan A. Sullivan | Colorado Division of Water Resources |
| Mike Sullivan | Colorado Division of Water Resources |
| Chris Beightel | Kansas Division of Water Resources |
| Dale Book | Spronk Water Engineers, Consultant for Kansas |
| Burke Griggs | Attorney, Kansas Department of Agriculture |
| Chelsea Juricek | Kansas Department of Agriculture |
| Sam Perkins | Kansas Department of Agriculture |
| Sam Speed | Kansas Attorney General’s Office |
| Scott Ross | Kansas Division of Water Resources |
| Jason Kepler | Nebraska Department of Natural Resources |
| Paul Koester | Nebraska Department of Natural Resources |
| Justin D. Lavene | Nebraska Attorney General’s Office |
| Tom O’Connor | Attorney, Nebraska Department of Natural Resources |
| James Schneider | Nebraska Department of Natural Resources |
| James R. Williams | Nebraska Department of Natural Resources |

## 47th Annual Report

Approval of the 47th Annual Report for the year 2007 was tabled pending additional review and inclusion of comments by the states.

**Report of the Commissioner from Nebraska**

Mr. Dunnigan stated that Nebraska was in compliance with the Republican River Compact for the five-year period ending in 2008, using current accounting procedures. The three primary Natural Resources Districts (NRDs) have been operating under new integrated management plans (effective beginning in 2008) which require that each district remain in compliance with the Compact. Therefore, in the future Nebraska as a whole will remain in compliance with the Republican River Compact.

He stated that the three states spent considerable time and effort to resolve disputes since the last meeting, in large part centered on events that occurred during 2005 and 2006. New Integrated Management Plans implemented beginning in 2007 appear to be working well; these plans include a requirement that water use by the three primary NRDs remain within the depletions allowed under the Compact. In addition, the NRDs and the Department were in the process of adding additional details regarding additional regulatory measures to be taken during dry years.

Mr. Dunnigan stated that there were a number of issues remaining to be resolved. The proposed augmentation plan by Colorado has not been approved by the states—Nebraska's primary concern is the accounting of the augmentation water. An additional issue to be resolved is the way the payments for prior noncompliance are to be accounted.

Nebraska believes that the most important finding by Karl Dreher, the arbitrator, is that the current method of calculating stream flow depletion [using the RRCA groundwater model] leads to significant errors when the streams become dry. The arbitrator agreed with Nebraska that the best measure of the total stream flow in a sub-basin is obtained by subtracting the results of a groundwater model run with all the stresses on from the results of a model run with all stresses off.

Mr. Dunnigan stated that a healthy surface water system will contribute to Nebraska's ability to comply with the Compact in the future, and expressed appreciation to the surface water districts in the basin. Nebraska will continue to participate in programs that decrease irrigation use in the basin, and will continue to explore streamflow augmentation and vegetation management.

James Williams provided the water administration report for Nebraska for the calendar year 2008 (and was continued during 2009). In August 2006, a call was placed on all appropriated reservoirs located above Swanson Lake, Enders Reservoir and Hugh Butler Lake. This call continued throughout 2008. During July 2008 a call was placed on all users on Red Willow Creek. On July 8, 2009 a call was placed on all junior permits above Cambridge; the call was removed above Cambridge July 16, 2009.

In 2008 the irrigation supply in Harlan County Reservoir was estimated by the Bureau of Reclamation to be more than 130,000 acre-feet. Water short year administration was not in effect during 2008.

Pioneer Irrigation District, Red Willow, Cambridge, Naponee, Franklin, Franklin Pump, Superior and Courtland Canals irrigated during 2008.

Surface water irrigators on Riverside Canal were compensated not to irrigate in 2008. The estimated consumptive use portion of Riverside canal's natural flow was protected through Harlan County Lake.

**Report of the Commissioner from Colorado**

Commissioner Wolfe stated that he appreciated Nebraska's report, although Colorado disagreed with Nebraska's interpretation of the arbiter's decision. Mr. Wolfe listed the streamflow for the North Fork, South Fork, and the Arikaree tributaries. Mr. Wolfe described storage in and releases from Bonny Reservoir, including a release of 1816 acre-feet in August 2008, and a release of 2,207 acre-feet during September 2008.

Mr. Wolfe highlighted land retirement efforts (totaling 32,000 acres) by the Republican River Water Conservation District, in cooperation with federal programs. The Yuma County Water Authority has purchased the majority of the senior water rights on the North Fork of the Republican River, including rights on the Pioneer and Laird ditches.

As of March 1, 2009, Colorado is now requiring totalizing water meters on all wells pumping 50 gallons per minute or more (approximately 4,000 wells). Prior to December 1st of each year well owners must report volumes pumped.

Colorado has added two staff members in the Republican Basin, with two more positions available pending funding. Megan Sullivan has been hired as the team leader for the group. The new staff will be able to assist with well measurement and data collection.

**Report of the Commissioner from Kansas**

Commissioner Barfield stated that former Kansas Governor Kathleen Sebelius was confirmed as the Secretary for the U.S. Department of Health and Human Services, and Mark Parkinson is now Kansas' 45th Governor. Adrian Polansky is no longer the Secretary of the Kansas Department of Agriculture, and has been confirmed as the State Executive Director for the USDA Farm Service Agency in Kansas. Josh Svaty has been appointed Acting Secretary of the Kansas Department of Agriculture.

Precipitation in Kansas has been near normal during 2009, with dry areas in north-central Kansas (in the Republican Basin) and southwest Kansas.

Kansas faced a budget shortfall of $700 million for 2009, resulting in a reduction of staffing in the Division of Water Resources of approximately 20% compared with 2008 staffing.

Kansas Senate Bill 64 requires water appropriation applicants to file a sworn statement providing evidence of legal access to or control of their point of diversion.

Twenty-three years of litigation between Colorado and Kansas regarding the Arkansas River has ended. The states are now operating under the final decree, and are continuing to work on some remaining issues.

Kansas continues to be in compliance within the Republican River Basin. Kansas continues to target retirement programs in the basin.

After Mr. Barfield completed his remarks, Scott Ross described conservation efforts in the Republican Basin led by two different groups. The Northwest Kansas Alliance group consists of stakeholders, including Groundwater Management District No. 4, county commissioners, equipment dealers, municipalities, and others. They are reviewing projects to promote conservation in the upstream portion of the basin, including recharge projects, water right buyouts, etc.

In the Lower Republican Basin the Lower Republican Stakeholders Group was assembled by the Kansas Water Office. This group includes the Kansas Bostwick Irrigation District and other irrigation districts, municipal representatives, the Kansas Department of Wildlife and Parks, the Bureau of Reclamation, and the Corps of Engineers. Project reviews include modifications to Lovewell Reservoir, off-stream storage sites in Kansas, and improved pipeline and canal deliveries.

There is a proposed additional marsh habitat at the Jamestown wildlife area, on a tributary to Buffalo Creek. The area is important for migrating waterfowl.

Kansas has completed the metering of all diversions in their portion of the Republican River groundwater model domain. In addition, Kansas has completed a model of the Solomon River Basin, which is within the Republican Groundwater Model domain.

**Bureau of Reclamation**

Aaron Thompson introduced key Reclamation staff in attendance. He described two documents prepared by Reclamation: Resources Management Activities (Attachment F), to be discussed by Brent Esplin, and Operation and Maintenance Activities (Attachment G), to be discussed by Marv Swanda.

Mr. Esplin stated that there was a lot of information in the report, but that he especially wanted to discuss the Lower Republican Feasibility Study that was authorized in May 2008. The study was authorized to look at water conservation and augmentation or storage options in the Lower Republican Basin. Despite being authorized, it has yet to be funded.

Reclamation is continuing to work with the irrigation districts in the Republican River Basin to improve water conservation, primarily to improve water conveyance.

Reclamation is also continuing to work with partners in both Nebraska and Kansas to install handicapped-accessible comfort stations and other facilities to comply with the Americans with Disabilities Act. These installations were scheduled to be completed during fiscal year 2010.

Mr. Swanda stated that he would also cover highlights in his report. Precipitation varied from 115 percent of normal at Swanson Lake to 150 percent of normal at Hugh Butler Lake. There were no deliveries to Frenchman Valley and the H & RW irrigation districts, as well as to two of the canals in the Frenchman Cambridge Irrigation District. Deliveries to the rest of the Reclamation irrigation lands varied from two and a half to six inches.

Mr. Swanda discussed highlights regarding each of the federal dams in the basin during 2008 as well as the performance to date during 2009.

**U.S. Geological Survey**

Phil Soenksen from the Lincoln, Nebraska office of the U.S.G.S. reported stream flows at gages in the Republican River Basin. The stream flows are included as Attachment H.

**Engineering Committee**

James Williams reported on the activities of the Engineering Committee. The Engineering Committee report is included as Attachment I.

The first assignment was to complete the user's manual for accounting procedures and provide a resolution for its adoption. The assignment was not completed.

The second assignment was for Nebraska and Colorado to provide additional data, and for all states to review the data. By September 15, 2008, Nebraska was to provide data responding to Kansas' August 1, 2008, letter to Nebraska. In addition, Colorado was to provide a final meter report by September 15, 2008. Comments and additional questions were due by October 1, 2008, and the information was to be reviewed by October 31, 2008. Nebraska provided a response (to Kansas's August 1, 2008 letter) by email on September 15, 2008. Colorado has not provided a final meter report due to data collection issues. The states did not provide follow-up questions or comments prior to October 31, 2008. On July 17, 2009, Kansas renewed its request for data necessary to complete the 2007 data exchanges including its specific request for backup data as per the FSS requirements for accounting data and a request for similar 2008 data.

The third assignment was to exchange by April 15, 2009, the information listed in Section V of the RRCA Accounting Procedures and Reporting Requirements, and other data required by that document. By July 15, 2009, the states were to exchange any updates to these data. Each state exchanged its model data sets by April 15, 2009 or shortly thereafter. A preliminary run of the RRCA groundwater model was developed by Willem Schreuder of Principia Mathematica and posted on the RRCA website he maintains for the Administration. The states exchanged their available final data by August 7, 2009, and Mr. Schreuder completed a run based on this data on August 7, 2009. The states were not able to complete a final accounting due to a number of issues that are in arbitration.

The fourth assignment was to continue efforts to resolve concerns related to varying methods of estimating ground and surface water irrigation recharge and return flows within the Republican River Basin and related issues. Little progress was made on this assignment.

The fifth assignment was to continue to review Colorado's augmentation proposal. The states have expended considerable effort on this project.

The final assignment was to retain Principia Mathematica to perform on-going maintenance of the groundwater model.

The Committee was able to reach agreement on one issue, and made the following recommendation to the Compact Administration:

> The accounting point used in the RRCA groundwater model for the North Fork Republican River Sub-Basin should be moved to the Colorado – Nebraska state line.

The Engineering Committee recommended that the Republican River Compact Administration assign the following tasks:

1. Finalize work on a user's manual for the RRCA Accounting Procedures and provide a recommendation to the Administration for adoption at next year's annual meeting.
2. Complete exchange of data requested by Kansas in its August 1, 2008, and July 17, 2009, letters by October 15, 2009.
3. Exchange by April 15, 2010, the information listed in Section V of the RRCA Accounting Procedures and Reporting Requirements. By July 15, 2010, the states will exchange any updates to these data.
4. Continue to review Colorado's augmentation proposal, as appropriate.
5. Continue efforts to resolve concerns related to varying methods of estimating ground and surface water irrigation recharge and return flows within the Republican River Basin and related issues. Within 90 days, the states will exchange information and the Engineering Committee will meet to recommend next steps
6. Develop a revision to the RRCA's Accounting Procedures to reflect agreements by the RRCA at its 2008 and 2009 annual meetings, and provide the RRCA with a recommendation of any appropriate formatting changes.
7. Retain Principia Mathematica to perform ongoing maintenance of the groundwater model and periodic updates requested by the Engineering Committee.
8. Continue development of a five-year accounting spreadsheet/database for adoption at the 2010 annual meeting or earlier.
9. Review accounting procedures to determine if Kansas groundwater CBCU in the Mainstem is properly included in the Mainstem virgin water supply calculation and if necessary, provide a recommendation to the RRCA at the next annual meeting.

**<u>Conservation Committee</u>**

Scott Guenthner from the Bureau of Reclamation provided a status report from the Conservation Committee. The committee has provided a short draft report (Attachment J), with a more substantial report expected during late August 2009. The states have provided support for the project, primarily through in-kind services. The field data collection has been completed by Dr. James Koelliker, Kansas State University, and Dr. Derrel Martin, University of Nebraska - Lincoln.

The purpose of the study is to quantify the effects of reservoirs and land terraces on stream flow in the basin. The states have identified 716 reservoirs, of which a sample of 32 has been monitored for four and a half years. Approximately 2.3 million acres of land terraces have been mapped in the basin, approximately 15 percent of the land area. Detailed information has been collected at five terrace sites. The terraces have been built over many years, so a survey to determine current storage capability was emphasized during the most recent year. Storage condition data was collected at 167 sites.

The study was intended to be completed by the 2009 annual meeting. The schedule has been modified, and final information is now expected by June 2010.

Mr. Dunnigan asked Mr. Guenthner if there were any preliminary figures or facts that could be provided. Mr. Guenthner responded that preliminary information showed that very little surface water runoff came from areas with terraces and small reservoirs—most of the water was used for evapotranspiration or was available for deep percolation to the groundwater.

Mr. Wolfe asked for clarification regarding the assessment of the condition of the terraces. Mr. Guenthner confirmed that the purpose was to have a current picture of terrace behavior in the basin, and the sampling was representative of the sites as a whole.

Mr. Barfield pointed out that there were some significant land use practices that were not being addressed by this study, such as tillage practices. Mr. Barfield asked that the final report be explicit in noting what was studied versus what practices were not studied.

## Recess

A break was taken from 9:38 a.m. to 9:50 a.m..

## Old Business

Dispute Resolutions and Arbitration. Mr. Barfield provided Kansas' summary of the dispute resolution process, including the arbitration completed prior to the 2009 Annual Meeting of the RRCA. The states executed a non-binding arbitration agreement on October 23, 2008. Mr. Karl Dreher served as arbitrator. On November 5, 2008, the arbitrator concluded that there were some legal issues that could be heard. The oral arguments on legal issues were heard on December 10, 2008, and the arbitrator issued his final decision on legal issues on January 22, 2009.

Discovery and depositions were conducted from December 2008 through April 2009. A hearing on the factual issues was conducted in Denver on from March 9 through March 19, 2009, with one additional day on April 14, 2009. On June 30, 2009, the arbitrator issued his final decision on factual issues. The states issued responses to the final decisions on July 30, 2009.

Mr. Barfield stated that he believed that the arbitration was conducted in a professional and courteous manner, especially given the tight time constraints for discovery, briefing, and trial. He stated that Kansas trusts that both the arbitration and the states' responses will not impede the work of the RRCA.

Colorado Compliance Pipeline Proposal. Mr. Wolfe presented and reviewed the history of Colorado's resolution regarding the Colorado Compliance Pipeline proposal (Attachment K). Mr. Wolfe pointed out the current proposal differed from the proposal presented at the Special Meeting of the RRCA in a couple of ways. One difference is the way the limitation on the amount of historical consumptive use of the groundwater rights that will be used to convey water to the North Fork. Net depletions due to pumping wells for the pipeline will be computed using the RRCA groundwater model. Pumping of any one well will be limited to 2,500 acre-feet per year. There would be both minimum and maximum total deliveries. Any substantial changes to the system, due to engineering design changes could be taken up by the RRCA. The Republican River Water Conservation District (RRWCD) would have the right to acquire additional groundwater rights for the purpose of increasing augmentation to the stream.

The resolution does not govern approval of any other augmentation plans in the future, and it does not present or waive other states' rights to claims or to seek damages for violations under the Compact and the Final Settlement Stipulation.

Mr. Barfield stated that Kansas did not wish to impede Colorado's ability to achieve compliance through the use of the proposed augmentation system. He reviewed the efforts of the states in attempting to come to an agreement. He stated that Colorado continues to substantially overuse its South Fork allocation, and that this issue must be addressed. He added that while Colorado may need to begin the dispute resolution process on the issue, he would like for the states to continue work towards finding solutions on these matters. He suggested that Colorado consider extending the pipeline to the South Fork Basin.

Mr. Dunnigan stated that the resolution is essentially unchanged from the one voted on during the special meeting in April 2009. Nebraska stated its concerns on the record at that meeting and the reasons for voting against the pipeline. The concerns were also set forth to Colorado in Nebraska's letter of April 10th, 2009. Nebraska's position has not changed, and therefore Nebraska would again have to vote no on the resolution.

Mr. Wolfe stated that the states were working to address the South Fork issues. In regards to the Haigler Canal, Colorado is still taking the position that this is not a compact-related issue because it is a decreed water right in Colorado. Therefore it is afforded all the same protection as any other water right in Colorado. Colorado would be willing to address the Haigler Canal through a separate agreement. Colorado has freed up significant surface water resources through the purchase of surface water rights in Colorado.

VOTED: Commissioner Wolfe voted in favor of the resolution; Commissioners Barfield and Dunnigan voted against the resolution. The motion failed.

Nebraska Crediting Issue. Mr. Dunnigan stated that Nebraska's position was made clear in a letter dated June 15, 2009, to the commissioners. The timeline was restated in a July 29, 2009, letter. The resolution is to approve the proposed crediting method outlined in the June 15, 2009, letter (Attachment L).

Mr. Barfield stated that he strongly disagree with the resolution, and stated that he did not believe that it had been properly presented to the RRCA in accordance with the dispute resolution provisions of the FSS. Mr. Barfield discussed the history of the proposal and associated discussion within the RRCA and the Engineering Committee. He stated that the proposal appears to substitute money for water in the accounting, and therefore Kansas must oppose it. Mr. Barfield said that Nebraska's crediting issue is procedurally defective, and that the subject is not appropriate for this meeting or action by the RRCA. Kansas disagrees with the arbiter's decision that the crediting issue can be brought before the RRCA.

Mr. Wolfe stated that this is a new issue that has not been dealt with before by a state or compact commission. Double penalizing a state is not acceptable. However, considering the novelty and importance of the issue, Colorado cannot support the resolution. Colorado would like to continue to work with Kansas and Nebraska to resolve the issue.

Mr. Dunnigan stated that Nebraska disagrees with Kansas's assertion that the issue has not been properly presented to the RRCA.

VOTED: Commissioner Dunnigan voted in favor of the resolution; Commissioners Barfield and Wolfe voted against the resolution. The motion failed.

Lower Republican Feasibility Study. Mr. Barfield stated that this study is to be a joint effort between the Bureau of Reclamation and the States of Kansas and Nebraska. Kansas has had funding for the project for some time. The states agreed at the 2008 meeting to jointly put together a letter to be used to obtain federal funding for the project.

After some discussion, Mr. Barfield agreed to draft a letter of support and to circulate it to the other states as agreed to at the 2008 meeting.

Compact Compliance. Mr. Barfield reviewed the history of Compact compliance in the Republican Basin, and stated that both Colorado and Nebraska have overused their allocations since signing the FSS. He stated that the states needed to take firm action to meet Compact obligations.

Mr. Dunnigan responded that Nebraska underused its allocation in both 2007 and 2008. Commissioners Barfield and Dunnigan agreed that both Kansas's and Nebraska's quoted compliance balances were estimates produced by the respective states, as the Engineering Committee has not finalized accounting for these years.

**New Business and Assignments to Committees**

Mr. Barfield asked if the RRCA had agreed to refer the Harlan County Lake Evaporation back to the Engineering Committee. Mr. Dunnigan answered that while it may be appropriate to discuss the issue within the RRCA, Nebraska did not believe that it should be referred to the Engineering Committee. Mr. Wolfe stated agreement that it could be discussed within the RRCA at a later point.

VOTED: The RRCA unanimously agreed to accept the Engineering Committee Report and assignments.

**Remarks from the Public**

Brad Edgerton, manager of the Frenchman Cambridge Irrigation District, reviewed the size of his district and recent history of irrigation and surface water shortages. Mr. Edgerton stated that it would be to the benefit to his district if Colorado were to be in compliance with the Compact. In order to facilitate the discussion of the Colorado Compliance Pipeline, he proposed that Colorado be allowed an allocation of 78.5 percent of any augmentation water pumped into the North Fork. This is the same percentage as the Colorado allocation on the Arikaree River.

Mr. Edgerton also stated that the district is concerned that Nebraska is overusing water upstream from the federal reservoirs. In February 2009 the district petitioned Nebraska Department of Natural Resources asking that the Republican River Basin be reevaluated to determine whether the basin is fully appropriated or overappropriated. The petition was denied, and a hearing is pending.

Stan Murphy, manager of the Republican River Water Conservation District (RRWCD), stated that he was speaking as a private citizen, and not as a representative of the RRWCD. Mr. Murphy reviewed the level of effort of the district, and expressed frustration with the lack of agreement on the Colorado Compliance Pipeline within the RRCA.

Tony Mangus, representing the Colorado Agriculture Preservation Association (CAPA), also expressed frustration with the lack of agreement on the Colorado Compliance Pipeline within the RRCA.

**Future Meeting Arrangements**

Colorado will chair the meeting in 2010. Colorado anticipates that the meeting will take place in Burlington, Colorado. The date and additional specifics were to be arranged at a later time.

## Adjournment

The meeting was adjourned at 10:46 a.m., on August 12, 2009.

# ATTACHMENT A

## AGENDA AND CALL-IN LOCATIONS
## SPECIAL MEETING OF THE
## REPUBLICAN RIVER COMPACT ADMINISTRATION
## APRIL 28, 2009

AGENDA

**SPECIAL MEETING OF THE**
**REPUBLICAN RIVER COMPACT ADMINISTRATION**

*April 28, 2009*
*9:00 a.m. MDT / 10:00 a.m. CDT*

Via Conference Call

I. Introductions

II. Review Agenda

III. Colorado Compact Compliance Pipeline – Augmentation Plan

A. Discussion on Colorado's CCP Resolution
B. Public Comments
C. Action on Colorado's CCP Resolution

IV. Future Process and Schedule

V. Adjourn

**CALL-IN LOCATIONS**

*Special Meeting of the Republican River Compact Administration*
*April 28, 2009*

| State | City | Details |
|---|---|---|
| Colorado | Burlington | Room A, Burlington Community and Education Center<br>340 South 14th Street<br>Burlington, Colorado |
| | Denver | Room 318 of the Centennial Building<br>1313 Sherman Street<br>Denver, Colorado |
| | Wray | Wray Ambulance Barn<br>304 West 3rd Street<br>Wray, Colorado |
| Kansas | Colby | Northwest Kansas Groundwater Management District No. 4<br>1175 South Range Ave.<br>Colby, Kansas |
| | Courtland | Kansas Bostwick Irrigation District Office<br>528 Main St.<br>Courtland, Kansas |
| | Stockton | Division of Water Resources, Stockton Field Office<br>820 S. Walnut St.<br>Stockton, KS 67669 |
| | Topeka | Kansas Dept of Agriculture, Division of Water Resources<br>109 SW 9th Street, 2nd Floor<br>Topeka, Kansas |
| Nebraska | Grand Island | Bureau of Reclamation, Nebraska-Kansas Area Office<br>203 West Second Street<br>Grand Island, NE 68802 |
| | Lincoln | Nebraska Department of Natural Resources<br>Nebraska State Office Building, 4th Floor<br>301 Centennial Mall South<br>Lincoln, Nebraska |
| | McCook | Bureau of Reclamation, McCook Field Office<br>1706 W. Third St.<br>McCook NE 69001 |

# ATTACHMENT B

## TRANSCRIPT OF THE
## SPECIAL MEETING OF THE
## REPUBLICAN RIVER COMPACT ADMINISTRATION
## APRIL 28, 2009

REPUBLICAN RIVER COMPACT ADMINISTRATION

SPECIAL TELEPHONIC MEETING

The above-entitled telephonic meeting took place at 1313 Sherman Street, Denver, Colorado, Room 318, at 9:05 a.m., on Tuesday, April 28, 2009.

P R O C E E D I N G S

COMMISSIONER DUNNIGAN: This is Brian Dunnigan; I'm the current chairman of the RRCA.

This is a special meeting of the RRCA and it is being conducted from ten call-in locations. We would request that at those locations you place your telephones on mute, if possible. There should be a sign-in sheet. These are to be faxed to the attention of James Williams at the Nebraska Department of Natural Resources, (402)471-2900, or you can scan those and e-mail them to James Williams.

This meeting is on the record utilizing a court reporter in Denver and will be included in the annual RRCA report. We ask that you speak clearly for the court reporter. Any spelling of your names would be greatly appreciated, if you're likely -- if you're going to speak. Each commissioner should acknowledge key staff and those that are with them today, and I already did that. I have Justin Lavene with me, James Schneider and Jim Williams.

Commissioner Barfield.

COMMISSIONER BARFIELD: Yes, thank you.

Yes, on the phone at the other locations, John Draper was mentioned, Dale Book, Scott Ross, our number of staff that are on. In addition here in

Topeka, we have a number of people around the table. I'll just -- it's such a large group, I will just mention who they are. Sam Speed with the Attorney General's Office; Chuck Beaver with our Kansas Department of Wildlife & Parks; Chris Beightel of my staff; Burke Griggs of the Department of Agriculture; Leland Rolfs, Katie Tietsort of our Topeka field office; Hongsheng Cao, Hank Ernst with our Kansas Water Office and myself. That is who is here in Topeka.

COMMISSIONER DUNNIGAN: Thank you, Commissioner Barfield.

Commissioner Wolfe.

COMMISSIONER WOLFE: Yes, good morning. This is Commissioner Dick Wolfe with the State of Colorado, and some of the key staff here with me today: Pete Ampe, First Assistant Attorney General at the Attorney General's Office of Colorado; Megan Sullivan, engineer advisor for Colorado; Mike Sullivan, Deputy State Engineer; Willem Schreuder, consultant to Colorado. And we have some other staff members here in the audience as well. And Alex Davis is also joining us. She's the assistant director for the Department of Natural Resources for Water. And we do have other folks here that I may mention in my introductory remarks when we get to that part of the agenda.

COMMISSIONER DUNNIGAN: Thank you, Commissioner Wolfe.

The second agenda item is to redo the agenda.

Are there any comments on the agenda that was distributed, I believe, yesterday?

Hearing none, we'll move on.

Commissioner Wolfe, the next agenda item is Colorado's Compact Compliance Pipeline. I will have you introduce that and discuss that.

COMMISSIONER WOLFE: Thank you, Commissioner Dunnigan.

First, I would like to just take this opportunity to thank a number of folks who have participated in this process certainly over the last few years, just quickly for recognition. A number of the staff members that I have already mentioned so far in my introductory remarks. We have some additional staff that have helped us out here. Keith Vander Horst and Chris Grimes of our Denver office have worked diligently on a lot of the activities in the basin, as well as Dave Keeler and Devan Ridnor in the Republican River Basin. And there is certainly a number of other staff as well that have participated in that, but those folks are here today with Katie Radke, who has been an integral part of our CREP and EQIP programs on behalf of the State of Colorado.

I would also like to thank the Republican River Conservation District and their staff and counsel who are with us today for their efforts over the last few years, as well as CAPA and their legal representation; the Bureau of Reclamation, Division of Wildlife and the Division of Parks and the Colorado Water Conservation Board, as well, for their help and assistance in financing part of the activities in the Basin.

And, of course, there are many other stakeholders who have been represented by counsel as well who represent individual water users in the Basin who have assisted Colorado over the past few years to achieve Compact Compliance and, in particular, developing the proposed Compact Compliance Pipeline, which is the subject of our meeting today.

I would also like to thank Kansas/Nebraska for their corporation during the past year providing feedback on our proposal. Colorado is committed to taking the appropriate steps to achieve Compact Compliance as soon as possible and has demonstrated that willingness as follows.

I'm going to touch on a few of the brief, a little bit of the history of brief steps that we have taken over the past years to achieve Compact Compliance.

First and foremost, the Republican River Conservation District has been integral in this effort to assist Colorado in its efforts to achieve Compact Compliance.

One of the things that they have done is instituted a water use fee, which is currently at $14.50 per irrigated acre, to generate sufficient revenue to implement a number of programs, including CREP and EQIP land retirement programs, and through those efforts they have taken out approximately 30,000 acres since 2007 and have -- working on another additional 30 acres through an amendment that is planned to take place through 2009 and beyond.

They have also undertaken a number of leases of surface water rights, including a combination lease purchase with the Yuma County Public Improvement District of $20 million for most of the senior water rights on the North Fork of the Republican River.

And lastly, the development and proposed construction of the Compact Compliance Pipeline, which is a $71 million project.

And all of these efforts by the Republican River Conservation District represent over $90 million that they have committed today as part of the Compact Compliance efforts, and we appreciate all that they have done.

The State has also moved forward in terms of promulgating well measurement rules in 2008 that require all wells to have meters or to approve power conversion coefficient to operate in 2009. We believe that this has effectively been accomplished and again, through the efforts of the users in the Basin that have worked cooperatively with us on this effort to get those rules in place and also our staff who has been integral in approving those testing and improving of those meters.

We've also started drafting Compact Compliance rules. These efforts started in 2006. This is another effort that gives the authority to the state engineer to administer wells in the Basin. We have also made efforts over the last couple of years on releasing water from Bonny Reservoir for out-of-priority storage.

And I would like to next just touch on a little bit of brief history of the Compact Compliance Pipeline proposal that we'll be presenting today.

This proposal was initially submitted to the RRCA in March of 2008. We have continued discussions with Kansas/Nebraska since then with formal meetings in April, May, August and November of 2008. Colorado originally addressed this proposal as a fast-track issue before the RRCA under Section 7.a. of the FSS, or the Final Settlement Stipulation, in April of 2008.

While we recognize that we are continuing productive negotiation towards a resolution of the issues for approval of the Compact Compliance Pipeline, we also recognize the need to proceed on a parallel path of the general dispute resolution process as provided for under Section 7.b. of the Final Settlement Stipulation.

We can no longer afford a delay in seeking ultimate approval of the Compact Compliance Pipeline so that Colorado can fulfill its obligations under the Republican River Compact.

What I would like to next do is confirm for everyone the proposed resolution exhibits that we've distributed to the two States. We are seeking action by the Republican River Compact Administration today on the proposed Compact Compliance Pipeline in order to facilitate a number of other transactions that must occur prior to the Republican River Water Conservation District closing on a loan with the seller of the water rights that will be used for augmentation. This represents an approximately $50 million transaction, principally funded by a loan from the Colorado Water Conservation Board.

What I would like to do is, for those of you who have the set of documents that represents the proposed resolution that was prepared by Colorado and the attached exhibits, I would like to just step through those briefly so that everyone knows and we have on the record what those documents represent.

First, the resolution that's titled "Resolution by the Republican River Compact Administration Regarding Approval of Colorado's Augmentation Plan and Related Accounting Procedures Submitted under Subsection III.B.1.k of the Final Settlement Stipulation," dated April 2009. There is a number of Whereas's that starts out in that proposed resolution. I would like to just highlight on top of page 2 three of the Whereas's which I think principally identify the introductory part of this resolution.

The first states, "Whereas, Subsection III.B.1.k of the Final Settlement Stipulation further provides that augmentation plans and related accounting procedures submitted under Subsection III.B.1.k shall be approved by the Republican River Compact Administration," or the RRCA, "prior to implementation."

Secondly, "Whereas, Section I.F. of the FSS also provides that: The RRCA may modify the RRCA Accounting Procedures or any portion thereof, in any manner consistent with the Compact and this stipulation."

And third and lastly, "Whereas, the State of Colorado and the RRWCD Water Activity Enterprise have submitted an augmentation plan and related accounting procedures to account for water delivered to the North Fork of the Republican River for the purpose of offsetting stream depletions in order to comply with Colorado's Compact Allocations."

Next, I would like to talk about the rest of the resolution which introduces the exhibits. First, the augmentation plans described in the application submitted by the State of Colorado and the Republican River Water Conservation District Water Activity Enterprise, which is attached to the resolution and identified as Exhibit 1.

The related accounting procedures are included in the revised RRCA Accounting Procedures and Reporting Requirements, and this is in parenthetical, Revised RRCA Accounting Procedures, end parenthetical, which are attached to this resolution and identified as Exhibit 2. The approval of the augmentation plan, the related accounting procedures will be subject to some following terms and conditions, and I would like to just highlight those in general terms for everyone here today.

First, what's identified paragraph 1 is that we provided that the average annual historic consumptive use of the groundwater rights that will be used for augmentation are listed in Exhibit C -- 3, excuse me, and shall not exceed the historical consumptive use amounts shown in column 7 of Exhibit 3.

Second, the net depletions from Colorado's Compact Compliance Wells shall be computed by the RRCA Groundwater Model and included in Colorado's Computed Beneficial Consumptive Use of groundwater pursuant to paragraph III.D.1 of the revised RRCA Accounting Procedures.

Third, the diversions from any individual Compact Compliance Well shall be limited to no more than 2500 acre-feet per year.

Fourth, there is -- the fourth provision in this resolution provides limitations on the Augmentation Water Supply Credit and there is a calculation of the projected Augmentation Water Supply Delivery to determine the limit on Augmentation Water Supply Credit. Those procedures are spelled out on pages 3 and 4 of the proposed resolution, and the example of this limitation is also provided for in the attached Exhibit 4.

Other salient provisions outlined in items 5 through 9 of the proposed resolution to ensure Compact -- excuse me, to ensure compliance with the other provisions of the FSS and the Compact and to recognize that this approval does not set precedence for any other State seeking approval of any future proposed augmentation plan and related accounting procedures.

What I would like to do at this time is also mention for the record those individuals who have provided in writing to us a support of this proposed Compact Compliance Pipeline. They have done so and provided these letters in writing because we knew that we would have this telephonic meeting today and felt that it would be more effective and efficient to just provide those letters to support in writing.

We're not going to read those into the record; however, I would like to identify, if I could, for the record those individuals or entities who have provided those letters of support. We do have those letters on record here, and I think each of them have been provided to both Commissioners Dunnigan and Barfield as well.

And if there are any folks, when we get to the public comment section, that would like to provide any additional comments beyond those letters of support, we would welcome those at that time.

Those that have provided those letters of support for approval of the Compact Compliance Pipeline include the Arikaree Groundwater Management District; Central Yuma Groundwater Management District; the City of Burlington; the City of Holyoke; the City of Wray; the City of Yuma; the Colorado Agricultural Preservation Association, or CAPA; the Colorado Corn Growers Association; the Farm Credit of Southern Colorado; the Frenchman Groundwater Management District; the Highline Electric Association; Kit Carson County; Logan County; the Marks Butte Groundwater Management District; Phillips County; the Plains Groundwater Management District; Quality Irrigation; the Republican River Water Conservation District through its Water Activity Enterprise; the Sandhills Groundwater Management District; Sedgwick County; the South Platte Basin Roundtable; Stratton Equity Group; the Town of Julesburg; and lastly, the W-Y Groundwater Management District.

At this time, I would welcome if there are any public comments that would like to be made, we would entertain those at this time.

Anything from Burlington?

MS. DANIEL: Yes, Dick. We have three people who would like to speak.

COMMISSIONER WOLFE: Could you identify yourself, please.

MS. DANIEL: I'm sorry. This is Deb Daniel. I'm the manager of the Plains and East Cheyenne Groundwater District in Colorado and there are three people from this location that would like to speak.

COMMISSIONER WOLFE: Okay, please proceed.

MS. DANIEL: Okay. First of all, I will introduce Dennis Corryell.

MR. CORRYELL: This is Dennis Corryell. I'm president of the Republican River Water Conservation District.

Specifically, I would like to urge you three commissioners, specifically Commissioner Dunnigan and Commissioner Barfield, to allow the Republican River Water Conservation District to construct this pipeline. All of our financing is in place and has been for a rather lengthy period of time.

And we really want to do everything that we have committed to do to help get Colorado into Compact Compliance, so I would just like to urge the commissioners to give us the go-ahead, give us the green light.

I know that you want to make sure that all of the technicalities are taken care of, but we really, really need to move forward with this pipeline so that Colorado is in compliance.

And I thank you for the opportunity to speak.

COMMISSIONER WOLFE: Thank you, Dennis.

Who is next? Could you please identify yourself for the record.

MR. PAUTLER: My name is Tim Pautler from Stratton. I represent the Plains Groundwater Management District on the RRWCD and I am its secretary.

I, too, would like to urge the Compact Administration to approve the efforts that Colorado is trying to put in place to meet Compact Compliance.

We're kind of caught between a rock and a hard spot here. We've implemented the fee assessment to pay for the pipeline and we have producers out here now that are taking a look at these tax notices that they're paying or have paid by this point in time and are wondering where the project is at.

We would certainly encourage full consideration of this issue by the States of Nebraska and Kansas and we would hope for a favorable outcome.

Thank you.

COMMISSIONER WOLFE: Thank you, Tim.

Who is the last one that would like to speak for the record, please.

MS. DANIEL: Again, this is Deb Daniel. I'm the manager of the Plains and East Cheyenne Groundwater District, and on behalf of the District I've been asked to speak.

First of all, I want to thank you for this opportunity to speak and participate during this important meeting. I know that all of the States have been diligent in trying to come into an agreement on how to reach compliance with Republican River Compact. I know you've analyzed all the values and statistics, but I hope you have not overlooked the original reason of the Compact.

At one time, 75 years ago, the residents of our three states knew that they had to make a difference for the good of all, and the residents came together, they worked out the fine solution. We're asking that Nebraska, Kansas and Colorado work in unity again and allow the residents of the Republican River Basin and Colorado to comply with the Compact and build this pipeline.

The people of this area have come together and found solutions. The well owners of the Basin in Colorado recognize that we must comply with the Compact and with your approval through the Republican River Conservation District, we will be funding this project.

So on behalf of the residents and the 3,766 well owners in the basin of Colorado we ask that Mr. Brian Dunnigan of Nebraska and Mr. David Barfield of Kansas to stand together with Dick Wolfe of Colorado and approve this augmentation plan.

Thank you.

COMMISSIONER WOLFE: Thank you, Deb.

Anybody from the Wray location that would like to provide public comment?

MR. KEELER: This is Dave Keeler, the Republican River Water Commissioner. I have Robin Wiley.

MR. WILEY: Good morning, Dick.

COMMISSIONER WOLFE: Good morning, Robin.

MR. WILEY: I can't hardly talk, I have a cold here, but I'm not sure what happened to the letters of support from Yuma County. I did just want to say the Yuma County and Yuma County Water Authority do also support the Compact Compliance Pipeline.

COMMISSIONER WOLFE: Okay. I apologize if I overlooked in my listing of who else provided those letters, we apologize. If that is, in fact, that those letters were submitted, we apologize that we failed in listing them.

MR. KEELER: I do have two others that have come forward.

The first one is Byron Weathers.

COMMISSIONER WOLFE: Okay. Could you identify yourself for the record, please.

MR. WEATHERS: This is Byron Weathers and I'm a producer here in Yuma County, Colorado and also president of the Colorado Corn Growers Association.

One of the issues that probably isn't very well known is that 70 percent of the corn that is raised in the state of Colorado is raised in the Republican River Basin here. And if Colorado does not come into Compact Compliance, we stand a chance of losing a lot of this irrigated ground that produces this crop. So it would be a very devastating thing to the State of Colorado and also to the corn industry itself if we did lose this.

And I thank the commissioners for this opportunity to come and visit and be at this meeting.

Thank you.

COMMISSIONER WOLFE: Thank you, Byron.

MR. KEELER: And our last one is Terry

Hall.

MR. HALL: Good morning, my name is Terry Hall. I'm manager of Y-W Electric Association. We also thought we sent in a letter of support, but since it wasn't on the list, I'll go ahead and give comments now.

Y-W Electric is a rural electric co-op that serves about 1500 irrigation wells in the Republican River Basin, mainly in Yuma and Washington County. And we support the construction of the Compliance Pipeline.

The alternative, as I see it, would be to shut off a large number of wells for Compact Compliance. Most of those are served by our electric co-op and that would be devastating financially to us.

So we support the efforts of the Republican River Water Conservation District and Yuma County and everything they have done to attempt to find a solution for Compact Compliance and we strongly support the construction of the compliance of the pipeline.

Thank you.

COMMISSIONER WOLFE: Thank you, Terry.

At this time I would entertain, are there any public comments from the location in Colby?

MR. LUHMAN: No, there are not.

COMMISSIONER WOLFE: Who was that that spoke, please? If you could identify yourself when you

respond.
MR. LUHMAN: Ray Luhman.
COMMISSIONER WOLFE: Is it -- Ray, could you repeat that name, please.
MR. LUHMAN: Yes. It's R-A-Y L-U-H-M-A-N.
COMMISSIONER WOLFE: Thank you. Courtland, Kansas.
MR. NELSON: This is Kenny Nelson. No comments from Courtland.
COMMISSIONER WOLFE: Thank you.
Stockton, Kansas.
MR. ROSS: This is Scott Ross. No comments from here.
COMMISSIONER WOLFE: And I -- I'll leave comments for David Barfield and Brian Dunnigan as separate because I know they will have specific comments, but are there any other besides them at Topeka that would like to make public comments beyond David's subsequent remarks?
COMMISSIONER BARFIELD: This is David Barfield. I confirm there is no public comments from here in Topeka.
COMMISSIONER WOLFE: All right.
Grand Island, Nebraska.
MR. THOMPSON: This is Aaron Thompson with

the Bureau, and there are no public comments or people that have come forward in this office.

COMMISSIONER WOLFE: Thank you, Aaron.

McCook, Nebraska.

MR. SWANDA: This is Marv Swanda with the Bureau. We have one individual that would like to comment.

COMMISSIONER WOLFE: All right, could you identify yourself for the record, please.

MR. EDGERTON: Thank you. My name is Brad Edgerton. I'm the manager of the Kansas Irrigation District located in southwestern Nebraska.

We have water rights dating back to 1890 and serve nearly 46,000 acres from Trenton to Alma, Nebraska. Of those, 40,000 acres receive water from Swanson Reservoir.

For the past six years zero water has been released from irrigation from Swanson Reservoir. During the same time Colorado has continued to illegally divert more than 66,000 acre-feet that has been appropriated to either Frenchman-Cambridge direct flow permits or reclamation storage permits. If this plan is not adopted today, then we encourage Colorado to adopt rules to administer wells.

Thank you.

COMMISSIONER WOLFE: Thank you, Brad.

Other than Commissioner Dunnigan in Lincoln, are there any folks there that would like to provide public comment at this time?

COMMISSIONER DUNNIGAN: There are not any people here in Lincoln that will provide other public comments.

COMMISSIONER WOLFE: Those that are just -- excuse me. I'm sorry, was someone wanting to speak?

Okay. Are there any others who are not at those locations who have just joined us by phone that would like to provide any public comment at this time?

Okay. Hearing none, I would like to at this time allow the commissioners from Nebraska and Kansas to provide any of their comments before we take action on the proposed resolution that we have presented today.

So, Commissioner Dunnigan, would you like to go next? Is that fine?

COMMISSIONER DUNNIGAN: That's fine. Thank you, Commissioner Wolfe.

I do have two points of clarification. Could you clarify whether the exhibits that you discussed were part of the e-mail that was sent on April 21 for Mike Sullivan, for the record, please.

COMMISSIONER WOLFE: Yes, they were attached to that e-mail. The proposed resolution, as well as Exhibits 1 through 4, should have been attached and I believe were attached to that e-mail that was sent out.

COMMISSIONER DUNNIGAN: Thank you.

Could you also clarify on the accounting procedures that those would be the latest version with the revision of April 2009?

COMMISSIONER WOLFE: That is correct. Those that were attached to that April 21 e-mail identified as Exhibit 2 are the latest proposed revisions to the accounting procedures and reporting requirements.

COMMISSIONER DUNNIGAN: Thank you.

COMMISSIONER WOLFE: And just for the record, it should reflect on the cover page these were originally revised July 27, 2005, updated November 7, 2008, and then updated again on January 26, 2009. And I think there was some recent discussion between Mike Sullivan and James Williams about some changes on page 27 that, I think, the -- this exhibit should reflect.

And, Mike Sullivan, could you confirm that for the record, please, if that is, in fact, the case.

MR. SULLIVAN: This is Mike Sullivan. The slight revision I made on, I believe, April 21 and was sent out should be the latest version. I made a correction that James Williams had found in the accounting procedure.

COMMISSIONER WOLFE: So I would like the record to reflect, even though I did read off on page 1 that they were updated January 26, that version should actually reflect changes as of April 21, 2009.

MR. SULLIVAN: Thank you, Commissioner Wolfe.

COMMISSIONER WOLFE: Thank you for those clarifications.

COMMISSIONER DUNNIGAN: The Nebraska Department of Natural Resources believes that streamflow augmentation may be a useful tool for achieving Compact Compliance and continues to support Colorado's efforts to achieve approval within the RRCA.

The three states have put considerable efforts into discussions of Colorado's plan. In addition to a multitude of e-mail messages and conference calls among the technical staff of the three states, the CCP was discussed during six RRCA engineering committee meetings during 2008.

At the most recent face-to-face meeting, Kansas and Nebraska traveled to Denver at Colorado's request for the primary purpose of discussion of the CCP. The RRCA contracted with a mediator to assist with the discussions so that it could be conducted in a more productive manner and lead to resolution of a number of issues.

In the Colorado proposal we do not see language that adequately addresses the following items: First, protection for Nebraska's surface water users on the North Fork Republican River; and second, effective limits on the water volumes pumped into the North Fork Republican River.

Regarding the first item, Nebraska has repeatedly stated that its surface water users cannot be harmed in the short-term or long-term by our approval of Colorado's augmentation proposal. Nebraska has not attempted to dictate a solution to Colorado, although we have put several ideas forward that have apparently been discarded by Colorado.

Water deliveries to Nebraska's portion of the Pioneer Ditch, known as Haigler Canal in Nebraska, have declined in recent years to levels that have been a cause for concern to the landowners. Nebraska has requested that Colorado implement a plan that does not lead to increased impact for this canal.

Recently, Colorado proposed the following language be added to the resolution under discussion. Quote, Nothing in this resolution shall reduce or otherwise alter the water rights that were the subject of Weiland, et al. v. the Pioneer Irrigation Company, 259 U.S. 498 (1922), and specifically recognized in Article V of the Compact. If at some future time streamflows are reduced to levels that may interfere with such water rights, the States of Colorado and Nebraska agree to confer at such time to seek resolution of the issue, end quote.

While we appreciate Colorado's recognition of the need to protect Nebraska's water users along the Haigler canal, deferring the solution to a problem which already has manifested itself is not acceptable to Nebraska.

Regarding the second item, Nebraska has favored a number of proposals that would limit the volume of Augmentation Water Supply Credit available. One such proposal would limit the credit to Colorado's deficit within the subbasin. Separate but related proposals would limit the negative impact in the mainstem due to Colorado's pumping.

Nebraska is concerned because, under the proposed accounting, the State of Nebraska will be responsible for conveying the augmentation water to

Hardy, in spite of the fact that much of it will be lost in transit.

We, therefore, do not believe that it is appropriate for Colorado to make up deficits on the South Fork Republican or the Arikaree Rivers by placing large volumes of water in the North Fork Republican River and asking Nebraska to take responsibility of the entire volume.

We understand, based on our discussions, that Colorado is planning on an operational period of two or three decades, and we are concerned that if pumping is not decreased during this time, the compliance will be even more difficult for Colorado to achieve at the end of that time.

Those are my prepared comments. Thank you.

COMMISSIONER WOLFE: Thank you, Commissioner Dunnigan.

Commissioner Barfield, would you like to provide your comments at this time?

COMMISSIONER BARFIELD: Yes, Commissioner Wolfe. Thank you.

On behalf of Kansas, I would like to say that Colorado's efforts here represent a positive step towards developing a plan to achieve compliance for the Republican River Compact and the Final Settlement

Stipulation.

Kansas recognizes that Colorado has invested significant efforts to develop this plan and to communicate that plan to both its stakeholders and other states. Kansas has no desire to delay Colorado's efforts to achieve compliance with its Compact obligation.

Kansas and Nebraska, as Brian has indicated, have worked diligently to respond to Colorado's efforts to develop its plan. I, my staff, and our consultants have taken part in numerous meetings with Colorado and Nebraska. Kansas has provided specific details and analysis to explain our concerns and has set forth concrete alternatives to address those concerns for Colorado's consideration.

As your resolution provides, subsection III.B.1.k of the FSS provides that augmentation plans and related accounting procedures shall be approved by the RRCA prior to implementation.

Despite diligent work, significant concerns remain regarding Colorado's interpretation of its requirements for complying with the Compact, especially on the South Fork tributary. Concerns remain related to details of Colorado's proposed accounting and to the operational limits Colorado proposes, among other things.

For these reasons, Kansas will be voting no regarding your request to approve this proposal. I would note for the record that Kansas has expressed its view that this subject is not appropriate to submit the FSS's dispute resolution process.

Despite today's vote, Kansas continues to believe that the States can reach agreement on Colorado's plan through additional negotiations and we would urge us to continue to do so.

Thank you.

COMMISSIONER WOLFE: Thank you, Commissioner Barfield.

I think at this time as far as the agenda goes, it's still under the item 3.C. in regards to action on Colorado's Compact Compliance Pipeline Resolution. Colorado recognizes there are still unresolved issues raised by Kansas and Nebraska, which may lead to an unfavorable approval today of the current proposed Compact Compliance Pipeline, but we also recognize the continuing settlement negotiations between the States and we appreciate your comments that you have provided today.

At this time, Colorado would entertain a formal motion to approve the Colorado Compact Compliance

Pipeline Resolution that was introduced today.

I move to have that approved.

COMMISSIONER BARFIELD: I would second the motion.

COMMISSIONER WOLFE: David Barfield seconded the motion.

I'm sorry, go ahead, Dave.

COMMISSIONER DUNNIGAN: Excuse me. I would ask for any discussion on the motion.

Hearing none, all those in favor say "aye."

COMMISSIONER WOLFE: Aye.

COMMISSIONER DUNNIGAN: All those opposed.

COMMISSIONER BARFIELD: Kansas votes no.

COMMISSIONER DUNNIGAN: Nebraska votes no.

Motion fails.

COMMISSIONER WOLFE: Given the vote that just occurred, Colorado would request that we continue this meeting for an additional two weeks, two to three weeks at least, to continue negotiations that have been ongoing between the three states.

Is there any discussion in regards to that? And we can certainly take that as part of discussion on the agenda on future process and schedule, and I would ask for any comments from Commissioner Dunnigan or Commissioner Barfield.

COMMISSIONER DUNNIGAN: Commissioner Wolfe, this is Commissioner Dunnigan, and Nebraska would be agreeable to that position to move forward.

COMMISSIONER BARFIELD: Dave Barfield here, and Kansas, as I indicated in my statements, it stands ready to continue to work toward resolving the issues that remain.

COMMISSIONER WOLFE: I could certainly offer up a proposed time and date if it is acceptable to continue our discussions to 9:30 a.m. Mountain Time on May 12, which is a Tuesday, which is two weeks from today, if that's acceptable to both Kansas and Nebraska, by phone again. And that would be to continue this special meeting.

COMMISSIONER BARFIELD: Dick, this is Dave Barfield. I am going to be, most of that week, in North Dakota for some other meetings. Maybe Brian is in that same meeting, but I can't -- I haven't conferred with my team as to the exact time that will work with us.

COMMISSIONER WOLFE: Okay. We -- I guess if it's acceptable, given that we might need to coordinate some schedules, that we could continue this meeting to an appropriate time in the next two to three weeks that will be confirmed by e-mail between the three states and notice would be provided of that continuation of the public meeting once it is set.

COMMISSIONER BARFIELD: This is Dave Barfield. That would be fine with us here.

COMMISSIONER WOLFE: Commissioner Dunnigan?

COMMISSIONER DUNNIGAN: That would be fine with us.

COMMISSIONER WOLFE: Colorado will take the lead in initiating that coordination of the meeting, the continuation of the special RRCA meeting, in two to three weeks by e-mail with the follow-up of public notice of the time and location. I would expect that it would be maybe a similar call-in like we have done today for that meeting.

And Commissioner Dunnigan, at this time that concludes Colorado's portion on the agenda. We would turn it back to you as the chairman to conclude the rest of the agenda.

COMMISSIONER DUNNIGAN: Thank you, Commissioner Wolfe.

Are there any other comments?

Commissioner Barfield?

COMMISSIONER BARFIELD: No, there are not.

COMMISSIONER DUNNIGAN: Hearing none, I would ask for motion to adjourn.

COMMISSIONER WOLFE: I think we would like to make the motion to continue the meeting until we establish the next meeting in two to three weeks.

COMMISSIONER DUNNIGAN: That would be fine. Thank you.

COMMISSIONER BARFIELD: Is that a motion?

COMMISSIONER WOLFE: That's a motion by me, Dick Wolfe.

COMMISSIONER BARFIELD: All right, I'll second.

COMMISSIONER DUNNIGAN: All those in favor?

COMMISSIONER BARFIELD: Aye.

COMMISSIONER DUNNIGAN: Aye.

COMMISSIONER WOLFE: Aye.

COMMISSIONER DUNNIGAN: Opposed?

We'll continue the meeting at a later date. Thank you.

COMMISSIONER WOLFE: All right, thank you all. We are going to discontinue or disconnect on this end at this time.

(The meeting was adjourned at 9:43 a.m.)

STATE OF COLORADO)
                  )  Ss.  REPORTER'S CERTIFICATE
COUNTY OF DENVER )

I, Dyann Labo, do hereby certify that I am a Registered Professional Reporter and Notary Public within the state of Colorado.

I further certify that this telephonic meeting was taken in shorthand by me at the time and place herein set forth and was thereafter reduced to typewritten form, and that the foregoing constitutes a true and correct transcript.

I further certify that I am not related to, employed by, nor of counsel for any of the parties or attorneys herein, nor otherwise interested in the result of the within action.

In witness whereof, I have affixed my signature this 6th day of May 2009.

___________________________
PATTERSON REPORTING & VIDEO
Dyann Labo
Registered Professional Reporter
and Notary Public

## A



## B



## C

## D

# ATTACHMENT C

## RESOLUTION PROPOSED BY COLORADO
*Regarding the*
## COMPACT COMPLIANCE PIPELINE
APRIL 28, 2009

RESOLUTION BY THE REPUBLICAN RIVER COMPACT ADMINISTRATION REGARDING APPROVAL OF COLORADO'S AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES SUBMITTED UNDER SUBSECTION III.B.1.k OF THE FINAL SETTLEMENT STIPULATION

April __, 2009

**Whereas,** the States of Kansas, Nebraska, and Colorado entered into a Final Settlement Stipulation ("FSS") as of December 15, 2002, to resolve pending litigation in the United States Supreme Court regarding the Republican River Compact ("Compact") in the case of *Kansas v. Nebraska and Colorado*, No. 126 Original;

**Whereas,** the FSS was approved by the United States Supreme Court on May 19, 2003;

**Whereas**, the State of Colorado's Computed Beneficial Consumptive Use of the waters of the Republican River Basin exceeded Colorado's Compact Allocation using the five-year running average to determine Compact compliance from 2003 through 2007, as provided in Subsection IV.D of the FSS;

**Whereas**, the Republican River Water Conservation District is a water conservation district created by Colorado statute to assist the State of Colorado to comply with the Compact;

**Whereas,** the Republican River Water Conservation District, acting by and through its Water Activity Enterprise ("RRWCD WAE"), has contracted to acquire fifteen Compact Compliance Wells in the Republican River Basin in Colorado for the sole purpose of offsetting stream depletions in order to comply with the State of Colorado's Compact Allocations;

**Whereas**, the RRWCD WAE has contracted to purchase groundwater rights in the Republican River Basin within Colorado and proposes to pump the historical consumptive use of all or some of these water rights from the Compact Compliance Wells into a pipeline and deliver that water into the North Fork of the Republican River near the Colorado/Nebraska State Line to offset stream depletions in order to comply with Colorado's Compact Allocations ("Colorado Compact Compliance Pipeline");

**Whereas,** the States of Kansas, Nebraska, and Colorado adopted a Moratorium on New Wells in Subsection III.A of the FSS, with certain exceptions set forth in subsection III.B of the FSS;

**Whereas**, Subsection III.B.1.k of the FSS provides that the Moratorium shall not apply to wells acquired or constructed by a State for the sole purpose of offsetting stream depletions in order to comply with its Compact Allocations, provided that such wells shall not cause any new net depletion to stream flow either annually or long term;

**Whereas**, Subsection III.B.1.k of the FSS further provides that augmentation plans and related accounting procedures submitted under this Subsection III.B.1.k shall be approved by the Republican River Compact Administration ("RRCA") prior to implementation;

**Whereas,** Subsection I.F of the FSS also provides that: "The RRCA may modify the RRCA Accounting Procedures, or any portion thereof, in any manner consistent with the Compact and this Stipulation;" and

**Whereas**, the State of Colorado and the RRWCD WAE have submitted an augmentation plan and related accounting procedures to account for water delivered to the North Fork of the Republican River for the purpose of offsetting stream depletions in order to comply with Colorado's Compact Allocations.

**Now, therefore,** it is hereby resolved that the RRCA approves the augmentation plan and the related accounting procedures submitted by the State of Colorado and the RRWCD WAE under Subsection III.B.1.k of the FSS, subject to the terms and conditions set forth herein. The augmentation plan is described in the application submitted by the State of Colorado and the RRWCD WAE, which is attached hereto as Exhibit 1. The related accounting procedures are included in the revised RRCA Accounting Procedures and Reporting Requirements ("revised RRCA Accounting Procedures"), which are attached hereto as Exhibit 2. This approval of the augmentation plan and the related accounting procedures shall be subject to the following terms and conditions:

1. The average annual historical consumptive use of the groundwater rights that will be diverted at the Compact Compliance Wells shall be as determined by the Colorado Ground Water Commission pursuant to its rules and regulations, provided that the average annual historical consumptive use of the groundwater rights listed on Exhibit 3 shall not exceed the 1corrected historical consumptive use amounts shown in column (7) on Exhibit 3. Annual diversions during any calendar year under the groundwater rights included in the augmentation plan shall be limited to the total average annual historical consumptive use of the rights, except as provided in paragraph 3 below.

2. Net depletions from the Colorado Compact Compliance Wells shall be computed by the RRCA Groundwater Model and included in Colorado's Computed Beneficial Consumptive Use of groundwater pursuant to paragraph III.D.1 of the revised RRCA Accounting Procedures. Groundwater pumping from the Compact Compliance Wells shall be measured by totalizing flow meters, and the measured groundwater pumping from such wells shall be included in the base "run" of the RRCA Groundwater Model in accordance with paragraph III.D.1 of the revised RRCA Accounting Procedures.

3. Diversions from any individual Compact Compliance Well shall be limited to no more than 2,500 acre feet per year. Banking of groundwater shall be permitted in accordance with the rules and regulations of the Colorado Ground Water Commission, subject to the limit on Augmentation Water Supply Credit in paragraph 4 below.

4. The Augmentation Water Supply Credit due to deliveries from the Colorado Compact Compliance Pipeline that will be applied against the Computed Beneficial Consumptive Use of water to offset stream depletions in order to comply with Colorado's Compact Allocations during any calendar year shall be limited as follows:

   <u>Calculation of Projected Augmentation Water Supply Delivery to Determine the Limit on Augmentation Water Supply Credit</u>

   Each year, using the procedures described below, Colorado will determine the Projected Augmentation Water Supply Delivery ("Projected Delivery") for the upcoming accounting year (the "subject accounting year") to estimate the volume of Augmentation Water Supply that will be delivered from the Colorado Compact Compliance Pipeline during the subject accounting year. The RRWCD WAE will begin deliveries from the Colorado Compact Compliance Pipeline during the subject accounting year based on the Projected Delivery, but actual deliveries will be adjusted during the course of the year based on hydrologic and climatic conditions and the need to offset stream depletions in order to comply with Colorado's Compact Allocations, subject to the limit on the Augmentation Water Supply Credit set forth below.

   The steps to determine the Projected Delivery and the limit on the Augmentation Water Supply Credit are as follows:

   A. Step 1. By March 31st of each year, Colorado will calculate Colorado's total Allocation and Colorado's Computed Beneficial Consumptive Use ("CBCU") for the previous accounting year using the procedures described in the revised RRCA Accounting Procedures, but using preliminary data where necessary.

   B. Step 2. Colorado will determine the Projected Delivery, which shall be the largest annual deficit or difference between Colorado's total annual Allocation and Colorado's CBCU during the 10 accounting years immediately preceding the subject accounting year; provided, however, that accounting years in which Colorado's total annual Allocation exceeds Colorado's CBCU shall not be used in determining the Projected Delivery.

   C. Step 3. The Colorado RRCA Member shall provide notice of the Projected Delivery determination to the Kansas and Nebraska RRCA Members by April 1 of each year.

D. Step 4. The Augmentation Water Supply Credit for the subject accounting year shall be limited to the Projected Delivery plus 4,000 acre-feet, or 140% of the Projected Delivery, whichever is greater.

Examples of how this limitation shall be applied are attached as Exhibit 4.

5. The preliminary design for the Colorado Compact Compliance Pipeline is described in the application attached hereto as Exhibit 1. The State of Colorado and the RRWCD WAE shall submit the final design for the Colorado Compact Compliance Pipeline to the RRCA and any changes to the final design after the Colorado Compliance Pipeline has been constructed. If the final design or changes to the final design of the Colorado Compliance Pipeline as constructed differ from the preliminary design in a way that would materially change the location of the Compact Compliance Wells or the river outlet structure, the RRCA may modify the terms and conditions of this approval.

6. The RRWCD WAE may acquire additional groundwater rights to be pumped through the Compact Compliance Wells upon the terms and conditions of this resolution. The State of Colorado and the RRWCD WAE shall file a notice with the RRCA identifying the additional groundwater rights and the historical consumptive use of the groundwater rights. The RRCA members shall have sixty days from the date the notice is given to review the information. If no objection is made within sixty days from the date the notice is given, the additional groundwater rights may be pumped through the Compact Compliance Wells upon the terms and conditions of this resolution. If an objection is made by any RRCA member, the objection shall be shall be given in writing to the RRWCD WAE within 60 days from the date the notice is given and the notice shall be treated as an application for approval of an augmentation plan and related accounting procedures under Subsection III.B.1.k of the FSS and the State of Colorado and the RRWCD WAE may submit any additional information to address the objection.

7. The approval of this augmentation plan and the related accounting procedures shall not govern the approval of any future proposed augmentation plan and related accounting procedures submitted by any other State under Subsection III.B.1.k of the FSS.

8. The approval of this augmentation plan and the related accounting procedures shall not waive any State’s rights to seek damages from any other State for violations of the Compact or the FSS subsequent to December 15, 2002.

9. Except for the approval of the augmentation plan and the related accounting procedures as provided herein, nothing in this Resolution shall relieve the State of Colorado from complying with the obligations set forth in the Compact or FSS.

Approved by the RRCA this ____ day of April, 2009.

| | |
|---|---|
| Brian Dunnigan, P.E.<br>Nebraska Member<br>Chairman, RRCA | date |
| David Barfield, P.E.<br>Kansas Member | date |
| Dick Wolfe, P.E.<br>Colorado Member | date |

# EXHIBIT 1 TO ATTACHMENT A

*Application for Approval of an*
*Augmentation Plan and Related Accounting Procedures*

*The Republican River Compact Compliance Pipeline*

Submitted by the

State of Colorado

And the

Republican River Water Conservation District
Acting by and through its
Water Activity Enterprise

March 2008.

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

Bill Ritter, Jr.
Governor

Harris D. Sherman
Executive Director

Dick Wolfe, P.E.
Director/State Engineer

# APPLICATION FOR APPROVAL OF AN AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES UNDER SUBSECTION III.B.I.K. OF THE FINAL SETTLEMENT STIPULATION IN KANSAS V. NEBRASKA AND COLORADO, NO. 126, ORIGINAL

## The Republican River Compact Compliance Pipeline

**Submitted by**

**The State of Colorado**
**And**
**The Republican River Water Conservation District, acting by and through its Water Activity Enterprise**

**March 2008**

STATE OF COLORADO
DIVISION OF WATER RESOURCES
1313 Sherman Street, Room 818
Denver, Colorado 80203
(303) 866-3581

| | |
|---|---|
| Colorado Compact Commissioner | Dick Wolfe |
| Colorado Engineer Advisor | Ken Knox |

REPUBLICAN RIVER WATER CONSERVATION DISTRICT
410 MAIN STREET, SUITE 8
WRAY, COLORADO 80758
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Tim Pautler, Secretary
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## LIST OF TABLES (follow text)



## LIST OF FIGURES (follow Tables)

# 1.0 INTRODUCTION

## 1.1. The Republican River Compact Compliance Pipeline

Subsection III.B.1.k of the Final Settlement Stipulation in *Kansas v. Nebraska and Colorado*, No. 126, Original (U.S. Sup. Court) allows the acquisition or construction of wells for the purpose of offsetting stream depletions in order to comply with a State's Compact Allocations. Subsection III.B.1.k states that these wells "shall not cause any new net depletion to stream flow either annually or long-term." It further states: "The determination of net depletions from these Wells will be computed by the RRCA Groundwater Model and included in the State's Computed Beneficial Consumptive Use. Augmentation plans and related accounting procedures submitted under this Subsection III.B.1.k shall be approved by the RRCA [Republican River Compact Administration] prior to implementation."

The Republican River Water Conservation District (RRWCD) was formed in 2004 to assist the State of Colorado to comply with the Compact, and the RRWCD, acting through its Water Activity Enterprise (WAE), has entered into contracts to purchase rights to ground water located north of the North Fork of the Republican River in the Republican River Basin in Colorado. These rights have an historical consumptive use of approximately 15,000 acre-feet per year. The RRWCD WAE is currently in the process of completing the engineering design of a 12.7 mile Compact Compliance Pipeline to deliver this water to the North Fork of the Republican River to offset stream depletions in order to comply with Colorado's Compact Allocations. The general location of the compact compliance pipeline is shown in Figure 1. The design is scheduled for completion in August of this year. Selection of the construction contractor is anticipated to be finalized by the first of October and construction on the pipeline and related facilities will commence in November. Construction of the pipeline is scheduled for completion of June of 2009 and approximately 11,000 ac-ft will be delivered between June and December to allow Colorado to meet its compact obligation in 2009.

The RRWCD WAE has applied for, and received preliminary approval, a $60.6 million loan from the Colorado Water Conservation Board Water Project Construction Fund to purchase these rights to and to construct the Compact Compliance Pipeline to offset stream depletions in order to comply within Colorado's Compact Allocations.

The State of Colorado on behalf of the RRWCD WAE requests that the RRCA approve an augmentation plan and related accounting procedures described in this application under Subsection III.B.1.k of the Final Settlement Stipulation for the Republican River Compact Compliance Pipeline.

### 1.2. Project Sponsor – The Republican River Water Conservation District, acting by and through its Water Activity Enterprise

The RRWCD is managed and controlled by a 15-member board of directors comprised of one member appointed by the county commissioners of each of the seven counties wholly or partially within the RRWCD, one member appointed by the boards of the seven ground water management districts within the RRWCD, and one member appointed by the Colorado Ground Water Commission. The RRWCD Board of Directors established the RRWCD Water Activity Enterprise (WAE) in October 2004.

The RRWCD Board of Directors imposed a use fee on the diversion of water within the District of $5.50 per assessed irrigated acre on diversions of ground water for irrigation use by post-compact wells within the District. The RRWCD Board recently increased the use fee to $14.50 per assessed irrigated acre to pay for the Republican River Compact Compliance Pipeline. There are approximately 500,500 assessed irrigated acres in the basin irrigated by post-compact wells and the RRWCD fee will generate approximately $7.3 million per year for operating expenses and to pay back the loans used to acquire the water rights and construct the compact compliance pipeline.

The RRWCD WAE uses a portion of the revenues collected from use fees to provide local cost-sharing for federal programs designed to retire irrigated acreage in the basin, including the Republican River Conservation Reserve Enhancement Program (CREP) and the Environmental Quality Improvement Program (EQIP). To date, approximately 30,000 irrigated acres have been voluntarily retired in the basin under CREP and EQIP, or approximately five percent (5%) of the irrigated acreage in the basin. An amendment to the Republican River CREP designed to retire an additional 30,000 irrigated acres has been submitted to the U.S. Department of Agriculture for approval. The RRWCD WAE has committed to provide local cost-sharing for a second Republican River CREP amendment that is proposed to retire an additional 30,000 acres. The CREP program is an important part of the RRWCD efforts to implement conservation measures in the basin to reduce groundwater pumping in Colorado to assist in meeting compact compliance obligations.

The RRWCD is located in northeastern Colorado and includes all of Yuma and Phillips Counties and those portions of Kit Carson, Lincoln, Logan, Sedgwick, and Washington Counties that overlie the Ogallala Aquifer. The RRWCD encompasses about 7,761 square miles or about 7.5% of Colorado's 104,247 square miles. There is currently about 545,000 irrigated acres within the Ogallala Aquifer in Colorado with 500,500 irrigated acres located within the RRWCD boundaries. With the exception of approximately 3,000 acres irrigated by surface water, virtually all the acreage in the basin is irrigated with ground water from the Ogallala Aquifer. A map of the RRWCD boundaries is shown in Figure 2.

## 2.0 AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES

The State of Colorado has exceeded its compact allocation by approximately 11,000 ac-ft/yr for period of 2003-2007. In order to comply with the State of Colorado's Compact Allocations, the RRWCD WAE has entered into contracts to acquire ground water rights that were historically used for irrigation in the Republican River Basin. The location of the lands that were historically irrigated with the water rights acquired by the RRWCD WAE is shown in Figures 3 and 4.

The RRWCD WAE will change the use of these existing rights and consolidate these rights at fifteen existing Republican River Compact Compliance Wells (Compact Compliance Wells) that will be used for the sole purpose of offsetting stream depletions in order to comply with the State of Colorado's Compact Allocations. Initially only eight of the wells will be active with an additional seven existing wells that will serve as backup if additional well capacity in needed in the future. The locations of the 15 wells are shown in Figure 4 (wells A1 through A8 are the initial wells, and the wells numbered B1 through B7 are the backup wells).

The compact compliance wells are located in the area of the Ogallala Aquifer in Colorado that has the greatest saturated thickness. The wells typically have 250 to 300 feet of saturated thickness. The well field is also located in the sand hills region of Colorado that has the highest recharge rates of any location in the Republican River Basin.

The Computed Beneficial Consumptive Use of the compact compliance wells, specifically the ground water impacts of these wells upon the stream system, will be determined by use of the RRCA Groundwater Model as the difference in streamflows using two runs of the model that is consistent with Section III.D.1 of the Republican River Compact Administration Accounting Procedures and Reporting Requirements.

The historical consumptive use of the rights that will be diverted at the Compact Compliance Wells was determined based on irrigation system and pump efficiency tests, power records, and crop records for ten year period from 1998 to 2007 as summarized in Table 1. The procedures for changing the use of existing rights to designated ground water based on historical consumptive use are established in the current Colorado Ground Water Commission rules. The Compact Compliance Wells will cause no new net depletions because pumping will be limited to the historical consumptive use of the existing rights.

The pumping under this plan for augmentation will be limited to the historical consumptive use of existing groundwater rights as determined by the Colorado Ground Water Commission pursuant to its rules and regulations, which permit banking of ground water once a change has been based on historical consumptive use. Pumping from the Compact Compliance Wells will be metered and included in the RRCA Groundwater Motel. The groundwater pumped by the Compact Compliance Wells will be delivered by a pipeline to the North Fork of the Republican River a short distance upstream from the streamflow gage at the Colorado-Nebraska state line (USGS gaging station number 06823000, North Fork Republican River at the Colorado-Nebraska State Line). The augmentation discharge will be measured and subtracted from the gaged flow of the North Fork of the Republican River to calculate the Annual Virgin Water Supply. The augmentation discharge to the North Fork of the Republican River from the Compact Consumptive Pipeline will be the Augmentation Credit for the purpose of offsetting stream depletions to comply with the State of Colorado’s Compact Allocations and shall be counted as a credit/offset against the Computed Beneficial Consumptive use of water allocated to Colorado

## 3.0 ENGINEERING ANALYSIS FOR THE COMPACT COMPLIANCE PIPELINE

Approximately 11,000 acre-feet of water per year needs to be supplied by the compact compliance pipeline to meet Colorado’s Compact obligation. The initial capacity of the main trunk of the pipeline will be 15,000 acre-feet per year using a nine-month delivery season. The pipeline is being designed so that it will be capable of delivering up to 25,000 ac-ft/yr by adding a pumping facility to deliver the water under a higher pressure.

### 3.1. Water Quality

All of the streamflow in the North Fork of the Republican River, with the exception of the occasional rainstorm event, is derived from groundwater inflow from the Ogallala Aquifer. The compact compliance pipeline will deliver groundwater from the Ogallala aquifer to the North Fork of the Republican River at the state line. Table 2 presents the ground water quality of the Ogallala aquifer relative to the water quality standards for the North Fork of the Republican River, as published by the Colorado Water Quality Control Commission. The water quality of the Ogallala Aquifer meets or exceeds drinking water standards. This is to be expected because the groundwater management districts in Colorado carefully monitor the water quality in the Ogallala Aquifer since the groundwater supplies agriculture uses along with domestic, municipal, and industrial uses. Thus, the water quality of ground water for the Republican River Compact Compliance Pipeline is appropriate for delivery to the North Fork of the Republican River to offset stream depletions.

### 3.2. Pipeline Design

The RRWCD WAE contracted with GEI Consultants to perform a preliminary feasibility study for the design of a compact compliance pipeline. The $50,000 study was completed in January of 2008. Based on the recommendations in this report, the RRWCD WAE has contracted with GEI Consultants to proceed with the final design of the compact compliance pipeline. The final design of the compact compliance pipeline is scheduled to be completion in August of 2008 and is budgeted to cost approximately $1 million dollars.

The preliminary design of the Republican River Compact Compliance Pipeline has been completed and is summarized in the following paragraphs. This summary is based on the preliminary design and the design refinements made in the last two months. The final design is currently under way and the general description included in this report will probably somewhat in the next few months as the design is finalized.

The well field to pump the water will consist of 8 wells numbered A1 through A8 as shown in Figure 4. The design of the pipeline will also allow for an additional 7 wells numbered B1 through B7 in Figure 4. These 7 additional wells will not initially be connected to the pipeline, but are available for future use if needed.

Water pumped from the individual wells will be collected in a series of pipes that will vary in size from 12” to 18” and the water will then be conveyed to a 1 million gallon re-regulating storage tank. The storage tank will provide reserve capacity allowing the main pipeline to operate for 2 hours at two-thirds capacity with no inflow to the tank from the well field. The storage tank will also provide protection of the main pipeline from surge and negative pressures that could develop if the main pipeline were connected directly to the well field collection system.

From the storage tank the water will flow by gravity through the main water 36-inch diameter conveyance pipeline approximately 12.7 miles to the North Fork of the Republican River following the general alignment shown on Figure 3. Releases from the tank will be regulated by a valve located near the tank, and an ultra-sonic flow meter will be provided approximately 30 feet downstream of the release valve. The main conveyance pipeline will be designed so that a pump could be added at the outlet of the storage tank to increase the capacity of the pipeline to approximately 25,000 ac-ft/yr in the future.

At this time, the most likely type of pipe material is PVC. The pipeline will be buried with minimum cover of three feet above the crown of the pipe. To assure integrity, the pipe will be properly bedded prior to filling the trench with well-compacted backfill. Access manholes, air release valves, and drain valves will be provided at appropriate locations along the pipeline, as determined during the final design and confirmed during construction.

Table 3 contains summaries of the preliminary cost estimates developed by GEI during the preliminary feasibility study for the Compact Compliance Pipeline project. The final cost estimates will be dependent upon the final design and the bids received by the contractors. The key milestone dates discussed in previous sections of this report are summarized Table 4. Achieving this schedule will enable full delivery of water to begin in the latter part of June 2009. The project should be able to deliver close to 11,000 acre-feet of water in by year-end 2009.

## 4.0 REQUEST FOR APPROVAL

The State of Colorado on behalf of the RRWCD WAE requests that RRCA approve an augmentation plan and related accounting procedures described above under Subsection III.B.1.k of the Final Settlement Stipulation for the Republican River Compact Compliance Pipeline.

# EXHIBIT 2 TO ATTACHMENT A

Proposed Changes to the

*Republican River Compact Administration*
*Accounting Procedures and Reporting Requirements*

Revised July 27, 2005
Updated November 7, 2008
Colorado Proposal, Updated January 26, 2009.

# Republican River Compact Administration

## ACCOUNTING PROCEDURES

## AND

## REPORTING REQUIREMENTS

Revised July 27, 2005

Updated November 7, 2008

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Colorado Proposal
Updated January 26, 2009

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## I. Introduction

This document describes the definitions, procedures, basic formulas, specific formulas, and data requirements and reporting formats to be used by the RRCA to compute the Virgin Water Supply, Computed Water Supply, Allocations, Imported Water Supply Credit, Augmentation Water Supply Credit, and Computed Beneficial Consumptive Use. These computations shall be used to determine supply, allocations, use and compliance with the Compact according to the Stipulation. These definitions, procedures, basic and specific formulas, data requirements and attachments may be changed by consent of the RRCA consistent with Subsection I.F of the Stipulation. This document will be referred to as the RRCA Accounting Procedures. Attached to these RRCA Accounting Procedures as Figure 1 is the map attached to the Compact that shows the Basin, its streams and the Basin boundaries.

## II. Definitions

The following words and phrases as used in these RRCA Accounting Procedures are defined as follows:

**Additional Water Administration Year -** a year when the projected or actual irrigation water supply is less than 130,000 Acre-feet of storage available for use from Harlan County Lake as determined by the Bureau of Reclamation using the methodology described in the Harlan County Lake Operation Consensus Plan attached as Appendix K to the Stipulation.

**Allocation(s):** the water supply allocated to each State from the Computed Water Supply;

**Annual:** yearly from January 1 through December 31;

**Augmentation Plan:** a detailed program used by a State to offset stream depletions in order to comply with its Compact Allocations. An Augmentation Plan shall be approved by the RRCA prior to implementation in accordance with Subsection III.B.1.k of the Stipulation;

**Augmentation Water Supply:** the water supply developed through the acquisition or construction of wells for the sole purpose of offsetting stream depletions in order to comply with a State's Compact Allocations in conformance with an Augmentation Plan;

**Augmentation Water Supply Credit:** the amount of water measured and discharged to the stream flow of a Designated Drainage Basin due to the acquisition or construction of wells for the purpose of offsetting stream depletions to comply with a States' Compact Allocation in conformance with an Augmentation Plan. The Augmentation Water Supply Credit of a State shall not be included in the Virgin Water Supply in the Designated Drainage Basin and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State;

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**Basin:** the Republican River Basin as defined in Article II of the Compact;

**Beneficial Consumptive Use:** that use by which the Water Supply of the Basin is consumed through the activities of man, and shall include water consumed by evaporation from any reservoir, canal, ditch, or irrigated area;

**Change in Federal Reservoir Storage:** the difference between the amount of water in storage in the reservoir on December 31 of each year and the amount of water in storage on December 31 of the previous year. The current area capacity table supplied by the appropriate federal operating agency shall be used to determine the contents of the reservoir on each date;

**Compact:** the Republican River Compact, Act of February 22, 1943, 1943 Kan. Sess. Laws 612, codified at Kan. Stat. Ann. § 82a-518 (1997); Act of February 24, 1943, 1943 Neb. Laws 377, codified at 2A Neb. Rev. Stat. App. § 1-106 (1995), Act of March 15, 1943, 1943 Colo. Sess. Laws 362, codified at Colo. Rev. Stat. §§ 37-67-101 and 37-67-102 (2001); Republican River Compact, Act of May 26, 1943, ch. 104, 57 Stat. 86;

**Computed Beneficial Consumptive Use:** for purposes of Compact accounting, the stream flow depletion resulting from the following activities of man:

Irrigation of lands in excess of two acres;
Any non-irrigation diversion of more than 50 Acre-feet per year;
Multiple diversions of 50 Acre-feet or less that are connected or otherwise combined to serve a single project will be considered as a single diversion for accounting purposes if they total more than 50 Acre-feet;
Net evaporation from Federal Reservoirs;
Net evaporation from Non-federal Reservoirs within the surface boundaries of the Basin;
Any other activities that may be included by amendment of these formulas by the RRCA;

**Computed Water Supply:** the Virgin Water Supply less the Change in Federal Reservoir Storage in any Designated Drainage Basin, and less the Flood Flows;

**Designated Drainage Basins:** the drainage basins of the specific tributaries and the Main Stem of the Republican River as described in Article III of the Compact. Attached hereto as Figure 3 is a map of the Sub-basins and Main Stem;

**Dewatering Well:** a Well constructed solely for the purpose of lowering the groundwater elevation;

**Federal Reservoirs:**

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Swanson Lake
Enders Reservoir
Hugh Butler Lake
Harry Strunk Lake
Keith Sebelius Lake
Harlan County Lake
Lovewell Reservoir

**Flood Flows:** the amount of water deducted from the Virgin Water Supply as part of the computation of the Computed Water Supply due to a flood event as determined by the methodology described in Subsection III.B.1.;

**Gaged Flow:** the measured flow at the designated stream gage;

**Guide Rock:** a point at the Superior-Courtland Diversion Dam on the Republican River near Guide Rock, Nebraska; the Superior-Courtland Diversion Dam gage plus any flows through the sluice gates of the dam, specifically excluding any diversions to the Superior and Courtland Canals, shall be the measure of flows at Guide Rock;

**Historic Consumptive Use:** that amount of water that has been consumed under appropriate and reasonably efficient practices to accomplish without waste the purposes for which the appropriation or other legally permitted use was lawfully made;

**Imported Water Supply**: the water supply imported by a State from outside the Basin resulting from the activities of man;

**Imported Water Supply Credit:** the accretions to stream flow due to water imports from outside of the Basin as computed by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State, except as provided in Subsection V.B.2. of the Stipulation and Subsections III.I. – J. of these RRCA Accounting Procedures;

**Main Stem**: the Designated Drainage Basin identified in Article III of the Compact as the North Fork of the Republican River in Nebraska and the main stem of the Republican River between the junction of the North Fork and the Arikaree River and the lowest crossing of the river at the Nebraska-Kansas state line and the small tributaries thereof, and also including the drainage basin Blackwood Creek;

**Main Stem Allocation:** the portion of the Computed Water Supply derived from the Main Stem and the Unallocated Supply derived from the Sub-basins as shared by Kansas and Nebraska;

**Meeting(s):** a meeting of the RRCA, including any regularly scheduled annual meeting or any special meeting;

**Modeling Committee:** the modeling committee established in Subsection IV.C. of the Stipulation;

**Moratorium**: the prohibition and limitations on construction of new Wells in the geographic area described in Section III. of the Stipulation;

**Non-federal Reservoirs:** reservoirs other than Federal Reservoirs that have a storage capacity of 15 Acre-feet or greater at the principal spillway elevation;

**Northwest Kansas:** those portions of the Sub-basins within Kansas;

**Replacement Well:** a Well that replaces an existing Well that a) will not be used after construction of the new Well and b) will be abandoned within one year after such construction or is used in a manner that is excepted from the Moratorium pursuant to Subsections III.B.1.c.-f. of the Stipulation;

**RRCA**: Republican River Compact Administration, the administrative body composed of the State officials identified in Article IX of the Compact;

**RRCA Accounting Procedures:** this document and all attachments hereto;

**RRCA Groundwater Model**: the groundwater model developed under the provisions of Subsection IV.C. of the Stipulation and as subsequently adopted and revised through action of the RRCA;

**State:** any of the States of Colorado, Kansas, and Nebraska;

**States:** the States of Colorado, Kansas and Nebraska;

**Stipulation:** the Final Settlement Stipulation to be filed in *Kansas v. Nebraska and Colorado*, No. 126, Original, including all Appendices attached thereto;

**Sub-basin**: the Designated Drainage Basins, except for the Main Stem, identified in Article III of the Compact. For purposes of Compact accounting the following Sub-basins will be defined as described below:

> North Fork of the Republican River in Colorado drainage basin is that drainage area above USGS gaging station number 06823000, North Fork Republican River at the Colorado-Nebraska State Line,

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Arikaree River drainage basin is that drainage area above USGS gaging station number 06821500, Arikaree River at Haigler, Nebraska,

Buffalo Creek drainage basin is that drainage area above USGS gaging station number 06823500, Buffalo Creek near Haigler, Nebraska,

Rock Creek drainage basin is that drainage area above USGS gaging station number 06824000, Rock Creek at Parks, Nebraska,

South Fork of the Republican River drainage basin is that drainage area above USGS gaging station number 06827500, South Fork Republican River near Benkelman, Nebraska,

Frenchman Creek (River) drainage basin in Nebraska is that drainage area above USGS gaging station number 06835500, Frenchman Creek in Culbertson, Nebraska,

Driftwood Creek drainage basin is that drainage area above USGS gaging station number 06836500, Driftwood Creek near McCook, Nebraska,

Red Willow Creek drainage basin is that drainage area above USGS gaging station number 06838000, Red Willow Creek near Red Willow, Nebraska,

Medicine Creek drainage basin is that drainage area above the Medicine Creek below Harry Strunk Lake, State of Nebraska gaging station number 06842500; and the drainage area between the gage and the confluence with the Main Stem,

Sappa Creek drainage basin is that drainage area above USGS gaging station number 06847500, Sappa Creek near Stamford, Nebraska and the drainage area between the gage and the confluence with the Main Stem; and excluding the Beaver Creek drainage basin area downstream from the State of Nebraska gaging station number 06847000 Beaver Creek near Beaver City, Nebraska to the confluence with Sappa Creek,

Beaver Creek drainage basin is that drainage area above State of Nebraska gaging station number 06847000, Beaver Creek near Beaver City, Nebraska, and the drainage area between the gage and the confluence with Sappa Creek,

Prairie Dog Creek drainage basin is that drainage area above USGS gaging station number 06848500, Prairie Dog Creek near Woodruff, Kansas, and the drainage area between the gage and the confluence with the Main Stem;

Attached hereto as Figure 2 is a line diagram depicting the streams, Federal Reservoirs and gaging stations;

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**Test hole:** a hole designed solely for the purpose of obtaining information on hydrologic and/or geologic conditions;

**Trenton Dam**: a dam located at 40 degrees, 10 minutes, 10 seconds latitude and 101 degrees, 3 minutes, 35 seconds longitude, approximately two and one-half miles west of the town of Trenton, Nebraska;

**Unallocated Supply**: the "water supplies of upstream basins otherwise unallocated" as set forth in Article IV of the Compact;

**Upstream of Guide Rock, Nebraska:** those areas within the Basin lying west of a line proceeding north from the Nebraska-Kansas state line and following the western edge of Webster County, Township 1, Range 9, Sections 34, 27, 22, 15, 10 and 3 through Webster County, Township 2, Range 9, Sections 34, 27 and 22; then proceeding west along the southern edge of Webster County, Township 2, Range 9, Sections 16, 17 and 18; then proceeding north following the western edge of Webster County, Township 2, Range 9, Sections 18, 7 and 6, through Webster County, Township 3, Range 9, Sections 31, 30, 19, 18, 7 and 6 to its intersection with the northern boundary of Webster County. Upstream of Guide Rock, Nebraska shall not include that area in Kansas east of the 99° meridian and south of the Kansas-Nebraska state line;

**Virgin Water Supply:** the Water Supply within the Basin undepleted by the activities of man;

**Water Short Year Administration:** administration in a year when the projected or actual irrigation water supply is less than 119,000 acre feet of storage available for use from Harlan County Lake as determined by the Bureau of Reclamation using the methodology described in the Harlan County Lake Operation Consensus Plan attached as Appendix K to the Stipulation.

**Water Supply of the Basin** or **Water Supply within the Basin:** the stream flows within the Basin, excluding Imported Water Supply;

**Well:** any structure, device or excavation for the purpose or with the effect of obtaining groundwater for beneficial use from an aquifer, including wells, water wells, or groundwater wells as further defined and used in each State's laws, rules, and regulations.

## III. Basic Formulas

The basic formulas for calculating Virgin Water Supply, Computed Water Supply, Imported Water Supply, Allocations and Computed Beneficial Consumptive Use are set forth below. The results of these calculations shall be shown in a table format as shown in Table 1.

Basic Formulas for Calculating Virgin Water Supply, Computed Water Supply, Allocations and Computed Beneficial Consumptive Use

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| | | |
|---|---|---|
| Sub-basin VWS | = | Gage + All CBCU – AWS +ΔS – IWS |
| Main Stem VWS | = | Hardy Gage – Σ Sub-basin gages + All CBCU in the Main Stem +ΔS – IWS |
| CWS | = | VWS - Δ S – FF |
| Allocation for each State in each Sub-basin And Main Stem | = | CWS x % |
| State's Allocation | = | Σ Allocations for Each State |
| State's CBCU | = | Σ State's CBCUs in each Sub-basin and Main Stem |

Abbreviations:

AWS = Augmentation Water Supply Credit
CBCU = Computed Beneficial Consumptive Use
FF = Flood Flows
Gage = Gaged Flow
IWS = Imported Water Supply Credit
CWS = Computed Water Supply
VWS = Virgin Water Supply
% = the ratio used to allocate the Computed Water Supply between the States. This ratio is based on the allocations in the Compact
Δ S = Change in Federal Reservoir Storage

## A. Calculation of Annual Virgin Water Supply

### 1. Sub-basin calculation:

The annual Virgin Water Supply for each Sub-basin will be calculated by adding: a) the annual stream flow in that Sub-basin at the Sub-basin stream gage designated in Section II., b) the annual Computed Beneficial Consumptive Use above that gaging station, and c) the Change in Federal Reservoir Storage in that Sub-basin; and from that total subtract any Imported Water Supply Credit and any Augmentation Water Supply Credit. The Computed Beneficial Consumptive Use will be calculated as described in Subsection III. D. Adjustments for flows diverted around stream gages and for Computed Beneficial Consumptive Uses in the Sub-basin between the Sub-basin stream gage and the confluence of the Sub-basin tributary and the Main Stem shall be made as described in Subsections III. D. 1 and 2 and IV. B.

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**2. Main Stem Calculation:**

The annual Virgin Water Supply for the Main Stem will be calculated by adding: a) the flow at the Hardy gage minus the flows from the Sub-basin gages listed in Section II, b) the annual Computed Beneficial Consumptive Use in the Main Stem, and c) the Change in Federal Reservoir Storage from Swanson Lake and Harlan County Lake; and from that total subtract any Imported Water Supply Credit for the Main Stem. Adjustments for flows diverted around Sub-basin stream gages and for Computed Beneficial Consumptive Uses in a Sub-basin between the Sub-basin stream gage and the confluence of the Sub-basin tributary and the Mains Stem shall be made as described in Subsections III. D. 1 and 2 and IV.B.,

**3. Imported Water Supply Credit Calculation:**

The amount of Imported Water Supply Credit shall be determined by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State. Currently, the Imported Water Supply Credits shall be determined using two runs of the RRCA Groundwater Model:

a. The “base” run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the current accounting year turned “on.” This will be the same “base” run used to determine groundwater Computed Beneficial Consumptive Uses.

b. The “no NE import” run shall be the run with the same model inputs as the base run with the exception that surface water recharge associated with Nebraska’s Imported Water Supply shall be turned “off.”

The Imported Water Supply Credit shall be the difference in stream flows between these two model runs. Differences in stream flows shall be determined at the same locations as identified in Subsection III.D.1.for the “no pumping” runs.
Should another State import water into the Basin in the future, the RRCA will develop a similar procedure to determine Imported Water Supply Credits.

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**4. Augmentation Water Supply Credit:**

The amount of Augmentation Water Supply Credit shall be the quantity of water delivered to the stream flow of a Designated Drainage Basin and shall be measured and subtracted from the Gaged Flow of the Designated Drainage Basin to calculate the Annual Virgin Water Supply. The Augmentation Water Supply Credit of a State shall not be included in the Annual Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water

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allocated to that State.

## B. Calculation of Computed Water Supply

On any Designated Drainage Basin without a Federal Reservoir, the Computed Water Supply will be equal to the Virgin Water Supply of that Designated Drainage Basin minus Flood Flows.

On any Designated Drainage Basin with a Federal Reservoir, the Computed Water Supply will be equal to the Virgin Water Supply minus the Change in Federal Reservoir Storage in that Designated Drainage Basin and minus Flood Flows.

### 1. Flood Flows

If in any calendar year there are five consecutive months in which the total actual stream flow[1] at the Hardy gage is greater than 325,000 Acre-feet, or any two consecutive months in which the total actual stream flow is greater than 200,000 Acre-feet, the annual flow in excess of 400,000 Acre-feet at the Hardy gage will be considered to be Flood Flows that will be subtracted from the Virgin Water Supply to calculate the Computed Water Supply, and Allocations. The Flood Flow in excess of 400,000 Acre-feet at the Hardy gage will be subtracted from the Virgin Water Supply of the Main Stem to compute the Computed Water Supply unless the Annual Gaged Flows from a Sub-basin were in excess of the flows shown for that Sub-basin in Attachment 1. These excess Sub-basin flows shall be considered to be Sub-basin Flood Flows.

If there are Sub-basin Flood Flows, the total of all Sub-basin Flood Flows shall be compared to the amount of Flood Flows at the Hardy gage. If the sum of the Sub-basin Flood Flows are in excess of the Flood Flow at the Hardy gage, the flows to be deducted from each Sub-basin shall be the product of the Flood Flows for each Sub-basin times the ratio of the Flood Flows at the Hardy gage divided by the sum of the Flood Flows of the Sub-basin gages. If the sum of the Sub-basin Flood Flows is less than the Flood Flow at the Hardy gage, the entire amount of each Sub-basin Flood Flow shall be deducted from the Virgin Water Supply to compute the Computed Water Supply of that Sub-basin for that year. The remainder of the Flood Flows will be subtracted from the flows of the Main Stem.

## C. Calculation of Annual Allocations

[1] These actual stream flows reflect Gaged Flows after depletions by Beneficial Consumptive Use and change in reservoir storage above the gage.

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Article IV of the Compact allocates 54,100 Acre-feet for Beneficial Consumptive Use in Colorado, 190,300 Acre-feet for Beneficial Consumptive Use in Kansas and 234,500 Acre-feet for Beneficial Consumptive Use in Nebraska. The Compact provides that the Compact totals are to be derived from the sources and in the amounts specified in Table 2.

The Allocations derived from each Sub-basin to each State shall be the Computed Water Supply multiplied by the percentages set forth in Table 2. In addition, Kansas shall receive 51.1% of the Main Stem Allocation and the Unallocated Supply and Nebraska shall receive 48.9% of the Main Stem Allocation and the Unallocated Supply.

## D. Calculation of Annual Computed Beneficial Consumptive Use

### 1. Groundwater

Computed Beneficial Consumptive Use of groundwater shall be determined by use of the RRCA Groundwater Model. The Computed Beneficial Consumptive Use of groundwater for each State shall be determined as the difference in streamflows using two runs of the model:

The “base” run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the current accounting year “on”.

The “no State pumping” run shall be the run with the same model inputs as the base run with the exception that all groundwater pumping and pumping recharge of that State shall be turned “off.”

An output of the model is baseflows at selected stream cells. Changes in the baseflows predicted by the model between the “base” run and the “no-State-pumping” model run is assumed to be the depletions to streamflows. i.e., groundwater computed beneficial consumptive use, due to State groundwater pumping at that location. The values for each Sub-basin will include all depletions and accretions upstream of the confluence with the Main Stem. The values for the Main Stem will include all depletions and accretions in stream reaches not otherwise accounted for in a Sub-basin. The values for the Main Stem will be computed separately for the reach above Guide Rock, and the reach below Guide Rock.

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### 2. Surface Water

The Computed Beneficial Consumptive Use of surface water for irrigation and non-irrigation uses shall be computed by taking the diversions from the river and subtracting the return flows to the river resulting from those diversions, as described in Subsections IV.A.2.a.-d. The Computed Beneficial Consumptive Use of surface water from Federal Reservoir and Non-Federal Reservoir evaporation shall be the net reservoir evaporation from the reservoirs, as described in Subsections IV.A.2.e.-f.

For Sub-basins where the gage designated in Section II. is near the confluence with the Main Stem, each State's Sub-basin Computed Beneficial Consumptive Use of surface water shall be the State's Computed Beneficial Consumptive Use of surface water above the Sub-basin gage. For Medicine Creek, Sappa Creek, Beaver Creek and Prairie Dog Creek, where the gage is not near the confluence with the Main Stem, each State's Computed Beneficial Consumptive Use of surface water shall be the sum of the State's Computed Beneficial Consumptive Use of surface water above the gage, and its Computed Beneficial Consumptive Use of surface water between the gage and the confluence with the Main Stem.

## E. Calculation to Determine Compact Compliance Using Five-Year Running Averages

Each year, using the procedures described herein, the RRCA will calculate the Annual Allocations by Designated Drainage Basin and total for each State, the Computed Beneficial Consumptive Use by Designated Drainage Basin and total for each State and the Imported Water Supply Credit and the Augmentation Water Supply Credit that a State may use for the preceding year. These results for the current Compact accounting year as well as the results of the previous four accounting years and the five-year average of these results will be displayed in the format shown in Table 3.

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## F. Calculations To Determine Colorado's and Kansas's Compliance with the Sub-basin Non-Impairment Requirement

The data needed to determine Colorado's and Kansas's compliance with the Sub-basin non-impairment requirement in Subsection IV.B.2. of the Stipulation are shown in Tables 4.A. and B.

## G. Calculations To Determine Projected Water Supply

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### 1. Procedures to Determine Water Short Years

The Bureau of Reclamation will provide each of the States with a monthly or, if requested by any one of the States, a more frequent update of the projected or actual irrigation supply from Harlan County Lake for that irrigation season using the methodology described in the Harlan County Lake Operation Consensus Plan, attached as Appendix K to the Stipulation. The steps for the calculation are as follows:

Step 1. At the beginning of the calculation month (1) the total projected inflow for the calculation month and each succeeding month through the end of May shall be added to the previous end of month Harlan County Lake content and (2) the total projected 1993 level evaporation loss for the calculation month and each succeeding month through the end of May shall then be subtracted. The total projected inflow shall be the 1993 level average monthly inflow or the running average monthly inflow for the previous five years, whichever is less.

Step 2. Determine the maximum irrigation water available by subtracting the sediment pool storage (currently 164,111 Acre-feet) and adding the summer sediment pool evaporation (20,000 Acre-feet) to the result from Step 1.

Step 3. For October through January calculations, take the result from Step 2 and using the Shared Shortage Adjustment Table in Attachment 2 hereto, determine the preliminary irrigation water available for release. The calculation using the end of December content (January calculation month) indicates the minimum amount of irrigation water available for release at the end of May. For February through June calculations, subtract the maximum irrigation water available for the January calculation month from the maximum irrigation water available for the calculation month. If the result is negative, the irrigation water available for release (January calculation month) stays the same. If the result is positive the preliminary irrigation water available for release (January calculation month) is increased by the positive amount.

Step 4. Compare the result from Step 3 to 119,000 Acre-feet. If the result from Step 3 is less than 119,000 Acre-feet Water Short Year Administration is in effect.

Step 5. The final annual Water-Short Year Administration calculation determines the total estimated irrigation supply at the end of June (calculated in July). Use the result from Step 3 for the end of May irrigation release estimate, add the June computed inflow to Harlan County Lake and subtract the June computed gross evaporation loss from Harlan County Lake.

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**2. Procedures to Determine 130,000 Acre Feet Projected Water Supply**

To determine the preliminary irrigation supply for the October through June calculation months, follow the procedure described in steps 1 through 4 of the "Procedures to determine Water Short Years" Subsection III. G. 1. The result from step 4 provides the forecasted water supply, which is compared to 130,000 Acre-feet. For the July through September calculation months, use the previous end of calculation month preliminary irrigation supply, add the previous month's Harlan County Lake computed inflow and subtract the previous month's computed gross evaporation loss from Harlan County Lake to determine the current preliminary irrigation supply. The result is compared to 130,000 Acre-feet.

**H. Calculation of Computed Water Supply, Allocations and Computed Beneficial Consumptive Use Above and Below Guide Rock During Water-Short Administration Years.**

For Water-Short-Administration Years, in addition to the normal calculations, the Computed Water Supply, Allocations, Computed Beneficial Consumptive Use and Imported Water Supply Credits, and Augmentation Water Supply Credits shall also be calculated above Guide Rock as shown in Table 5C. These calculations shall be done in the same manner as in non-Water-Short Administration years except that water supplies originating below Guide Rock shall not be included in the calculations of water supplies originating above Guide Rock. The calculations of Computed Beneficial Consumptive Uses shall be also done in the same manner as in non-Water-Short Administration years except that Computed Beneficial Consumptive Uses from diversions below Guide Rock shall not be included. The depletions from the water diverted by the Superior and Courtland Canals at the Superior-Courtland Diversion Dam shall be included in the calculations of Computed Beneficial Consumptive Use above Guide Rock. Imported Water Supply Credits and Augmentation Water Supply Credits above Guide Rock, as described in Sub-section III.I., may be used as offsets against the Computed Beneficial Consumptive Use above Guide Rock by the State providing the Imported Water Supply Credits or Augmentation Water Supply Credits.

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The Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage shall be determined by taking the difference in stream flow at Hardy and Guide Rock, adding Computed Beneficial Consumptive Uses in the reach (this does not include the Computed Beneficial Consumptive Use from the Superior and Courtland Canal diversions), and subtracting return flows from the Superior and Courtland Canals in the reach. The Computed Water Supply above Guide Rock shall be determined by subtracting the Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage from the total Computed Water Supply. Nebraska's Allocation above Guide Rock shall be determined by subtracting 48.9% of the Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage from Nebraska's total Allocation.

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Nebraska's Computed Beneficial Consumptive Uses above Guide Rock shall be determined by subtracting Nebraska's Computed Beneficial Consumptive Uses below Guide Rock from Nebraska's total Computed Beneficial Consumptive Use.

**I. Calculation of Imported Water Supply Credits During Water-Short Year Administration Years.**

Imported Water Supply Credit during Water-Short Year Administration years shall be calculated consistent with Subsection V.B.2.b. of the Stipulation.

The following methodology shall be used to determine the extent to which Imported Water Supply Credit, as calculated by the RRCA Groundwater Model, can be credited to the State importing the water during Water-Short Year Administration years.

**1. Monthly Imported Water Supply Credits**

The RRCA Groundwater Model will be used to determine monthly Imported Water Supply Credits by State in each Sub-basin and for the Main Stem. The values for each Sub-basin will include all depletions and accretions upstream of the confluence with the Main Stem. The values for the Main Stem will include all depletions and accretions in stream reaches not otherwise accounted for in a Sub-basin. The values for the Main Stem will be computed separately for the reach 1) above Harlan County Dam, 2) between Harlan County Dam and Guide Rock, and 3) between Guide Rock and the Hardy gage. The Imported Water Supply Credit shall be the difference in stream flow for two runs of the model: a) the "base" run and b) the "no State import" run.

During Water-Short Year Administration years, Nebraska's credits in the Sub-basins shall be determined as described in Section III. A. 3.

**2. Imported Water Supply Credits Above Harlan County Dam**

Nebraska's Imported Water Supply Credits above Harlan County Dam shall be the sum of all the credits in the Sub-basins and the Main Stem above Harlan County Dam.

**3. Imported Water Supply Credits Between Harlan County Dam and Guide Rock During the Irrigation Season**

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a. During Water-Short Year Administration years, monthly credits in the reach between Harlan County Dam and Guide Rock shall be determined as the differences in the stream flows between the two runs at Guide Rock.

b. The irrigation season shall be defined as starting on the first day of release of water from Harlan County Lake for irrigation use and ending on the last day of release of water from Harlan County Lake for irrigation use.

c. Credit as an offset for a State's Computed Beneficial Consumptive Use above Guide Rock will be given to all the Imported Water Supply accruing in the reach between Harlan County Dam and Guide Rock during the irrigation season. If the period of the irrigation season does not coincide with the period of modeled flows, the amount of the Imported Water Supply credited during the irrigation season for that month shall be the total monthly modeled Imported Water Supply Credit times the number of days in the month occurring during the irrigation season divided by the total number of days in the month.

**4. Imported Water Supply Credits Between Harlan County Dam and Guide Rock During the Non-Irrigation Season**

a. Imported Water Supply Credit shall be given between Harlan County Dam and Guide Rock during the period that flows are diverted to fill Lovewell Reservoir to the extent that imported water was needed to meet Lovewell Reservoir target elevations.

b. Fall and spring fill periods shall be established during which credit shall be given for the Imported Water Supply Credit accruing in the reach. The fall period shall extend from the end of the irrigation season to December 1. The spring period shall extend from March 1 to May 31. The Lovewell target elevations for these fill periods are the projected end of November reservoir level and the projected end of May reservoir level for most probable inflow conditions as indicated in Table 4 in the current Annual Operating Plan prepared by the Bureau of Reclamation.

c. The amount of water needed to fill Lovewell Reservoir for each period shall be calculated as the storage content of the reservoir at its target elevation at the end of the fill period minus the reservoir content at the start of the fill period plus the amount of net evaporation during this period minus White Rock Creek inflows for the same period.

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d. If the fill period as defined above does not coincide with the period of modeled flows, the amount of the Imported Water Supply Credit during the fill period for that month shall be the total monthly modeled Imported Water Supply Credit times the number of days in the month occurring during the fill season divided by the total number of days in the month.

e. The amount of non-imported water available to fill Lovewell Reservoir to the target elevation shall be the amount of water available at Guide Rock during the fill period minus the amount of the Imported Water Supply Credit accruing in the reach during the same period.

f. The amount of the Imported Water Supply Credit that shall be credited against a State's Consumptive Use shall be the amount of water imported by that State that is available in the reach during the fill period or the amount of water needed to reach Lovewell Reservoir target elevations minus the amount of non-imported water available during the fill period, whichever is less.

### 5. Other Credits

Kansas and Nebraska will explore crediting Imported Water Supply that is otherwise useable by Kansas.

## J. Calculations of Compact Compliance in Water-Short Year Administration Years

During Water-Short Year Administration, using the procedures described in Subsections III.A-D, the RRCA will calculate the Annual Allocations for each State, the Computed Beneficial Consumptive Use by each State, the Imported Water Supply Credit, and the Augmentation Water Supply Credit that a State may use to offset Computed Beneficial Consumptive Use in that year. The resulting annual and average values will be calculated as displayed in Tables 5 A-C and E.

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If Nebraska is implementing an Alternative Water-Short-Year Administration Plan, data to determine Compact compliance will be shown in Table 5D. Nebraska’s compliance with the Compact will be determined in the same manner as Nebraska’s Above Guide Rock compliance except that compliance will be based on a three-year running average of the current year and previous two year calculations. In addition, Table 5 D. will display the sum of the previous two-year difference in Allocations above Guide Rock and Computed Beneficial Consumptive Uses above Guide Rock minus any Imported Water Credits and compare the result with the Alternative Water-Short-Year Administration Plan’s expected decrease in Computed Beneficial Consumptive Use above Guide Rock.  Nebraska will be within compliance with the Compact as long as the three-year running average difference

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in Column 8 is positive and the sum of the previous year and current year deficits above Guide Rock are not greater than the expected decrease in Computed Beneficial Consumptive Use under the plan.

## IV. Specific Formulas

### A. Computed Beneficial Consumptive Use

#### 1. Computed Beneficial Consumptive Use of Groundwater:

The Computed Beneficial Consumptive Use caused by groundwater diversion shall be determined by the RRCA Groundwater Model as described in Subsection III.D.1.

#### 2. Computed Beneficial Consumptive Use of Surface Water:

The Computed Beneficial Consumptive Use of surface water shall be calculated as follows:

a) Non-Federal Canals

Computed Beneficial Consumptive Use from diversions by non- federal canals shall be 60 percent of the diversion; the return flow shall be 40 percent of the diversion

b) Individual Surface Water Pumps

Computed Beneficial Consumptive Use from small individual surface water pumps shall be 75 percent of the diversion; return flows will be 25 percent of the diversion unless a state provides data on the amount of different system types in a Sub-basin, in which case the following percentages will be used for each system type:

| | |
|---|---|
| Gravity Flow. | 30% |
| Center Pivot | 17% |
| LEPA | 10% |

c) Federal Canals

Computed Beneficial Consumptive Use of diversions by Federal canals will be calculated as shown in Attachment 7. For each Bureau of

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Reclamation Canal the field deliveries shall be subtracted from the diversion from the river to determine the canal losses. The field delivery shall be multiplied by one minus an average system efficiency for the district to determine the loss of water from the field. Eighty-two percent of the sum of the field loss plus the canal loss shall be considered to be the return flow from the canal diversion. The assumed field efficiencies and the amount of the field and canal loss that reaches the stream may be reviewed by the RRCA and adjusted as appropriate to insure their accuracy.

d) Non-irrigation Uses

Any non-irrigation uses diverting or pumping more than 50 acre-feet per year will be required to measure diversions. Non-irrigation uses diverting more than 50 Acre-feet per year will be assessed a Computed Beneficial Consumptive Use of 50% of what is pumped or diverted, unless the entity presents evidence to the RRCA demonstrating a different percentage should be used.

e) Evaporation from Federal Reservoirs

Net Evaporation from Federal Reservoirs will be calculated as follows:

(1) Harlan County Lake, Evaporation Calculation

April 1 through October 31:

Evaporation from Harlan County Lake is calculated by the Corps of Engineers on a daily basis from April 1 through October 31. Daily readings are taken from a Class A evaporation pan maintained near the project office. Any precipitation recorded at the project office is added to the pan reading to obtain the actual evaporation amount. The pan value is multiplied by a pan coefficient that varies by month. These values are:

| | |
|---|---|
| March | .56 |
| April | .52 |
| May | .53 |
| June | .60 |
| July | .68 |
| August | .78 |
| September | .91 |

October 1.01

The pan coefficients were determined by studies the Corps of Engineers conducted a number of years ago. The result is the evaporation in inches. It is divided by 12 and multiplied by the daily lake surface area in acres to obtain the evaporation in Acre-feet. The lake surface area is determined by the 8:00 a.m. elevation reading applied to the lake's area-capacity data. The area-capacity data is updated periodically through a sediment survey. The last survey was completed in December 2000.

November 1 through March 31

During the winter season, a monthly total evaporation in inches has been determined. The amount varies with the percent of ice cover. The values used are:

HARLAN COUNTY LAKE

Estimated Evaporation in Inches
Winter Season -- Monthly Total

PERCENTAGE OF ICE COVER

| | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 0.88 | 0.87 | 0.85 | 0.84 | 0.83 | 0.82 | 0.81 | 0.80 | 0.78 | 0.77 | 0.76 |
| FEB | 0.90 | 0.88 | 0.87 | 0.86 | 0.85 | 0.84 | 0.83 | 0.82 | 0.81 | 0.80 | 0.79 |
| MAR | 1.29 | 1.28 | 1.27 | 1.26 | 1.25 | 1.24 | 1.23 | 1.22 | 1.21 | 1.20 | 1.19 |
| OCT | 4.87 | | | NO ICE | | | | | | | |
| NOV | 2.81 | | | NO ICE | | | | | | | |
| DEC | 1.31 | 1.29 | 1.27 | 1.25 | 1.24 | 1.22 | 1.20 | 1.18 | 1.17 | 1.16 | 1.14 |

The monthly total is divided by the number of days in the month to obtain a daily evaporation value in inches. It is divided by 12 and multiplied by the daily lake surface area in acres to obtain the evaporation in Acre-feet. The lake surface area is determined by the 8:00 a.m. elevation reading applied to the lake's area-capacity data. The area-capacity data is updated periodically through a sediment survey. The last survey was completed in December 2000.

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To obtain the net evaporation, the monthly precipitation on the lake is subtracted from the monthly gross evaporation. The monthly precipitation is calculated by multiplying the sum of the month's daily precipitation in inches by the average of the end of the month lake surface area for the previous month and the end of the month lake surface area for the current month in acres and dividing the result by 12 to obtain the precipitation for the month in acre feet.

The total annual net evaporation (Acre-feet) will be charged to Kansas and Nebraska in proportion to the annual diversions made by the Kansas Bostwick Irrigation District and the Nebraska Bostwick Irrigation District during the time period each year when irrigation releases are being made from Harlan County Lake. For any year in which no irrigation releases were made from Harlan County Lake, the annual net evaporation charged to Kansas and Nebraska will be based on the average of the above calculation for the most recent three years in which irrigation releases from Harlan County Lake were made. In the event Nebraska chooses to substitute supply for the Superior Canal from Nebraska's allocation below Guide Rock in Water-Short Year Administration years, the amount of the substitute supply will be included in the calculation of the split as if it had been diverted to the Superior Canal at Guide Rock.

(2) Evaporation Computations for Bureau of Reclamation Reservoirs

The Bureau of Reclamation computes the amount of evaporation loss on a monthly basis at Reclamation reservoirs. The following procedure is utilized in calculating the loss in Acre-feet.

An evaporation pan reading is taken each day at the dam site. This measurement is the amount of water lost from the pan over a 24-hour period in inches. The evaporation pan reading is adjusted for any precipitation recorded during the 24-hour period. Instructions for determining the daily pan evaporation are found in the "National Weather Service Observing Handbook No. 2 – Substation Observations." All dams located in the Kansas River Basin with the exception of Bonny Dam are National Weather Service Cooperative Observers. The daily evaporation pan readings are totaled at the end of each month and converted to a "free water surface" (FWS) evaporation, also referred to as "lake" evaporation. The FWS evaporation is determined by multiplying the observed pan evaporation by a coefficient of .70 at each of the reservoirs. This coefficient can be affected by several factors including water and air

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temperatures. The National Oceanic and Atmospheric Administration (NOAA) has published technical reports describing the determination of pan coefficients. The coefficient used is taken from the "NOAA Technical Report NWS 33, Map of coefficients to convert class A pan evaporation to free water surface evaporation". This coefficient is used for the months of April through October when evaporation pan readings are recorded at the dams. The monthly FWS evaporation is then multiplied by the average surface area of the reservoir during the month in acres. Dividing this value by twelve will result in the amount of water lost to evaporation in Acre-feet during the month.

During the winter months when the evaporation pan readings are not taken, monthly evaporation tables based on the percent of ice cover are used. The tables used were developed by the Corps of Engineers and were based on historical average evaporation rates. A separate table was developed for each of the reservoirs. The monthly evaporation rates are multiplied by the .70 coefficient for pan to free water surface adjustment, divided by twelve to convert inches to feet and multiplied by the average reservoir surface area during the month in acres to obtain the total monthly evaporation loss in Acre-feet.

To obtain the net evaporation, the monthly precipitation on the lake is subtracted from the monthly gross evaporation. The monthly precipitation is calculated by multiplying the sum of the month's daily precipitation in inches by the average of the end of the month lake surface area for the previous month and the end of the month lake surface area for the current month in acres and dividing the result by 12 to obtain the precipitation for the month in acre feet.

f) Non-Federal Reservoir Evaporation:

For Non-Federal Reservoirs with a storage capacity less than 200 Acre-feet, the presumptive average annual surface area is 25% of the area at the principal spillway elevation. Net evaporation for each such Non-Federal Reservoir will be calculated by multiplying the presumptive average annual surface area by the net evaporation from the nearest climate and evaporation station to the Non-Federal Reservoir. A State may provide actual data in lieu of the presumptive criteria.

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Net evaporation from Non-Federal Reservoirs with 200 Acre-feet of storage or greater will be calculated by multiplying the average annual surface area (obtained from the area-capacity survey) and the net evaporation from the nearest evaporation and climate station to the reservoir. If the average annual surface area is not available, the Non-Federal Reservoirs with 200 Acre-feet of storage or greater will be presumed to be full at the principal spillway elevation.

**B. Specific Formulas for Each Sub-basin and the Main Stem**

All calculations shall be based on the calendar year and shall be rounded to the nearest 10 Acre-feet using the conventional rounding formula of rounding up for all numbers equal to five or higher and otherwise rounding down.

Abbreviations:

AWS = Augmentation Water Supply Credit
CBCU = Computed Beneficial Consumptive Use
CWS = Computed Water Supply
D = Non-Federal Canal Diversions for Irrigation
Ev = Evaporation from Federal Reservoirs
EvNFR = Evaporation from Non-Federal Reservoirs
FF = Flood Flow
GW = Groundwater Computed Beneficial Consumptive Use (includes irrigation and non-irrigation uses)
IWS = Imported Water Supply Credit from Nebraska
M&I = Non-Irrigation Surface Water Diversions (Municipal and Industrial)
P = Small Individual Surface Water Pump Diversions for Irrigation
RF = Return Flow
VWS = Virgin Water Supply
c = Colorado
k = Kansas
n = Nebraska
ΔS = Change in Federal Reservoir Storage
% = Average system efficiency for individual pumps in the Sub-basin
% BRF = Percent of Diversion from Bureau Canals that returns to the stream
### = Value expected to be zero

### 3. North Fork of Republican River in Colorado [2]

CBCU Colorado = 0.6 x Haigler Canal Diversion Colorado + 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc

CBCU Kansas = GWk

CBCU Nebraska = 0.6 x Haigler Canal Diversion Nebraska + GWn

Note: The diversion for Haigler Canal is split between Colorado and Nebraska based on the percentage of land irrigated in each state

VWS = North Fork of the Republican River at the State Line, Stn. No. 06823000 + CBCUc + CBCUk + CBCUn + Nebraska Haigler Canal RF– IWS -AWS

Note: The Nebraska Haigler Canal RF returns to the Main Stem

CWS = VWS - FF

Allocation Colorado = 0.224 x CWS

Allocation Nebraska = 0.246 x CWS

Unallocated = 0.53 x CWS

### 4. Arikaree River [2]

CBCU Colorado = 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Arikaree Gage at Haigler Stn. No. 06821500 + CBCUc + CBCUk + CBCUn – IWS

[2] The RRCA will investigate whether return flows from the Haigler Canal diversion in Colorado may return to the Arikaree River, not the North Fork of the Republican River, as indicated in the formulas. If there are return flows from the Haigler Canal to the Arikaree River, these formulas will be changed to recognize those returns.

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CWS = VWS - FF

Allocation Colorado = 0.785 x CWS

Allocation Kansas = 0.051 x CWS

Allocation Nebraska = 0.168 x CWS

Unallocated =-0.004 x CWS

**5. Buffalo Creek**

CBCU Colorado = 0.6 x Dc + % x Pc + 0.5 x M&In + EvNFRc + GWc

CBCU Kansas = GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Buffalo Creek near Haigler Gage Stn. No. 06823500 + CBCUc + CBCUk + CBCUn – IWS

CWS = VWS - FF

Allocation Nebraska = 0.330 x CWS

Unallocated = 0.670 x CWS

**6. Rock Creek**

CBCU Colorado = GWc

CBCU Kansas = GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Rock Creek at Parks Gage Stn. No. 06824000 + CBCUc + CBCUk + CBCUn – IWS

CWS = VWS - FF

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Allocation Nebraska = 0.400 x CWS

Unallocated = 0.600 x CWS

**7. South Fork Republican River**

CBCU Colorado = 0.6 x Hale Ditch Diversion + 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + Bonny Reservoir Ev + GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = South Fork Republican River near Benkelman Gage Stn. No. 06827500 + CBCUc + CBCUk + CBCUn + ΔS Bonny Reservoir – IWS

CWS = VWS - ΔS Bonny Reservoir - FF

Allocation Colorado = 0.444 x CWS

Allocation Kansas = 0.402 x CWS

Allocation Nebraska = 0.014 x CWS

Unallocated = 0.140 x CWS

**8. Frenchman Creek in Nebraska**

CBCU Colorado = GWc

CBCU Kansas = GWk

CBCU Nebraska = Culbertson Canal Diversions x (1-%BRF) + Culbertson Extension x (1-%BRF) + 0.6 x Champion Canal Diversion + 0.6 x Riverside Canal Diversion + 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + Enders Reservoir Ev + GWn

VWS = Frenchman Creek in Culbertson, Nebraska Gage Stn. No.

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06835500 + CBCUc + CBCUk + CBCUn + 0.17 x Culbertson Diversion RF + Culbertson Extension RF + ΔS Enders Reservoir – IWS

Note: 17% of the Culbertson Diversion RF and 100% of the Culbertson Extension RF return to the Main Stem

CWS = VWS - ΔS Enders Reservoir – FF

Allocation Nebraska = 0.536 x CWS

Unallocated = 0.464 x CWS

**9. Driftwood Creek**

CBCU Colorado = GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Driftwood Creek near McCook Gage Stn. No. 06836500 + CBCUc + CBCUk + CBCUn – 0.24 x Meeker Driftwood Canal RF - IWS

Note: 24 % of the Meeker Driftwood Canal RF returns to Driftwood Creek

CWS = VWS – FF

Allocation Kansas = 0.069 x CWS

Allocation Nebraska = 0.164 x CWS

Unallocated = 0.767 x CWS

**10. Red Willow Creek in Nebraska**

CBCU Colorado = GWc

CBCU Kansas = GWk

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| | |
|---|---|
| CBCU Nebraska | = 0.1 x Red Willow Canal CBCU + 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + 0.1 x Hugh Butler Lake Ev + GWn<br><br>Note:<br>Red Willow Canal CBCU = Red Willow Canal Diversion x (1- % BRF)<br><br>90% of the Red Willow Canal CBCU and 90% of Hugh Butler Lake Ev charged to Nebraska's CBCU in the Main Stem |
| VWS | = Red Willow Creek near Red Willow Gage Stn. No. 06838000 + CBCUc + CBCUk + CBCUn + 0.9 x Red Willow Canal CBCU + 0.9 x Hugh Butler Lake Ev + 0.9 xRed Willow Canal RF + ΔS Hugh Butler Lake – IWS<br><br>Note: 90% of the Red Willow Canal RF returns to the Main Stem |
| CWS | = VWS - ΔS Hugh Butler Lake - FF |
| Allocation Nebraska | = 0.192 x CWS |
| Unallocated | = 0.808 x CWS |

**11. Medicine Creek**

| | |
|---|---|
| CBCU Colorado | = GWc |
| CBCU Kansas | = GWk |
| CBCU Nebraska | = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn<br><br>Note: Harry Strunk Lake Ev charged to Nebraska's CBCU in the Main Stem.<br><br>CU from Harry Strunk releases in the Cambridge Canal is charged to the Main stem (no adjustment to the VWS |

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formula is needed as this water shows up in the Medicine Creek gage).

| | |
|---|---|
| VWS | = Medicine Creek below Harry Strunk Lake Gage Stn. No. 06842500 + CBCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage + Harry Strunk Lake Ev + ΔS Harry Strunk Lake– IWS |
| | Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem |
| CWS | = VWS - ΔS Harry Strunk Lake - FF |
| Allocation Nebraska | = 0.091 x CWS |
| Unallocated | = 0.909 x CWS |

**12. Beaver Creek**

| | |
|---|---|
| CBCU Colorado | = 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc |
| CBCU Kansas | = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk |
| CBCU Nebraska | = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn |
| VWS | = Beaver Creek near Beaver City gage Stn. No. 06847000 + BCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage – IWS |
| | Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem |
| CWS | = VWS – FF |
| Allocation Colorado | = 0.200 x CWS |

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Allocation Kansas = 0.388 x CWS

Allocation Nebraska = 0.406 x CWS

Unallocated = 0.006 x CWS

**13. Sappa Creek**

CBCU Colorado = GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn

VWS = Sappa Creek near Stamford gage Stn. No. 06847500 – Beaver Creek near Beaver City gage Stn. No. 06847000 + CBCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage – IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS - FF

Allocation Kansas = 0.411 x CWS

Allocation Nebraska = 0.411 x CWS

Unallocated = 0.178 x CWS

**14. Prairie Dog Creek**

CBCU Colorado = GWc

CBCU Kansas = Almena Canal Diversion x (1-%BRF) + 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + Keith Sebelius Lake Ev + GWk

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CBCU Nebraska = 0.6 x Dn below gage + % x Pn below gage + 0.5 x M&In below gage + EvNFRn + GWn below gage

VWS = Prairie Dog Creek near Woodruff, Kansas USGS Stn. No. 06848500 + CBCUc + CBCUk + CBCUn - 0.6 x Dn below gage - % x Pn below gage - 0.5 x M&In below gage - EvNFRn below gage + ΔS Keith Sebelius Lake – IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS- ΔS Keith Sebelius Lake - FF

Allocation Kansas = 0.457 x CSW

Allocation Nebraska = 0.076 x CWS

Unallocated = 0.467 x CWS

**15. The North Fork of the Republican River in Nebraska and the Main Stem of the Republican River between the junction of the North Fork and the Arikaree River and the Republican River near Hardy**

CBCU Colorado = GWc

CBCU Kansas =
(Deliveries from the Courtland Canal to Kansas above Lovewell) x (1-%BRF)
+ Amount of transportation loss of Courtland Canal deliveries to Lovewell that does not return to the river, charged to Kansas
+ (Diversions of Republican River water from Lovewell Reservoir by the Courtland Canal below Lovewell) x (1-%BRF)
+ 0.6 x Dk
+ % x Pk
+ 0.5 x M&Ik
+ EvNFRk
+ Harlan County Lake Ev charged to Kansas
+ Lovewell Reservoir Ev charged to the Republican River

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+ GWk

CBCU Nebraska =
Deliveries from Courtland Canal to Nebraska lands x (1- %BRF)
+ Superior Canal x (1- %BRF)
+ Franklin Pump Canal x (1- %BRF)
+ Franklin Canal x (1- %BRF)
+ Naponee Canal x (1- %BRF)
+ Cambridge Canal x (1- %BRF)
+ Bartley Canal x (1- %BRF)
+ Meeker-Driftwood Canal x (1- %BRF)
+ 0.9 x Red Willow Canal CBCU
+ 0.6 x Dn
+ % x Pn
+ 0.5 x M&In
+ EvNFRn
+ 0.9 x Hugh Butler Lake Ev
+ Harry Strunk Lake Ev
+ Swanson Lake Ev
+ Harlan County Lake Ev charged to Nebraska
+ GWn

Notes:
The allocation of transportation losses in the Courtland Canal above Lovewell between Kansas and Nebraska shall be done by the Bureau of Reclamation and reported in their "Courtland Canal Above Lovewell" spreadsheet. Deliveries and losses associated with deliveries to both Nebraska and Kansas above Lovewell shall be reflected in the Bureau's Monthly Water District reports. Losses associated with delivering water to Lovewell shall be separately computed.

Amount of transportation loss of the Courtland Canal deliveries to Lovewell that does not return to the river, charged to Kansas shall be 18% of the Bureau's estimate of losses associated with these deliveries.

Red Willow Canal CBCU = Red Willow Canal Diversion x (1- % BRF)

10% of the Red Willow Canal CBCU is charged to Nebraska's CBCU in Red Willow Creek sub-basin

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10% of Hugh Butler Lake Ev is charged to Nebraska's CBCU in the Red Willow Creek sub-basin

None of the Harry Strunk Lake EV is charged to Nebraska's CBCU in the Medicine Creek sub-basin

VWS =

Republican River near Hardy Gage Stn. No. 06853500
- North Fork of the Republican River at the State Line, Stn. No. 06823000
- Arikaree Gage at Haigler Stn. No. 06821500
- Buffalo Creek near Haigler Gage Stn. No. 06823500
- Rock Creek at Parks Gage Stn. No. 06824000
-South Fork Republican River near Benkelman Gage Stn. No. 06827500
- Frenchman Creek in Culbertson Stn. No. 06835500
- Driftwood Creek near McCook Gage Stn. No. 06836500
- Red Willow Creek near Red Willow Gage Stn. No. 06838000
- Medicine Creek below Harry Strunk Lake Gage Stn. No. 06842500
- Sappa Creek near Stamford Gage Stn. No. 06847500
- Prairie Dog Creek near Woodruff, Kansas Stn. No. 68-485000

+ CBCUc
+ CBCUn

+ 0.6 x Dk
+ % x Pk
+ 0.5 x M&Ik
+ EvNFRk
+ Harlan County Lake Ev charged to Kansas
+Amount of transportation loss of the Courtland Canal above the Stateline that does not return to the river, charged to Kansas

- 0.9 x Red Willow Canal CBCU
- 0.9 x Hugh Butler Ev
- Harry Strunk Ev

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+ 0.6 x Dn below Medicine Creek gage
+ % x Pn below Medicine Creek gage
+ 0.5 * M&In below Medicine Creek gage
+ EvNFRn below Medicine Creek gage

+ 0.6 x Dn below Beaver Creek gage
+ % x Pn below Beaver Creek gage
+ 0.5 * M&In below Beaver Creek gage
+ EvNFRn below Beaver Creek gage

+ 0.6 x Dn below Sappa Creek gage
+ % x Pn below Sappa Creek gage
+ 0.5 * M&In below Sappa Creek gage
+ EvNFRn below Sappa Creek gage

+ 0.6 x Dn below Prairie Dog Creek gage
+ % x Pn below Prairie Dog Creek gage
+ 0.5 * M&In below Prairie Dog Creek gage
+ EvNFRn below Prairie Dog Creek gage

+ Change in Storage Harlan County Lake
+ Change in Storage Swanson Lake

- Nebraska Haigler Canal RF
- 0.17 x Culbertson Canal RF
- Culbertson Canal Extension RF to Main Stem
+ 0.24 x Meeker Driftwood Canal RF which returns to Driftwood Creek
- 0.9 x Red Willow Canal RF

+ Courtland Canal at Kansas-Nebraska State Line Gage Stn No. 06852500
- Courtland Canal RF in Kansas above Lovewell Reservoir

-IWS

Notes:
None of the Nebraska Haigler Canal RF returns to the North Fork of the Republican River

83% of the Culbertson Diversion RF and none of the Culbertson Extension RF return to Frenchman Creek

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24 % of the Meeker Driftwood Canal RF returns to Driftwood Creek.

10% of the Red Willow Canal RF returns to Red Willow Creek

Courtland Canal RF in Kansas above Lovewell Reservoir = 0.015 x (Courtland Canal at Kansas-Nebraska State Line Gage Stn No. 06852500)

| | |
|---|---|
| CWS | = VWS - Change in Storage Harlan County Lake - Change in Storage Swanson Lake - FF |
| Allocation Kansas | = 0.511 x CWS |
| Allocation Nebraska | = 0.489 x CWS |

## V. Annual Data/ Information Requirements, Reporting, and Verification

The following information for the previous calendar year shall be provided to the members of the RRCA Engineering Committee by April 15th of each year, unless otherwise specified.

All information shall be provided in electronic format, if available.

Each State agrees to provide all information from their respective State that is needed for the RRCA Groundwater Model and RRCA Accounting Procedures and Reporting Requirements, including but not limited to the following:

### A. Annual Reporting

#### 1. Surface water diversions and irrigated acreage:

Each State will tabulate the canal, ditch, and other surface water diversions that are required by RRCA annual compact accounting and the RRCA Groundwater Model on a monthly format (or a procedure to distribute annual data to a monthly basis) and will forward the surface water diversions to the other States. This will include available diversion, wasteway, and farm delivery data for canals diverting from the Platte River that contribute to Imported Water Supply into the Basin. Each State will provide the water right number, type of use, system type, location, diversion amount, and acres irrigated.

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**2. Groundwater pumping and irrigated acreage:**

Each State will tabulate and provide all groundwater well pumping estimates that are required for the RRCA Groundwater Model to the other States.

**Colorado** – will provide an estimate of pumping based on a county format that is based upon system type, Crop Irrigation Requirement (CIR), irrigated acreage, crop distribution, and irrigation efficiencies. Colorado will require installation of a totalizing flow meter, installation of an hours meter with a measurement of the pumping rate, or determination of a power conversion coefficient for 10% of the active wells in the Basin by December 31, 2005. Colorado will also provide an annual tabulation for each groundwater well that measures groundwater pumping by a totalizing flow meter, hours meter or power conversion coefficient that includes: the groundwater well permit number, location, reported hours, use, and irrigated acreage.

**Kansas** - will provide an annual tabulation by each groundwater well that includes: water right number, groundwater pumping determined by a meter on each well (or group of wells in a manifold system) or by reported hours of use and rate; location; system type (gravity, sprinkler, LEPA, drip, etc.); and irrigated acreage. Crop distribution will be provided on a county basis.

**Nebraska** – will provide an annual tabulation through the representative Natural Resource District (NRD) in Nebraska that includes: the well registration number or other ID number; groundwater pumping determined by a meter on each well (or group of wells in a manifold system) or by reported hours of use and rate; wells will be identified by; location; system type (gravity, sprinkler, LEPA, drip, etc.); and irrigated acreage. Crop distribution will be provided on a county basis.

**3. Climate information:**

Each State will tabulate and provide precipitation, temperature, relative humidity or dew point, and solar radiation for the following climate stations:

| State | Identification | Name |
|---|---|---|
| Colorado | | |
| Colorado | C050109 | Akron 4 E |
| Colorado | C051121 | Burlington |
| Colorado | C054413 | Julesburg |
| Colorado | C059243 | Wray |
| Kansas | C140439 | Atwood 2 SW |
| Kansas | C141699 | Colby 1SW |
| Kansas | C143153 | Goodland |
| Kansas | C143837 | Hoxie |

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| | | |
|---|---|---|
| Kansas | C145856 | Norton 9 SSE |
| Kansas | C145906 | Oberlin1 E |
| Kansas | C147093 | Saint Francis |
| Kansas | C148495 | Wakeeny |
| Nebraska | C250640 | Beaver City |
| Nebraska | C250810 | Bertrand |
| Nebraska | C252065 | Culbertson |
| Nebraska | C252690 | Elwood 8 S |
| Nebraska | C253365 | Gothenburg |
| Nebraska | C253735 | Hebron |
| Nebraska | C253910 | Holdredge |
| Nebraska | C254110 | Imperial |
| Nebraska | C255090 | Madrid |
| Nebraska | C255310 | McCook |
| Nebraska | C255565 | Minden |
| Nebraska | C256480 | Palisade |
| Nebraska | C256585 | Paxton |
| Nebraska | C257070 | Red Cloud |
| Nebraska | C258255 | Stratton |
| Nebraska | C258320 | Superior |
| Nebraska | C258735 | Upland |
| Nebraska | C259020 | Wauneta 3 NW |

**4. Crop Irrigation Requirements:**

Each State will tabulate and provide estimates of crop irrigation requirement information on a county format. Each State will provide the percentage of the crop irrigation requirement met by pumping; the percentage of groundwater irrigated lands served by sprinkler or flood irrigation systems, the crop irrigation requirement; crop distribution; crop coefficients; gain in soil moisture from winter and spring precipitation, net crop irrigation requirement; and/or other information necessary to compute a soil/water balance.

**5. Streamflow Records from State-Maintained Gaging Records:**

Streamflow gaging records from the following State maintained gages will be provided:

| Station No. | Name |
|---|---|
| 00126700 | Republican River near Trenton |
| 06831500 | Frenchman Creek near Imperial |
| 06832500 | Frenchman Creek near Enders |

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| | |
|---|---|
| 06835000 | Stinking Water Creek near Palisade |
| 06837300 | Red Willow Creek above Hugh Butler Lake |
| 06837500 | Red Willow Creek near McCook |
| 06841000 | Medicine Creek above Harry Strunk Lake |
| 06842500 | Medicine Creek below Harry Strunk Lake |
| 06844000 | Muddy Creek at Arapahoe |
| 06844210 | Turkey Creek at Edison |
| 06847000 | Beaver Creek near Beaver City |
| | Republican River at Riverton |
| 06851500 | Thompson Creek at Riverton |
| 06852000 | Elm Creek at Amboy |
| | Republican River at the Superior-Courtland Diversion Dam |

**6. Platte River Reservoirs:**

The State of Nebraska will provide the end-of-month contents, inflow data, outflow data, area-capacity data, and monthly net evaporation, if available, from Johnson Lake; Elwood Reservoir; Sutherland Reservoir; Maloney Reservoir; and Jeffrey Lake.

**7. Water Administration Notification:**

The State of Nebraska will provide the following information that describes the protection of reservoir releases from Harlan County Lake and for the administration of water rights junior in priority to February 26, 1948:

Date of notification to Nebraska water right owners to curtail their diversions, the amount of curtailment, and length of time for curtailment.
The number of notices sent.
The number of diversions curtailed and amount of curtailment in the Harlan County Lake to Guide Rock reach of the Republican River.

**8. Moratorium:**

Each State will provide a description of all new Wells constructed in the Basin Upstream of Guide Rock including the owner, location (legal description), depth and diameter or dimension of the constructed water well, casing and screen information, static water level, yield of the water well in gallons per minute or gallons per hour, and intended use of the water well.

Designation whether the Well is a:

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a. Test hole;

b. Dewatering Well with an intended use of one year or less;

c. Well designed and constructed to pump fifty gallons per minute or less;

d. Replacement Water Well, including a description of the Well that is replaced providing the information described above for new Wells and a description of the historic use of the Well that is replaced;

e. Well necessary to alleviate an emergency situation involving provision of water for human consumption, including a brief description of the nature of the emergency situation and the amount of water intended to be pumped by and the length of time of operation of the new Well;

f. Transfer Well, including a description of the Well that is transferred providing the information described above for new Wells and a description of the Historic Consumptive Use of the Well that is transferred;

g. Well for municipal and/or industrial expansion of use;

Wells in the Basin in Northwest Kansas or Colorado. Kansas and Colorado will provide the information described above for new Wells along with copies of any other information that is required to be filed with either State of local agencies under the laws, statutes, rules and regulations in existence as of April 30, 2002, and;

Any changes in State law in the previous year relating to existing Moratorium.

**9. Non-Federal Reservoirs:**

Each State will conduct an inventory of Non Federal Reservoirs by December 31, 2004, for inclusion in the annual Compact Accounting. The inventory shall include the following information: the location, capacity (in Acre-feet) and area (in acres) at the principal spillway elevation of each Non-Federal Reservoir. The States will annually provide any updates to the initial inventory of Non-Federal Reservoirs, including enlargements that are constructed in the previous year.

Owners/operators of Non-Federal Reservoirs with 200 Acre-feet of storage capacity or greater at the principal spillway elevation will be required to provide an area-capacity survey from State-approved plans or prepared by a licensed professional engineer or land surveyor.

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**10. Augmentation Plan:**

Each State will provide a description of the wells, measuring devices, conveyance structure(s), and other infrastructure to describe the physical characteristics, water diversions, and consumptive use associated with each augmentation plan. The States will provide any updates to the plan on an annual basis.

## B. RRCA Groundwater Model Data Input Files

1. Monthly groundwater pumping, surface water recharge, groundwater recharge, and precipitation recharge provided by county and indexed to the one square mile cell size.

2. Potential Evapotranspiration rate is set as a uniform rate for all phreatophyte vegetative classes – the amount is X at Y climate stations and is interpolated spatially using kriging.

## C. Inputs to RRCA Accounting

### 1. Surface Water Information

a. Streamflow gaging station records: obtained as preliminary USGS or Nebraska streamflow records, with adjustments to reflect a calendar year, at the following locations:

Arikaree River at Haigler, Nebraska
North Fork Republican River at Colorado-Nebraska state line
Buffalo Creek near Haigler, Nebraska
Rock Creek at Parks, Nebraska
South Fork Republican River near Benkelman, Nebraska
Frenchman Creek at Culbertson, Nebraska
Red Willow Creek near Red Willow, Nebraska
Medicine Creek below Harry Strunk Lake, Nebraska*
Beaver Creek near Beaver City, Nebraska*
Sappa Creek near Stamford, Nebraska
Prairie Dog Creek near Woodruff, Kansas
Courtland Canal at Nebraska-Kansas state line
Republican River near Hardy, Nebraska
Republican River at Superior-Courtland Diversion Dam near Guide Rock,
Nebraska (new)*

b. Federal reservoir information: obtained from the United States Bureau of Reclamation:

Daily free water surface evaporation, storage, precipitation, reservoir release information, and updated area-capacity tables.
Federal Reservoirs:
Bonny Reservoir
Swanson Lake
Harry Strunk Lake
Hugh Butler Lake
Enders Reservoir
Keith Sebelius Lake
Harlan County Lake
Lovewell Reservoir

c. Non-federal reservoirs obtained by each state: an updated inventory of reservoirs that includes the location, surface area (acres), and capacity (in Acre-feet), of each non-federal reservoir with storage capacity of fifteen (15) Acre-feet or greater at the principal spillway elevation. Supporting data to substantiate the average surface water areas that are different than the presumptive average annual surface area may be tendered by the offering State.

d. Diversions and related data from USBR

Irrigation diversions by canal, ditch, and pumping station that irrigate more than two (2) acres
Diversions for non-irrigation uses greater than 50 Acre-feet
Farm Deliveries
Wasteway measurements
Irrigated acres

e. Diversions and related data – from each respective State

Irrigation diversions by canal, ditch, and pumping station that irrigate more than two (2) acres
Diversions for non-irrigation uses greater than 50 Acre-feet
Wasteway measurements, if available

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**2. Groundwater Information**

(From the RRCA Groundwater model as output files as needed for the accounting procedures)

a. Imported water - mound credits in amount and time that occur in defined streamflow points/reaches of measurement or compliance – ex: gaging stations near confluence or state lines

b. Groundwater depletions to streamflow (above points of measurement or compliance – ex: gaging stations near confluence or state lines)

**3. Summary**

The aforementioned data will be aggregated by Sub-basin as needed for RRCA accounting.

**D. Verification**

**1. Documentation to be Available for Inspection Upon Request**

a. Well permits/ registrations database
b. Copies of well permits/ registrations issued in calendar year
c. Copies of surface water right permits or decrees
d. Change in water right/ transfer historic use analyses
e. Canal, ditch, or other surface water diversion records
f. Canal, ditch, or other surface water measurements
g. Reservoir storage and release records
h. Irrigated acreage
i. Augmentation Plan well pumping and augmentation delivery records

**2. Site Inspection**

a. Accompanied – reasonable and mutually acceptable schedule among representative state and/or federal officials.

b. Unaccompanied – inspection parties shall comply with all laws and regulations of the State in which the site inspection occurs.

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Table 1: Annual Virgin and Computed Water Supply, Allocations and Computed Beneficial Consumptive Uses by State, Main Stem and Sub-basin

| Designated Drainage Basin | Col. 1: Virgin Water Supply | Col. 2: Computed Water Supply | Col. 3: Allocations | | | | Col. 4: Computed Beneficial Consumptive Use | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Colorado | Nebraska | Kansas | Unallocated | Colorado | Nebraska | Kansas |
| North Fork in Colorado | | | | | | | | | |
| Arikaree | | | | | | | | | |
| Buffalo | | | | | | | | | |
| Rock | | | | | | | | | |
| South Fork of Republican River | | | | | | | | | |
| Frenchman | | | | | | | | | |
| Driftwood | | | | | | | | | |
| Red Willow | | | | | | | | | |
| Medicine | | | | | | | | | |
| Beaver | | | | | | | | | |
| Sappa | | | | | | | | | |
| Prairie Dog | | | | | | | | | |
| North Fork of Republican River in Nebraska and Main Stem | | | | | | | | | |
| Total All Basins | | | | | | | | | |
| North Fork Of Republican River in Nebraska and Mainstem Including Unallocated Water | | | | | | | | | |
| Total | | | | | | | | | |

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Table 2: Original Compact Virgin Water Supply and Allocations

| Designated Drainage Basin | Virgin Water Supply | Colorado Allocation | % of Total Drainage Basin Supply | Kansas Allocation | % of Total Drainage Basin Supply | Nebraska Allocation | % of Total Drainage Basin Supply | Unallo-cated | % of Total Drainage Basin Supply |
|---|---|---|---|---|---|---|---|---|---|
| North Fork - CO | 44,700 | 10,000 | 22.4 | | | 11,000 | 24.6 | 23,700 | 53.0 |
| Arikaree River | 19,610 | 15,400 | 78.5 | 1,000 | 5.1 | 3,300 | 16.8 | -90 | -0.4 |
| Buffalo Creek | 7,890 | | | | | 2,600 | 33.0 | 5,290 | 67.0 |
| Rock Creek | 11,000 | | | | | 4,400 | 40.0 | 6,600 | 60.0 |
| South Fork | 57,200 | 25,400 | 44.4 | 23,000 | 40.2 | 800 | 1.4 | 8,000 | 14.0 |
| Frenchman Creek | 98,500 | | | | | 52,800 | 53.6 | 45,700 | 46.4 |
| Driftwood Creek | 7,300 | | | 500 | 6.9 | 1,200 | 16.4 | 5,600 | 76.7 |
| Red Willow Creek | 21,900 | | | | | 4,200 | 19.2 | 17,700 | 80.8 |
| Medicine Creek | 50,800 | | | | | 4,600 | 9.1 | 46,200 | 90.9 |
| Beaver Creek | 16,500 | 3,300 | 20.0 | 6,400 | 38.8 | 6,700 | 40.6 | 100 | 0.6 |
| Sappa Creek | 21,400 | | | 8,800 | 41.1 | 8,800 | 41.1 | 3,800 | 17.8 |
| Prairie Dog Creek | 27,600 | | | 12,600 | 45.7 | 2,100 | 7.6 | 12,900 | 46.7 |
| Sub-total Tributaries | 384,400 | | | | | | | 175,500 | |
| Main Stem + Blackwood Creek | 94,500 | | | | | | | | |
| Main Stem + Unallocated | 270,000 | | | 138,000 | 51.1 | 132,000 | 48.9 | | |
| Total | 478,900 | 54,100 | | 190,300 | | 234,500 | | | |

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Table 3A: Table to Be Used to Calculate Colorado's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

Deleted: ¶

| Colorado | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit and/or Augmentation Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit and/or Augmentation Water Supply Credit<br>Col 1 – (Col 2- Col 3) |
| Year<br>t= -4 | | | | |
| Year<br>t= -3 | | | | |
| Year<br>t= -2 | | | | |
| Year<br>t= -1 | | | | |
| Current Year<br>t= 0 | | | | |
| Average | | | | |

Table 3B. Table to Be Used to Calculate Kansas's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

| Kansas | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit<br>Col 1 – (Col 2- Col 3) |
| Year<br>t= -4 | | | | |
| Year<br>t= -3 | | | | |
| Year<br>t= -2 | | | | |
| Year<br>t= -1 | | | | |
| Current Year<br>t= 0 | | | | |

| | | | | |
|---|---|---|---|---|
| Average | | | | |

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Table 3C. Table to Be Used to Calculate Nebraska's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

| Nebraska | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Col 1 – (Col 2- Col 3) |
| Year T= -4 | | | | |
| Year T= -3 | | | | |
| Year T= -2 | | | | |
| Year T= -1 | | | | |
| Current Year T= 0 | | | | |
| Average | | | | |

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Table 4A: Colorado Compliance with the Sub-basin Non-impairment Requirement

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| | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 |
|---|---|---|---|---|---|---|
| Sub-basin | Colorado Sub-basin Allocation (5-year running average) | Unallocated Supply (5-year running average) | Credits from Imported Water Supply and/or Augmentation Water Supply (5-year running average) | Total Supply Available = Col 1+ Col 2 + Col 3 (5-year running average) | Colorado Computed Beneficial Consumptive Use (5-year running average) | Difference Between Available Supply and Computed Beneficial Consumptive Use = Col 4 – Col 5 (5-year running average) |
| North Fork Republican River Colorado | | | | | | |
| Arikaree River | | | | | | |
| South Fork Republican River | | | | | | |
| Beaver Creek | | | | | | |

Table 4B: Kansas Compliance with the Sub-basin Non-impairment Requirement

| | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 |
|---|---|---|---|---|---|---|---|
| Sub-basin | Kansas Sub-basin Allocation (5-year running average) | Unallocated Supply (5-year running average) | Unused Allocation from Colorado (5-year running average) | Credits from Imported Water Supply (5-year running average) | Total Supply Available = Col 1+ Col 2+ Col 3 + Col 4 (5-year running average) | Kansas Computed Beneficial Consumptive Use (5-year running average) | Difference Between Available Supply and Computed Beneficial Consumptive Use = Col 5 – Col 6 (5-year running average) |
| Arikaree River | | | | | | | |
| South Fork Republican River | | | | | | | |
| Driftwood Creek | | | | | | | |
| Beaver Creek | | | | | | | |
| Sappa Creek | | | | | | | |
| Prairie Dog Creek | | | | | | | |

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Table 5A: Colorado Compliance During Water-Short Year Administration

| Colorado | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col 4 |
| Year | Allocation minus Allocation for Beaver Creek | Computed Beneficial Consumptive minus Computed Beneficial Consumptive Use for Beaver Creek | Imported Water Supply Credit and/or Augmentation Water Supply Credit excluding Beaver Creek | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit and/or Augmentation Water Supply Credit for All Basins Except Beaver Creek<br>Col 1 – (Col 2 – Col 3) |
| Year T= -4 | | | | |
| Year T= -3 | | | | |
| Year T= -2 | | | | |
| Year T= -1 | | | | |
| Current Year T= 0 | | | | |
| Average | | | | |

Table 5B: Kansas Compliance During Water-Short Year Administration

| Kansas | | | | | | |
|---|---|---|---|---|---|---|
| Year | Allocation | | | Computed Beneficial Consumptive Use` | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit |
| Column | 1 | 2 | 3 | 4 | 5 | 6 |
| | Sum Sub-basins | Kansas's Share of the Unallocated Supply | Total Col 1 + Col 2 | | | Col 3 – (Col 4 – Col 5) |
| Previous Year | | | | | | |
| Current Year | | | | | | |
| Average | | | | | | |

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Table 5C: Nebraska Compliance During Water-Short Year Administration

| Nebraska | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Allocation | | | Computed Beneficial Consumptive Use | | | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Above Guide Rock |
| Column | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 |
| | State Wide Allocation | Allocation below Guide Rock | State Wide Allocation above Guide Rock | State Wide CBCU | CBCU below Guide Rock | State Wide CBCU above Guide Rock | Credits above Guide Rock | Col 3 – (Col 6 – Col 7) |
| Previous Year | | | | | | | | |
| Current Year | | | | | | | | |
| Average | | | | | | | | |

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Table 5D: Nebraska Compliance Under a Alternative Water-Short Year Administration Plan

| Year | Allocation | | | Computed Beneficial Consumptive Use | | | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Above Guide Rock |
|---|---|---|---|---|---|---|---|---|
| Column | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 |
| | State Wide Allocation | Allocation below Guide Rock | State Wide Allocation above Guide Rock | State Wide CBCU | CBCU below Guide Rock | State Wide CBCU above Guide Rock | Credits above Guide Rock | Col 3 – (Col 6- Col 7) |
| Year = -2 | | | | | | | | |
| Year = -1 | | | | | | | | |
| Current Year | | | | | | | | |
| Three-Year Average | | | | | | | | |
| Sum of Previous Two-year Difference | | | | | | | | |
| Expected Decrease in CBCU Under Plan | | | | | | | | |

Table 5E: Nebraska Tributary Compliance During Water-Short Year Administration

| Year | Sum of Nebraska Sub-basin Allocations | Sum of Nebraska's Share of Sub-basin Unallocated Supplies | Total Available Water Supply for Nebraska | Computed Beneficial Consumptive Use | Imported Water Supply Credit | Difference between Allocation And the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit |
|---|---|---|---|---|---|---|
| | Col 1 | Col 2 | `Col 3 | Col 4 | Col 5 | Col 6 |
| Previous Year | | | | | | Col 3 -(Col 4-Col 5) |
| Current Year | | | | | | |
| Average | | | | | | |

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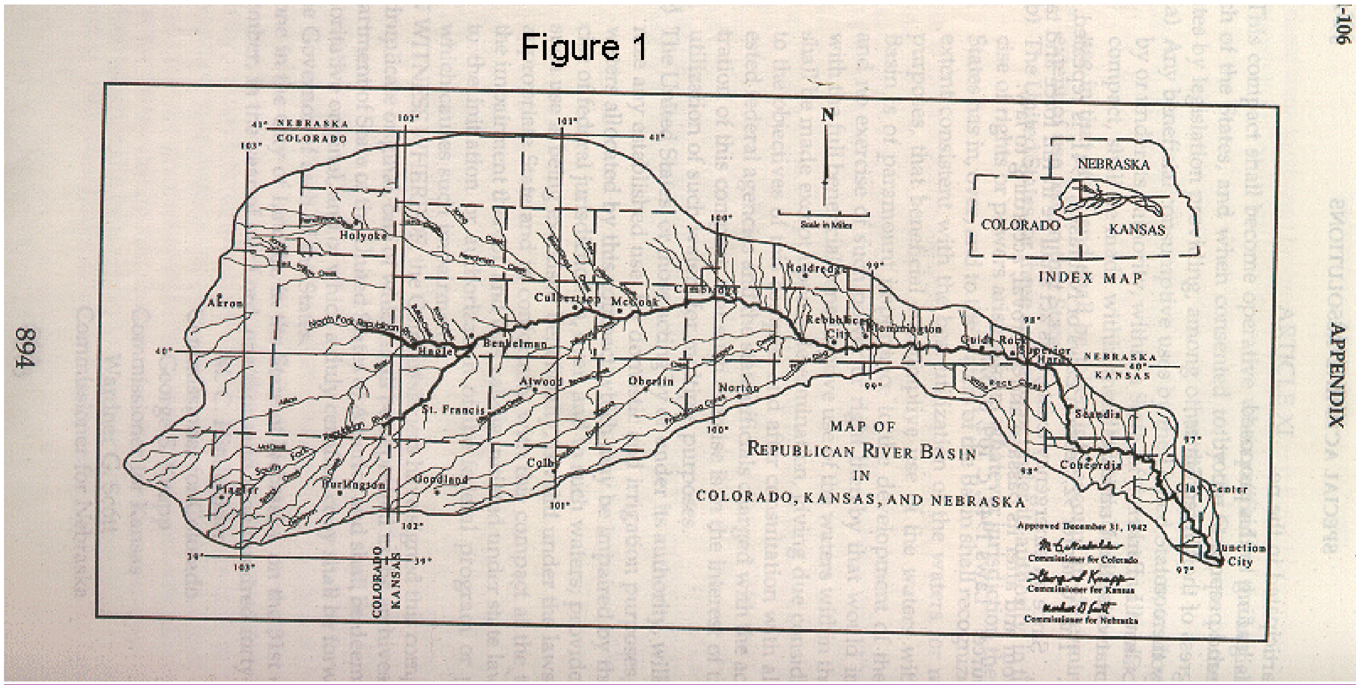
Figure 1




Basin Map Attached to Compact that Shows the Streams and the Basin Boundaries

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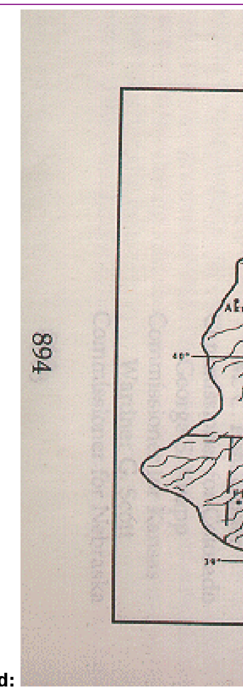
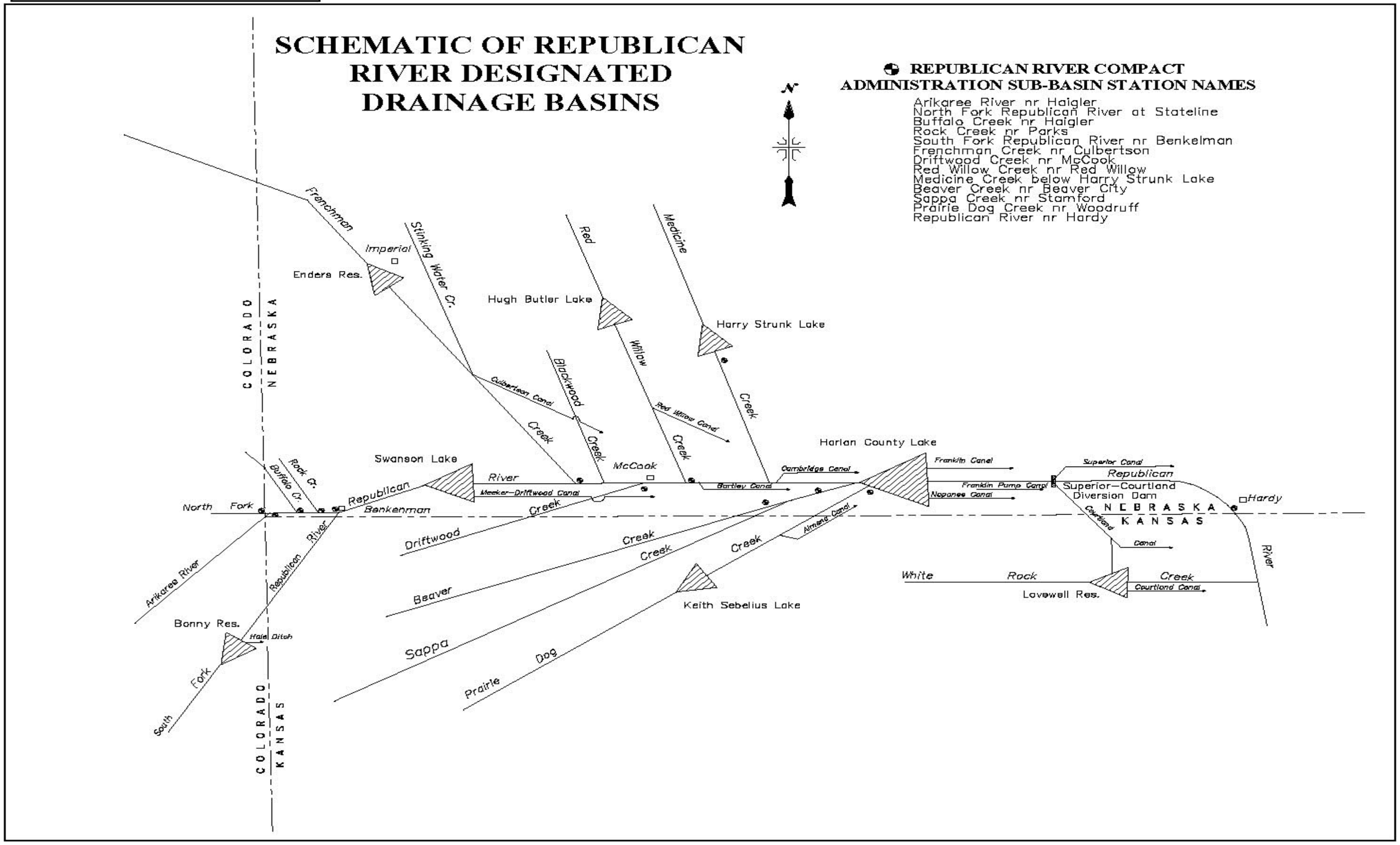
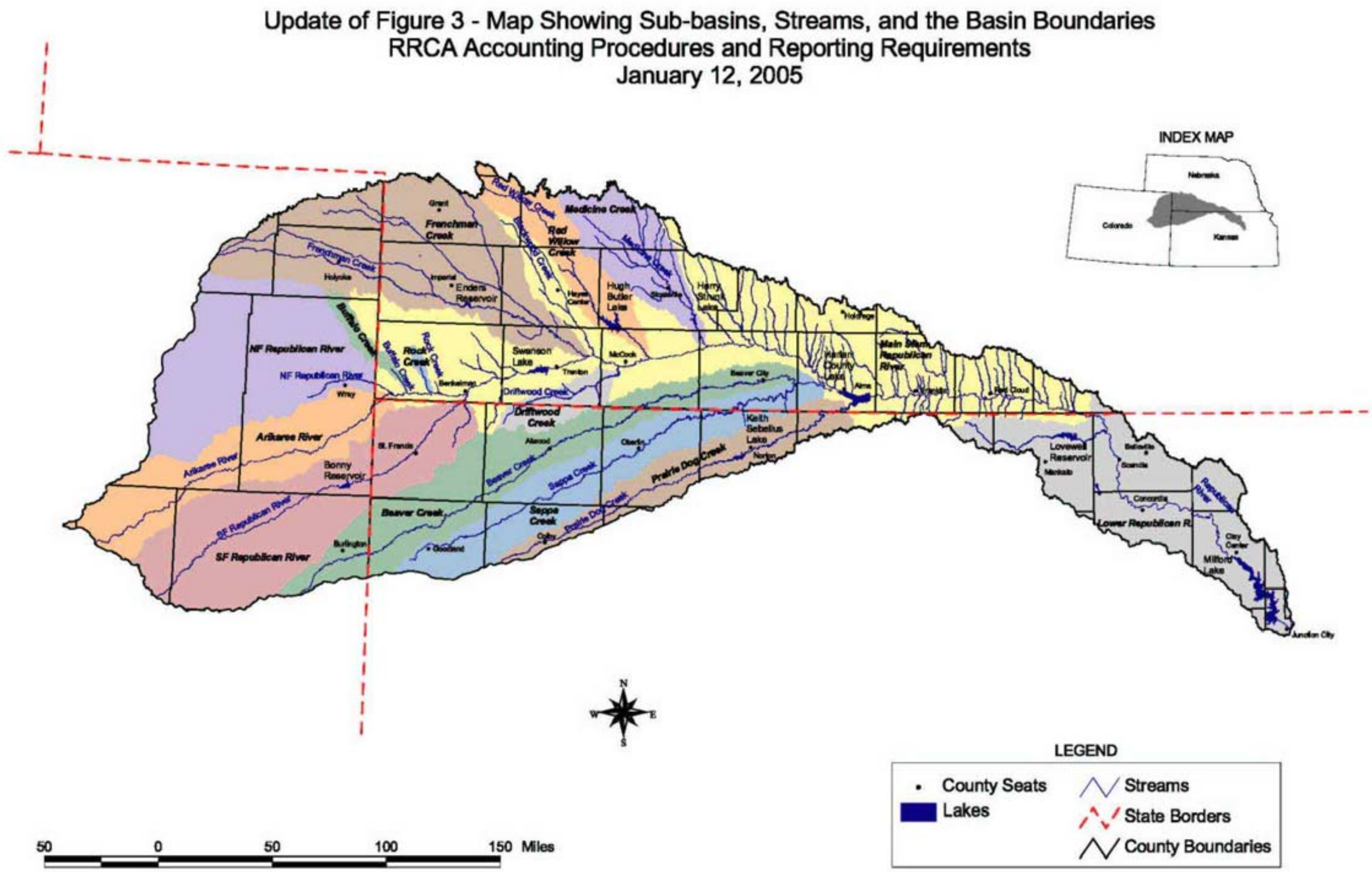


Figure 2




Line Diagram of Designated Drainage Basins Showing Federal Reservoirs and Sub-basin Gaging Stations




Map Showing Sub-basins, Streams, and the Basin Boundaries

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Attachment 1: Sub-basin Flood Flow Thresholds

| Sub-basin | Sub-basin Flood Flow Threshold Acre-feet per Year[3] |
|---|---|
| Arikaree River | 16,400 |
| North Fork of Republican River | 33,900 |
| Buffalo Creek | 4,800 |
| Rock Creek | 9,800 |
| South Fork of Republican River | 30,400 |
| Frenchman Creek | 51,900 |
| Driftwood Creek | 9,400 |
| Red Willow Creek | 15,100 |
| Medicine Creek | 55,100 |
| Beaver Creek | 13,900 |
| Sappa Creek | 26,900 |
| Prairie Dog | 15,700 |

[3] Flows considered to be Flood Flows are flows in excess of the 94% flow based on a flood frequency analysis for the years 1971-2000. The Gaged Flows are measured after depletions by Beneficial Consumptive Use and change in reservoir storage. For the purpose of compliance with III.B.1, the Gaged Flows shall not include Augmentation Water Supply Credits delivered in any calendar year.

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Attachment 2: Description of the Consensus Plan for Harlan County Lake

The Consensus Plan for operating Harlan County Lake was conceived after extended discussions and negotiations between Reclamation and the Corps. The agreement shaped at these meetings provides for sharing the decreasing water supply into Harlan County Lake. The agreement provides a consistent procedure for: updating the reservoir elevation/storage relationship, sharing the reduced inflow and summer evaporation, and providing a January forecast of irrigation water available for the following summer.

During the interagency discussions the two agencies found agreement in the following areas:

- The operating plan would be based on current sediment accumulation in the irrigation pool and other zones of the project.
- Evaporation from the lake affects all the various lake uses in proportion to the amount of water in storage for each use.
- During drought conditions, some water for irrigation could be withdrawn from the sediment pool.
- Water shortage would be shared between the different beneficial uses of the project, including fish, wildlife, recreation and irrigation.

To incorporate these areas of agreement into an operation plan for Harlan County Lake, a mutually acceptable procedure addressing each of these items was negotiated and accepted by both agencies.

1. Sediment Accumulation.

The most recent sedimentation survey for Harlan County project was conducted in 1988, 37 years after lake began operation. Surveys were also performed in 1962 and 1972; however, conclusions reached after the 1988 survey indicate that the previous calculations are unreliable. The 1988 survey indicates that, since closure of the dam in 1951, the accumulated sediment is distributed in each of the designated pools as follows:

| | |
|---|---|
| Flood Pool | 2,387 Acre-feet |
| Irrigation Pool | 4,853 Acre-feet |
| Sedimentation Pool | 33,527 Acre-feet |

To insure that the irrigation pool retained 150,000 Acre-feet of storage, the bottom of the irrigation pool was lowered to 1,932.4 feet, msl, after the 1988 survey.

To estimate sediment accumulation in the lake since 1988, we assumed similar conditions have occurred at the project during the past 11 years. Assuming a consistent rate of deposition since 1988, the irrigation pool has trapped an additional 1,430 Acre-feet.

A similar calculation of the flood control pool indicates that the flood control pool has captured an additional 704 Acre-feet for a total of 3,090 Acre-feet since construction.

The lake elevations separating the different pools must be adjusted to maintain a 150,000-acre-foot irrigation pool and a 500,000-acre-foot flood control pool. Adjusting these elevations results in the following new elevations for the respective pools (using the 1988 capacity tables).

| | |
|---|---|
| Top of Irrigation Pool | 1,945.70 feet, msl |
| Top of Sediment Pool | 1,931.75 feet, msl |

Due to the variability of sediment deposition, we have determined that the elevation capacity relationship should be updated to reflect current conditions. We will complete a new sedimentation survey of Harlan County Lake this summer, and new area capacity tables should be available by early next year. The new tables may alter the pool elevations achieved in the Consensus Plan for Harlan County Lake.

2. Summer Evaporation.

Evaporation from a lake is affected by many factors including vapor pressure, wind, solar radiation, and salinity of the water. Total water loss from the lake through evaporation is also affected by the size of the lake. When the lake is lower, the surface area is smaller and less water loss occurs. Evaporation at Harlan County Lake has been estimated since the lake's construction using a Weather Service Class A pan which is 4 feet in diameter and 10 inches deep. We and Reclamation have jointly reviewed this information and assumed future conditions to determine an equitable method of distributing the evaporation loss from the project between irrigation and the other purposes.

During those years when the irrigation purpose expected a summer water yield of 119,000 Acre-feet or more, it was determined that an adequate water supply existed and no sharing of evaporation was necessary. Therefore, evaporation evaluation focused on the lower pool elevations when water was scarce. Times of water shortage would also generally be times of higher evaporation rates from the lake.

Reclamation and we agreed that evaporation from the lake during the summer (June through September) would be distributed between the irrigation and sediment pools based on their relative percentage of the total storage at the time of evaporation. If the sediment pool held 75 percent of the total storage, it would be charged 75 percent of the evaporation. If the sediment pool held 50 percent of the total storage, it would be charged 50 percent of the evaporation. At the bottom of the irrigation pool (1,931.75 feet, msl) all of the evaporation would be charged to the sediment pool.

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Due to downstream water rights for summer inflow, neither the irrigation nor the sediment pool is credited with summer inflow to the lake. The summer inflows would be assumed passed through the lake to satisfy the water right holders. Therefore, Reclamation and we did not distribute the summer inflow between the project purposes.

As a result of numerous lake operation model computer runs by Reclamation, it became apparent that total evaporation from the project during the summer averaged about 25,000 Acre-feet during times of lower lake elevations. These same models showed that about 20 percent of the evaporation should be charged to the irrigation pool, based on percentage in storage during the summer months. About 20 percent of the total lake storage is in the irrigation pool when the lake is at elevation 1,935.0 feet, msl. As a result of the joint study, Reclamation and we agreed that the irrigation pool would be credited with 20,000 Acre-feet of water during times of drought to share the summer evaporation loss.

Reclamation and we further agreed that the sediment pool would be assumed full each year. In essence, if the actual pool elevation were below 1,931.75 feet, msl, in January, the irrigation pool would contain a negative storage for the purpose of calculating available water for irrigation, regardless of the prior year's summer evaporation from sediment storage.

3. Irrigation withdrawal from sediment storage.

During drought conditions, occasional withdrawal of water from the sediment pool for irrigation is necessary. Such action is contemplated in the Field Working Agreement and the Harlan County Lake Regulation Manual: "Until such time as sediment fully occupies the allocated reserve capacity, it will be used for irrigation and various conservation purposes, including public health, recreation, and fish and wildlife preservation."

To implement this concept into an operation plan for Harlan County Lake, Reclamation and we agreed to estimate the net spring inflow to Harlan County Lake. The estimated inflow would be used by the Reclamation to provide a firm projection of water available for irrigation during the next season.

Since the construction of Harlan County Lake, inflows to the lake have been depleted by upstream irrigation wells and farming practices. Reclamation has recently completed an in-depth study of these depleted flows as a part of their contract renewal process. The study concluded that if the current conditions had existed in the basin since 1931, the average spring inflow to the project would have been 57,600 Acre-feet of water. The study further concluded that the evaporation would have been 8,800 Acre-feet of water during the same period. Reclamation and we agreed to use these values to calculate the net inflow to the project under the current conditions.

In addition, both agencies also recognized that the inflow to the project could continue to decrease with further upstream well development and water conservation farming. Due to these

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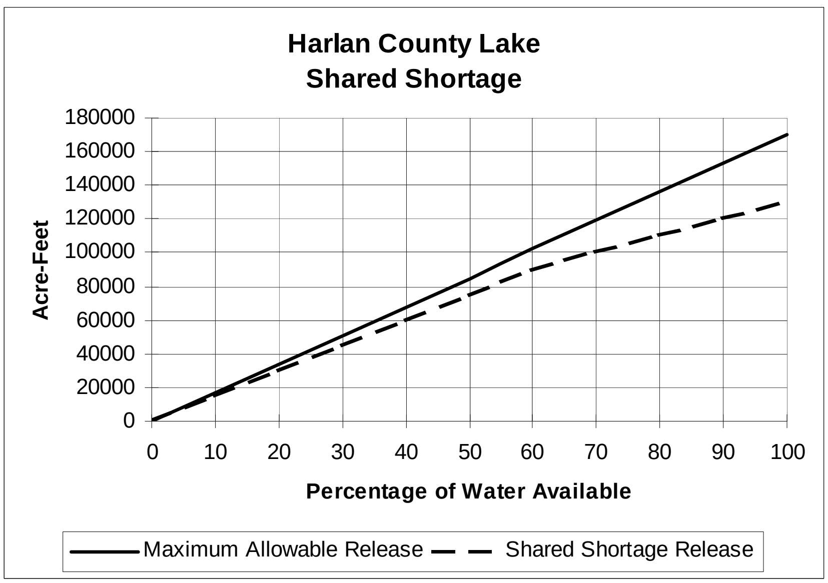
concerns, Reclamation and we determined that the previous 5-year inflow values would be averaged each year and compared to 57,600 Acre-feet. The inflow estimate for Harlan County Lake would be the smaller of these two values.

The estimated inflow amount would be used in January of each year to forecast the amount of water stored in the lake at the beginning of the irrigation season. Based on this forecast, the irrigation districts would be provided a firm estimate of the amount of water available for the next season. The actual storage in the lake on May 31 would be reviewed each year. When the actual water in storage is less than the January forecast, Reclamation may draw water from sediment storage to make up the difference.

4. Water Shortage Sharing.

A final component of the agreement involves a procedure for sharing the water available during times of shortage. Under the shared shortage procedure, the irrigation purpose of the project would remove less water then otherwise allowed and alleviate some of the adverse effects to the other purposes. The procedure would also extend the water supply during times of drought by “banking” some water for the next irrigation season. The following graph illustrates the shared shortage releases.




5. Calculation of Irrigation Water Available

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Each January, the Reclamation would provide the Bostwick irrigation districts a firm estimate of the quantity of water available for the following season. The firm estimate of water available for irrigation would be calculated by using the following equation and shared shortage adjustment:

| Storage + Summer Sediment Pool Evaporation + Inflow – Spring Evaporation=Maximum Irrigation Water Available |
|---|

The variables in the equation are defined as:

- Maximum Irrigation Water Available. Maximum irrigation supply from Harlan County Lake for that irrigation season.
- Storage. Actual storage in the irrigation pool at the end of December. The sediment pool is assumed full. If the pool elevation is below the top of the sediment pool, a negative irrigation storage value would be used.
- Inflow. The inflow would be the smaller of the past 5-year average inflow to the project from January through May, or 57,600 Acre-feet.
- Spring Evaporation. Evaporation from the project would be 8,800 Acre-feet which is the average January through May evaporation.
- Summer Sediment Pool Evaporation. Summer evaporation from the sediment pool during June through September would be 20,000 Acre-feet. This is an estimate based on lower pool elevations, which characterize the times when it would be critical to the computations.

6. Shared Shortage Adjustment

To ensure that an equitable distribution of the available water occurs during short-term drought conditions, and provide for a “banking” procedure to increase the water stored for subsequent years, a shared shortage plan would be implemented. The maximum water available for irrigation according to the above equation would be reduced according to the following table. Linear interpolation of values will occur between table values.

Shared Shortage Adjustment Table

| Irrigation Water Available (Acre-feet) | Irrigation Water Released (Acre-feet) |
|---|---|
| 0 | 0 |
| 17,000 | 15,000 |
| 34,000 | 30,000 |
| 51,000 | 45,000 |
| 68,000 | 60,000 |

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| | |
|---|---|
| 85,000 | 75,000 |
| 102,000 | 90,000 |
| 119,000 | 100,000 |
| 136,000 | 110,000 |
| 153,000 | 120,000 |
| 170,000 | 130,000 |

7. Annual Shutoff Elevation for Harlan County Lake

The annual shutoff elevation for Harlan County Lake would be estimated each January and finally established each June.

The annual shutoff elevation for irrigation releases will be estimated by Reclamation each January in the following manner:

1. Estimate the May 31 Irrigation Water Storage (IWS) (Maximum 150,000 Acre-feet) by taking the December 31 irrigation pool storage plus the January-May inflow estimate (57,600 Acre-feet or the average inflow for the last 5-year period, whichever is less) minus the January-May evaporation estimate (8,800 Acre-feet).
2. Calculate the estimated Irrigation Water Available, including all summer evaporation, by adding the Estimated Irrigation Water Storage (from item 1) to the estimated sediment pool summer evaporation (20,000 AF).
3. Use the above Shared Shortage Adjustment Table to determine the acceptable Irrigation Water Release from the Irrigation Water Available.
4. Subtract the Irrigation Water Release (from item 3) from the Estimated IWS (from item 1). The elevation of the lake corresponding to the resulting irrigation storage is the Estimated Shutoff Elevation. The shutoff elevation will not be below the bottom of the irrigation pool if over 119,000 AF of water is supplied to the districts, nor below 1,927.0 feet, msl. If the shutoff elevation is below the irrigation pool, the maximum irrigation release is 119,000 AF.

The annual shutoff elevation for irrigation releases would be finalized each June in accordance with the following procedure:

1. Compare the estimated May 31 IWS with the actual May 31 IWS.
2. If the actual end of May IWS is less than the estimated May IWS, lower the shutoff elevation to account for the reduced storage.
3. If the actual end of May IWS is equal to or greater than the estimated end of May IWS, the estimated shutoff elevation is the annual shutoff elevation.
4. The shutoff elevation will never be below elevation1,927.0 feet, msl, and will not be below the bottom of the irrigation pool if more than 119,000 Acre-feet of water is supplied to the districts.

Attachment 3: Inflows to Harlan County Lake 1993 Level of Development

BASELINE RUN - 1993 LEVEL INFLOW TO HARLAN COUNTY RESERVOIR

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1931 | 10.2 | 10.8 | 13.4 | 5.0 | 18.8 | 15.8 | 4.3 | 1.8 | 1.8 | 0.0 | 0.1 | 0.1 | 82.1 |
| 1932 | 6.8 | 16.6 | 18.5 | 4.6 | 3.8 | 47.6 | 3.8 | 2.8 | 4.8 | 0.0 | 0.0 | 0.4 | 109.7 |
| 1933 | 0.4 | 0.0 | 3.9 | 30.2 | 31.0 | 5.4 | 1.8 | 0.0 | 10.4 | 0.0 | 2.6 | 5.5 | 91.2 |
| 1934 | 2.1 | 0.0 | 3.2 | 1.8 | 0.7 | 7.3 | 0.8 | 0.0 | 1.3 | 0.0 | 2.2 | 0.0 | 19.4 |
| 1935 | 0.3 | 0.1 | 0.7 | 4.2 | 0.8 | 389.3 | 6.1 | 19.1 | 26.1 | 2.4 | 5.2 | 0.9 | 455.2 |
| 1936 | 0.3 | 0.0 | 11.9 | 0.0 | 35.9 | 4.7 | 0.4 | 0.0 | 1.8 | 0.0 | 1.6 | 3.8 | 60.4 |
| 1937 | 4.8 | 12.9 | 6.0 | 2.5 | 0.0 | 12.6 | 6.3 | 6.9 | 2.4 | 0.0 | 0.0 | 12.4 | 66.8 |
| 1938 | 9.9 | 7.8 | 8.7 | 10.4 | 18.7 | 8.6 | 7.3 | 7.8 | 4.9 | 0.2 | 0.0 | 4.7 | 89.0 |
| 1939 | 2.7 | 7.5 | 9.6 | 12.2 | 6.6 | 13.3 | 5.0 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 61.0 |
| 1940 | 0.0 | 0.0 | 12.2 | 5.2 | 4.6 | 23.7 | 2.8 | 3.2 | 0.0 | 3.6 | 0.0 | 1.4 | 56.7 |
| 1941 | 0.0 | 10.6 | 10.6 | 7.7 | 17.2 | 67.1 | 28.9 | 19.7 | 14.9 | 8.3 | 6.7 | 7.1 | 198.8 |
| 1942 | 3.3 | 10.6 | 0.5 | 34.1 | 30.8 | 83.9 | 11.7 | 10.9 | 36.5 | 3.1 | 8.7 | 0.3 | 234.4 |
| 1943 | 1.2 | 11.2 | 14.6 | 31.4 | 4.7 | 28.3 | 4.8 | 0.3 | 0.9 | 0.0 | 0.0 | 11.8 | 109.2 |
| 1944 | 0.1 | 4.3 | 9.0 | 43.1 | 31.9 | 63.9 | 26.6 | 15.4 | 0.5 | 0.3 | 3.0 | 4.5 | 202.6 |
| 1945 | 4.3 | 7.8 | 5.7 | 9.5 | 4.1 | 53.5 | 5.0 | 0.9 | 1.5 | 5.0 | 6.0 | 6.3 | 109.6 |
| 1946 | 5.9 | 11.2 | 9.3 | 4.9 | 7.0 | 3.1 | 1.6 | 11.4 | 28.1 | 129.9 | 25.0 | 12.1 | 249.5 |
| 1947 | 1.1 | 3.2 | 10.4 | 8.2 | 11.9 | 195.4 | 22.3 | 5.9 | 2.9 | 0.2 | 0.3 | 0.3 | 262.1 |
| 1948 | 6.2 | 9.8 | 24.1 | 5.4 | 0.2 | 39.8 | 13.5 | 6.8 | 4.2 | 0.0 | 0.1 | 0.1 | 110.2 |
| 1949 | 2.0 | 1.5 | 25.2 | 16.3 | 49.0 | 57.4 | 9.2 | 5.5 | 2.1 | 3.0 | 2.8 | 0.3 | 174.3 |
| 1950 | 0.3 | 5.7 | 10.8 | 10.9 | 28.9 | 10.1 | 12.7 | 9.3 | 7.8 | 7.2 | 3.8 | 3.1 | 110.6 |
| 1951 | 3.8 | 3.4 | 7.1 | 5.3 | 42.0 | 39.9 | 42.1 | 10.1 | 36.0 | 15.5 | 14.8 | 8.9 | 228.9 |
| 1952 | 16.4 | 21.4 | 26.3 | 23.8 | 34.6 | 4.0 | 9.3 | 3.1 | 1.5 | 11.7 | 4.3 | 0.1 | 156.5 |
| 1953 | 1.8 | 4.6 | 5.3 | 3.3 | 15.1 | 9.5 | 1.8 | 0.2 | 0.0 | 0.0 | 2.8 | 0.1 | 44.5 |
| 1954 | 1.0 | 6.8 | 1.9 | 3.2 | 7.1 | 2.4 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 23.6 |
| 1955 | 0.0 | 4.0 | 6.3 | 4.8 | 2.9 | 6.4 | 2.7 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 28.5 |
| 1956 | 1.6 | 3.4 | 2.9 | 2.4 | 1.3 | 1.5 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 13.7 |
| 1957 | 0.0 | 4.1 | 6.2 | 12.8 | 3.5 | 62.4 | 21.3 | 1.2 | 2.0 | 3.4 | 4.5 | 4.7 | 126.1 |
| 1958 | 0.8 | 3.0 | 14.2 | 14.0 | 18.7 | 1.3 | 3.4 | 2.2 | 0.0 | 0.4 | 0.0 | 0.6 | 58.6 |
| 1959 | 1.9 | 15.4 | 16.4 | 8.5 | 13.6 | 4.2 | 1.4 | 1.2 | 0.0 | 4.3 | 1.0 | 4.5 | 72.4 |
| 1960 | 1.4 | 12.3 | 71.4 | 23.9 | 21.7 | 53.7 | 14.1 | 3.2 | 0.0 | 0.0 | 0.2 | 2.8 | 204.7 |
| 1961 | 2.3 | 6.4 | 7.7 | 7.4 | 26.5 | 24.0 | 7.2 | 4.9 | 0.0 | 2.3 | 4.8 | 1.7 | 95.2 |

Attachment 3: Inflows to Harlan County Lake 1993 Level of Development

BASELINE RUN - 1993 LEVEL INFLOW TO HARLAN COUNTY RESERVOIR

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 4.5 | 9.1 | 16.2 | 9.9 | 14.4 | 42.6 | 41.6 | 21.1 | 2.3 | 8.7 | 8.3 | 5.7 | 184.4 |
| 1963 | 3.4 | 18.2 | 18.2 | 15.0 | 12.7 | 14.7 | 3.4 | 6.1 | 8.7 | 0.8 | 5.3 | 1.8 | 108.3 |
| 1964 | 5.4 | 7.6 | 8.3 | 8.4 | 9.9 | 11.9 | 7.2 | 6.5 | 2.4 | 1.9 | 1.4 | 2.3 | 73.2 |
| 1965 | 6.0 | 8.1 | 11.1 | 12.8 | 32.8 | 40.0 | 22.9 | 6.5 | 37.2 | 53.7 | 19.5 | 11.0 | 261.6 |
| 1966 | 8.9 | 21.4 | 15.7 | 11.4 | 12.0 | 34.7 | 12.4 | 2.5 | 3.5 | 5.4 | 6.8 | 5.7 | 140.4 |
| 1967 | 7.2 | 11.5 | 11.5 | 12.9 | 9.1 | 75.3 | 43.7 | 15.3 | 4.4 | 7.3 | 6.9 | 5.4 | 210.5 |
| 1968 | 3.9 | 10.2 | 8.5 | 11.6 | 10.8 | 12.5 | 3.1 | 2.7 | 1.6 | 2.0 | 4.3 | 3.4 | 74.6 |
| 1969 | 4.2 | 10.8 | 24.5 | 15.1 | 18.9 | 17.5 | 17.0 | 12.6 | 16.6 | 9.2 | 11.8 | 9.9 | 168.1 |
| 1970 | 3.5 | 8.7 | 8.5 | 10.5 | 11.1 | 7.7 | 4.6 | 3.2 | 0.5 | 3.3 | 4.7 | 4.5 | 70.8 |
| 1971 | 4.1 | 10.3 | 12.4 | 12.8 | 18.3 | 7.2 | 8.4 | 6.2 | 1.9 | 4.2 | 7.3 | 7.1 | 100.2 |
| 1972 | 5.5 | 8.1 | 9.2 | 8.3 | 14.8 | 8.5 | 6.5 | 4.4 | 0.1 | 2.9 | 7.6 | 4.1 | 80.0 |
| 1973 | 11.4 | 14.2 | 19.0 | 16.2 | 17.4 | 20.9 | 9.1 | 1.9 | 8.4 | 19.6 | 11.9 | 13.2 | 163.2 |
| 1974 | 13.2 | 13.4 | 12.0 | 14.3 | 15.4 | 17.2 | 5.5 | 0.0 | 0.0 | 0.0 | 4.9 | 5.5 | 101.4 |
| 1975 | 7.2 | 8.2 | 13.6 | 14.8 | 12.0 | 48.1 | 11.6 | 7.4 | 0.1 | 3.0 | 6.2 | 7.3 | 139.5 |
| 1976 | 7.0 | 10.2 | 10.1 | 16.0 | 12.1 | 3.5 | 2.2 | 1.8 | 0.9 | 1.0 | 3.2 | 3.1 | 71.1 |
| 1977 | 4.4 | 9.6 | 12.9 | 21.2 | 31.5 | 12.1 | 5.9 | 1.9 | 10.6 | 4.1 | 5.5 | 5.3 | 125.0 |
| 1978 | 5.0 | 6.5 | 20.6 | 12.9 | 11.8 | 3.8 | 0.0 | 1.0 | 0.0 | 0.0 | 0.3 | 1.6 | 63.5 |
| 1979 | 1.3 | 7.6 | 21.5 | 18.8 | 15.9 | 5.4 | 10.4 | 10.6 | 1.6 | 0.9 | 3.6 | 6.2 | 103.8 |
| 1980 | 5.7 | 9.3 | 11.6 | 15.2 | 10.4 | 2.1 | 2.5 | 0.0 | 0.0 | 0.0 | 2.5 | 2.2 | 61.5 |
| 1981 | 5.5 | 6.0 | 11.6 | 14.9 | 22.5 | 6.4 | 11.5 | 16.3 | 4.3 | 2.5 | 6.7 | 6.2 | 114.4 |
| 1982 | 5.3 | 12.5 | 17.9 | 14.3 | 26.8 | 27.1 | 8.9 | 2.7 | 0.0 | 6.5 | 6.3 | 15.5 | 143.8 |
| 1983 | 6.5 | 9.7 | 27.2 | 16.4 | 41.4 | 74.2 | 10.7 | 7.6 | 3.8 | 3.1 | 6.7 | 5.2 | 212.5 |
| 1984 | 6.8 | 14.6 | 17.2 | 32.9 | 40.6 | 15.5 | 8.1 | 4.5 | 0.0 | 5.5 | 4.8 | 6.2 | 156.7 |
| 1985 | 6.9 | 14.1 | 13.6 | 11.9 | 27.4 | 9.9 | 10.0 | 2.0 | 6.0 | 8.5 | 5.6 | 5.8 | 121.7 |
| 1986 | 9.1 | 9.4 | 12.2 | 11.7 | 34.3 | 13.0 | 13.5 | 4.6 | 3.3 | 5.9 | 5.4 | 7.1 | 129.5 |
| 1987 | 5.9 | 9.2 | 19.7 | 24.1 | 24.3 | 11.7 | 19.0 | 5.7 | 2.3 | 2.7 | 8.2 | 7.0 | 139.8 |
| 1988 | 6.2 | 13.7 | 11.6 | 15.2 | 15.2 | 7.0 | 17.9 | 10.4 | 0.6 | 2.0 | 5.9 | 5.4 | 111.1 |
| 1989 | 5.4 | 5.9 | 10.5 | 9.1 | 11.4 | 11.8 | 14.0 | 6.2 | 0.2 | 3.1 | 3.1 | 3.5 | 84.2 |
| 1990 | 6.6 | 7.7 | 13.2 | 9.7 | 15.5 | 1.4 | 4.3 | 10.7 | 0.6 | 3.2 | 2.0 | 2.7 | 77.6 |
| 1991 | 2.4 | 8.0 | 9.0 | 10.6 | 15.2 | 3.9 | 1.9 | 0.5 | 0.0 | 0.0 | 2.7 | 4.8 | 59.0 |
| 1992 | 8.0 | 8.8 | 12.7 | 8.5 | 4.5 | 6.1 | 6.5 | 9.4 | 2.4 | 6.9 | 6.7 | 5.2 | 85.7 |
| 1993 | 5.2 | 14.4 | 71.6 | 22.7 | 21.0 | 17.0 | 68.0 | 37.5 | 23.3 | 16.8 | 30.1 | 17.7 | 345.3 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg | 4.5 | 8.8 | 14.1 | 13.0 | 17.2 | 30.6 | 11.0 | 6.2 | 5.4 | 6.3 | 5.0 | 4.7 | 126.8 |

Attachment 4: Evaporation Loss Harlan County Lake 1993 Level of Development

BASELINE - 1993 LEVEL FLOWS - HARLAN COUNTY EVAPORATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1931 | 0.7 | 0.9 | 1.6 | 2.9 | 4.2 | 7.4 | 6.9 | 5.2 | 2.7 | 2.1 | 1.2 | 0.4 | 36.2 |
| 1932 | 0.6 | 0.8 | 1.5 | 2.7 | 4.1 | 5.0 | 6.8 | 5.0 | 2.7 | 2.1 | 1.2 | 0.4 | 32.9 |
| 1933 | 0.6 | 0.8 | 1.4 | 2.5 | 3.8 | 7.8 | 6.1 | 4.2 | 2.7 | 2.1 | 1.2 | 0.4 | 33.6 |
| 1934 | 0.6 | 0.8 | 1.4 | 2.4 | 4.5 | 6.5 | 8.0 | 6.2 | 2.7 | 2.0 | 1.2 | 0.4 | 36.7 |
| 1935 | 0.6 | 0.8 | 1.3 | 2.3 | 2.2 | 3.6 | 9.7 | 6.2 | 3.1 | 2.5 | 1.4 | 0.5 | 34.2 |
| 1936 | 0.7 | 0.9 | 1.6 | 2.9 | 5.5 | 6.8 | 8.7 | 6.5 | 2.7 | 2.1 | 1.2 | 0.4 | 40.0 |
| 1937 | 0.6 | 0.8 | 1.4 | 2.5 | 3.6 | 4.0 | 6.2 | 6.5 | 2.7 | 2.1 | 1.2 | 0.4 | 32.0 |
| 1938 | 0.6 | 0.9 | 1.5 | 2.7 | 3.4 | 4.9 | 6.5 | 5.7 | 2.7 | 2.1 | 1.2 | 0.4 | 32.6 |
| 1939 | 0.6 | 0.8 | 1.4 | 2.6 | 4.3 | 4.9 | 6.8 | 4.6 | 2.7 | 2.1 | 1.2 | 0.4 | 32.4 |
| 1940 | 0.6 | 0.8 | 1.4 | 2.4 | 3.5 | 5.0 | 6.5 | 4.6 | 2.7 | 2.1 | 1.2 | 0.4 | 31.2 |
| 1941 | 0.6 | 0.8 | 1.4 | 2.5 | 3.9 | 4.2 | 6.7 | 5.3 | 2.8 | 2.1 | 1.3 | 0.5 | 32.1 |
| 1942 | 0.6 | 0.9 | 1.5 | 2.8 | 4.0 | 5.2 | 8.3 | 5.1 | 3.2 | 2.5 | 1.5 | 0.5 | 36.1 |
| 1943 | 0.7 | 1.0 | 1.8 | 3.2 | 4.3 | 5.7 | 7.9 | 6.3 | 2.7 | 2.1 | 1.2 | 0.4 | 37.3 |
| 1944 | 0.6 | 0.8 | 1.4 | 2.7 | 4.2 | 5.3 | 7.0 | 5.8 | 3.5 | 2.6 | 1.5 | 0.5 | 35.9 |
| 1945 | 0.7 | 1.0 | 1.8 | 3.1 | 3.8 | 3.0 | 6.7 | 5.7 | 2.9 | 2.2 | 1.3 | 0.5 | 32.7 |
| 1946 | 0.6 | 0.9 | 1.6 | 2.8 | 3.5 | 5.1 | 5.6 | 4.4 | 2.9 | 2.7 | 1.8 | 0.6 | 32.5 |
| 1947 | 1.0 | 1.5 | 2.9 | 3.2 | 3.4 | -1.2 | 5.8 | 5.3 | 3.7 | 1.7 | 0.5 | 0.1 | 27.9 |
| 1948 | 0.8 | 0.7 | 1.5 | 3.6 | 3.1 | 2.4 | 4.2 | 4.7 | 3.0 | 2.7 | 0.8 | 0.3 | 27.8 |
| 1949 | 0.1 | 0.9 | 0.7 | 1.8 | 1.1 | 0.7 | 6.5 | 4.1 | 3.1 | 1.7 | 1.5 | 0.4 | 22.6 |
| 1950 | 0.7 | 0.1 | 0.8 | 2.8 | 2.0 | 5.6 | 0.8 | 2.8 | 4.5 | 2.3 | 1.6 | 0.6 | 24.6 |
| 1951 | 0.5 | 0.2 | 2.1 | 0.7 | -0.1 | 1.9 | 3.5 | 4.1 | 0.4 | 3.1 | 2.2 | 0.9 | 19.5 |
| 1952 | 1.1 | 1.2 | 1.9 | 2.5 | 5.2 | 6.2 | 1.5 | 3.4 | 3.6 | 2.9 | 1.1 | -0.1 | 30.5 |
| 1953 | 0.5 | 1.0 | 1.5 | 2.9 | 4.7 | 4.5 | 4.6 | 6.6 | 5.3 | 3.3 | 0.1 | 0.0 | 35.0 |
| 1954 | 0.7 | 0.6 | 2.2 | 3.6 | 0.3 | 4.9 | 6.7 | 1.6 | 3.6 | 1.6 | 1.5 | 0.6 | 27.9 |
| 1955 | 0.5 | 1.0 | 2.1 | 4.6 | 3.4 | -0.5 | 7.3 | 6.9 | 2.7 | 2.6 | 1.4 | 0.4 | 32.4 |
| 1956 | 0.6 | 1.1 | 1.9 | 2.8 | 3.9 | 4.5 | 5.0 | 3.7 | 4.7 | 3.7 | 1.3 | 0.5 | 33.7 |
| 1957 | 0.7 | 1.0 | 1.3 | 0.5 | -0.6 | -1.1 | 6.1 | 3.7 | 2.3 | 1.7 | 1.2 | 0.4 | 17.2 |
| 1958 | 0.7 | 0.1 | 1.0 | 0.6 | 2.3 | 4.4 | 1.0 | 1.9 | 3.3 | 3.3 | 1.0 | 0.6 | 20.2 |
| 1959 | 0.4 | 1.0 | 1.1 | 2.1 | 1.0 | 3.5 | 5.0 | 4.8 | 2.3 | 0.7 | 1.5 | 0.6 | 24.0 |
| 1960 | 0.1 | 0.7 | 2.0 | 2.7 | 0.9 | 0.1 | 4.9 | 3.6 | 3.9 | 2.0 | 1.3 | 0.4 | 22.6 |
| 1961 | 0.9 | 1.0 | 1.4 | 2.7 | -1.1 | 0.6 | 5.1 | 2.9 | 1.2 | 2.4 | 0.7 | 0.1 | 17.9 |

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Attachment 4: Evaporation Loss Harlan County Lake 1993 Level of Development

BASELINE - 1993 LEVEL FLOWS - HARLAN COUNTY EVAPORATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 0.6 | 0.6 | 0.9 | 3.7 | 3.4 | 1.5 | 0.3 | 1.6 | 2.0 | 2.0 | 1.7 | 0.3 | 18.6 |
| 1963 | 0.7 | 1.4 | 1.3 | 4.5 | 4.6 | 6.3 | 6.1 | 3.1 | -0.8 | 2.7 | 1.5 | 0.4 | 31.8 |
| 1964 | 0.8 | 0.8 | 1.7 | 3.2 | 5.6 | 1.2 | 6.9 | 3.0 | 3.0 | 3.3 | 1.2 | 0.6 | 31.3 |
| 1965 | 0.4 | 0.7 | 1.2 | 2.8 | 1.5 | -0.5 | 2.0 | 2.8 | -3.9 | 1.7 | 2.1 | 0.4 | 11.2 |
| 1966 | 0.9 | 0.8 | 2.9 | 2.7 | 7.5 | 2.8 | 5.8 | 3.7 | 2.7 | 2.8 | 1.5 | 0.4 | 34.5 |
| 1967 | 0.7 | 1.2 | 2.5 | 3.0 | 2.0 | -2.9 | 1.6 | 4.5 | 3.5 | 2.0 | 1.6 | 0.4 | 20.1 |
| 1968 | 0.9 | 1.2 | 2.8 | 2.6 | 3.2 | 4.9 | 4.7 | 1.8 | 2.3 | 0.7 | 1.2 | 0.2 | 26.5 |
| 1969 | 0.4 | 0.6 | 2.4 | 3.3 | 0.1 | 3.8 | -0.7 | 2.9 | 2.2 | -1.0 | 1.5 | 0.4 | 15.9 |
| 1970 | 0.7 | 1.4 | 2.3 | 2.8 | 4.7 | 4.4 | 6.5 | 5.9 | 0.9 | 1.0 | 1.5 | 0.7 | 32.8 |
| 1971 | 0.7 | 0.2 | 2.0 | 2.9 | 0.7 | 5.1 | 3.4 | 4.5 | 1.4 | 1.5 | 0.2 | 0.5 | 23.1 |
| 1972 | 0.8 | 1.3 | 2.0 | 1.7 | 1.1 | 0.0 | 3.3 | 1.8 | 2.1 | 1.7 | -0.4 | 0.1 | 15.5 |
| 1973 | 0.5 | 1.1 | -0.7 | 2.5 | 3.4 | 6.7 | -1.7 | 4.2 | -3.0 | 0.2 | 0.2 | 0.2 | 13.6 |
| 1974 | 0.7 | 1.5 | 2.6 | 1.5 | 3.7 | 2.5 | 9.1 | 2.6 | 3.4 | 1.4 | 1.1 | 0.3 | 30.4 |
| 1975 | 0.7 | 0.7 | 2.0 | 2.1 | 0.8 | 1.1 | 4.3 | 2.7 | 3.0 | 3.4 | 0.7 | 0.6 | 22.1 |
| 1976 | 0.8 | 1.2 | 1.7 | 0.7 | 1.5 | 5.0 | 5.9 | 5.7 | -0.2 | 1.4 | 1.4 | 0.7 | 25.8 |
| 1977 | 0.7 | 1.3 | 0.2 | 1.1 | 0.0 | 4.6 | 4.0 | 0.6 | 2.0 | 1.6 | 1.0 | 0.4 | 17.5 |
| 1978 | 0.5 | 0.7 | 1.2 | 3.4 | 3.9 | 6.2 | 7.1 | 4.5 | 4.5 | 3.0 | 1.1 | 0.5 | 36.6 |
| 1979 | 0.5 | 0.6 | 1.1 | 3.9 | 4.4 | 4.6 | 3.5 | 5.1 | 4.1 | 2.8 | 1.4 | 0.7 | 32.7 |
| 1980 | 0.5 | 0.6 | 1.2 | 3.4 | 3.7 | 4.7 | 6.8 | 6.0 | 3.9 | 2.7 | 1.3 | 0.6 | 35.4 |
| 1981 | 0.5 | 0.6 | 1.2 | 3.8 | 3.2 | 4.8 | 4.2 | 3.7 | 2.9 | 1.7 | 1.3 | 0.7 | 28.6 |
| 1982 | 0.5 | 0.7 | 1.2 | 3.9 | 3.8 | 3.9 | 5.1 | 3.8 | 2.9 | 2.2 | 1.4 | 0.8 | 30.2 |
| 1983 | 0.5 | 0.7 | 1.4 | 2.9 | 4.2 | 5.3 | 8.6 | 7.2 | 4.6 | 1.8 | 1.5 | 0.6 | 39.3 |
| 1984 | 0.6 | 0.8 | 1.4 | 2.9 | 4.2 | 5.8 | 7.2 | 5.7 | 4.7 | 1.4 | 1.4 | 0.7 | 36.8 |
| 1985 | 0.5 | 0.7 | 1.3 | 2.3 | 4.0 | 4.5 | 5.6 | 3.5 | 3.8 | 1.5 | 1.5 | 0.7 | 29.9 |
| 1986 | 0.6 | 0.7 | 1.3 | 2.8 | 4.4 | 5.8 | 6.7 | 4.0 | 2.7 | 1.3 | 1.4 | 0.7 | 32.4 |
| 1987 | 0.5 | 0.8 | 1.3 | 3.1 | 4.2 | 6.2 | 6.9 | 3.5 | 3.1 | 2.2 | 1.4 | 0.7 | 33.9 |
| 1988 | 0.5 | 0.7 | 1.3 | 3.5 | 4.9 | 6.6 | 4.6 | 4.8 | 3.5 | 2.2 | 1.4 | 0.7 | 34.7 |
| 1989 | 0.5 | 0.7 | 1.2 | 4.2 | 4.5 | 4.4 | 4.8 | 3.6 | 3.0 | 2.5 | 1.4 | 0.7 | 31.5 |
| 1990 | 0.5 | 0.7 | 1.2 | 3.0 | 3.5 | 5.6 | 6.4 | 4.0 | 5.0 | 3.4 | 1.4 | 0.6 | 35.3 |
| 1991 | 0.5 | 0.7 | 1.2 | 2.8 | 3.3 | 5.5 | 6.0 | 5.0 | 5.1 | 3.2 | 1.3 | 0.6 | 35.2 |
| 1992 | 0.6 | 0.7 | 1.2 | 1.8 | 3.2 | 2.2 | 4.1 | 3.5 | 4.2 | 2.9 | 1.9 | 1.0 | 27.3 |

Deleted: July

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 0.6 | 0.5 | 1.0 | 2.2 | 3.1 | 4.6 | 4.2 | 4.9 | 4.5 | 4.4 | 3.1 | 1.2 | 34.3 |
| Avg | 0.6 | 0.8 | 1.5 | 2.7 | 3.2 | 3.9 | 5.3 | 4.3 | 2.8 | 2.2 | 1.3 | 0.5 | 29.1 |

| **Trigger Calculations Based on Harlan County Lake Irrigation Supply** | Units-1000 Acre-feet | Irrigation Trigger | 119.0 | Assume that during irrigation release season | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Total Irrigation Supply | 130.0 | HCL Inflow = Evaporation Loss | | | | | | | | | |
| | | Bottom Irrigation | 164.1 | | | | | | | | | | |
| | | Evaporation Adjust | 20.0 | | | | | | | | | | |
| | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| 1993 Level AVE inflow | 6.3 | 5 | 4.7 | 4.5 | 8.8 | 14.1 | 13.0 | 17.2 | 30.6 | 11.0 | 6.2 | 5.4 | 126.8 |
| 1993 Level AVE evap | 2.2 | 1.3 | 0.5 | 0.6 | 0.8 | 1.5 | 2.7 | 3.2 | 3.9 | 5.3 | 4.3 | 2.8 | 29.1 |
| (1931-93) | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Avg. Inflow Last 5 Years | 10.8 | 13.0 | 12.3 | 12.9 | 16.6 | 22.4 | 19.4 | 18.1 | 14.8 | 16.5 | 11.0 | 4.7 | 172.6 |

Attachment 5: Projected Water Supply Spread Sheet Calculations

| **Year 2001-2002 Oct - Jun Trigger and Irrigation Supply Calculation** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Calculation Month | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** |
| Previous EOM Content | 236.5 | 235.9 | 238.6 | 242.9 | 248.1 | 255.1 | 263.8 | 269.6 | 276.2 |
| Inflow to May 31 | 73.6 | 67.3 | 62.3 | 57.6 | 53.1 | 44.3 | 30.2 | 17.2 | 0.0 |
| Last 5 Yrs Avg Inflow to May 31 | 125.6 | 114.8 | 101.7 | 89.5 | 76.6 | 59.9 | 37.5 | 18.1 | 0.0 |
| Evap to May 31 | 12.8 | 10.6 | 9.3 | 8.8 | 8.2 | 7.4 | 5.9 | 3.2 | 0.0 |
| Est. Cont May 31 | 297.3 | 292.6 | 291.6 | 291.7 | 293.0 | 292.0 | 288.1 | 283.6 | 276.2 |
| Est. Elevation May 31 | 1944.44 | 1944.08 | 1944.00 | 1944.01 | 1944.11 | 1944.03 | 1943.72 | 1943.37 | 1942.77 |
| Max. Irrigation Available | 153.2 | 148.5 | 147.5 | 147.6 | 148.9 | 147.9 | 144.0 | 139.5 | 132.1 |
| Irrigation Release Est. | 120.1 | 117.4 | 116.8 | 116.8 | 118.1 | 117.1 | 116.8 | 116.8 | 116.8 |
| Trigger - Yes/No | NO | YES | YES | YES | YES | YES | YES | YES | YES |
| 130 kAF Irrigation Supply - Yes/No | NO | NO | NO | NO | NO | NO | NO | NO | NO |

Attachment 5: Projected Water Supply Spread Sheet Calculations

| | | | | |
|---|---|---|---|---|
| **Year 2002<br>Jul - Sep<br>Final Trigger and<br>Total Irrigation Supply<br>Calculation** | | | | |
| | | | | |
| Calculation Month | | **Jul** | **Aug** | **Sep** |
| Previous EOM Irrigation Release Est. | | 116.8 | 116.0 | 109.7 |
| Previous Month Inflow | | 5.5 | 0.5 | 1.3 |
| Previous Month Evap | | 6.3 | 6.8 | 6.6 |
| Irrigation Release Estimate | | 116.0 | 109.7 | 104.4 |
| Final Trigger - Yes/No | | YES | | |
| 130 kAF Irrigation Supply - Yes/No | | NO | NO | NO |

Deleted: July 2005

Attachment 6: Computing Water Supplies and Consumptive Use Above Guide Rock

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Main Stem VWS | Hardy gage | Superior-Courtland Diversion Dam Gage | Courtland Canal Diversions | Superior Canal Diversions | Courtland Canal Returns | Superior Canal Returns | Total Bostwick Returns Below Guide Rock | NE CBCU Below Guide Rock | KS CBCU Below Guide Rock | Total CBCU Below Guide Rock | Gain Guide Rock to Hardy | VWS Guide Rock to Hardy | Main Stem Virgin Water Supply Above Guide Rock | Nebraska Main Stem Allocation Above Hardy | Kansas Main Stem Allocation Above Hardy | Nebraska Guide Rock to Hardy Allocation | Kansas Guide Rock to Hardy Allocation |
| | | | | | | | Col F+ Col G | | | Col I + Col J | + Col B - Col C+ Col K - Col H | + Col L + Col K | Col A - Col M | .489 x Col N | .511 x Col N | .489 x Col M | .511 x Col M |

Deleted: July 2005

Attachment 7: Calculations of Return Flows from Bureau of Reclamation Canals

| Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 | Col 9 | Col 10 | Col 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| Canal | Canal Diversion | Spill to Waste-way | Field Deliveries | Canal Loss | Average Field Loss Factor | Field Loss | Total Loss from District | Percent Field and Canal Loss That Returns to the Stream | Total Return to Stream from Canal and Field Loss | Return as Percent of Canal Diversion |
| Name Canal | Headgate Diversion | Sum of measured spills to river | Sum of deliveries to the field | +Col 2 - Col 4 | 1 -Weighted Average Efficiency of Application System for the District* | Col 4 x Col 6 | Col 5 + Col 7 | Estimated Percent Loss* | Columns 8 x Col 9 | Col 10/Col 2 |
| Example | 100 | 5 | 60 | 40 | 30% | 18 | 58 | 82% | 48 | 48% |
| Culbertson | | | | | 30% | | | | | |
| Culbertson Extension | | | | | 30% | | | | | |
| Meeker-Driftwood | | | | | 30% | | | | | |
| Red Willow | | | | | 30% | | | | | |
| Bartley | | | | | 30% | | | | | |
| Cambridge | | | | | 30% | | | | | |
| Naponne | | | | | 35% | | | | | |
| Franklin | | | | | 35% | | | | | |
| Franklin Pump | | | | | 35% | | | | | |
| Almena | | | | | 30% | | | | | |
| Superior | | | | | 31% | | | | | |
| Nebraska Courtland | | | | | 23% | | | | | |
| Courtland Canal Above Lovewell (KS) | | | | | 23% | | | | | |
| Courtland Canal Below Lovewell | | | | | 23% | | | | | |

*The average field efficiencies for each district and percent loss that returns to the stream may be reviewed and, if necessary, changed by the RRCA to improve the accuracy of the estimates.

# EXHIBIT 3 TO ATTACHMENT A

*Rights to Designated Groundwater*

Revised March 2009.

# Exhibit 3
## Rights to Designated Groundwater

| | | | Values Submitted and Recommended for Approval by Colorado Groundwater Commission | | | |
|---|---|---|---|---|---|---|
| Field Number | Permit #1 | Permit #2 | Acreage in Change of Use Form | Colorado Groundwater Commission Historical Consumptive Use (ac-ft/yr) | Application Date to Colorado Groundwater Commission | Corrected Historical Consumptive Use (ac-ft/yr) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 1-1 | 12967-FP | 16920-FP | 194 | 345 | 2/25/2008 | 333 |
| 1-2 | 14403-FP | | 181 | 279 | 10/22/2008 | 279 |
| 1-3 | 14019-FP | | 133 | 217 | 2/25/2008 | 206 |
| 1-4 | 14018-FP | | 164 | 252 | 2/25/2008 | 234 |
| 1-5 | 19372-FP | | 136 | 218 | 2/25/2008 | 211 |
| 1-6 and 1-7 | 18780-FP | | 127 | 192 | 2/25/2008 | 192 |
| **Subtotal** | | | **935** | **1,502** | | **1,455** |
| 2-1 | 14396-FP | | 130 | 192 | 2/25/2008 | 180 |
| 2-2 | 13858-FP | | 133 | 228 | 2/25/2008 | 206 |
| 2-3 | 13859-FP | 16069-FP | 188 | 270 | 2/25/2008 | 260 |
| 2-4 | 13857-FP | | 147 | 229 | 2/25/2008 | 217 |
| 2-5 | 14398-FP | | 144 | 240 | 2/25/2008 | 230 |
| 2-6 | 13856-FP | 16067-FP | 164 | 249 | 2/25/2008 | 249 |
| **Subtotal** | | | **906** | **1,408** | | **1,342** |
| 3-1 | 14397-FP | | 127 | 192 | 2/25/2008 | 184 |
| 3-2 | 14027-FP | | 153 | 251 | 2/25/2008 | 237 |
| 3-3 | 14022-FP | | 180 | 289 | 2/25/2008 | 255 |
| 3-4 | 14023-FP | | 133 | 219 | 2/25/2008 | 197 |
| 3-5 | 14600-FP | | 124 | 197 | 2/25/2008 | 187 |
| 3-6 | 15285-FP | | 98 | 161 | 2/25/2008 | 140 |
| 3-7 | 20896-FP | | 107 | 169 | 2/25/2008 | 168 |
| **Subtotal** | | | **922** | **1,479** | | **1,369** |
| 4-1 | 13513-FP | 16074-FP | 186 | 302 | 2/25/2008 | 257 |
| 4-2 | 14028-FP | | 146 | 218 | 2/25/2008 | 202 |
| 4-3 | 14753-FP | | 185 | 310 | 2/25/2008 | 267 |
| 4-4 | 13522-FP | | 135 | 204 | 2/25/2008 | 189 |
| 4-5 | 14024-FP | | 93 | 141 | 2/25/2008 | 129 |
| 4-6 | 13509-FP | 16075-FP | 179 | 284 | 2/25/2008 | 273 |
| 4-7 | 13511-FP | | 123 | 192 | 2/25/2008 | 173 |
| 4-8 | 18781-FP | | 128 | 216 | 2/25/2008 | 206 |
| 4-9 | 21476-FP | | 88 | 144 | 2/25/2008 | 139 |
| 5-1 | 18783-FP | | 173 | 273 | 2/25/2008 | 273 |
| **Subtotal** | | | **1,437** | **2,285** | | **2,108** |
| 6-0 | 19004-FP | | 82 | 141 | 10/22/2008 | 141 |
| 6-1 | 19005-FP | | 124 | 178 | 2/25/2008 | 174 |
| 6-2 | 18966-FP | | 94 | 172 | 2/25/2008 | 172 |
| 6-3 | 18018-FP | | 148 | 230 | 2/25/2008 | 218 |
| 6-4,6-5 | 18017-FP | 19001-FP | 245 | 361 | 2/25/2008 | 353 |
| 6-6, 6-7 | 23222-FP | | 148 | 230 | 10/22/2008 | 230 |
| 6-8 | 18019-FP | | 107 | 173 | 2/25/2008 | 163 |
| 6-9, 6-10 | 18014-FP | | 176 | 259 | 2/25/2008 | 247 |
| 6-11,12,13,14 | 18013-FP | | 250 | 350 | 2/25/2008 | 350 |
| 6-15, 6-16 | 18011-FP | | 244 | 431 | 2/25/2008 | 421 |
| 6-17, 6-18, 6-19 | 18015-FP | | 329 | 549 | 2/25/2008 | 497 |
| 6-20, 6-21 | 18012-FP | 19000-FP | 208 | 322 | 2/25/2008 | 317 |
| **Subtotal** | | | **2,155** | **3,397** | | **3,283** |

# Exhibit 3

## Rights to Designated Groundwater

| Field Number | Permit #1 | Permit #2 | Acreage in Change of Use Form | Colorado Groundwater Commission Historical Consumptive Use (ac-ft/yr) | Application Date to Colorado Groundwater Commission | Corrected Historical Consumptive Use (ac-ft/yr) |
|---|---|---|---|---|---|---|
| | | | Values Submitted and Recommended for Approval by Colorado Groundwater Commission | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 7-1 | 13813-FP | 16923-FP | 126 | 206 | 2/25/2008 | 203 |
| 7-2, 7-2A | 13814-FP | | 219 | 334 | 2/25/2008 | 323 |
| 7-3, 7-3a | 13815-FP | | 197 | 291 | 2/25/2008 | 311 |
| 7-13, 7-14 | 14718-FP | | 358 | 526 | 2/25/2008 | 526 |
| 7-15, 7-16 | 14121-FP | | 285 | 437 | 2/25/2008 | 420 |
| 7-17, 7-18 | 14719-FP | | 263 | 455 | 2/25/2008 | 424 |
| 7-19 [a)] | 14122-FP | | 131 | 215 | 2/25/2008 | 204 |
| 7-21, 7-21A | 12589-FP | | 251 | 376 | 2/25/2008 | 372 |
| 7-23 | 12567-FP | | 126 | 201 | 2/25/2008 | 201 |
| **Subtotal** | | | **1,957** | **3,041** | | **2,983** |
| Wiley | 4319-FP | 4922-FP | 65 | 75 | 10/22/2008 | 75 |
| Wilder1 | 20198-FP | | 124 | 194 | 10/22/2008 | 194 |
| Wilder2 | 20196-FP | | 163 | 249 | 10/22/2008 | 249 |
| **Subtotal** | | | **352** | **518** | | **518** |
| | | | | | | |
| **Total** | | | **8,664** | **13,630** | | **13,059** |

a) Permit allows for irrigation of parcels 7-19 and 7-20. Only the portion of permit historically used to irrigate parcel 7-19 is included in this table.

**Explanation of Columns**

(1) Field Number as shown on the Figures submitted to the Colorado Groundwater Commission in the change of use applications.

(2) Final permit for the Northern High Plains Designated Ground Water Basin. See permit for well location, priority date, and other information, including any allowable commingling with other permits.

(3) Second permit associated with the permit shown in column 2. Typically, these are permits for additional acreage, but see permit for details.

(4) Average acreage reported in change of use form submitted to the Colorado Groundwater

(5) Historical consumptive use determined from irrigated acreage, crop records and power records. For permits in February 25, 2008 application the values are from the March 19, 2008 DWR Publication letter. For permits in October 22, 2008 submittal the values are from the December 8, 2008 DWR Publication letter.

(6) Date permit was submitted for change of use to the Colorado Groundwater Commission.

(7) In April of 2008 Marc Groff, a consultant for the State of Nebraska, identified an error in the consumptive use calculations made in the February 25, 2008 submittal to the Colorado Groundwater Commission. This error was documented by the State of Colorado in a memorandum provided to the State of Nebraska and the State of Kansas entitled "Revisions to Crop Irrigation Requirement Use Estimates included in March 2008 RRCA Submittal for the Republican River Compact Compliance" dated May 18, 2008. This error was corrected and was not included in the October 22, 2008 submittal. The Consumptive Use values shown in Column 7 are the corrected February 25, 2008 values and the October 22, 2008 values.

# EXHIBIT 4 TO ATTACHMENT A

Examples of Delivery Limitations

Revised February 13, 2009

**Exhibit 4 Hypothetical Calculations of the Projected Delivery and the Limit on Augmentation Water Supply Credit**

| A | B | C | D | E | F | G | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Colorado's Total Allocation | Computed Beneficial Consumptive Use | Deficit or Difference | Projected Delivery | Max Aug. Water Supply (AWS) Credit | Measured Pipeline Deliveries | Annual Calculation = Alloc - (CBCU - Deliveries) | Five-year running average | ***Limited??*** | Remarks |
| 1993 | 42,214 | 35,274 | 6940 | | | 0 | 6,940 | | | |
| 1994 | 35,831 | 32,967 | 2864 | | | 0 | 2,864 | | | |
| 1995 | 40,714 | 35,125 | 5589 | | | 0 | 5,589 | | | |
| 1996 | 39,659 | 36,469 | 3190 | | | 0 | 3,190 | | | |
| 1997 | 32,641 | 35,442 | (2801) | 0 | 4,000 | 0 | -2,801 | **3156** | | No previous deficit; therefore, Max AWS Credit is 4000 af |
| 1998 | 33,294 | 36,148 | (2854) | 2,801 | 6,801 | 0 | -2,854 | **1198** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger |
| 1999 | 37,782 | 38,217 | (435) | 2,854 | 6,854 | 0 | -435 | **538** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger |
| 2000 | 31,427 | 37,691 | (6264) | 2,854 | 6,854 | 0 | -6,264 | **(1833)** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger |
| 2001 | 27,572 | 36,132 | (8560) | 6,264 | 10,264 | 0 | -8,560 | **(4183)** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger |
| 2002 | 20,741 | 35,228 | (14487) | 8,560 | 12,560 | 0 | -14,487 | **(6520)** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger |
| 2003 | 21,420 | 33,470 | (12050) | 14,487 | 20,282 | 0 | -12,050 | **(8359)** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2004 | 22,540 | 33,670 | (11130) | 14,487 | 20,282 | 13,069 | 1,939 | **(7884)** | | Deliveries begin, but limited to Hist. CU b/c there has been no banking |
| 2005 | 25,040 | 35,460 | (10420) | 14,487 | 20,282 | 13,069 | 2,649 | **(6102)** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2006 | 21,090 | 30,760 | (9670) | 14,487 | 20,282 | 13,069 | 3,399 | **(3710)** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2007 | 24,520 | 32,850 | (8330) | 14,487 | 20,282 | 13,069 | 4,739 | **135** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2008 | 27,000 | 32,000 | (5000) | 14,487 | 20,282 | 2,000 | -3,000 | **1945** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2009 | 27,000 | 33,000 | (6000) | 14,487 | 20,282 | 4,000 | -2,000 | **1157** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2010 | 27,000 | 33,000 | (6000) | 14,487 | 20,282 | 4,000 | -2,000 | **228** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2011 | 21,000 | 33,000 | (12000) | 14,487 | 20,282 | 20,500 | 8,282 | **1204** | ***Limited to Max*** | Deliveries > Hist. CU b/c of banking, but Max AWS Credit applies |
| 2012 | 27,000 | 32,000 | (5000) | 14,487 | 20,282 | 4,000 | -1,000 | **56** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2013 | 27,000 | 33,000 | (6000) | 12,050 | 16,870 | 4,000 | -2,000 | **256** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2014 | 32,641 | 35,442 | (2801) | 12,000 | 16,800 | 3,000 | 199 | **696** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2015 | 33,294 | 36,148 | (2854) | 12,000 | 16,800 | 3,000 | 146 | **1125** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2016 | 37,782 | 38,217 | (435) | 12,000 | 16,800 | 4,000 | 3,565 | **182** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2017 | 31,427 | 37,691 | (6264) | 12,000 | 16,800 | 6,500 | 236 | **429** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2018 | 27,572 | 36,132 | (8560) | 12,000 | 16,800 | 9,000 | 440 | **917** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2019 | 20,741 | 35,228 | (14487) | 12,000 | 16,800 | 13,000 | -1,487 | **580** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2020 | 21,420 | 33,470 | (12050) | 14,487 | 20,282 | 13,000 | 950 | **741** | | Max AWS Credit is 140% of Projected Delivery because it is larger |

= formula amended to account for lack of data for 10 yrs

| | |
|---|---|
| A | Accounting Year |
| B | From RRCA Accounting |
| C | From RRCA Accounting |
| D | Allocation (B) minus CBCU © |
| E | Largest Deficit in previous 10 years |
| F | E + 4000 or E * 140% whichever is larger |
| G | Augmentation Water Pumped during the accounting year |
| H | Annual Calculation = Alloc - (CBCU - Deliveries) (B-(C-G)) |
| I | Running Average = ave of this year plus previous 4 years (Column H) |
| J | Flag that notes if pumping (G) exceeds AWS limit (F) |

# ATTACHMENT D

## AGENDA

## ANNUAL MEETING OF THE RRCA
## LINCOLN, NEBRASKA
## AUGUST 12, 2009

AGENDA FOR
**CONTINUATION OF APRIL 28TH SPECIAL MEETING**
**REPUBLICAN RIVER COMPACT ADMINISTRATION**

*August 12, 2009, 8:00 AM*
*The Cornhusker Hotel, Lincoln, Nebraska*

1. Call to order
2. Adjournment

AGENDA FOR
**49TH ANNUAL MEETING OF THE**
**REPUBLICAN RIVER COMPACT ADMINISTRATION**

1. Introductions
2. Modification and adoption of the agenda
3. Approval of previous Annual Meeting minutes and transcript from August 13, 2008
4. Report of chairman and commissioner's reports
   a. Nebraska
   b. Colorado
   c. Kansas
5. Federal Reports
   d. Bureau of Reclamation
   e. U.S. Army Corps of Engineers—(invited, unable to attend)
   f. U.S. Geological Survey
6. Committee Reports
   g. Engineering Committee
      i. Assignments from 2008 Annual Meeting
      ii. Committee recommendations to RRCA
      iii. Other matters
      iv. Recommended assignments for Engineering Committee
      v. Response to Kansas data requests
   h. Conservation Committee
7. Old Business
   i. Dispute Resolution
      i. Arbitration
      ii. Colorado Compliance Pipeline (augmentation) proposal
      iii. Nebraska crediting issue
   j. Lower Republican Feasibility Study
   k. Compact compliance
8. New business and assignments to compact committees
   l. Action on Engineering Committee Report and assignments
   m. Additional items
9. Remarks from the public
10. Future meeting arrangements
11. Adjournment

# ATTACHMENT E

# TRANSCRIPT

# ANNUAL MEETING OF THE RRCA
# LINCOLN, NEBRASKA
# AUGUST 12, 2009

49TH ANNUAL MEETING OF THE
REPUBLICAN RIVER COMPACT ADMINISTRATION

The Cornhusker Hotel
333 South 13th Street
Lincoln, Nebraska

Convened, pursuant to notice at 8:07 a.m. on August 12, 2009,

BEFORE:

Chairman Brian Dunnigan, Director, Nebraska Department of Natural Resources; Commissioner David W. Barfield, P.E. Chief Engineer, Division of Water Resources; Commissioner Dick Wolfe, P.E., State Engineer, Director, for Colorado Department of Natural Resources.

A P P E A R A N C E S

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# I N D E X

I N D E X (Cont'd)



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REPORTERS CERTIFICATE:

I, KELLY S. HORSLEY, reporter for ACE REPORTING, certify that I reported the proceedings in this matter; that the transcript is a true, accurate and complete extension of the recording made of those proceedings.

IN TESTIMONY WHEREOF, I have hereunto set my hand at Lincoln, Nebraska, this _____day of August, 2008.

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______________________Reporter

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PROCEEDINGS:

CHAIRMAN DUNNIGAN: Good morning. Welcome to Lincoln, Nebraska. My name is Brian Dunnigan, and I'm the Director of the Department of Natural Resources, and I also serve as the Chairman of the Republican River Compact Administration this year, actually until the end of the second meeting you have this morning.

At this time I would like to call to order, the continuation of the April 28th, 2009, Special Meeting of the Republication of the Republican River Compact Administration. The remaining issues to be discussed will be handled in the annual meeting.

At this point, I would entertain a motion to adjourn that special meeting.

COMMISSIONER BARFIELD: I move to adjourn the special meeting.

CHAIRMAN DUNNIGAN: So moved.

Second?

COMMISSIONER WOLFE: Second.

CHAIRMAN DUNNIGAN: All in favor?

Aye.

COMMISSIONER WOLFE: Aye.

COMMISSIONER BARFIELD: Aye.

CHAIRMAN DUNNIGAN: Meeting adjourned.

At this time I would to call the 49th Annual Meeting of the Republican River Compact Administration to order.

Again, my name is Brian Dunnigan. There are agendas on the back table. If you didn't get an agenda when you came in the door, please free to pick up an agenda.

Before I introduce my staff, I would like to recognize some of our Nebraska partners in the audience: NRD managers, Jasper Fannin, Mike Clements, John Thorburn and Dan Smith, in the back; irrigation district managers: Brad Edgerton, Mike Delka.

I would like to introduce my staff from the DNR right now. To my immediate right is Jim Schneider, to his right is James Williams. Jason Kepler should be in the room. He was manning the computer yesterday, Jason; Paul Koester; Tom O'Connor. And to my immediate left is Justin Lavene from the Attorney General's Office.

Commissioner Wolfe, if you would introduce your staff and others.

COMMISSIONER WOLFE: Good morning. Dick Wolfe, State Engineer for Colorado and Commissioner for Colorado. And I want to thank Nebraska for hosting it this year, and for the fine facility. Appreciate the accommodations and our request today under our tight time constraints to do that here, so we do appreciate that.

Again, I would like to recognize some of my staff, but before that I would like to recognize some of the other Colorado delegation that's joined us here today as well in the audience. With the Republican River Water Conservation District, Dennis Coryell is here, the president; and Stan Murphy, I'm not sure -- he's here, but I'm not sure he's in the room yet. He's the manager for the district. And David Robbins, their lead counsel. He's here in the front row. Also representing Colorado here today is William Schreuder, our modeler, for both the state of Colorado and assist the district, as well. And also Tony Magnus is here. He's with the Colorado Agricultural Preservation Association in the basin. And also in the audience is Alex Davis, who is the assistant director in the Department of Natural Resources over water. Here at the table with me is Pete Ampe, to my left. He is the First Assistant Attorney General from the Attorney General's Office over interstate litigation. To my immediate right is Mike Sullivan, my Deputy State Engineer. And to his right is Meg Sullivan, Engineer Advisor for the state of Colorado. And I think I've probably covered everybody that's here from Colorado. So, thank you.

CHAIRMAN DUNNIGAN: Thank you, Commissioner Wolfe.

Commissioner Barfield?

COMMISSIONER BARFIELD: Thank you, Commissioner Dunnigan. My name is David Barfield. I'm the Kansas Chief Engineer and Commissioner for Kansas. And, again, as Dick has indicated, appreciate your fine hosting of the annual meeting and work session last night.

I'll make the introductions for Kansas. Here at the table to my right is Scott Ross, water commissioner for our Stockton field office that covers much of the basin in the Republican Basin. And to my left is Burke Griggs, attorney with the Department of Agriculture. He replaced Lee Ross who attended these meetings, probably 25 of these meetings. And I was thinking last night as I was getting my remarks together that I -- in view of that 25 years serving the compact administration, probably should have prepared a resolution honoring him. I'll probably take the next opportunity to do so because his work, I think, greatly served this administration. So, we'll get that done. Others with the state of Kansas in the crowd here, Sam Speed is with our Kansas Attorney General's Office. Normally John Draper, our counsel of record is with us. He is in England. His son is getting married, so he is not with us today. Also here today, Chris Beightel. He is program manager for the water services -- water services management program for the division; Sam Perkins, a modeler. We also have Chelsea Jericek, who is on Scott's staff. She replaced Mark Billinger, who went on to other employment. And Dale Book, consultant for Kansas. That's it.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

Moving on to Item 2 on the agenda, modification and adoption of the proposed agenda. I would ask if there are any modifications to the agenda at this time.

COMMISSIONER BARFIELD: I know of none. I would move adoption of the agenda as provided.

COMMISSIONER WOLFE: Second.

CHAIRMAN DUNNIGAN: So moved. All in favor?

Aye.

COMMISSIONER WOLFE: Aye.
COMMISSIONER BARFIELD: Aye
CHAIRMAN DUNNIGAN: Agenda approved.
Moving to item 3. Approval of previous annual meeting minutes and transcript from the August 13th, 2008, meeting. Would there be a motion to approve the annual meeting minutes and transcript from the August 13th, 2008, meeting?
COMMISSIONER WOLFE: I just want to make sure I'm clarified on this. We do have an annual meeting summary and was there recently minutes that were drafted up that James had just sent out? I just want to make sure what we have before us that we're trying to act on. Is it the summary or the draft minutes that have just recently been sent out?
COMMISSIONER DUNNIGAN: It would be the meeting minutes and the annual --
MR. WILLIAMS: Let me clarify that. What we are proposing is that the annual report would consist of the minutes and all of the attachments, and so it would be both documents that were sent out. And the attachments would include transcripts from the meeting, the annual meeting and the special meetings that took place ending with the August 13 meeting, 2008.

COMMISSIONER BARFIELD: I would want to table this motion or handle it in some other way. I appreciate the hard work of the State of Nebraska to produce minutes that we received, I think, on the way up here. I believe the best procedure is to review those and in the tradition of the past, provide comments and a markup and eventually jointly developed meeting minutes that we can approve at a subsequent time. That's what I believe is appropriate. I think we ought to review the transcripts and agree on the transcripts of the meeting. I think we've done that, as well. I don't have any objection to reviewing those minutes and having -- I'm sorry, reviewing those transcripts and having agreed-upon transcripts. But I would propose we do both actions and do that with the greatest diligence we can to complete it.

So, do we need a motion to that effect or --

COMMISSIONER WOLFE: I just move that we table the action on the minutes at this time until we continue it at a subsequent meeting.

COMMISSIONER BARFIELD: Okay, I would second.

CHAIRMAN DUNNIGAN: Move and second, any

discussion?

COMMISSIONER BARFIELD: Well, again, I want to see this task completed with as much diligence as we can make it. So, the purpose of the tabling is just to make sure that work can be done.

CHAIRMAN DUNNIGAN: And we'll make sure that that happens, Commissioner.

COMMISSIONER BARFIELD: Right.

CHAIRMAN DUNNIGAN: Thank you.

COMMISSIONER BARFIELD: Hopefully, we'll have a special meeting and approve the minutes in due course here.

CHAIRMAN DUNNIGAN: All those in favor of the motion signify by saying aye.

Aye.

COMMISSIONER BARFIELD: Aye.

COMMISSIONER WOLFE: Aye.

CHAIRMAN DUNNIGAN: Motion carries.

Item 4 on the agenda is a Report of Chairman and Commissioner's Reports. Nebraska will begin followed by Colorado and Kansas.

While conflicts over past events may have captured recent headlines, I'm pleased to begin by informing you all that the State of Nebraska is in compliance with the Republican River Compact.

Using current accounting procedures, Nebraska has had positive balances during 2007 and 2008, resulting in a positive five-year average for the period ending in 2008. Based on preliminary estimates, it appears Nebraska will be in compliance for the five-year compliance period ending in 2009. This is a testament to the work conducted to date in partnership with the Nebraska Natural Resources Districts, its surface water users, and the people of the Republican River Basin.

During the past year, the state of Colorado, Kansas and Nebraska has spent considerable time and effort to resolve the dispute centered on events that occurred in 2005 and 2006. Much of that dispute arose from or involved regulatory measures implemented originally in the wake of the final settlement stipulation.

However, those measures and the results occasioned by them are old news and does not merit further attention. Indeed, as evidenced by the outcome of the recent arbitration, there is little to be gained from revisiting the past, and our focus should be directed toward the future.

In the future, Nebraska will remain in compliance with the Republican River Compact. The primary NRDs, in partnership with the Department of Natural Resources, have had new integrated management plans in place for a year-and-a-half. These IMPs appear to be working well. Among other things, the IMPs clearly state that each of the NRDs cannot deplete more than their share of the water of the basin. This is not merely a goal, but rather a requirement of each plan. With that said, Nebraska is aware the IMPs would benefit from additional detail. At last year's RRCA annual meeting I stated, quote, the Department and the Natural Resources Districts feel that it is important to investigate other options and further regulations that can be incorporated into future plans addressing water-short years, end of quote. To that end, my staff and I have met on many occasions with managers of the NRDs and with their boards. The purpose of these meetings has been to lay out how the Department calculates the allowable depletions in each district, and to begin the discussion of specific situations in which additional regulatory measures need to be taken. It is our desire to implement these changes prior to this meeting; however, many hours of staff time were taken up by the arbitration process and that delayed implementation. We expect these additional controls to be in place early next year.

In the future, we also must address Colorado's proposal to augment stream flow by pumping groundwater supplies directly to the North Fork of the Republican River. To date the states have been unable to agree on several issues. Nebraska's principal concern remains rooted in proper accounting for the augmentation water, and will need to be resolved before Nebraska can endorse that plan.

In the future, we also must work toward resolution of certain accounting issues. Some of which, in turn, are essential to the proper evaluation of the Colorado plan. Nebraska proposed a number of changes to the RRCA accounting procedures that were part of the recent arbitration. And I would like to comment on what I believe to be the most important finding by the arbitrator. The current method of calculating stream flow depletion leads to significant errors when the streams become dry. The arbitrator agreed with Nebraska that the best measure of the total stream flow in a sub-basin is obtained by subtracting the results of a groundwater model run with all stressors on from the results of a model run with all stressors off. The concept was originally proposed by Kansas, which identified it as the virgin water supply metric. The arbitrator suggested that the states continue to discuss how to implement this estimate of total stream flow. It is our hope that this can be done in a timely manner.

In the future, we will need to work closely with our friends who reply on surface water diversions and, in turn, to help with the Republican River system. While stream flow may not return to levels seen 50 years ago, we will continue to see improvement over time as the IMPs take hold.

It is our belief that a healthy surface water system will contribute to Nebraska's ability to comply with the compact. I would like to publicly recognize the successful partnership that we have seen in the past with a number of surface water districts including, but not limited to, the Frenchman Valley Irrigation District, managed by Don Felker; the Frenchman Irrigation District, managed by Brad Edgerton; and the Nebraska Bostwick Irrigation District, managed by Mike Delka. These and other districts and the respective boards will continue to play an important role in the basin.

The future also holds continuing participation in the conservation reserve enhancement program and the environmental quality incentive program. Nebraska will continue to explore stream augmentation. Vegetation management has increased stream flow and the capacity of the stream channel. Nebraska will continue to take an active role in the engineering committee and will always work with the other states to improve existing accounting methods and ensure they accurately reflect water use in the basin.

Finally, in the future, the very near future, we must resolve an issue presented by Nebraska concerning the proper way to recognize in the accounting, any damages paid for -- paid for past noncompliance. Resolution of this so called crediting issue is key to ensuring that when a state is wrong, it is made whole, but not over compensated, and that the offending state is not inadvertently punished by paying for the same violation twice.

As counsel for Kansas indicated in an arbitration hearing on this issue in December, 2008, we might not even have a disagreement about the crediting issue. It is time we find that out. And if we can't agree, it must be resolved.

In closing, I wish to assure you all, as well as my counterparts from the neighboring states, that Nebraska will continue to comply with the Republican River Compact. The state will continue to evaluate needs of the basin and make changes as necessary to stay in compliance in a spirit of openness, transparency and partnership. We expect to continue to work with all stakeholders in the basin, including the other states, the NRDs, the surface water districts and individual users and the Bureau of Reclamation. As I recently explained during arbitration, noncompliance is not an option for the state of Nebraska.

At this point, I'll turn to James Williams to give a water administration report for Nebraska for the calendar year 2008.

MR. WILLIAMS: While this water administration report is for the calendar year 2008, I will include a number of other dates in order to place water administration within context.

In August, 2006, the Bureau of Reclamation placed a call on all appropriated reservoirs located above Swanson Lake, Enders Reservoir and Hugh Butler Lake. This call continued throughout 2008.

In July, 2008, a call was placed on all users on Red Willow Creek. This call included Meeker-Driftwood, Culbertson and Bartley Canals.

July 8, 2009, a call was placed on all junior permits above Cambridge. The call was removed above Cambridge, July 16, 2009.

During 2009, the call was continued on Swanson Lake, Enders Reservoir and Hugh Butler Lake.

July 11, 2009, a call was placed on all junior permits, Medicine Creek.

In 2008, the irrigation supply in Harlan County Reservoir was estimated by the Bureau of Reclamation to be more than 130,000 acre-feet. Therefore, water short-year administration was not in effect during 2008.

Pioneer Irrigation District, Red Willow, Cambridge, Naponee, Franklin, Franklin Pump, Superior and Courtland Canals all were able to irrigate during 2008.

Surface water irrigators on Riverside Canal were compensated not to irrigate in 2008. The estimated consumptive use portion of Riverside Canal's natural flow was protected through Harlan County Lake.

CHAIRMAN DUNNIGAN: Thank you, Mr. Williams.

Commissioner Wolfe?

COMMISSIONER WOLFE: Thank you,

Commissioner Dunnigan. Again, Dick Wolfe, commissioner for the state of Colorado.

I would also just to report briefly on some of the hydrologic conditions from Colorado's perspective in 2008 and then also just update the Commission on what Colorado's activities have been in 2008 as far as compact compliance.

I appreciate your fine report. I just want to make one point that Colorado disagrees with Nebraska's interpretation of the arbiter's decision, but we will continue to go forward and address reasonable concerns that have been raised by both Kansas and Nebraska on that.

As far as hydrologic conditions, I'm just going to touch on some of the main tributaries that we typically report on. The North Fork, total stream flow at the state line gage was 21,640-acre fee, which is 9,070 acre-feet less than the 1935 to 2008 average of 30,710 acre-feet.

On the South Fork of the Republican, total stream flow at the Benkelman gage was 1420 acre-feet. This improved over 2007's total flow of 674 acre-feet and the previous three years of zero flow. The average annual flow on the South Fork at Benkelman from 1938 to 2008 is 26,270 acre-feet. And I would certainly note coming in to 2009, the stream flows on the South Fork have gained as well and we continue to see improved conditions on these tributaries since the drought year starting in 2002. So, we seem to be coming out of that and things are looking favorable.

The Arikaree, total flow at the Haigler gage was 1570 acre-feet. And this, again, continues to be a significant decline from the 12,600 acre-feet annual average for the period 1933 to 2008.

As far as Bonny Reservoir, which is located on the South Fork of the Republican, just north of Burlington, active storage as of Sunday, August 9th, 2009, was 10,200 acre-feet. The capacity at the top, the conservation pool is 41,340 acre-feet. Capacity at the top of the flood pool is 170,160 acre-feet.

Colorado, in its efforts to continue to reach compact compliance and address issues, particularly on the South Fork, has made a number of releases from Bonny Reservoir, some starting in 2007 and then more releases were made starting in August of 2008. We released 1816 acre-feet in August of 2008. In September of 2008, we released 2,207 acre-feet, in all this reporting, though, this is not in the 2008 report. In May of 2009, we released an additional 884 acre-feet; and in June of 2009, an additional 1,048 acre-feet.

I would like to just touch on some of the efforts that Colorado has undertaken in 2008 as far as compact compliance.

I, first, would like to note that I appreciate both Kansas and Nebraska's cooperation regarding our negotiations that we've had on trying to get our compact compliance pipeline approved that we introduced to the compact administration starting in March of 2008. And we've had numerous discussions, as you know, over this past year. And we do appreciate your continued cooperation and ideas about how we can try to bring this to resolution. And I am confident that we will get there, hopefully, here in the near future.

But in addition to that part of the efforts by, not only Colorado and the Republican River Water Conservation District, there's been numerous activities that the District has undertaken to achieve compact compliance. And I think it's indicative of our annual report, in terms of compact compliance numbers, that we've continued to see a decline in our deficit on an annual basis due to some of these efforts. There's been a number of land retirement programs that the District has undertaken in the last few years with some of their leveraging of their own dollars that they use from fee assessment, with some of the CREP and EQIP dollars that are available from the federal government. They have taken out, since 2006, currently about 32,000 acres that been enrolled in EQIP and CREP programs, which are -- Twenty thousand acres of those is in the CREP program and about 11,000 acres in the EQIP program.

The District has also moved forward in conjunction with the Yuma County Water Authority to purchase the majority of the senior water rights on the North Fork of the Republican, principally the Pioneer and Laird ditches. The Yuma County Water Authority closed on the purchase of those water rights in December of 2008. And that was a result of a -- also in addition to that, there was a bond issue that was passed by the voters in Yuma County in November of 2008 for about 15 million dollars. Of that 20 million dollar purchase of those water rights, the $5 million is a lease that was entered into by the District, with the Yuma County Water Authority for the lease of those water rights for 20 years.

Colorado also has undertaken the adoption of measurement rules for the high capacity wells in the basin. They were adopted in 2008. We went through a rule-making process. They were effective December of 2008. And the rules required as of March 1st, 2009, that all the high capacity wells pumping 50 gallons per minute or more to either install a totalizing flow meter or an approved alternative method -- measurement method like the power conversion coefficient method, or to be declared inactive. And so we've -- that has occurred this year. We have approximately 4,000 wells that are subject under -- to those rules and have enrolled into one of those options.

The rules also require that prior to December 1st, well owners must report their annual pumping amounts. And so we are in the process of -- this being our first year of well meter compliance under those rules, we are collecting that data and hope to have additional information certainly next year as part of our report.

Lastly, I would like to just comment on that due to approval of a decision item by the Legislature about a year ago that approved additional staffing in the basin to address our compact compliance efforts, they did approve Colorado to hire four additional staff members in the basin. We have hired two of those individuals out of the four. But due to budget constraints, we've been unable to fill the last two positions. But the two that we have hired, in addition to the existing staff we already had out there, is a team leader over that group, and that's Megan Sullivan, who successfully was hired into that position; and also a deputy groundwater commissioner position in the basin, in addition to the two staff members we already had there. And we still have two other positions pending that we hope, if economic conditions improve, that we can fill those to help in our efforts in terms of the well measurement and data collection program in the basin in our compact compliance efforts.

And with that, that concludes my report, Commissioner.

CHAIRMAN DUNNIGAN: Thank you, Commissioner Wolfe.

Commissioner Barfield?

COMMISSIONER BARFIELD: Thank you, Commissioner Dunnigan.

With respect to the various assertions that you made related to Nebraska's current compliance and causes for improvement compliance numbers in '07 and

'08 and assertions of the sufficiencies of your current actions, I think there's places on the agenda to speak to those later. We have a very different view of those matters, as well as the arbiter's decision and the crediting proposal, but we'll get to those in due course.

With respect to my report, first of all, I would like to report on a couple of changes in administration. Our former governor, Kathleen Sebelius of Kansas, was confirmed as secretary for the U.S. Department of Health and Human Services earlier this year, and, therefore, our Lieutenant Governor, Mark Parkinson, became Kansas's 45th governor on April 28th. Former Department of Agriculture Secretary, Adrian Polansky, who is my boss, was appointed recently as State Executive Director for the USDA's Farm Service agency in Kansas. As a result, we now have a new Secretary of Agriculture as well, Josh Swaty, a fifth-generation Kansas farmer and three-term state representative, has been appointed Acting Secretary pending senate confirmation.

Climate conditions, I normally have a brief report on that. While conditions vary considerably around our state, 2009, like 2008, on the whole, is a much closer to a normal precipitation than previous years. One exception, actually, is the north central portion of Kansas, including the main stem Republican River, as well as parts of southwest Kansas that remain dry. In fact, we are currently doing some administration in the main stem Republican River as a result of those shortages.

I normally report a bit on legislative activities of general interest or specific to the basin. This last legislative session in Kansas was dominated by budget issues. We had a shortfall of approximately 700 million in our state budget and have suffered a series of budget reductions over the last year in with the 2010 budget allocations. Staffing for the Division of Water Resources is approximately 20 percent less than a year ago. Despite that we're doing our best efforts to fulfill our legislative mandated responsibilities.

In terms of legislation, there wasn't a significant number of water bills. There was a bill to extend the sunset date on a water appropriation fees. There was additional legislative activity but no resolution to an issue on how intensive groundwater use control areas will be established.

There was one bill, Senate Bill 64, that required applicants to file a sworn statement for evidence of legal access to or control of their point of diversion when filing water appropriation applications. That has a very interesting history behind it, but I won't go into here.

In terms of litigation with our neighboring states, again, we often report on this. And I'm actually pleased to provide a bit of a report here on the dispute of some 23 years with the state of Colorado on the Arkansas River. We've long been saying that this litigation was nearly complete. I don't know how many years we've brought that report, but it's been a number of years. Last year I did report on this that the states had developed a final decree that the special master had sent to the U.S. Supreme Court early last year. That report was received. The Court , as is its case or its custom in many of these cases, to provide an opportunity for exceptions. Only one exception was filed, and that was not related to the decree itself that we had pretty much worked out between the two states, but Kansas was seeking to recover additional costs. The Court declined to provide those additional costs.

That left only one matter pending before the retained jurisdiction of the Court, and that was a requirement to have an evaluation of the sufficiency of what are called Colorado's use rules, to determine if they provided sufficient replacements to offset their post-compact well pumping. The sufficiencies of those rules were to be evaluated for the period 1997/2006. Kansas and Colorado spent a significant amount of time looking at those use rules and their sufficiency. And as a result, negotiated some refinements in terms of the administration of those use rules and other related agreements. It's a 15-page document. But as a result of that agreement, the states agreed that the retained jurisdiction of the Court could lapse. That was filed last week with the U.S. Supreme Court and, therefore, ended 23 years of litigation between the two states. We are now operating under that final decree. We actually continue to have issues between us, and are working through those as states and have a similar dispute resolution process there as is here. And we look forward to working with the state of Colorado in a new era on that particular basin.

With respect to the Republican River Basin, Kansas continues to be fully in compliance with our requirements under the Final Settlement Stipulation and the Compact. Much of that is because we closed our alluvial groundwater use and surface water use within the basin to new appropriations in 1984. Kansas continues to target some of our retirement programs in those basins to assure future compliance.

I'll turn to Scott Ross to provide a bit of a report on some other activities within the basin.

MR. ROSS: Thank you. These activities are localized activities within the basin. As you may recall from last year, Commissioner Barfield reported on -- 89 which is the disposition of any damages that might be collected as a result of that passage. We have two groups: the Northwest Kansas Alliance Group. They are a group of stakeholders, including Groundwater Management District No. 4, County Commissioner's irrigation equipment dealers municipalities and others to review projects and potential opportunities to promote conservation projects in Northwest Kansas in the upstream part of the basin. That includes some recharge projects, water right buyouts and a municipal borrowed plant for potential use for the Dakota aquifer and another one of the smaller projects. A similar group was assembled by the Kansas Water Office, Lower Republican Stakeholders Group. That includes Kansas-Bostwick Irrigation District and municipal representatives irrigation interests, Kansas Department of Wildlife and Parks, the livestock industry, the Bureau of Reclamation and the Corps of Engineers. Project review in that area include modifications to Lovewell, to increase the storage. Same off-stream storage sites in Kansas, aquifer recharge, improve pipeline and improve canal system deliveries. Much of this discussion has been focused on the present study done by the Bureau of Reclamation.

I've also been working with Jamestown wildlife area. It's an area in the lower part of the Republican. It's on a tributary of Buffalo Creek. They've proposed to develop an additional marsh habitat there. And this area is becoming an importing and emerging area for migrating waterfowl. Kansas has completed the metering of all the diversions in the Republican River model domain area. That was completed -- In fact, we just completed at our last inspections, so about a week ago. So, that data should be available for the 2009 season.

Kansas completed a model of the Solomon River Basin, which is within the model domain area. The upper portion of that -- Reservoirs intersects the high plains aquifer. And the groundwater management district No. 4 in conjunction with the division of water resources are exploring the opportunities to use that model identified by the groundwater management district.

That concludes my portion of the report.

COMMISSIONER BARFIELD: That concludes Kansas's reports.

CHAIRMAN DUNNIGAN: Thank you, Kansas.

At this point, we'll move to Agenda Item 5, which are the Federal Reports. And Aaron Thompson, I believe, will give the Bureau of Reclamation Report. Aaron?

MR. THOMPSON: Good morning, Commissioners Dunnigan, Wolfe and Barfield. It's nice to be here this morning.

I'm Aaron Thompson, with the Bureau of Reclamation. I would like to take a minute to introduce the staff that's in the audience. We have Mike Kube from our Grand Island office raising his hand; Jack Wergin, also from our Grand Island office; Craig Scott from our McCook field office. And from our Billings office, with the conservation committee, we have Scott Guenthner and Patrick Erger.

We've prepared two documents: Resources Management Activities for the year; and O&M,

Operation and Maintenance activities for the year. We'll have Brent Esplin, our deputy area manager, go over the resource management activities; and Marv Swanda, McCook field office manager, briefly go over our operations and maintenance activities, in the interest of time.

MR. ESPLIN: Thanks, Aaron. Good morning, Commissioners. I'm going to just hit on a couple of highlights from the report that's there. There's lots of information in there that I'll hit on, but I would just like hit on the Lower Republican Feasibility Study that was authorized in May of 2008. I know that's on the agenda later, so I won't spend much time on it. But it was authorized to look at water conservation and augment -- or storage options in the Lower Republican Basin. That study was authorized but has not yet been funded. There's nothing in the FY 2010 budget to Congress, to my knowledge. And I guess we're under the assumption that the states are still interested in that feasibility study once appropriate -- once federal appropriations are made.

I would like to hit on just two more items. The other item is reclamation continues to work with our irrigation districts in the Republican River

Basin on water conservation activities. Several of those districts have received challenge grants from reclamation to improve water conveyance efficiencies, also do some water measurement.

The third item I'll touch on is the reclamation continues to work with our managing partners in both states, Nebraska and Kansas, on ADA retrofits. That's American with Disabilities Act. We continue to install handicapped, accessible comfort stations and also vault plates and those kind of things. Our plan is to have all that work completed by the end of fiscal year '10. I think we're on our way with that. We just wrote out some contracts recently, some of the basins or some of the reservoirs around Red Willow, Swanson and Enders. And so that's some of the main activities. I'll leave it -- rest of that to the report. And those that want to know more, but there are other activities going on, but I'll just highlight those three items.

THE REPORTER: Could you state your name?

MR. ESPLIN: Oh, sorry, Brent Esplin.

THE REPORTER: Spell your last name, please.

MR. ESPLIN: E-s-p-l-i-n.

THE REPORTER: Thank you.

MR. SWANDA: Good morning. Marv Swanda. I would like to -- I'll just hit some of the high spots on the report. That's available on the back table for those of you that grabbed that. And it addresses the 2008 operations at our reservoirs, including Harlan County. And I'll just kind of bring you up to date on the current status of operations at our facilities for 2009. And so I'll just kind of go through this.

Precipitation in 2008 in the basin varied from 115 percent of normal at Swanson Lake, to 150 percent of normal at the Hugh Butler Lake. Inflows varied from 37 percent of the most probable forecast at Enders, to 192 percent of the most probable forecast at Harry Strunk Lake. Farm deliveries to our irrigation districts in 2008 varied from zero inches to Frenchman Valley, H & RW and two of the canals in Frenchmen-Cambridge. We delivered three inches to Red Willow, six to Cambridge, just under two inches to Almena, two-and-a-half inches Bostwick in Nebraska, and four to five inches down in the Kansas-Bostwick area.

At Bonny Reservoir -- I'll just kind of touch on each reservoir. In 2008, the reservoir level began the year at 23-1/2 foot below the top of conservation. Above average rainfall during the month of August caused the reservoir level to increase. And beginning on August 15th, releases were made in accordance with orders from the state of Colorado for compact compliance. A total of 4,087 acre-feet of river outflow was recorded for this purpose. And the release was shut off on October 2nd. The release resulted in a reservoir level reaching a new historic low elevation on October 9th.

Enders Reservoir. The 2008 inflow into Enders was 4,700 acre-feet, which is below the dry-year forecast. The reservoir level began the year at about 19.7 feet below top of conservation. Due to extremely low water supply available, no water was released from Enders in 2008. This was the seventh consecutive year that H&RW did not divert water from the reservoir, and the third consecutive year that Frenchman-Cambridge did not -- Frenchman-Valley did not divert water.

Swanson Lake. The average inflow of just over 19,000 in 2008 was between the dry and normal year forecast. Again, due to extremely low water supply there, no water was released from Swanson Lake. Irrigation diversions were not made into

Meeker or Bartley Canals, which is the sixth consecutive year for the Meeker Canal.

Hugh Butler. The annual inflow in 2008 was just over 13,000 acre-feet, which was between the dry and normal year forecast. May precipitation totaled 8.3 inches at the dam, the most ever recorded for the month. Irrigation releases began on June 22nd, and ended early September.

Harry Strunk Lake. The inflow of 69,700 acre-feet was above the wet-year forecast in 2008. The reservoir failed in April, late April, and increased to almost eight feet in the flood pool by May 25th. Lake inflows exceeded historic highs for the month of May. Uncontrolled releases through the spillway reached over 1,000 CFS. Harry Strunk Lake was only -- ended up only about 0.8 foot below the top of conservation at the end of the year, so a very good year for that particular lake.

Keith Sebelius Lake in Kansas, in 2008, total inflow just over 14,000, which was slightly below the wet-year forecast. Irrigation releases were made during July and August reducing the lake level by 2.5 feet. Norton Dam recorded almost nine inches of precip during October, the greatest ever recorded for the month at the dam. Harlan County in

2008. 2008 was -- started out approximately 5 feet below the top of conservation. Runoff from late May storms increased the reservoir level, just over 4 feet. And flood releases began out of the lake near the end of May and continued through June 25th. And the reservoir level reached 2 feet -- approximately 2 feet into the flood pool. The available irrigation supply from Harlan County on June 30th, as we indicated, was above the water-short year number, and we supplied that information to the Commissioners. Harlan County Dam recorded 8.6 inches of precip during October, the greatest ever recorded for the month. A 10-year summary of Harlan County Lake operations is included in this report on Table 3.

Lovewell Reservoir. In 2008, the beginning elevation was about 1.5 feet below the top of conservation. Storms in late May also produced significant runoff that raised the elevation just over 3 feet. And the reservoir level peaked at just under 5 feet into the flood pool.

And now I would like to just touch on where we're at in 2009 and give you kind of an update on that.

Bonny Reservoir level -- we're about 21 feet below the top of conservation. We've had almost

17 inches of precip out there in the first seven months of the year, which is 143 percent of normal. Reservoir inflow for the period is the greatest since 2001, but only half of the historic high. Releases have been made into Hale Ditch and also for compact compliance purposes. The reservoir level is currently .2, just below where we were last year at this time.

At Swanson Lake, the level is currently 14 feet from full and is nearly the same as last year at this time. Precip is running above normal, about 126 percent of normal to this point for this year. Frenchman-Cambridge Irrigation District is irrigating from Swanson Lake for the first time since 2002.

Enders Reservoir. The reservoir level is currently 21 feet below full with normal precip during this period is running about 13 inches. Due to the water supply shortage, H&RW Irrigation District, again, is not irrigating for the eighth year in a row. This is the sixth consecutive year that Frenchman-Valley Irrigation District has not received storage water for irrigation.

At Hugh Butler Lake, the lake level is currently 8 feet below full. Irrigation releases are being made from Hugh Butler this year for diversions into Red Willow and Bartley Canals by Frenchman-Cambridge Irrigation District.

Harry Strunk Lake. The lake is currently 3 feet below the top of conservation. Reservoir releases for Cambridge Canal began on May 19th. And precip at the dam is running about 124 percent of normal at this time.

Keith Sebelius Lake currently just over 10 feet below full. Irrigation releases began on July 8th from there with very limited delivery expected in 2009 by the Almena Irrigation District.

Harlan County. The current water surface is approximately one foot below full. The available irrigation supply from Harlan County on June 30th was 156,000 acre-feet, as indicated to the commissioners, where a water-short year administration would not be in effect. Irrigation releases began on June 25th.

The reservoir level at Lovewell currently 3.5 feet below the top of conservation. Lovewell recorded only 12.2 inches of precip during the first seven months of the year, which is 71 percent on average. The Corps allowed us 5 percent in the flood pool, just prior to the irrigation season. And the irrigation releases began on May 18th.

One thing, I don't believe the Corps has a representative here today. So, I would indicate we have been working with them to revise the water regulation manual on Lovewell. And what that will do will allow us in certain years, based on the water supply in Harlan County, it'll allow us to store up to 2 feet of water, additional water in the Lovewell, just prior to the irrigation season when certain triggers are met. And I believe we are to the point they are having a public meeting on August 25th or 26th, I'm not sure, in Belleville, Kansas, to discuss the need -- the activities related to this change in the water manual. And so there'll be a notice, if you have not seen it already, out on that. So, we've very hopeful that we can get that in place, then that will allow us some additional storage in the drier years.

Just a couple of other things I'll quickly mention is our safety of dams' activities. We've had an issue at Norton Dam that should be completed by the fall of this year. And there's two other issues at Enders and Red Willow Dam related to under drains on our -- out in our work structures and we're continuing to work on those and determine a fix for those.

And that concludes my report.

CHAIRMAN DUNNIGAN: Thank you, Mr. Swanda.
Anything else from the Bureau?
MR. THOMPSON: No, nothing else.
CHAIRMAN DUNNIGAN: Thank you very much for your report.
The Corps of Engineers was invited, but they were unable to attend. So, we'll move to the U.S. Geological Survey and Phil Soenksen for USGS's report.
MR. SOENKSEN: My name is Phil Soenksen. I'm the surface water specialist with the U.S. Geological Survey here in Lincoln, Nebraska. And I'm going to be reporting on the stream flow gages that we publish records for from the Republican River Basin.
The sheet that I've handed out, the summary sheet, lists all the stations I'm reporting on. You'll see that they're broken out into three groups. The first group of 10 is primarily based on how they're funded. Those 10 are funded by the National Stream Flow Information Program, which is a federal program through the U.S. Geological Survey. And those are the ones that I refer to as a compact station because that's why they are -- they were received instant funding because of the compact.

Then there are another two stations that are funded through other mechanisms. The Corps of Engineers supports one of them; the Republican River near Orleans; and then the other one, which is funded party by Bureau of Reclamation, partly by us, and I -- and I think partly by DNR.

Then the third group of stations are stations that are operated by the Department of Natural Resources that we then provide -- They cooperate with us to -- We put those on the web and then review and publish those records through our annual publication.

The other thing to take note of is, there's several web sites down at the bottom on the left that -- All the data that I show here is readily accessible on line. The publications that we put out are now done electronically. We don't put out a paper report anymore. That's available.

And, Commissioners, you do have a copy of all of those, what we now call site data sheets, for each of the stations. Those are at the back. And then you have two copies of the actual presentation, and two copies of the summary sheet.

And all of those -- all of that, what we call site data sheets, are available on the web. You can also get the date in a electronic format, which is what I did, to create the graphs that I'm going show here today.

Okay. Next slide. This shows the summary sheet that you have and the breakout of the three types of stations. Just briefly -- I'm not going to go through all of those. But just briefly, the color coding on the right, the first column, if it's brown, it's less than the long-term mean average flow for that site. If it's green, it was above for the last year. And by the last year, I'm talking about water year, which runs from October, 2007, to September 30th of 2008. That is how we have for years, I'm not sure why, broken things out. It's called the water year. And so you can see that the two stations were above the long-term mean out of those 16 for 2008.

The next column shows the ranking and the number of years. So the first station, Arikaree at Haigler last year was 70th, counting from the top. So, it was the 70th highest out of 76 years of record there. And the green simply means it was more flow than the previous year. And the brown indicates it was less than the previous year in 2007.

Okay, next slide. Okay, this is the first step of stations, again, operated by us, by the U.S.

Geological Survey and funded by the National Stream Flow Information Program.

Next slide, please. Okay, the first station -- and I'm going to go in what's called the downstream order. That's how we number our stations. So if you actually look at the eight-digit number, they'll be getting bigger as we go down through these. And that's done from up -- what's considered upstream to downstream.

So, the first site is the Arikaree River down in the southwest corner of the state of Nebraska, very near the borders with Colorado and Kansas.

Next slide. This shows then -- All of the slides are going to be the same. Just a quick summary slide, I think you can get a good feel for the historic flows of -- Each of the individual years is plotted as the square. And then the black and the red represent the cumulative mean and the cumulative median. So, based on the number of years of record that were available at that point, that was the mean and the median for each of the years. And so then you can see off to the right is -- I think we're getting 2008 on there, maybe not, but pretty close, is the data for the current year. And some of the same information that's on the summary sheet, then, again, summarized up above just for perspective, giving you the high year, the low year, the mean and the median, the period of record, and the rank, and then the actual flow for last year.

Okay, next slide. Okay. Then the next one is the North Fork Republican River, very near Arikaree on the state line. The picture on the lower right shows the control that we put in. The old control was in pretty bad condition. We tried to repair it. In the process of repairing it, about a year ago, it basically collapsed. And so we had to pump a lot of money into it in short order. And we built a completely new control, which I've heard, is working pretty well, based on the reports from guys in the field, which is good, because that's certainly an important gage, pretty much right on the state line.

Okay, the next slide. Here again, record, for the period of record. A little bit higher flow from last year.

And if you have any questions on a particular station, just -- I won't be -- I may not be able to see if you're -- put your hand up, but speak up if you have any questions. I think the data just, you know, I'm not going to interpret the data. It is what it is.  But if you do have any questions, just stop me.

Next slide, please.  The next station is a tributary to the Republican coming in on what we call the left side as we look downstream from the north, Buffalo Creek, near Haigler, a little bit downstream of where the Arikaree and the North Fork come together.

Next slide.  And, again, the data there. Is 2008 actually coming on there?  Could you -- I'm just wondering if we're getting -- Okay.  All right.

Okay, next slide.  Okay, thank you.  Next station is another left bank trib, Rock Creek, at Park.  And I guess nothing -- just a little bit farther downstream and the data for that site.  And this is one site where ,if you look at the ranking, it was 68 out of 68, which means it was -- Last year was the lowest on record for that station.

Next slide.  South Fork Republican River, near Benkelman, right near the border with Kansas before it comes into -- as it comes into Nebraska. It's been dry for a number of years.  We finally had some flow the last few years, but the picture on the lower right shows the channel as it was commonly seen for quite a while here.

Next slide. And you can see those zero flow years, but we've actually had a little bit of flow here. But last year was No. 68 out of 71 years of record.

Next slide. Okay. Frenchman Creek at Culbertson. This is near the mouth. A little bit later -- The state has a gage up by Palisade, which you can see upstream of there, and we'll be looking at that. But we're going through all the NSIP stations first and then we'll go back upstream and catch the other ones. So this is farther downstream past Swanson Lake and --

Okay, next slide. Now here you -- There's -- Because of the effect of Enders Reservoir, which was not shown on the map, it was a little further upstream, we break the record out on some of those sites that have reservoirs upstream with records before and after so that the dash line represents the mean and the medians after the reservoir went in. And the solid lines represent before it went in. And then some of the statistics on the right also give the mean and the median before and after the reservoir. And, see, the last couple of years, you know, it's had some increased flows, you know, than compared to the previous number of years.

Okay, next slide. Okay. Now this is the right bank tributary, Driftwood Creek and kind of a poor picture there, but my digital camera wasn't working too well that day, so it looks kind of reddish, but it doesn't really look like that.

Next slide. And this shows a period of record there. Again, some increased flows the last couple of years. Down there we had actually a pretty high peak flow there a couple of years ago.

Next slide. Okay, Red Willow Creek. Back on the left, again, we have a reservoir upstream.

Next slide. And so you can see the change from before the reservoir was in effect to after the reservoir was in effect. And, again, this last year we had some increased flow, so that it's, you know, at least above the mean and median since the reservoir went into effect.

Okay, next slide. Sappa Creek, right bank tributary, that comes in just above Harlan County. Beaver Creek comes into Sappa Creek above the station.

Next slide. And again the record there. A little bit of increased flow the last couple of years, still below the mean and the median.

Next slide. Okay, Courtland Canal now. We've moved down the basin below Harlan County. And Courtland Canal, which takes out of the Republican and goes down to Lovewell and extends beyond Lovewell.

Next slide. And showing the record for -- Last year was a drop off from the year before.

Okay, next slide. Okay. Now these are the two sites that we operate with other funding, Corps of Engineers and DNR and Bureau of Reclamation help fund some of these sites. There's only two.

Okay, next slide. The first one -- Now we've moved back up the basin to McCook, down below where Frenchman Creek comes in, but upstream of Red Willow Creek, also downstream of Driftwood. Okay. And again the period of record there. Slightly increased flows from the last couple of years but still below the mean and the median.

Okay. Republican River near Orleans above where it goes into Harlan County. And we've had some pretty good flows there the last couple of years. We actually had to make some bridge measurements. We've been making everything with weighting measurements prior to that but had some pretty good flows there.

Okay. The last four then are sites that are operated by Nebraska Department of Natural Resources. They do all the field work. We simply provide some support for the telemetry and put it on the web and then we review it and, hence, publish it then as a site data sheet like the other sites.

And the first one is Republican River at Stanton, up above Swanson Lake, and the record there.

Next slide. Frenchman Creek at Palisade that we referred to before, a little farther upstream from Culbertson, the gage that we operate, and, again, the period of record there.

Okay, next slide. Republican River at Cambridge and just downstream of Medicine Creek. And because of the effect of Medicine Creek, we've put the record before and after Harry Strunk Lake. And you see the last couple of years again approaching the mean and median with some increased flows but still below.

Next slide. Last site is Republican River at Guide Rock. And this site was on the highway and DNR has moved it recently to just below Courtland Canal so they can better document the flows that, you know, that aren't diverted because there are some tributaries in between there, and the period of record there. And you can see the last -- 2008, you know, again, some flows between the mean and the median there.

And with that, I'll take any questions. The new -- I was the data chief, but we have a new data chief coming in. His name is Jason -- I'm not even sure how to say it -- Lambrecht. He'll be reporting here, I think, the end of the week. So, he would be a contact for you regarding data issues. I'm still there. I'm the surface water specialist and I could still answer questions. So, if anybody has any questions and would like to obtain some of that data, my phone number is on the summary sheet there. And I would be glad to help anybody download data or answer any questions, but Jason would be available as well, so any questions?

COMMISSIONER BARFIELD: Actually, I have a couple of comments, I guess. Appreciate this report and obviously the very useful data of the USGS.

I note in your report that the Hardy gage is not included. I guess that's because the Kansas section is responsible for the maintenance of the record, is that correct?

MR. SOENKSEN: Yeah. Kansas USGS operates that station.

COMMISSIONER BARFIELD: Right. I wonder if it would be possible to coordinate with that office and have that included in your report. The Hardy gage is a, you know, very critical gage to the compact administration.

MR. SOENKSEN: I guess I could have been doing that. I mean, because, like I said, I get the data right off the web. So, it wouldn't be hard to include that, just add that in so...

COMMISSIONER BARFIELD: I think that would be helpful.

MR. SOENKSEN: Okay.

COMMISSIONER BARFIELD: To just create a more complete record.

The Compact Administration has adopted a water year that's the calendar year. The USGS obviously has its water year starting October 1. I think it would be a bit more useful to have these reports reflect the calendar year or the compact year, but I'm not sure how much trouble that would be.

MR. SOENKSEN: I mean, we can do it. It's a matter of -- we'll have to use preliminary data through the end of the year. And that isn't so hard, except that sites that are ice effected, it's hard.

A lot of times we don't get ice effected records worked until after the end of the winter, which makes it a little -- Well, I mean, we can obviously do that but -- We're working on -- The survey is working on a process where we publish our data faster and faster. And so that should become actually easier and easier. Well, it becomes harder and harder, but it should be more doable because we have limitations put on us when to get that data out. And so if this is a priority, we can try to make that a priority to get those records worked and then they can be included in the report, so...

COMMISSIONER BARFIELD: Thank you.

CHAIRMAN DUNNIGAN: Okay.

COMMISSIONER WOLFE: I just wanted to make a brief comment to thank the USGS for their cooperation in working with, particularly Colorado, when we've had requests to check some of gages, particularly this year when we started getting flow at Benkelman. And when we have seen some anomalies there to get right out, so we appreciate your response in this.

And I would be remiss in not also thanking the Bureau after their report for their cooperation this year as well. We've had a lot of activity regarding operations at Bonny this year and we greatly appreciated their response from this, with Marv and others, and Aaron, in our request to make releases out of the reservoir. So I wanted to thank them as well at this time.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

I see no other questions. Thank you, Phil.

At this particular point in time, I would like to recognize State Senator Tom Carlson, who walked in a little while ago. Thank you for coming, Senator Carlson.

Moving again to Agenda Item 6, Committee Reports. We'll start with the engineering committee. Mr. Williams, please?

MR. WILLIAMS: Thank you. I would like to recognize Megan Sullivan and Scott Ross as my colleagues on the engineering committee for the second year in a row.

We had a very high level of activity this year. Much of our work was related to the Colorado augmentation plan and discussions related to that. We had a total of three face-to-face meetings and quite a number of conference calls.

I'll go over the work assignments and

agreements and recommendations to the RRCA.

Our first assignment was to complete the users manual for accounting procedures and provide a resolution for its adoption, and this assignment was not completed.

Our second assignment was by September 15, Nebraska will provide data, responding to Kansas, August 1, 2008, letter to Nebraska. In addition, Colorado was to provide a final meter report by the same date. And comments and additional questions were due by October 1 and the information was to be reviewed by October 31.

Working on that assignment, Nebraska provided a response to Kansas's August letter by email and letter on September 15, 2008. Colorado had some data collection issues and was not able to provide a final meter report. And the states did not provide follow-up questions or comments prior to October 31, 2008.

On July 17, 2009, Kansas renewed its request for data necessary to complete the 2007 data exchanges.

Assignment No. 3, we were to exchange by April 15 the information listed in the accounting procedures. And by July 15, the states were to exchange any updates to that data. The states completed their preliminary data shortly after April 15, and had very minor changes prior to August 7, when the final computer groundwater model run was completed.

The states have not been able to complete an accounting for 2008 due to a number of issues that are in arbitration.

An additional work assignment was to continue efforts to resolve concerns related to varying methods of estimating ground and surface water irrigation recharge and return flows within the Republican River Basin, and very little progress was made on that assignment.

Another assignment, fifth consignment, was to continue to review Colorado's augmentation proposal. And the states, as I said earlier, have expended a great amount of effort on that.

Our final assignment was to retain Principia Mathematica to maintain the groundwater model and associated web sites, and this was completed.

The committee has a single recommendation for an accounting change to present to the RRCA, and that is, that the accounting point used in the RRCA groundwater model for the North Fork Republican River Sub-Basin should be moved to the Colorado-Nebraska state line in accordance with Article 3 of the Republican River Compact.

The committee recommends the following assignments for the coming year.

No. 1, finalize work on a users manual for the accounting procedures and provide a recommendation to the administration for adoption at next year's meeting.

No. 2, complete exchange of data request by Kansas in its August 1, 2008, and July 17, 2009, letters by October 15, 2009.

No. 3, exchange by April 15, 2010, the information listed in Section 5 of the accounting procedures. And by July 15, 2010, the states will exchange any updates to the data.

No. 4, continue to review Colorado's augmentation proposal, as appropriate.

No. 5, continue efforts to resolve concerns relating to varying methods of estimating ground and surface water irrigation recharge and return flows. Within 90 days, the states will exchange pertinent information, and the engineering committee will meet to develop recommended steps to resolve the issue.

No. 6, develop a revision to the RRCA accounting procedures to reflect agreements by the RRCA at its 2008 and 2009 annual meetings, and provide the RRCA with recommendation of any appropriate formatting changes.

No. 7, retain Principia Mathematica to perform ongoing maintenance of the groundwater model and periodic updates requested by the engineering committee.

No. 8, continued development of a five-year accounting spreadsheets/database for adoption at the 2010 annual meeting or earlier.

No. 9, review accounting procedures to determine if Kansas groundwater, CBCU and the mainstem is properly included in the mainstem version water supply calculation. And if necessary provide a recommendation to the RRCA at the next annual meeting.

The final item on today's agenda for the engineering committee report is to discuss a response to Kansas's data request. And I believe we had a fruitful discussion yesterday during our working session. And I think we've got a good pathway forward. I wanted to see if there were any other comments related to that one item.

COMMISSIONER BARFIELD: Thank you. Let me just provide a brief response. I would just affirm that. We had a good discussion yesterday during the work session on these requests and the states' responses. We had some good discussion on questions we had regarding the data that's been provided. Colorado provided its assurance that it would provide the meter data we've requested and Nebraska assured us that they would cooperate with us as we review the data they provided and its sufficiency. So, that would be my comments.

CHAIRMAN DUNNIGAN: Thank you. Other questions.

(No response.)

CHAIRMAN DUNNIGAN: Okay. We will have action on Item 8.

We'll move along to the conservation committee that Scott Guenthner will present. Thank you, Scott.

MR. GUENTHNER: Good morning. I'm Scott Guenthner. I'm with the Bureau of Reclamation. I'm here today on behalf of the Conservation Committee to provide you with a status report on the conservation study. If you recall, this study is to quantify the impacts of these non-federal reservoirs and land terraces in the basin.

I provided the email last Friday, August 7th, a copy of our draft report. It's a 26-page report. Normally we would provide a more substantial report. We haven't done that this year, in the interest of time, but we will be producing that report later in August. I didn't mention this yesterday, but I think you probably ought to consider the email report you got probably a draft version. I don't expect it will change much at all, but we probably should rely on the report we actually produce later in August.

I might mention that on the committee, I should point out, Megan Sullivan, for Colorado; James Williams, for Nebraska; and Scott Ross, Kansas, are also on the committee. And we coordinate the un-kind services through them. And most all the documents we prepare are reviewed through them for the states. I might also mention that much of the real work for the study are done under contract with Reclamation. We provide many of the funds. The states provide un-kind services. Dr. James Koelliker from Kansas State is here in the audience and so is Dr. Derrel Martin. They're providing the field data collection aspect in the modeling aspect of the study.

Since the study is really geared to quantifying the effects of reservoirs and land terraces, you can sort of think of it in two components. The states have identified 716 reservoirs. And of those, we've monitored 32 of those reservoirs for about four-and-a-half years. That data collection, field data collection, is done now. Some of the data has been analyzed and some of that work is presented in the report. We've mapped 2.3 million acres of land terraces in the basin. I think we heard yesterday it was 14 or 15 percent of the land area in the basin. We have collected detailed information in the field at five terrace sites. That's a fairly small number considering there's about 23,000 terraced fields in the basin. But we've collected a lot of intense data. And some of that data is also analyzed and presented in the draft status report. So, we've got all of the field work done and much of that data has been analyzed. There is some remaining to be analyzed.

One of the last big pieces of work was done this year. One of the gaps in the study or gaps in information we had was these terraces, which comprise so much of the basin, have been built over many years. And we didn't really know what the storage condition of these terraces were. We knew how they were designed, but we didn't really know what the storage condition was. So one of the big efforts in the last year or year-and-a-half was to do a sampling of those terrace sites. We sampled about 167 sites, collected data and determined the storage condition. That's a key element of the work you have to complete. So that field work is also done. We're in the process of summarizing that data. So all the field data we've collected at the reservoir terrace sites and the terrace condition survey, that information will be used in a modeling analysis that will actually quantify the effects. I think we had anticipated that that work would be complete now. It was originally designed as a five-year study. And this is the fifth annual report. So, it should have been done, but it is not. We've identified the tasks that are necessary to complete that. And we expect that by January 15th, we will be able to transmit to you folks the quantified effects of the terraces and reservoirs.

Subsequent to that, between January and June, we expect to produce a users guide for the water balance model, and then other documentation to support the study, and we expect that to be completed by June.

There are at least four other reports, besides the status reports, that we provided you. Three of them are associated with master's thesis' that have been produced out of UN-L, and one of them is associated with a doctorate thesis that has been produced out of Kansas State. Those are identified in the report.

The only other thing I have to mention is that the Final Settlement Stipulation, which is what really what prompted this particular study, it identified what the study costs are expected to do and that the states' share should not exceed $250,000. You'll notice in the report that we don't have any information today as to what the study costs of the states have been in the last year, but I think, once we get those, we'll see that the states' contribution is in that $250,000 range. Most of that, or all of it, has been provided through un-kind services and the balance of the funding then has come from Reclamation from various sources.

That concludes my report.

CHAIRMAN DUNNIGAN: Scott, I have a question. It sounds like there's still a bit of work to do. But can you relate any preliminary conclusions that you're finding about this study or are those still yet to be quantified?

MR. GUENTHNER: Well, I think we have some conclusions from modeling. I think there's other conclusions that come directly out of the field work. I think, without getting into too much detail, for the land terraces, they retain almost all the runoff in the terraces, if you look at a long-term situation, 30 years or so. They retain 90 percent of the runoff in the terraces. That water is used up in either ET or goes to some sort of deperculation. I think we can say the same for small reservoirs. They retain upwards of 90 percent or more of the runoff that goes into those reservoirs. Where, at one time, water -- this runoff would become stream flow and go father downstream. Now it's mostly captured in the reservoirs. For the reservoirs, a small percentage of it goes to evaporation. The majority goes to deperculation of some sort.

CHAIRMAN DUNNIGAN: Thank you.

MR. GUENTHNER: And that information is really contained in our draft report.

I should also mention that this draft report that we emailed out to the commissioners is not widely distributed. It was distributed to the commissioner and to certain -- a certain group that is loosely called the conservation committee. So it is not widely distributed at this point.

CHAIRMAN DUNNIGAN: Commissioner Wolfe?

COMMISSIONER WOLFE: I just want a quick clarification on that. Your preliminary conclusions you just stated are based on this limited set of sites you sampled and is not conclusive of sites that wouldn't be maintained in an adequate condition?

MR. GUENTHNER: Well, it would be based on the information we collect at the sites. And I think it might have been extrapolated out to be representative of the sites across the basin. So they're not -- I guess what I'm getting at is, it's not like you would take a terrace system that was constructed in new condition and is reflective of that. It's reflective of the actual sites in the basin.

COMMISSIONER WOLFE: So it's going to be an assessment of --

MR. GUENTHNER: That's right.

COMMISSIONER WOLFE: -- kind of the conditions as a whole in the basin?

MR. GUENTHNER: That's correct.

COMMISSIONER WOLFE: Thank you.

CHAIRMAN DUNNIGAN: Any other questions?

COMMISSIONER BARFIELD: Well, I have questions or comments, I'm not sure.

Again, I want to just -- appreciate the report that you provided here and commend the committee and the researchers for their work here. I think that there's a lot of interesting insights that are starting to come out of this -- these studies. And I think as you work toward completion of the study, I would encourage the committee to meet more regularly and assure that the report sort of adequately captures the study results and to try and make those as understandable as possible. This study looks at the effects of terraces and non-federal reservoirs or ponds and their effect on hydrologic system, helping us to better understand those. I think it needs to be recognized that the study focuses only on these two practices. They are very significant land treatment practices, tillage practices, for example, and the like that also have a profound effect and maybe arguably more profound that are not being studied. And I guess I would request as you write up the report that you just sort of make more explicit what you looked at, what you didn't look at, and maybe some sort of estimate of sort of the accuracy or estimates, both, again, what's been studied, what's not been looked at so people can sort of understand maybe better the fuller picture.

MR. GUENTHNER: I think, you know, in our preparation of documentation, which we expect was to be done by next June, we should be able to cover all of those aspects. I think the people doing the work understand that. And I think we've attempted to get that into reports. But we're sort of in the middle of the -- well, we're actually in the end of the study. But in preparing some of these reports, that gets missed occasionally. So we'll try to get that taken care of in our summary documents.

COMMISSIONER BARFIELD: I didn't really see that discussion in the current draft, so I appreciate that. Thank you.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

Other questions?

(No response.)

CHAIRMAN DUNNIGAN: At this point in the agenda, I would look at the commissioners. It's about 9:30. We could take a five- or ten-minute break and reconvene, or we could keep going, and I would ask the thoughts you may have.

COMMISSIONER WOLFE: I think a five-minute break would be fine.

CHAIRMAN DUNNIGAN: We're going to take a five-minute. And we'll try to be very punctual because we do have a bit of a deadline we're working under today. Thank you.

(A recess was taken from 9:38 a.m. to 9:50 a.m.)

CHAIRMAN DUNNIGAN: We'll go back on the record. We're to Agenda Item 7, Old Business. And the first item is Dispute Resolutions and Arbitration.

And I would look at Commissioner Barfield.

COMMISSIONER BARFIELD: Yes. I agreed to sort of at least start us off here with a brief summary of the arbitration, and I'm sure other states may want to add to it.

So the purpose of this statement is to summarize the non-binding arbitration that ended last month.

By 2007 disputes arose regarding Nebraska's compliance with the 2003 Final Settlement Stipulation and Compact, specifically, for the first water-short year compliance tests for 2005/2006. Nebraska added a number of accounting issues that they saw as related to the issue of its compliance. These disputes were presented to the RRCA that the compact administration, pursuant to the dispute resolution process, set forth in the Final Settlement Stipulation. The RRCA addressed these disputes but did not resolve them despite a series of special meetings in the first half of 2008.

As a result, the state submitted these disputes to non-binding arbitration in an executed and arbitration agreement on October 23, 2008. Mr. Karl Dreher served as arbitrator.

The arbitration, the first of its kind, under the Compact and FSS was divided into legal issues and factual issues.

On November 5, 2008, the arbitrator conducted -- concluded that there were some legal issues that could be heard. Each of the states filed openings, responses and replied briefs on these issues. The arbitrator heard oral arguments on these legal issues in Denver on December 10, 2008, and issued its final decision on them on January 22, 2009. This decision narrowed the scope of discovery and the hearing on the factual issues.

From December, 2008, to April, 2009, the states conducted discovery and depositions and submitted expert reports on the factual issues. These issues included the extent of Nebraska's violations for 2005 and 2006, the amount of economic damages to Kansas, as a result of these violations, Nebraska's proposed changes to the RRCA's accounting procedures and the steps that will be necessary for Nebraska's future compliance with the FSS and the Compact.

The arbitrator conducted a hearing on these issues in Denver beginning March 9 and the session on March 19th, 2009.

On April 14, 2009, the arbitrator convened -- reconvened the hearing for one final day to accept testimony and evidence from the Bureau of Reclamation.

On June 30, 2009, the arbitrator issued his final decision on factual issues. This decision concluded with 12 recommendations and incorporated the decision on legal issues of January 22, 2009.

On July 30, 2009, the states issued their responses to the final decisions. As might be expected, the states accepted and rejected the recommendations of the final decision according to their respective positions. The arbitrator's recommendations and the states' respective responses to them are public information and available from the states.

Kansas believes the arbitration was conducted in a professional and courteous manner, especially given the tight time constraints for discovery, briefing and trial. Kansas trusts that both the arbitration and the states responses to it will not impede the important work of this administration.

That's my statement on it.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

Commissioner Wolfe?

COMMISSIONER WOLFE: Yeah, I just wanted to thank David for the great summary of that. And I agree, too, that we hope that the arbitration process set out in the FSS is a -- if needed upon, relied upon is accessible and done professionally. And I echo your comments as well, and I appreciate your remarks.

CHAIRMAN DUNNIGAN: Thank you.

The next item is the Colorado Compliance Pipeline proposal. Commissioner Wolfe?

COMMISSIONER WOLFE: Thank you, Commissioner Dunnigan. I'm not going to read the resolution in its entirety, but basically present it to you. Both Kansas and Nebraska have seen this proposed resolution.

What we have before you is -- and I'll read the title of the resolution. This is a resolution by the Republican River Compact Administration regarding approval of Colorado's augmentation plan and related accounting procedures submitted under Subsection III.B.1.k of the Final Settlement Stipulation, and this is dated August 12th, 2009.

As many know, we had originally submitted Colorado's Compact Compliance Pipeline proposal or its augmentation plan proposal in March of 2008 to the Commission or Administration, and so we've been working on it since then. We had taken initial action on this resolution in April of this year via phone conference. What has changed since the resolution that was presented for action in April were a couple of items. And I'll just highlight those, and I'll just generally, conceptually, present to you, and for the audience, what's embodied in the resolution. Of course, there's a number of typical "Whereas's" that lead into the conditions in the resolution. We have a number of things that we pointed out in here that are pertinent in regards to our Compact Compliance Pipeline and a number of exhibits associated with that. And I'll just briefly go over those.

Some of the conditions that are in here that I would like to highlight -- We've got conditions about the limitations on the amount of historical consumptive use of the groundwater rights that will be used for conveyance of the water in the pipeline to the North Fork. And there's an attached Exhibit 3 that describes now what the water rights that the District is involved with for that pipeline represents a little over 13,500 acre-feet.

Exhibit 1, that's attached to this, was the original proposal that outlined the whole project that we presented in March of 2008. And it gives a lot of details in there about the construction of the pipeline location and a lot of the characteristics of that.

Exhibit 2, that's attached to this resolution, contains the accounting procedures that have been modified to reflect the conditions that are outlined in this proposal. This proposal also recognizes that the net completions that will be computed from the Compact Compliance Pipeline -- or Compact Compliance Wells will be computed using the

RRCA groundwater model.

We've also put the limitations in here on any individual amount of pumping from an individual well limited to 2500 acre-feet per year.

Condition No. 4, under this proposal, is a step and example of the projected augmentation water delivery from the pipeline to the North Fork.

We've got steps in here that we would go through in terms of the process to determine the projected water delivery and the limitations that would be imposed upon that. We have a minimum delivery that we would be required to make, and we've also got a maximum delivery that we could not exceed underneath Condition No. 4.

We outline in Condition No. 5 in here that the preliminary design that was presented in Exhibit 1, it's the intent of the District to follow that as close as they can but, as you know, through final design process, there may be some minor modifications to that. And this condition just basically says if there's any changes to that, anything that's substantially different from that, certainly the RRCA could take it up for further modifications if they believed that, say, alignment of that was significantly changed to effect the terms and conditions that are proposed in here.

We also incorporated a provision that would allow the Republican River Water Conservation District to acquire additional groundwater rights because the -- and put into the pipeline. The pipeline has been designed and constructed for obviously a far greater capacity than what is available with the initial purchase of the water rights that the District is involved with. And so this has some conditions in here in which the District in the state can incorporate additional groundwater rights into that pipeline.

We also point out, as we made clear, that the approval of this augmentation plan related to accounting procedures shall not govern any future approval by any other state under Subsection III.B.1.k. And also it doesn't present or waive any other states' rights to claims or seek for damages for any violations under the Compact or the FSS.

And the last condition we have in here is that the -- nothing in the resolution shall relieve the state of Colorado from complying with the obligations set forth in the Compact or the FSS, other than -- except for what's approved under this augmentation plan and related accounting procedures.

And I just wanted to mention, as far as Exhibit -- I think I referenced Exhibits 1 through 3.

The last exhibit that's in here, Exhibit 4, relates to the Condition No. 4 in the proposed resolution that's an example spreadsheet. It shows how this would typically operate with those minimum and maximum delivery limits in there, as well as our projected delivery credit. And it's merely used as an example for purposes of this resolution.

And that's, I guess, in essence, what is contained in our resolution that we bring before this Administration today for action.

CHAIRMAN DUNNIGAN: Thank you, Commissioner Wolfe. Would you like to move?

COMMISSIONER WOLFE: I would certainly at this time -- So we could open it up for discussion, I would request and move that the Commission adopt the proposed resolution that I just discussed dated August 12th, 2009.

CHAIRMAN DUNNIGAN: Second, Commissioner Barfield, discussion?

COMMISSIONER BARFIELD: I'll second it for discussion purposes, or were you seconding it?

CHAIRMAN DUNNIGAN: I would, but I thought you were seconding.

COMMISSIONER BARFIELD: I second it for discussion purposes.

CHAIRMAN DUNNIGAN: Okay.

COMMISSIONER WOLFE: Thank you.

CHAIRMAN DUNNIGAN: Discussion?

COMMISSIONER BARFIELD: If I may, Commission Dunnigan?

Again, I would like to express appreciation to the state of Colorado for its efforts here. Obviously, we recognize the very significant work that you are doing to develop this proposal and very significant resources to develop, you know, a defendable supply to offset your depletions.

Kansas does not wish to impede the state of Colorado from achieving compliance with the Compact via the vehicle of an augmentation plan that is recognized in the Final Settlement Stipulation as one avenue. That being said, the settlement required that argumentation plans have the approval of the RRCA to make sure all the necessary conditions are there to ensure it's done in a way that meets the needs of the states. Kansas has, as you know, Commissioner Wolfe, as well as Nebraska, put a lot of time and resources into this issue. We have diligently met with you on many conference calls and so forth, numerous meetings, numerous time in analyzing the proposal. We sought to express our concerns as specifically as possible. We've offered counter proposals where proposals of Colorado have not been satisfactory. You know, we're not there yet. Colorado is substantially overusing its South Fork allocation, as you know, including the use of Kansas's specific allocation on the South Fork, and this issue must be addressed.

In addition, there remain a number of details in the plan that we believe require additional work. Those were discussed, I think, at some level of detail in our discussions and, I think, summarized at our April meeting.

I think, while Colorado may need to initiate the dispute resolution process at this stage, I still want to continue to encourage the states to continue to work towards finding solutions on these matters because I think they're best found through negotiations, and I still think they're possible.

As I suggested in the past, one possible possibility I think we need to explore is extending the North Fork Pipeline into the South Fork Basin in Kansas. I think that has the potential for settling a number of key factors that have kept us at an impasse. So, that's my comments.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

The resolution before us today is essentially unchanged from the one voted on during the special meeting in April. Nebraska stated her concerns and reasons for voting no for the record during that meeting. Our concerns were also set forth to Colorado in Nebraska's letter of April 10th, 2009. Our position has not changed, and for that reason, we'll have to vote no today, as well.

Any other discussion?

(No response.)

CHAIRMAN DUNNIGAN: Call a vote.

COMMISSIONER WOLFE: Sorry, maybe just a followup comment. Just for the record and appreciate an echo of Commissioner Barfield's comments about trying to continue to seek resolution of this through an informal process. And we recognize the -- what's provided for under the FSS is maybe a backstop, if nothing else, to continue this process along the lines of dispute resolution, if needed.

And as you're aware, I remember our discussion yesterday and the correspondence in the last couple of weeks, that we are working to address the South Fork issue and the tributary issue and will continue to explore options out there.

And, likewise, I guess, in terms of Nebraska's positions on that, I think we've made it clear that we think some of the issues that we're trying to address, as far as the South Fork issues, addresses one of your two issues in your letter from April. The second one in regards to the Haigler Canal, I think Colorado is still taking the position that we believe that this is not a Compact-related issue because it is a decreed water right in Colorado. And it's afforded all the same protection as any other water right in Colorado in terms of our administration in accordance with the law to protect it against any injury, and we've attempted to address that through a separate, maybe, agreement, if you will and we'll continue to support that.

I think I would like to also point out for the record that through the efforts of many of the Colorado water users and the purchase of many, if not almost all of the senior water rights on the North Fork, this has made a significant amount of the supply available, but it is available and has been taken, certainly this year is evident of that, by the

Haigler Canal to satisfy their water rights. So I think Colorado has taken significant steps to address the concerns that Nebraska has raised about potential impacts to the Haigler Canal. I think it's evident by what has transpired in the last year and the operation of that, those rights on the North Fork this year. So I would like to just make the record reflect that. And we will continue to administer the Haigler Canal water right in accord with the law, but we still think this is a separate issue from the Compact Compliance Pipeline.

CHAIRMAN DUNNIGAN: Thank you.

Any other discussion?

(No response.)

CHAIRMAN DUNNIGAN: I'll call for a vote. All those in favor for the motion as presented by Commissioner by Wolfe please signify by saying aye.

COMMISSIONER WOLFE: Aye.

CHAIRMAN DUNNIGAN: Opposed, same sign?

COMMISSIONER BARFIELD: No.

CHAIRMAN DUNNIGAN: No.

Motion fails.

COMMISSIONER WOLFE: Thank you.

COMMISSIONER WOLFE: And we do have a complete package available for the recorder, if needed, that's here, of all the -- of the resolution and all the attached exhibits, if needed. We'll make that part of the record, please.

(Exhibit No. 1 was marked, offered and received in evidence. See Index.)

And if you guys need to look at that, what we're submitting, make sure it's in accordance with what we voted on.

CHAIRMAN DUNNIGAN: The next item under Old Business is Nebraska's crediting issue. Nebraska's position on this issue is clearly outlined in a June 15th, 2009, letter to the commissioners. Nebraska revised it's time line and restated its commitment to this issue in a letter dated July 29th, 2009. The resolution would approve the proposal to resolve the crediting issue, as outlined in the June 15th, 2009, letter. I will distribute that again. It's the same resolution that we discussed during the working session last night.

I would ask for the resolution and the letter to be made part of the record.

(Exhibit No. 2 was marked, offered and received in evidence. See Index.)

At this time, I would move to approve this resolution. Is there a second?

COMMISSIONER WOLFE: Second.

CHAIRMAN DUNNIGAN: Discussion?

COMMISSIONER BARFIELD: Commissioner Dunnigan, I have some discussion here. I guess, as I said last night, I want to state that I strongly disagree with this resolution, the characterization that this issue has been properly been presented to the RRCA in accordance with the dispute resolution provisions of the FSS.

As you noted, Commissioner Wolfe and I received your letter on June 17th. It raises this issue of concern and asks the RRCA to address it stating the states may or may not be in agreement on it.

Nebraska asked for a fast track determination on this matter. It seems to have little urgency, in my opinion. The schedule indicated an expectation the RRCA would need to resolve the matter by July 15th. In transmitting the proposal, you indicated you would call to discuss the matter, which did not occur. As the deadline approached and with the arbitrator's decision on this matter, I wrote to inquire about Nebraska's intent. I received the reply, again, you noted, affirming Nebraska's intent to move forward.

Until last night there had been no discussion of this matter by the RRCA or its engineering committee, other than a brief procedural discussion by the engineering committee. Despite Nebraska raising the matter and Nebraska chairing this administration with it bearing the responsibility to call the meeting. Even after our discussion last night, I'm not particularly clear on exactly what Nebraska is seeking to accomplish with this resolution as it related to past violations, as related to potential future violations that Nebraska is pursuing.

Now with regard to the substance of the matter, it appears, to me anyway, in putting forth this issue before the Administration, Nebraska is proposing to substitute money for water. This proposal flatly contradicts the Compact and so Kansas must oppose it. The Compact actively apportions the waters of the Republican Basin, binds the states to remain within its allocations. The Compact, the settlement, have no provision for exchanging water for money as Nebraska seems to be suggesting here. Consequently, Nebraska's crediting proposal is alien to the Final Settlement Stipulation and the RRCA accounting procedures, which serves the Compact of providing agreed upon methods for calculating water supply and the use within the basin. Remedies for Compact violations are not specified by the Compact, by the Administration, by the Final Settlement Stipulation or its accounting procedures. Hydrologic calculations and remedies for violations must remain separate if the accounting procedures are to remain with their integrity. Nebraska's proposal attacks that integrity by requesting that the issue of remedy for violations be included in the calculations.

Nebraska's crediting issue is also procedurally defective. It's a request that is not an appropriate subject for this meeting or for action by the RRCA.

Kansas disagrees with the arbiter's decision that the crediting issue can be brought before the RRCA. It's beyond the RRCA's purview.

Nebraska, in it's June 15th letter, maintains a crediting issue was done properly before the arbitrator, and the arbitrator resolved these issues against Nebraska.

In addition, this issue cannot be decided. It is a solution to dispute that at this point is only hypothetical.

In summary, the crediting issue contradicts the Compact and the FSS by attempting to rationalize noncompliance. In doing so, it fundamentally distorts the FSS and the accounting procedures.

In addition, it's procedurally improper and unright. Therefore, we strongly oppose it.

CHAIRMAN DUNNIGAN: Commissioner Wolfe?

COMMISSIONER WOLFE: Thank you, Commissioner. Colorado recognizes the significance of the issue. And to the best of our knowledge, this type of issue has never been dealt with in any state or compact commission. Obviously, somehow double penalizing a state is not acceptable. However, considering both the novelty and the importance of this issue, Colorado cannot support Nebraska's resolution at this time.

We would like to continue to work with Nebraska and Kansas to determine how to solve the issue. And in the end, Nebraska's proposal may be the best. We understand Nebraska wants to vote on this today and we understand the support that desires whether or not Nebraska votes non-binding arbitration. Colorado will continue to work with Nebraska and Kansas to better understand the Nebraska proposal and so all states can fully understand the effects of the various ways that this issue can be resolved. Thank you.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

Nebraska disagrees with Kansas's assertion that it has not been properly presented -- this issue has not been properly presented to the RRCA.

If there is no other discussion, I'll call for a vote. All those in favor of the resolution before us, please signify by saying aye.

Aye.

Those opposed, same sign?

COMMISSIONER BARFIELD: No.

COMMISSIONER WOLFE: Aye.

CHAIRMAN DUNNIGAN: Motion fails.

The next item on the agenda under Old Business is the Lower Republican Feasibility Study.

Commissioner Barfield?

COMMISSIONER BARFIELD: Just give me a moment. Well, let me attempt without my notes here.

A couple matters related to the feasibility study. I think the Bureau briefly reported on this matter in their report. This feasibility study is sort of an outgrowth of some work that was done jointly by the states and the Bureau of Reclamation in assessing some alternatives to improve management in the Lower Basin. The study is anticipated to be a joint study between the Bureau and the states of Kansas and Nebraska. We have been working to find -- obtain federal authorization for the feasibility study, as well as funding. And so far, that was -- We've got authorization in the last year but have not obtained federal funding. The state of Kansas has had funding in its budget year for many years now. And I believe that -- Well, I won't speak for the state of Nebraska on this matter.

Last year I noted in reviewing the transcript that we had committed to jointly developing a letter that could be used to support obtaining the federal appropriation, if necessary. I note that that did not occur this year. I would encourage us to get that on the agenda and get that completed for the coming year.

The state of Kansas is interested in some of the alternatives that were evaluated in the predecessor to the feasibility study that identified a number of potential alternatives to improve the use of the water supply in the Lower Basin. One of those included raising the Lovewell Dam. And we have been working to determine whether some of the work in the feasibility study could potentially be started while we wait for those appropriations at the federal level in view of the funding that we have available. The state of Kansas is working with the Corps of Engineers through a similar cost share program to conduct these sorts of studies. And this last year, we worked with the Corps and in coordination with the Bureau of Reclamation to do one specific study task in the feasibility study plan of study, and that was accomplished. And we're currently in discussions with the Bureau and the Corps about maybe other additional work that can be done while we wait the appropriation through the Bureau of Reclamation. So, I wanted to, I guess, make sure that the Administration was apprized of this. We've been working to make sure the state of Nebraska, in particular, is aware of the activities and invited and to participate in any way that you think is meaningful. So, I guess I give that report and take any questions you have.

CHAIRMAN DUNNIGAN: I don't have any questions. But I did attend the engineering committee meeting and the briefing by the Bureau on the status of the feasibility study going forward. And Nebraska will continue to evaluate the appraisal study , the scope of work for the feasibility study and Nebraska's role in this study with the hope that it will provide tangible benefits to both states, especially during dry years when the Bostwick Irrigation District may experience a limited irrigation supply.

And I guess just to clarify, I think last year, Commissioner Barfield, you were going to draft that letter up. Will you be drafting that letter up this year --

COMMISSIONER BARFIELD: Yes.

CHAIRMAN DUNNIGAN: -- and circulating it to the Commission -- to other commissioners?

COMMISSIONER BARFIELD. Yes, I will. I was the one that was to do that task and I did not get it complete and I will endeavor to get that done as soon as possible and circulate it to you all.

CHAIRMAN DUNNIGAN: Any other comments or questions on that agenda item?

COMMISSIONER WOLFE: No comments, but we appreciate the update on the study. Thank you.

CHAIRMAN DUNNIGAN: Seeing none, that moves us to Agenda Item 8, New Business and Assignments to Compact Committees.

COMMISSION BARFIELD: Excuse me. We had one more item under Old Business, I believe.

CHAIRMAN DUNNIGAN: Excuse me. I already crossed it off. We do. It was inadvertent.

Compact Compliance.

COMMISSIONER BARFIELD: Thank you, Chairman Dunnigan.

CHAIRMAN DUNNIGAN: Yes, thanks.

COMMISSIONER BARFIELD. I'll try and keep this short. Well, you know, Kansas does continue to recognize and appreciate the efforts of both the state of Colorado and Nebraska to achieve compliance. We recognize that these matters are difficult. It's now been six years since the State signed the Final Settlement Stipulation and the Court entered the decree approving that settlement.

First, with respect to Colorado, you know, Colorado has reported on its various efforts to achieve compliance, yet it has been unable to do so for the past six years, overusing almost 60,000 acre-feet during that period. Again, as I stated earlier, we appreciate the very significant efforts that Colorado makes to develop a defendable supply to offset its completions via this augmentation plan. But in the meantime, Kansas farmers, and particularly those on the South Fork Basin continue to suffer water shortages and the inability to develop their allocation fully due to their consistent overuse of the South Fork allocations. You know, Colorado is required to take all actions necessary to eliminate its excessive depletions on the South Fork and elsewhere. Although the Compact Compliance Plan has been approved -- although, if and when, the Compact Compliance Plan is approved, may help, Kansas points out that the Compact does not excuse violations when a state is crafting a plan. Each state is responsible for meeting its compliance obligations under the Compact and the FSS. And the state that knows the status quo will inevitably lead to violation must take firm action to meet its Compact obligations.

With respect to Nebraska, it's been, again, six years since the FSS was signed. Nebraska has also taken steps, but Kansas remains concerned about the sufficiencies of those actions. The arbiter accepted Kansas's calculations that Nebraska exceeded its' 2005 allocation by 42,680 acre-feet and its 2006 allocation by 36,100 acre-feet.

In addition, during the first four years of the accounting the FSS, Nebraska overused its allocation by approximately 140,000 acre-feet. These are years of diminished supply in the basin and Nebraska's violations were extreme and resulted in damages to Kansas users, as I've reported to this Administration previously.

As a result of very wet years in 2007 and in

2008, the pattern of overuse of Nebraska's allocation has been temporarily suspended. In Nebraska, the 2007 year, precipitation was 91 percentile. That was not the case for Kansas and Colorado that actually remained experiencing less than median precipitation in those years.

2008, the precipitation of Nebraska was 71 percentile. You know, we see that a principal cause, if not the principal cause for Nebraska's improved numbers to be precipitation that is substantially above normal, producing additional water supply and reducing pumping and surface water use. Kansas is concerned that with renewed dry conditions that Nebraska will, again, be overusing its allocations.

Nebraska asserted earlier in the meeting, in your opening statement, that it was in compliance for the five-year average of 2008. Kansas does not accept this statement. If Harlan County Reservoir evaporation is shared in 2006 and 2007, as we believe is appropriate, Nebraska would not be in compliance for that period.

As I testified in the arbitration trial, continued allocations allowed by the Republican River Basin Natural Resource District under their Integrated Management Plan will not reduce groundwater depletions as is required to achieve compliance but will result in increases in groundwater depletions in the future.

Again, Kansas's main concern here is that in drier years when a Kansas farmer needs the reliable surface water supplies most, Kansas's approach to compliance is designed to fail again despite its assertions otherwise.

Again, the arbitrator agreed with Kansas here finding Nebraska's Integrated Management Plans to be inadequate and serve compliance with the Compact, that additional groundwater reductions were necessary to achieve compliance.

He also found that Nebraska, in addition to making additional cuts to groundwater, needed to develop additional firm supplies to provide water during critical dry periods.

As we noted in the past, the majority of Nebraska's consumptive use is attributable to groundwater pumping. Thus, groundwater pumping is a double threat to compliance, as it has an immediate effect on the water supply, but its legacy effects will hamper Nebraska's future compliance, as well. Kansas continues to urge Nebraska to take the hard actions necessary, to reign in its unsustainable groundwater consumption.

That concludes my statement.

CHAIRMAN DUNNIGAN: Thank you, Commissioner.

Commissioner Wolfe, anything?

COMMISSIONER WOLFE: No, no further comments.

CHAIRMAN DUNNIGAN: Nebraska categorically denies and disagrees with Kansas's assertion regarding their interpretation of the arbitrator's decision and adequacy of Nebraska's regulatory measures, including Nebraska's IMPs. Nebraska currently is in compliance with the Compact according to the current accounting rules. Harlan County evap is not shared. Much, if not all of Kansas's report, was based on years prior to 2006.

For the record, I would like to note that in 2007, Nebraska underused its allocation by 31,000 acre-feet and in 2008 by almost 86,000 acre-feet. Wet and dry periods happen. That is why we have averaging under the Final Settlement Stipulation.

Any other comments?

COMMISSIONER BARFIELD: I just note the numbers you reference are Nebraska's estimates, as the engineering committee has not concluded any estimates, correct?

CHAIRMAN DUNNIGAN: As were Kansas's

numbers, yes.

COMMISSIONER BARFIELD: That's correct as well. I agree.

CHAIRMAN DUNNIGAN: Moving to Agenda Item 8 now in order. New Business and Assignments to the Compact Committees. Action on the Engineering Committee Report and Assignments. I would entertain a motion to approve the engineering report and their assignments for the coming year. Is there a second?

COMMISSIONER WOLFE: So moved.

CHAIRMAN DUNNIGAN: Second.

Discussion?

COMMISSIONER BARFIELD: I just have one additional item, I guess. I agree with the report and all the assignments contained therein. Again, I appreciate the diligent work of the engineering committee and the cooperation there.

Last night we had a discussion about this Harlan County evaporation issue. Kansas presented to the working session an alternative -- a new alternative that we had presented by a letter, I think, to the state of Nebraska, during the dispute resolution process, the RRCA portion of that, but had, to my recollection anyway, never been discussed by the Administration or its engineering committee. And so I sort of brought forward that discussion and asked that the administration consider assigning to the engineering committee additional discussion on this matter. I probably had agreement to that matter, but I guess I would just ask if continued discussion of alternatives to address Harlan County evaporation splits would be appropriate for the engineering committee.

CHAIRMAN DUNNIGAN: If there was a misunderstanding on that item being assigned back to the engineering committee, I'll take responsibility for that. It was our understanding that that wouldn't go back to the engineering committee. We certainly could have discussions about it at the RRCA level. We feel that it's already been in the engineering committee and would probably be referred back up anyway. So in the context of that particular item, and the other items under arbitration, we would be glad to discuss it through the Compact Administration and not assign it back to the engineering committee. So if there is confusion on that --

COMMISSIONER BARFIELD: Okay. Well -- So how would you like to proceed on the matter?

CHAIRMAN DUNNIGAN: We can discuss it through a special meeting or something else. And as I said, we would want to discuss it in terms of the other issues, accounting issues that were arbitrated.

COMMISSIONER BARFIELD: Okay, that's fine.

CHAIRMAN DUNNIGAN: Any other discussion?

COMMISSIONER WOLFE: I would just like to comment on that. I agree, maybe it would be best to address this at a special meeting or a continuation of this meeting, since we'll have other matters and recommendations from the engineering committee to look at, maybe we'll just contain that in part of the future meetings. Probably no point to send it back down to the engineering committee at this point.

CHAIRMAN DUNNIGAN: At this time, I would call for a vote on the motion, unless there's other discussion.

COMMISSIONER BARFIELD: Well, my attorney here is -- We sort of left something hanging there. And I think he's suggesting it maybe isn't -- I guess with respect to the Harlan County evaporation issue then, let's just leave -- I asked a question as to whether that should be discussed by the engineering committee. I've heard you indicate not, and that's fine. So we'll vote here in a moment on approving the engineering committee report and assignments to the engineering committee based on the report we have in front of us, correct?

CHAIRMAN DUNNIGAN: Correct.

COMMISSIONER BARFIELD: And let's just leave other action on the Harlan County or other accounting disputes without any particular assignment at this point. Is that the intention?

COMMISSIONER WOLFE: Yes.

COMMISSIONER BARFIELD: Okay, thank you.

CHAIRMAN DUNNIGAN: All right.

Call for a vote on the motion. All those in favor signify by saying aye.

Aye.

COMMISSIONER WOLFE: Aye.

COMMISSIONER BARFIELD: Aye.

CHAIRMAN DUNNIGAN: Opposed, same sign.

(No response.)

Motion carries.

The next item on the agenda is additional items.

And at this point, I would ask Commissioner Barfield if you have any additional items or closing remarks?

COMMISSIONER BARFIELD: I don't have any additional items or closing remarks.

CHAIRMAN DUNNIGAN: Commissioner Wolfe?

COMMISSIONER WOLFE: None at this time, Commissioner. Thank you.

CHAIRMAN DUNNIGAN: I don't have any either.

Moving to Agenda Item 9, Remarks from the public. If there are any remarks from the public, I would ask you to step up to the podium. Please give your name and spell your name for the court reporter. Thank you.

MR. EDGERTON: My name is Brad Edgerton, E-d-g-e-r-t-o-n. I'm the manager of Frenchman Cambridge Irrigation District. Thank you for the opportunity to speak today.

The past decade has been a struggle for the Frenchman Cambridge Irrigation District, which, by the way, is the largest irrigation district in the Republican River Basin. Frenchman Cambridge serves nearly 46,000 acres, using four separate canal systems. The District holds 41 natural flow permits with priority dates ranging from 1890 to 1987. The State has granted the District the right to divert 531 CFS from the rivers and streams. In addition to the District's natural flow permits, the Federal Government holds storage use permits on the District's project acres. The District has contract agreements with the Federal Government to deliver a total of

143,217 acre-feet of storage water from three federal reservoirs.

The largest of the three reservoirs is Swanson Lake, near Trenton, Nebraska. Prior to this year, the last time water was released from this reservoir was six years ago. During the same period, Colorado has repeatedly overused her annual compact allocation which, to date, exceeds 65,000 acre-feet during this period.

I am encouraged by the efforts Colorado is taking to comply with the Republican River Compact. Its obvious the folks in Eastern Colorado are willing to do what is necessary to achieve compliance. I know there are several issues to resolve before the Colorado pipeline can be constructed.

Frenchman Cambridge needs Colorado to comply with the Compact. Therefore, I offer the following suggestion so that everyone can move off center on this issue.

Colorado was granted 22.4 percent of the water supply on the North Fork of the Republican River. If Colorado did pump water into the stream without an approved augmentation plan, more than likely the small percentage would not justify the construction expense of the pipeline.

However, Colorado is allocated 78.5 percent of the supply on the Arikaree Sub-Basin. This percentage may justify the construction of the pipeline without an approved augmentation plan.

I would suggest to Kansas and Nebraska to allow Colorado to pump augmentation water into the North Fork and receive an equivalent of the Arikaree River allocation.

Kansas and Nebraska would retain some leverage over Colorado with the remaining 21.5 percent loss in pipeline water credit.

The second major concern of Frenchman Cambridge is the amount of water currently being mined from the aquifer above the federal reservoirs in Nebraska. In February, 2009, Frenchman Cambridge petitioned Nebraska DNR asking that the Republican River Basin be reevaluated to correctly identify whether the Basin is fully appropriated, which is the current designation, or, if, in fact, the basin should be designated as over-appropriated. Frenchman Cambridge Irrigation District's petition asked the DNR to look at the stream reach upstream of the Cambridge Diversion Dam. Our petition was denied. We have since requested a hearing and received notice July 21st this year that we have been granted a hearing.

No date has been set for this hearing.

An over-appropriated designation would require the State and the NRDs to develop IMP plans that would bring the basin back to the fully appropriated level of development. Frenchman Cambridge is simply asking the State to evaluate the basin once so that the state leaders and resource managers can develop and implement the appropriate rules for the area that have seen the greatest declines in the basin's water supply.

Karl J. Dreher recently recommended that Nebraska's IMPs for the upper, middle and the lower NRDs are inadequate to ensure compliance with the Compact and the FSS during prolonged dry conditions, such as occurred from 2002 through 2006. Nebraska and the Republican River NRDs should make further reductions in consumptive groundwater withdrawals beyond what's required in the current IMPs and obtain permanent interruptible supply contracts with surface water irrigators to ensure compliance with the Compact and FSS during prolonged dry conditions.

Frenchman Cambridge agrees that further reductions in groundwater consumptive pumping must occur. As far as the permanent, interruptible water supply, the reality is that even with the above normal precipitation the past two-and-a-half years, Frenchman Cambridge cannot tell its water users today that they will receive an eight-inch supply from the District in 2010. This doesn't allow for long term planning or long term agreements.

To date, neither the State nor NRD officials have sat down with the District to discuss long term agreements.

I thank you for the opportunity to address you today. Thank you.

CHAIRMAN DUNNIGAN: Thank you, Mr. Edgerton.

Others from the public?

MR. MURPHY: My name is Stan Murphy from the -- I'm actually the manager for the Republican River Water Conservation District.

THE REPORTER: Spell your last name, please.

MR. MURPHY: M-u-r-p-h-y.

I would like to speak as an individual, not on behalf of the water district. To come down here and -- it's very frustrating to watch the political tap dance. We've got 4,000 irrigators -- irrigation wells out there, 20-some municipalities. These people are all being assessed 14, 15 acre-feet for irrigation compiling a lot of money, putting a lot of effort into this, trying to go to the bank to pay the debt. And we walk in here and Kansas says, "Well, you don't have enough to pay the whole debt so we're not going to take any of it, you know. South Fork's an issue, so we can't take this money so you can't build your pipeline." Nebraska says, "We've got the Haigler Canal. We want to protect that and make sure we get water down there to the people on the Haigler Canal." At the same time, you don't want the water to be delivered to Nebraska because Swanson Reservoir could collect it and then irrigators are going to use it and increase your consumptive use. How are we going to solve this problem, people, if we can't get together and actually look at it logically and sort out what's really pertinent to the issue here, the pipeline? We're just trying to get this thing built to take care of that part of it. Now the other issues, kick them aside and let's get this thing solved. I would request from the other states, if you would send me in writing what your objections are to the pipeline so that I can put them on our website so people can see what they're actually being -- trying to confront here. Any questions, I would be glad to answer them, but it's very frustrating. Thank you.

CHAIRMAN DUNNIGAN: Mr. Murphy, did you sign the sign-in sheet with your address?

MR. MURPHY: I did, yes.

CHAIRMAN DUNNIGAN: Thank you.

Others from the public?

MR. MANGUS: I'm Tony Mangus, M-a-n-g-u-s. I represent CAPA. CAPA is an organization of farmers, ranchers, and we try to work with the state and our WRCD and whatever we can do.

The South Fork is an issue. And I guess I'll go back to maybe personal. That's my area down there. The South Fork has some issues, Bonny Reservoir one of them. And the state is recognizing the issue of the inflow in the Bonny. My point being is there's issues from the state line in Kansas on up to Benkelman. And my point being, Kansas needs to take some responsibility in the condition of the river from there up as far as invasive species. And I'm kind of with Stan on this. I mean, nobody -- You guys cannot sit down and -- I've been here three years, Junction City, and I really haven't seen nothing get done. I mean, it's just a dog and pony show. Kansas and Nebraska wants their cake and to eat, too, and the icing, and you name it. And Colorado is trying to do something. And I believe that you're impeding our efforts for it. That's all I have to say.

THE REPORTER: Could you spell CAPA for me?

MR. MANGUS: Colorado Agriculture Preservation Association.

THE REPORTER: Thank you.

CHAIRMAN DUNNIGAN: Thank you.

Other remarks from the public?

(No response.)

Seeing none, we'll move to Agenda Item 10, Future Meeting Arrangements. The next annual meeting will be hosted by Colorado.

Commissioner Wolfe, do you have any tentative dates in mind at this particular time?

COMMISSIONER WOLFE: We don't have any particular dates. I mean, in light of our discussion yesterday, having this by August 1, I guess we can still attempt to do that. We'll probably, within the very near future here in the next couple weeks or so, send out some dates to see if we can get that set up. We anticipate we're going to have that -- the location in Burlington, Colorado, just due to facilities, hotel arrangements, that type of thing. It's the most -- probably our best accommodations to do it in Burlington. So, we'll confirm that, but that's tentatively -- We'll have to find some dates and locations that -- or dates with availability for our location in Burlington. So that's why we don't have anything exact at this point, but we'll get that sent out.

Since this does turn to Colorado now, as far as conducting these meetings, we will also facilitate any special meetings that need to take place. in light of the discussion today and continuation of our discussions on -- settlement discussions on the pipeline proposal. I would anticipate, since there was action items under the engineering committee assignments, that we had had some follow up things there, that it would be my recommendation that we not adjourn this meeting today, but actually continue it to address those issues there, if that is appropriate.

COMMISSIONER BARFIELD: Maybe we need to talk about that. I mean, you're suggesting we have a special meeting some time before -- between now and the annual meeting? Is that what I heard you say?

COMMISSIONER WOLFE: Yes, that's correct, or...

COMMISSIONER BARFIELD: Is it necessary to sort of continue this meeting to make that happen or do we --

COMMISSIONER WOLFE: Well, I think -- You could do it -- handle it a couple of different ways. I mean, there were some assignments on there that we could take up as commissioners at a continuation of this meeting or discussions on -- as far as the Compact Compliance Pipeline or adjourn it and have it as a special meeting but, yeah, form over substance so either way is fine with us.

COMMISSIONER BARFIELD: I think I would prefer to just sort close the annual meeting and just -- if you want to state for the record that we intend to have a special meeting this fall, I think that would be appropriate.

COMMISSIONER WOLFE: That's fine. Procedurally, we get there either way, so we're fine with that.

CHAIRMAN DUNNIGAN: Okay. I would look for a motion to adjourn the annual meeting.

COMMISSIONER WOLFE: So moved.

COMMISSIONER BARFIELD: Second.

CHAIRMAN DUNNIGAN: Second.

CHAIRMAN DUNNIGAN: All those in favor?

Aye.

COMMISSIONER WOLFE: Aye.

COMMISSIONER BARFIELD: Aye.

CHAIRMAN DUNNIGAN: Opposed, same sign?

Meeting adjourned. Thank you very much.

(Adjourned at 10:46 a.m., on August 12, 2009.)

# ATTACHMENT F

## BUREAU OF RECLAMATION
## REPORT OF RESOURCES MANAGEMENT ACTIVITIES

RECLAMATION
*Managing Water in the West*

# Resources Management Activities

## Nebraska-Kansas Area Office

## Bureau of Reclamation

Republican River Compact Administration
Lincoln, Nebraska
August 12, 2009

**Lower Republican Basin Feasibility Study**
**Pre-feasibility Activities**

Title V, Section 510, of the Consolidated Natural Resources Act, S. 2789, Public Law 110-229 (May 8, 2008), authorized the Bureau of Reclamation to conduct the Lower Republican River Basin Feasibility Study (FS) to improve water supply reliability, increase water storage, and to improve water management efficiency. A copy of Section 510 of the Public Law is included on the next page. Federal funds have not been appropriated for Reclamation to perform any of the study tasks, however Kansas is beginning a few tasks in support of the FS.

**Public Assistance to States Program**

In conjunction with the Corps of Engineers (COE) Public Assistance to States (PAS) Program, the Kansas Water Office (KWO) and the Kansas Division of Water Resources (KDWR) continue to take advantages of opportunities to work on tasks identified in the Plan of Study Lower Republican Feasibility Study.

The first PAS Program effort was aerial surveys to obtain orthophotography and topography of the reservoir and embankment areas at Lovewell Reservoir. The reservoir area was flown in early spring of 2009. The survey data can be used in the Feasibility Study for analyzing alternatives involving increased storage at Lovewell Reservoir.

Another PAS Program effort includes possible development of a model covering the Republican Basin from Harlan County Dam to Milford Reservoir which will be used to evaluate alternatives and available water supplies. Initial discussions have been held with Reclamation, COE, KWO, KDWR, and the Nebraska Department of Natural Resources. Model development should be supported by Reclamation and both states because the model could also be used in future basin operations.

**Bathymetric Survey Program**

The KWO is working with the Kansas Biological Survey through the Bathymetric Survey Program. This survey program measures reservoir storage and sediment accumulation. Data from this program is used to estimate the sediment rate in reservoirs and the chemical composition of the sediment that has been deposited. The KBS plans on completing a survey of Lovewell Reservoir in 2010. This would provide an updated reservoir capacity data for Lovewell, which will prove valuable tool for evaluating alternatives.

**Consolidated Natural Resources Act of 2008**
**S. 2789 - Public Law 110-229** **May 8, 2008**

## TITLE V – Bureau of Reclamation and United States Geological Survey Authorizations

## SEC. 510. REPUBLICAN RIVER BASIN FEASIBILITY STUDY.

(a) AUTHORIZATION OF STUDY. - Pursuant to reclamation laws, the Secretary of the Interior, acting through the Bureau of Reclamation and in consultation and cooperation with the States of Nebraska, Kansas, and Colorado, may conduct a study to -

(1) determine the feasibility of implementing a water supply and conservation project that will -

(A) improve water supply reliability in the Republican River Basin between Harlan County Lake in Nebraska and Milford Lake in Kansas, including areas in the counties of Harlan, Franklin, Webster, and Nuckolls in Nebraska
and Jewel, Republic, Cloud, Washington, and Clay in Kansas (in this section referred to as the ‘‘Republican River Basin’’);

(B) increase the capacity of water storage through modifications of existing projects or through new projects that serve areas in the Republican River Basin; and

(C) improve water management efficiency in the Republican River Basin through conservation and other available means and, where appropriate, evaluate integrated water resource management and supply needs in the Republican River Basin; and

(2) consider appropriate cost-sharing options for implementation of the project.

(b) COST SHARING. - The Federal share of the cost of the study shall not exceed 50 percent of the total cost of the study, and shall be nonreimbursable.

(c) COOPERATIVE AGREEMENTS. - The Secretary shall undertake the study through cooperative agreements with the State of Kansas or Nebraska and other appropriate entities determined by the Secretary.

(d) COMPLETION AND REPORT. -

(1) IN GENERAL. - Except as provided in paragraph (2), not later than 3 years after the date of the enactment of this Act, the Secretary of the Interior shall complete the study and transmit to the Congress a report containing the results of the study.

(2) EXTENSION. - If the Secretary determines that the study cannot be completed within the 3-year period beginning on the date of the enactment of this Act, the Secretary -

(A) shall, at the time of that determination, report to the Congress on the status of the study, including an estimate of the date of completion; and

(B) complete the study and transmit to the Congress a report containing the results of the study by not later than that date.

(e) SUNSET OF AUTHORITY. - The authority of the Secretary to carry out any provisions of this section shall terminate 10 years after the date of the enactment of this Act.

## Frenchman Valley Appraisal Study

At the request of the Nebraska Department of Natural Resources, Reclamation began an appraisal study to examine opportunities for more efficient management in the Frenchman Basin which has experienced dramatically reduced surface water supplies, including reduced inflows to Enders Reservoir.

Study partners included Reclamation, the Nebraska Department of Natural Resources, Frenchman Valley Irrigation District, the H&RW Irrigation District, the Riverside Irrigation Company, the Upper Republican Natural Resource District, the Middle Republican Natural Resource District, and the Nebraska Game and Parks Commission.

Reclamation's Frenchman Unit (Unit) lacks the water supply to provide the benefits envisioned when the project was formulated, most notably supplying irrigation water from Enders Reservoir to project acres of the Unit. The purpose of the study is to determine whether the problems and alternatives analyzed have sufficient potential to justify further Federal involvement while meeting the following study objectives:

- Maintain the viability of the FVID and H&RWID
- Maintain recreation at Enders Reservoir
- Protect the Federal investment in the Unit

Three alternative plans were developed:

- Flow-Through Alternative
- Recreation Alternative, and
- Groundwater Recharge Alternative.

These alternatives were compared to the Future-Without Project Condition, which represents the project future conditions if no Federal action were taken.

The study reviewed and updated the conclusions and recommendations from the 1977 Frenchman Unit Appraisal Report.

A Final Draft has been completed and will be distributed to cooperating agencies for a final review.

## Reclamation Assistance to Kansas
## Evaluation of Water Conservation Projects

In 2008, the Kansas Legislature passed Substitute for Senate Bill 89 (SB89), which established the procedure for the distribution of any moneys recovered from disputes relating to the Republican River Compact from either Colorado or Nebraska. Reclamation is providing financial and technical assistance for the evaluation of water conservation projects in both the Upper and Lower Republican Basins.

### Republican River Basin Conservation Alliance

The Republican River Basin Conversation Projects Alliance (Alliance) was formed to craft a cooperative and coordinated application for specific water conservation projects to be completed if and when Republican River Compact award funds accrue to Kansas from either Colorado or Nebraska. The Alliance consists of a wide representation of stakeholders in northwestern Kansas, including representatives from County Commissions; Cities; Irrigation Districts; Groundwater Management Districts; Production Agriculture; Economic development; RC&Ds; Financial institutions; area Industry; Animal feeding; the Upper Republican Basin Advisory Committee; Farm Bureau's and the Environment. Wayne Bossert, Manager of GMD #4 serves as Alliance Chair. The Alliance has brainstormed and created an initial list of potential conservation projects. The Alliance plans to make specific project recommendations on conservation projects at the appropriate time to the Director, Kansas Water Office.

One alternative involves an evaluation of the best use of water due to the Kansas Upper Republican basin by Colorado to comply with the compact and Final Settlement Stipulation. To meet Colorado’s obligations, there are on-going discussions that Colorado may deliver between 2,500 and 5,000 acre feet to the South Fork Republican River basin at the Colorado-Kansas state line or possibly at some point near St. Francis.

Through a cooperative agreement with the Kansas Water Office, Reclamation is providing assistance to conduct a reconnaissance level study on options for the beneficial uses of Compact water provided by Colorado. The evaluations are to consider the economic benefits, social and environmental benefits, potential conservation benefits, and an estimate of the costs to implement.

### Lower Republican River Stakeholder Advisory Committee

The Lower Republican River Stakeholder Advisory Committee (LRRSAC) is a group of water users/interests in the basin that will develop a list of potential projects and provide a report to Tracy Streeter, Director of the Kansas Water Office. The group is co-chaired by Susan Stover of the Kansas Water Office and Scott Ross of the Kansas Division of Water Resources. The LRRSAC hopes to provide this report by November, 2009.

The LRRSAC contains representatives from the Kansas Water Office, Kansas Division of Water Resources, Kansas Department of Wildlife and Parks, Corps of Engineers, Bureau of Reclamation, Kansas Bostwick Irrigation District No. 2, City of Concordia, City of Clay Center, and a number of irrigators, both surface and groundwater users.

Alternatives evaluated include increasing storage opportunities, improving surface water delivery system efficiency, improving on-farm irrigation efficiency, reducing demands, aquifer recharge, reduce Minimum Desirable Streamflow violations, and improving water quality.

Water conservation projects identified by the LRRSAC support the direction of the Final Settlement Stipulation (Settlement). Through the Settlement, Nebraska and Kansas, in agreement with the United States, agreed to minimize bypass at the Superior-Courtland Diversion Dam and to pursue system improvements in the basin, including measures to improve the ability to utilize the water supply below Hardy, Nebraska, on the main stem.

The LRRSAC has been utilizing a number of Reclamation reports on the Lower Republican to evaluate alternatives, including the *Draft – Lower Republican River, Kansas – Water Augmentation Analysis*, May, 2002, the *Value Study Report, Proposals for More Efficient Management of Lower Republican River Water Supplies*, December 17, 2002 and the *Appraisal Report, Lower Republican River Basin, Nebraska and Kansas*, January, 2005.

**Substitute for Senate Bill 89**

In 2008, the Kansas Legislature passed Substitute for Senate Bill 89 (SB89), which established the procedure for the distribution of any moneys recovered from disputes relating to the Republican River Compact from either Colorado or Nebraska. SB89 also established the Republican River Water Conservation Projects - Nebraska Moneys Fund (RRWCP-NE Fund) and the Republican River Water Conservation Projects - Colorado Moneys Fund (RRWCP-CO Fund). The RRWCP-NE and RRWCP-CO funds are to be administered by the Director, Kansas Water Office. After the Interstate Litigation Fund is restored to it's $20 million target level, two thirds of the funds received from Colorado will go into the RRWCP-CO Fund, to be used in the Upper Republican River Basin for conservation projects and one third will go into the State Water Plan Fund for water conservation projects – with priority given to projects that will directly enhance Kansas' ability to stay in compliance with the Compact. If any funds are received from Nebraska, (again, after the Interstate Litigation Fund is restored), two thirds of the funds received from Nebraska will go into the RRWCP-NE Fund to be used in the Lower Republican River Basin for water conservation projects and one third go into the State Water Plan Fund. The Director and the Chief Engineer of the Division of Water Resources are to review and approve each proposed project for which moneys would be expended, with Substitute for SB 89 providing broad guidance.

## Meeker Driftwood Appraisal Study

Through the FY10 General Investigations Program, the Nebraska Game and Parks Commission submitted a proposal to conduct an appraisal study on the Meeker Driftwood Unit of the Frenchman-Cambridge Division. The purpose of the Meeker-Driftwood Appraisal Study is to evaluate alternative program activities, structural measures, and/or incentives that might assist in optimizing the existing facilities, provide increased lake level benefits, and provide ongoing recharge for Swanson Reservoir and the irrigated acres it serves.

The study area is defined as the entire drainage area of the Meeker-Driftwood Unit of the Frenchman-Cambridge Irrigation District located primarily in Dundy and Hitchcock counties which feeds Swanson Reservoir and the Meeker and Driftwood canal systems below it.

This Meeker Driftwood Unit has experienced reduced ground and surface water supplies both as a function of historic groundwater utilization and as a consequence of the ongoing drought situation in the basin. Swanson Reservoir has experienced greatly reduced inflows and has been limited to 20-30% of capacity for the last few years. This study may have potential benefits to Nebraska as related to the Republican River Compact. Declining inflows and consistently low reservoir levels have major environmental, economic, and social impacts on the watershed, including agricultural users and recreational interests.

An evaluation of alternative uses and allocations of the limited surface water will allow for more effective planning on the parts of both irrigation interests and natural resource agencies relative to how to expend resources and funds in the basin.

## FY12 Proposals
## General Investigations Program

The overall goal of Reclamation's Investigations Program (or Geographically Defined Program) is the formulation of plans to address current and projected needs, problems, and opportunities by conserving and managing the available natural resources. With the emphasis on water management and less on construction, the program is geared to assisting with cost-shared studies and technical assistance activities that are environmentally responsible and well planned.

Areas of specific interest and emphasis for selection of proposals include: completion of ongoing studies, watersheds where existing Reclamation projects can contribute to the solution, watershed/regional-scale problems and opportunities, clear Reclamation mission, and other local, state, and/or federal participation,

### Nebraska FY 12 Proposals

Niobrara River Basin Management Alternatives Assessment (Nebraska Department of Natural Resources)

Study to evaluate conjunctive management alternatives related to Mirage Flats Irrigation District and optimization strategies for augmentation and retiming related to the Ainsworth Irrigation District. Study will target management of the hydrologically connected waters in the Niobrara Basin upstream of Box Butte Reservoir and the Mirage Flats Irrigation District.

Playa Wetlands Groundwater Recharge in South Platte and Upper Republican River Basins (Nebraska Game and Parks Commission)

Study to investigate the role of playa wetlands in providing groundwater recharge that may contribute to maintenance of stream flows in the Platte and Republican River watersheds. There are more than 15,000 individual playa wetlands in western Nebraska and they are all in the Platte and Republican River watersheds. Playa wetlands are within the Platte and Republican River watersheds in eastern Colorado and northern Kansas.

### Kansas FY12 Proposals

Lovewell Reservoir Fish Entrainment (Kansas Water Office)

Study for the evaluation and installation of a barrier system or combination of systems to reduce fish loss from Lovewell Reservoir as a result of entrainment during irrigation releases.

Minimum Pool Development at Kansas Reservoirs (Kansas Water Office)

Evaluate the economic impacts of minimum pool development in Keith Sebelius Lake and Webster Reservoir.

Providing surplus water to Jamestown Wildlife Area (Kansas Water Office, Kansas Department of Wildlife and Parks)

Study to evaluate alternative to provide excess and/or off-season, surplus irrigation water from the Lower Republican area to the marshes at the Jamestown Wildlife Area, Water stored in the marshes will be available for later release back into the basin. This will provide a dependable water supply to the wetlands while still providing water for late winter alluvial aquifer recharge and helping meet minimum desirable streamflow,(MDS), in the Republican River at Concordia, Kansas.

Northwest Kansas Water Distribution Project (Kansas Water Office)

Pending approval by the Republican River Compact Administration, Colorado will deliver compact water to the Kansas stateline. Evaluations of options are needed for Kansas to make efficient, beneficial use of this water.

Smoky Hill Basin Groundwater Modeling (Kansas Water Office)

Modflow modeling of the Smoky Hill River alluvial valley from the Kansas-Colorado state line to Kanopolis Reservoir. Study area includes Kanopolis and Cedar Bluff Reservoirs (which are experiencing declining inflows), two intensive groundwater use control areas, the well fields for Hays and Russell, and also Minimum Desirable Streamflow issues.

Kickapoo Reservoir (Kansas Water Office)

The Kickapoo Tribe is seeking construction of a reservoir on their reservation in Brown County to supplement its water supplies. An appraisal study is needed, leading to Feasibility Study, and eventually the planning, design, construction and operation plans.

Streamflow availability modeling – Missouri River Basin (Kansas Water Office)

Model to determine availability for water appropriation and ecosystem needs on Kansas tributaries to the Missouri River.

Isolated Aquifer System Characterization (Kansas Water Office)

Important but geographically limited fresh water aquifers are becoming more intensely developed. Hydrologic models are needed as an analytical tool in for water management and planning. Study areas include the Upper Sumner, McPherson, Dakota, and Glacial Drift Aquifers.

# 2008 – 2009 Republican Water Conservation Activities

## Republican River Basin Irrigation Management Project

Reclamation continues to provide financial assistance through the WCFSP to the University of Nebraska Extension Service for an irrigation management demonstration project. In 2008, field demonstrations included sites located near Alma, Edison, Loomis, Imperial, Benkelman, and Curtis. Information is presented at annual field days at each site and at an average of 16 other meetings/conferences per year.

The primary goal of the program is to demonstrate research-based irrigation management strategies in farmer fields and provide a hands-on practical teaching environment for farmers and consultants to learn how to implement these practices.

## Canal Automation Workshop

In March of 2009, Reclamation held a canal automation workshop in Red Cloud to demonstrate some cost effective, low maintenance canal automation techniques that have been implemented in area irrigation districts (Ainsworth ID, Twin Loups ID, and Bostwick ID in Nebraska).

## Frenchman-Cambridge Irrigation District

Reclamation provided financial assistance through the Water Conservation Field Services Program (WCFSP) for upgrading farm deliveries.

## Almena Irrigation District No. 5

Reclamation is providing financial and technical assistance through the WCFSP for a buried pipe lateral project.

## Bostwick Irrigation District in Nebraska

Reclamation is providing financial and technical assistance through both the Water 2025 Program and the WCFSP for the replacement of open ditch laterals with buried pipe. Also providing technical and financial assistance for the automation of 10 check structures on Franklin Canal.

On August 4, 2009, Commissioner Mike Conner announced that the Bostwick Irrigation District in Nebraska has been selected for two challenge grants. Projects include the replacement of open ditch laterals with buried pipe and a System Optimization Review, which will review the entire District and make recommendations for system improvements.

## Kansas Bostwick Irrigation District No. 2

Reclamation is providing financial and technical assistance through the Water 2025 Program for the replacement of open ditch laterals with buried pipe.

## Water Rights Mapping

**Frenchman-Cambridge Water Rights**

Reclamation worked with the Nebraska Department of Natural Resources (NDNR) and the Frenchman-Cambridge Irrigation District in the map transfer process, which resulted in an approval

**Bostwick Irrigation District in Nebraska**

NDNR worked with the Bostwick Irrigation District for mapping the entire district for the map transfer process. Reclamation recently completed cultural resource review of the Bostwick Irrigation District in Nebraska for the map transfer.

**Kansas Bostwick Irrigation District No. 2**

Reclamation has been working with the Kansas Division of Water Resources (KDWR) to map the Kansas Bostwick Irrigation District and the private irrigation water rights in the Lower Republican Basin.

**Almena Irrigation District No. 5**

Reclamation worked with KDWR to map the Almena Irrigation District water rights and the private rights from Norton Dam to the Kansas-Nebraska state line.

**Future Project Mapping Activities**

Reclamation plans to begin mapping the project acres of the Frenchman Valley Irrigation District and H & RW Irrigation District

Reclamation plans to provide assistance to the Republican Basin Natural Resource Districts to map private water rights within Reclamation project boundaries (co-mingled water rights).

## Drought Assistance

Reclamation provides drought assistance through the Reclamation States Emergency Drought Relief Act of 1991.

**Kansas Automated Weather Stations**

In 2008 Reclamation provided $112,000 of drought assistance funds to purchase equipment for an additional ten automated weather stations to be installed throughout Kansas. Kansas. Kansas requested an additional $75,000 for additional automated weather stations. This request was included as part of the Recovery Act but has not been funded.

**Nebraska – Municipal Well**

The Village of Stockville has been approved for drought assistance for the installation of a municipal well. Reclamation continues to work out the details of this well project, which should be completed by spring of 2010.

## Reservoir Management

### ADA compliance activities

NKAO has completed American with Disabilities Act (ADA) related evaluations and action plans for all of the NKAO reservoirs. The Great Plains Region has set a goal to complete universal accessibility upgrades at Reclamation facilities by 2010. In order to complete the required ADA retrofits by 2010, Reclamation has entered into Title 28 cost share cooperative agreements with the Nebraska Game and Parks Commission and Kansas Department of Wildlife and Parks, made vault toilet purchases through our Indefinite Delivery/Indefinite Quantity Contract, and will have four construction contracts in place for work at six reservoirs this year.

### Funding shortages in Nebraska Parks

Nebraska Game and Parks Commission has informed Reclamation of possible reduced services at three Reclamation reservoirs; Enders, Swanson and Box Butte. Because of declining reservoir water levels, these three facilities have received reduced visitation over the last ten years. Reclamation continues to work with the Commission by assisting them in land resources management using cost sharing cooperative agreements such as shoreline erosion protection, fencing, and noxious weed controls.

### Invasive Species

The threat to the proper function of all aspects of NKAO projects caused by exotic and invasive species has become a serious issue for both Reclamation and our managing partners and contractors. Currently, the majority of issues impacting the NKAO are related to invasive plant and noxious weed infestations at the reservoirs. Invasive plant and noxious weed problems have been increasing in scope and severity due to declining water levels in many of facilities, increased costs associated with control measures, and increased political pressure to remove water consuming species from riparian areas. The control of noxious weed and invasive species has become a serious budgetary issue for the NKAO's managing partners in Nebraska and Kansas.

The greatest potential threat to the NKAO's projects from exotic species would occur from an infestation of Zebra and/or Quagga Mussels (ZQM) at the reservoirs and associated water distribution facilities. Many of the NKAO's projects areas are located within a day's travel from waters known to be infested with ZQM. The NKAO has been working with our managing partners to increase public awareness, and perform monitoring at high risk reservoirs.

# ATTACHMENT G

# BUREAU OF RECLAMATION
# OPERATION AND MAINTENANCE REPORT

RECLAMATION
*Managing Water in the West*

# OPERATION

# AND

# MAINTENANCE

# REPORT

# REPUBLICAN RIVER

# COMPACT MEETING

**LINCOLN, NEBRASKA**

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

**U.S. Department of the Interior**
**Bureau of Reclamation**
**Great Plains Region**
**Nebraska-Kansas Area Office**

**August 12, 2009**

**REPUBLICAN RIVER COMPACT MEETING**
August 12, 2009
Lincoln, Nebraska

## 2008 Operations

As shown on the attached Table 1, precipitation in the Republican River Basin varied from 115 percent of normal at Swanson Lake to 150 percent of normal at Hugh Butler Lake. Total precipitation at Reclamation dams ranged from 22.20 inches at Bonny Dam to 34.10 inches at Lovewell Dam.

Inflows varied from 37 percent of the most probable forecast at Enders Reservoir to 192 percent of the most probable forecast at Harry Strunk Lake. Inflows into Enders Reservoir totaled 4,770 AF while inflows at Harlan County Lake totaled 224,841 AF.

Average farm delivery values for each irrigated acre were as follows:

| District | Farm Delivery |
|---|---|
| Frenchman Valley | 0.0 inches |
| H&RW | 0.0 inches |
| Frenchman-Cambridge | |
| - Meeker-Driftwood, Bartley | 0.0 inches |
| - Red Willow Canal | 3.0 inches |
| - Cambridge Canal | 6.0 inches |
| Almena | 1.7 inches |
| Bostwick in NE | 2.6 inches |
| Kansas-Bostwick | |
| - Above Lovewell | 4.1 inches |
| - Below Lovewell | 5.5 inches |

## 2008 Operation Notes

**Bonny Reservoir** -- The reservoir level began the year at elevation 3648.39 feet (23.6 feet below the top of conservation). Above average rainfall during the month of August caused the reservoir level to increase to a peak elevation of 3651.25 feet on August 15th. Beginning on August 15th releases were made in accordance with orders of the State of Colorado for Republican River Compact compliance. A total of 4,087 AF of river outflow was recorded for this purpose from August 15th through October 2nd. The release resulted in the reservoir level reaching a new historic low elevation of 3648.05 feet on October 9th. A total of 193 AF was released into Hale Ditch during the year. The reservoir elevation at the end of the year was 22.0 feet below the top of conservation at 3649.96 feet (second lowest end of December storage on record).

**Enders Reservoir** -- The 2008 inflow into Enders Reservoir of 4,770 AF was below the dry-year forecast. This was the 41st consecutive year with below-normal inflows in which the conservation pool did not fill. The reservoir level began the year at elevation 3092.64 feet (19.7 feet below top of conservation). The reservoir level increased slightly during the spring to a peak elevation of 3092.90 feet on June 8th.

The reservoir level gradually decreased the remainder of the year. Due to the extremely low water supply available, no water was released from Enders Reservoir. This was the seventh consecutive year that H&RW Irrigation District did not divert water and the third consecutive year that Frenchman Valley Irrigation District did not divert water. The end of the year reservoir level was 21.3 feet below the top of conservation.

**Swanson Lake --** The annual inflow of 19,296 AF to Swanson Lake was between the dry-year and normal-year forecast. The lake level began the year at elevation 2735.00 feet and peaked at 2738.49 feet (13.5 feet below the top of conservation) on June 7th. The reservoir level gradually decreased to an elevation of 2736.58 feet on October 13th. Due to the extremely low water supply available, no water was released from Swanson Lake. Irrigation diversions were not made into Meeker-Driftwood or Bartley Canals. This was the sixth consecutive year that the district did not deliver water from the Meeker-Driftwood Canal. At the end of the year the reservoir level was 14.8 feet below the top of conservation at 2737.16 feet.

**Hugh Butler Lake --** The annual inflow of 13,743 AF into Hugh Butler Lake was between the dry-year and normal-year forecast. The reservoir level at the first of the year was 2574.18 ft, 7.6 feet below the top of conservation. May precipitation totaled 8.32 inches at the dam, the most ever recorded for the month. The reservoir level gradually increased peaking at 2577.44 feet (4.4 feet below full) on June 27th. Irrigation releases began on June 22nd and ended on September 4th dropping the pool level 2.4 feet. The level of Hugh Butler Lake at the end of the year was 6.5 feet below the top of conservation.

**Harry Strunk Lake --** The inflow of 69,752 AF was above the wet-year forecast. The reservoir level at the beginning of 2008 was only .3 foot below the top of conservation. Releases were made during early 2008 to maintain a reservoir elevation of approximately .5 foot below the top of conservation. The reservoir filled on April 29th and increased to elevation 2373.83 feet (7.7 feet into flood pool) on May 25th as a result of runoff from storms that occurred above the lake during May 23rd and 24th. Lake inflows exceeded historic highs for the month of May. Uncontrolled releases through the spillway reached over 1000 cfs. The reservoir level dropped from the flood pool on August 2nd. Irrigation releases during July, August and early September reduced the reservoir elevation to 2364.31 feet on September 6th. Harry Strunk Lake was only 0.8 foot below the top of conservation at the end of the year.

**Keith Sebelius Lake** -- The total inflow of 14,265 AF was slightly below the wet-year forecast. The reservoir level was 16.2 feet below the top of conservation pool at the first of the year. A storm system on May 22nd and 23rd produced significant rainfall across the region. Norton Dam recorded 5.05 inches over the two day period. The lake level increased 6.8 feet as a result of the runoff and peaked at elevation 2295.87 feet on June 4th (8.4 feet below the top of conservation). Irrigation releases were made during July and August reducing the lake level by 2.5 feet. In July of 2007, the Kansas Department of Wildlife and Parks and the Almena Irrigation District entered into a Memorandum of Agreement (MOA) to maintain a minimum pool elevation in the reservoir for ten years. Norton Dam recorded 8.94 inches of precipitation during October, the greatest ever recorded for the month. The lake level ended the year at elevation 2293.86 feet (10.4 feet below the top of conservation).

**Harlan County Lake** -- Harlan County Lake began 2008 approximately 4.7 feet below the top of conservation pool, at 1941.08 feet. Runoff from late May storms increased the reservoir level 4.2 feet. Flood releases began on May 28th and continued through June 25th at which time irrigation demands exceeded inflows and the lake level reached 1948.0 feet. The available irrigation supply from Harlan County Lake on June 30th was 210,000 AF, indicating that "Water Short Year Administration" would not be in effect. Irrigation releases continued through September 5th reducing the lake level to elevation 1945.64 feet. Harlan County Dam recorded 8.60 inches of precipitation during October, the greatest ever recorded for the month. Runoff from the October storms increased the lake level to 1947.31 feet on November 3rd. Flood releases began on November 3rd and were made throughout the remainder of the year to reduce lake levels back to the top of conservation. The reservoir elevation was 1946.12 ft (0.4 foot in the flood pool) on December 31, 2008. A ten year summary of Harlan County Lake operations is shown on Table 3.

**Lovewell Reservoir** -- The reservoir elevation at the beginning of 2008 was 1.5 feet below the top of conservation pool. The pool level gradually increased, filling the conservation capacity on April 26th (1582.6 feet). Storms in late May produced significant runoff that raised the elevation 3.3 feet. The reservoir level peaked at 1587.31 feet on June 4th (4.7 feet into the flood pool). A flood release was made from May 28th through June 25th, and again from July 21st through July 31st. Irrigation releases to the canal began on May 27th and continued throughout the irrigation season. Releases were also made to the creek from August 14th through September 15th to lower the reservoir pool for maintenance activities. The reservoir refilled to elevation 1582.38 feet by late October when a release resumed to the creek. The release continued into late December. The reservoir level at the end of the year was 1581.13 feet (1.5 feet below the top of conservation).

## Current Operations

Table 2 shows a summary of data for the first seven months of 2009.

**Bonny Reservoir –** The reservoir level is approximately 21 feet below the top of conservation. Bonny Dam has recorded 16.66 inches of precipitation during the first seven months of the year (143% of average). Reservoir inflow for the period is the greatest since 2001, but only half of the historic average. Releases have been made into Hale Ditch and also for compact compliance. The reservoir level is .2 foot less than last year at this time.

**Swanson Lake –** The lake level is **c**urrently 14 feet from full and is nearly the same as last year at this time. Precipitation for the year is 126% of normal (17.06 inches). Frenchman-Cambridge Irrigation District is irrigating from Swanson Lake for the first time since 2002.

**Enders Reservoir -** The reservoir level is currently 21 feet below full and .4 foot below last year at this time. Enders Dam recorded 20.88 inches of precipitation during the first seven months of the year. Normal precipitation during this period is 12.92 inches. Due to the water supply shortage, H&RW Irrigation District is not irrigating for the eighth year in a row. This is the sixth consecutive year that Frenchman-Valley Irrigation District has not received storage water for irrigation.

**Hugh Butler Lake –** The lake level is currently 8 feet below full. The precipitation total so far this year is 15.09 inches (118% of normal). The lake level is 2 feet below last year at this time. Irrigation releases are being made from Hugh Butler Lake this year for diversions into Red Willow and Bartley Canals.

**Harry Strunk Lake –** The lake level is currently 3 feet below the top of conservation. The lake filled on April 26th with the reservoir level peaking on June 16th at 1.2 feet into the flood pool. Reservoir releases for the seasoning of Cambridge Canal began on May 19th. Precipitation at the dam during the first seven months of the year was 17.13 inches (124% of normal).

**Keith Sebelius Lake –** Currently 10.4 feet below full. Lake level is .6 foot above last year at this time. Irrigation releases began on July 8th with a very limited delivery expected in 2009. Precipitation at the dam during the first seven months of the year was 15.47 inches (96% of normal).

**Harlan County Lake –** The current water surface level is approximately one foot below full. The lake level is .5 foot below last year at this time. Harlan County Dam has recorded 15.77 inches of precipitation so far this year. The available irrigation supply from Harlan County Lake on June 30th was 156,000 AF, indicating that "Water-Short Year Administration" would not be in effect. Irrigation releases began on June 25th.

**Lovewell Reservoir –** The reservoir level is currently 3.5 feet below the top of conservation and approximately 2 feet below last years elevation at this time. Lovewell Dam recorded only 12.24 inches of precipitation during the first seven months of the year (71% of average). The Corps of Engineers allowed storing 5 percent in the flood pool (elevation 1583.4 feet) just prior to the irrigation season. Irrigation releases began on May 18th.

## Other Items

### Inspections

Comprehensive Facility Reviews were conducted at Bonny, Cedar Bluff, Kirwin, Norton, and Webster Dams during 2008. Annual Site Inspections were conducted at all other NKAO facilities in 2008.

### Safety of Dams

Norton Dam – Construction of a filter drain system to collect seepage through the left abutment and the outlet works was completed in the fall of 2007. Another minor seep was discovered during drain construction that will require some additional remediation. Reclamation is currently evaluating options and anticipates scheduling construction activities for the late summer or early fall of 2009.

Enders Dam - A small depression was discovered near the outlet works stilling basin in August 2004. The depression has been attributed to a failure of the basin underdrain system. Reclamation installed additional instrumentation in the area and has collected additional data on water levels around the basin. Additional weight was added to the basin in June 2007 to increase the stability of the outlet basin after a 10 ft rise in lake elevation. In the fall of 2008, Reclamation completed a drain grouting operation and installed temporary drainage features to correct the problem. Installation of a permanent groundwater control system is scheduled for the spring of 2010.

Red Willow Dam – The river outlet works stilling basin was dewatered for inspection in July 2005. During the inspection a small quantity of fine clean sand was discovered near the right basin under drain system outlet indicating that material was being transported through the basin underdrain system. Plugs were installed in the drain outlets to prevent any further movement of material. Final design and implementation of selected alternatives to address the problem is scheduled to be completed in 2010.

Trenton Dam - The left abutment embankment toe drain was reported damaged near the outfall in the 2004 CFR examination and as a result an O&M recommendation to repair the pipe outfall was made. Subsequently, during the 2005 Annual Site Inspection a depression was discovered left of the spillway just left of the left abutment embankment toe drain alignment. In FY09 Reclamation plans to evaluate alternatives to modify the existing toe drain, allowing access for video inspection equipment.

<u>Emergency Management Operations</u>

Orientation Meetings are held annually to discuss the Emergency Action Plan (EAP) for all NKAO dams. Federal, state, county and local organizations that would be impacted by an emergency at NKAO dams are invited to attend. Radios which contact the downstream 24-hour warning points are tested monthly.

Functional exercises were held for the Box Butte Dam Emergency Action Plan (EAP), Trenton Dam EAP, Red Willow Dam EAP, Medicine Creek Dam EAP and Lovewell Dam EAP in 2008.

<u>Standing Operating Procedures</u>

All NKAO SOP’s have been updated based on the current guidelines.

<u>Water Conservation</u>

Reclamation continues to provide technical and financial assistance for water conservation projects through the Water Conservation Field Services Program, the Water 2025 Challenge Grant Program, and the new Water for American Program. Past assistance has included on-farm irrigation efficiency demonstrations, improved water measurement, replacement of open ditch laterals with buried pipe, remote monitoring installations, canal automation projects, and educational and training opportunities for local, state, and other federal water management personnel.

<u>Security</u>

Security at all Reclamation dams has increased since September 11, 2001. Site security plans for all fifteen NKAO facilities have been finalized and published. In 2008 NKAO and RO personnel completed a Periodic Security Review of Glen Elder Dam. FY09 Periodic Security Reviews are scheduled for Bonny, Cedar Bluff, Kirwin, Norton, and Webster Dams.

**TABLE 1**
**NEBRASKA-KANSAS PROJECTS**
**Summary of Precipitation, Reservoir Storage and Inflows**
**CALENDAR YEAR 2008**

| Reservoir | Total Precip. Inches | Percent Of Average % | Storage 12-31-07 AF | Storage 12-31-08 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 | 14.56 | 86 | 5,895 | 6,375 | 480 | 9,572 | JUN 25 | 3,608 | AUG 14 | 11,286 | 73 |
| Merritt | 21.35 | 104 | 60,831 | 61,100 | 269 | 66,959 | JUN 1 | 41,554 | SEP 7 | 182,099 | 99 |
| Calamus | 27.82 | 115 | 111,215 | 109,027 | -2,188 | 128,582 | MAY 27 | 73,324 | SEP 16 | 266,651 | 102 |
| Davis Creek | 35.85 | 145 | 9,684 | 10,126 | 442 | 30,177 | JUL 8 | 8,791 | APR 23 | 46,785 | 97 |
| Bonny | 22.20 | 130 | 7,947 | 9,276 | 1,329 | 10,460 | AUG 15 | 7,675 | OCT 9 | 12,159 | 102 |
| Enders | 22.45 | 118 | 16,885 | 15,368 | -1,517 | 17,134 | JUN 8 | 14,973 | OCT 11 | 4,770 | 37 |
| Swanson | 22.93 | 115 | 45,211 | 51,989 | 6,778 | 56,388 | JUN 7 | 44,427 | JAN 1 | 19,296 | 55 |
| Hugh Butler | 29.38 | 150 | 24,993 | 26,451 | 1,458 | 29,513 | JUN 27 | 24,993 | JAN 1 | 13,743 | 94 |
| Harry Strunk | 28.89 | 140 | 34,153 | 33,151 | -1,002 | 51,158 | MAY 25 | 31,502 | SEP 5 | 69,752 | 192 |
| Keith Sebelius | 33.74 | 138 | 9,732 | 16,313 | 6,581 | 19,166 | JUN 4 | 9,722 | JAN 1 | 14,265 | 183 |
| Harlan County | 30.31 | 133 | 255,393 | 319,311 | 63,918 | 357,333 | JUN 6 | 255,637 | JAN 1 | 224,841 | 184 |
| Lovewell | 34.10 | 124 | 31,273 | 31,438 | 165 | 51,414 | JUN 4 | 20,187 | SEP 17 | 90,852 | 142 |
| Kirwin | 40.49 | 172 | 24,096 | 88,425 | 64,329 | 88,615 | DEC 31 | 24,077 | JAN 2 | 85,559 | 387 |
| Webster | 36.39 | 154 | 17,720 | 68,885 | 51,165 | 68,885 | DEC 31 | 17,686 | JAN 2 | 59,868 | 318 |
| Waconda | 31.11 | 122 | 142,983 | 206,420 | 63,437 | 319,346 | OCT 27 | 142,713 | JAN 3 | 407,850 | 299 |
| Cedar Bluff | 26.84 | 128 | 86,517 | 83,542 | -2,975 | 89,201 | JUN 3 | 83,035 | DEC 27 | 12,383 | 80 |

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

**JANUARY - JULY 2009**

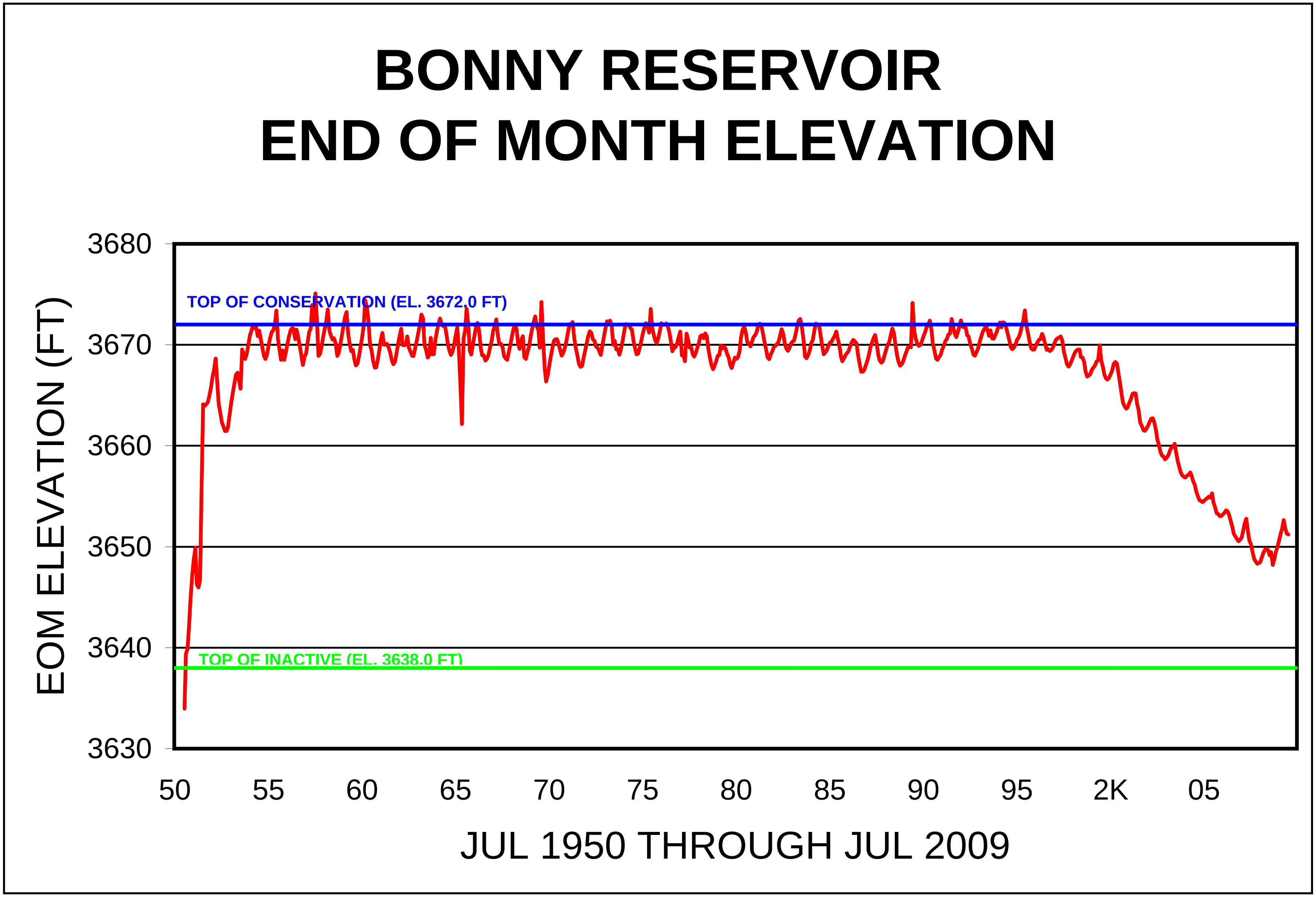
| Reservoir | Precip. Inches | Percent Of Average % | Storage 7/31/2008 AF | Storage 7/31/2009 AF | Gain or Loss AF | Inflow AF | Percent Of Most Probable % |
|---|---|---|---|---|---|---|---|
| Bonny | 16.66 | 143 | 8,558 | 10,420 | 1,862 | 7,578 | 89 |
| Enders | 20.88 | 162 | 16,191 | 15,879 | (312) | 4,283 | 56 |
| Swanson | 17.06 | 126 | 53,986 | 57,813 | 3,827 | 27,833 | 99 |
| Hugh Butler | 15.09 | 118 | 26,506 | 26,044 | (462) | 6,898 | 72 |
| Harry Strunk | 17.13 | 124 | 34,942 | 32,471 | (2,471) | 26,726 | 110 |
| Keith Sebelius | 15.47 | 96 | 16,996 | 16,421 | (575) | 4,463 | 77 |
| Harlan County | 15.77 | 106 | 319,446 | 312,259 | (7,187) | 78,555 | 90 |
| Lovewell | 12.24 | 71 | 35,576 | 28,255 | (7,321) | 25,324 | 100 |
| Kirwin | 17.35 | 115 | 57,908 | 100,092 | 42,184 | 56,641 | 343 |
| Webster | 14.39 | 94 | 39,609 | 83,874 | 44,265 | 45,651 | 313 |
| Waconda | 12.48 | 77 | 225,518 | 219,798 | (5,720) | 156,232 | 151 |
| Cedar Bluff | 10.82 | 78 | 86,436 | 80,725 | (5,711) | 6,126 | 56 |

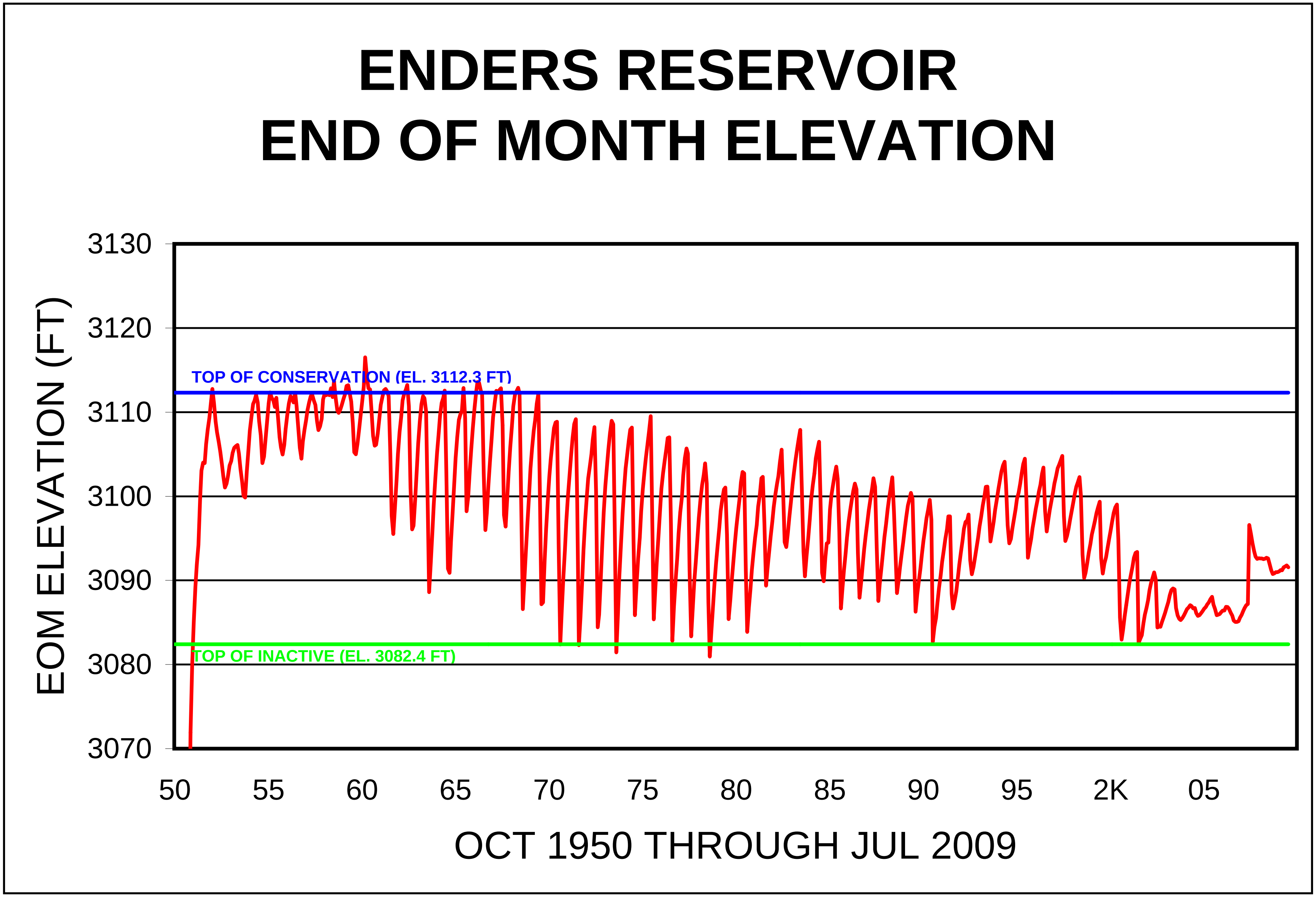
## HARLAN COUNTY LAKE

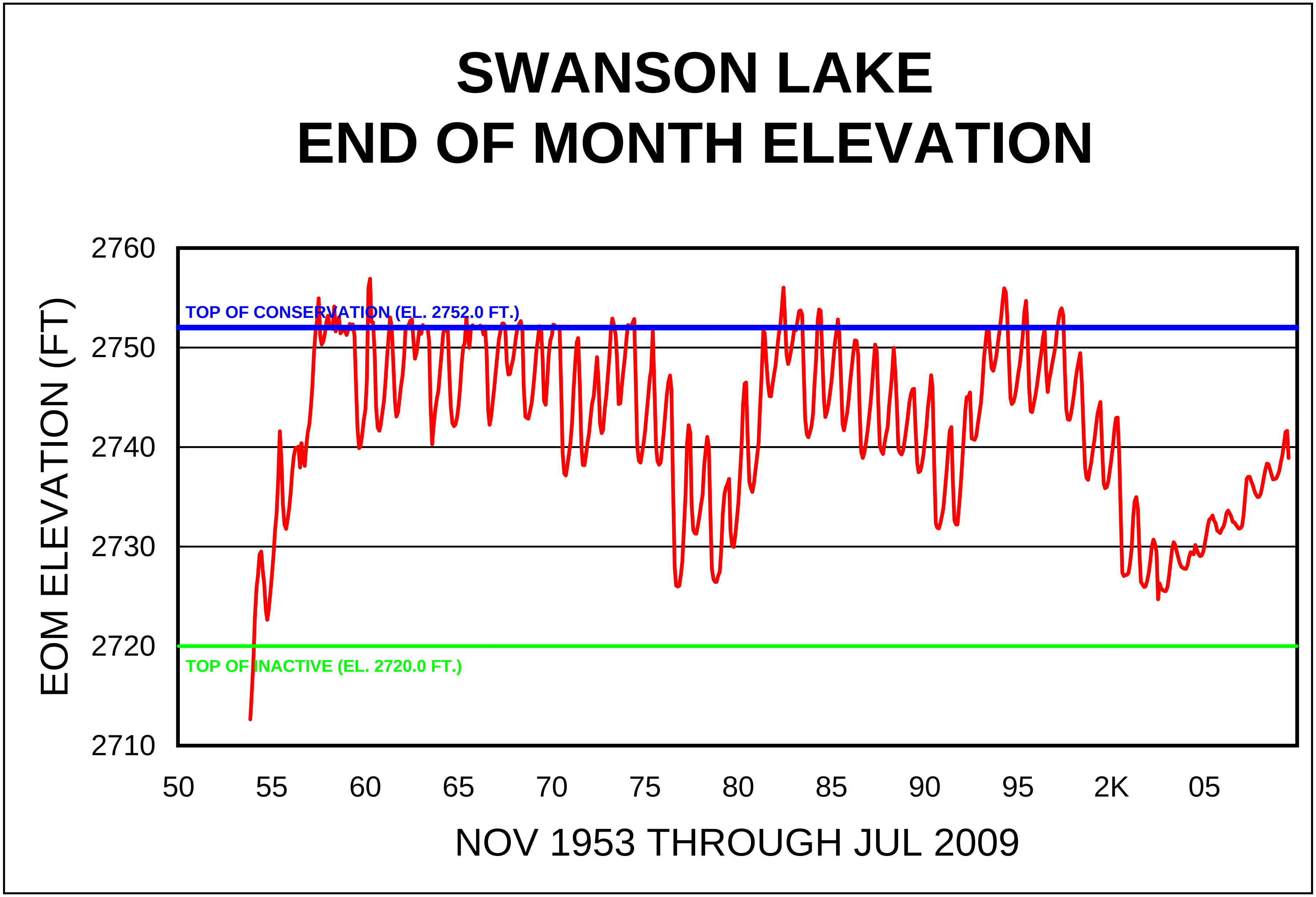
| Year | Inflow (AF) | Outflow (AF) | Gross Evap. (AF) | Precip. (Inches) | Precip. (% of Average) (22.76 inches) | Rep. Basin Reclamation Dams (% of Average) | End of Year Content (AF) | **Projected Irrig. Water Supply On June 30th (AF)** |
|---|---|---|---|---|---|---|---|---|
| 1999 | 164,141 | 99,304 | 42,472 | 24.74 | 109% | 95% | 292,312 | **186,700** |
| 2000 | 134,191 | 166,484 | 45,006 | 23.20 | 102% | 87% | 215,004 | **174,400** |
| 2001 | 157,844 | 87,346 | 40,833 | 27.97 | 123% | 109% | 242,853 | **152,600** |
| 2002 | 60,094 | 98,518 | 43,988 | 16.86 | 74% | 60% | 160,463 | **116,100** |
| 2003 | 48,430 | 51,237 | 34,307 | 16.70 | 73% | 93% | 113,346 | **62,000** |
| 2004 | 25,099 | 0 | 30,601 | 22.83 | 100% | 111% | 107,050 | **0** |
| 2005 | 53,682 | 0 | 32,620 | 22.51 | 99% | 107% | 128,111 | **14,100** |
| 2006 | 30,077 | 12,280 | 29,609 | 20.62 | 91% | 101% | 116,299 | **14,400** |
| 2007 | 198,528 | 21,237 | 38,197 | 26.92 | 118% | 114% | 255,393 | **111,700** |
| 2008 | 224,841 | 114,938 | 45,985 | 30.31 | 133% | 131% | 319,311 | **210,000** |

*NOTE: On June 30, 2009 Projected Irrig. Water Supply was 156,000 AF.

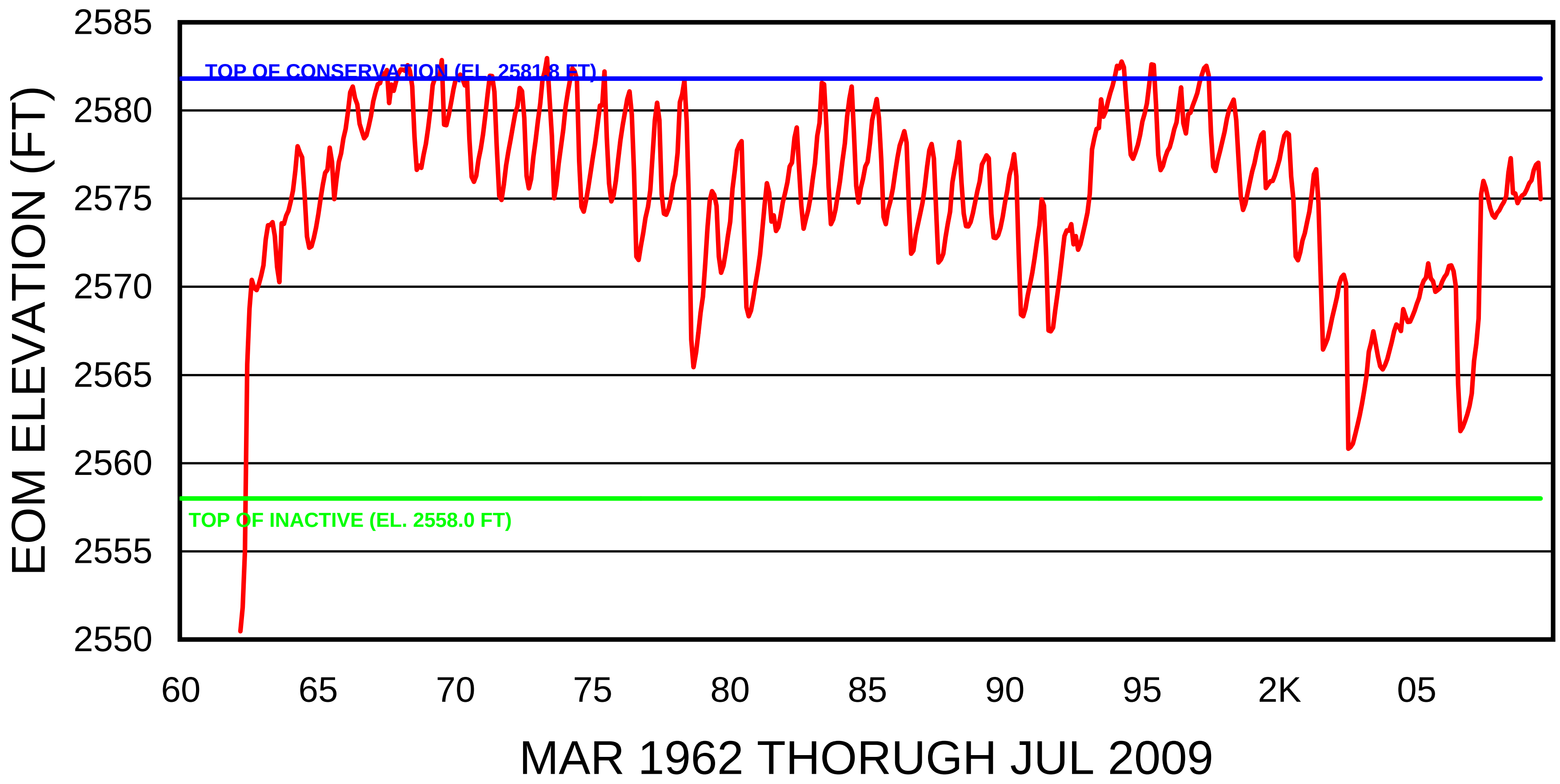
RECLAMATION
*Managing Water in the West*


BONNY RESERVOIR
END OF MONTH ELEVATION
TOP OF CONSERVATION (EL. 3672.0 FT)
TOP OF INACTIVE (EL. 3638.0 FT)
EOM ELEVATION (FT)
3680
3670
3660
3650
3640
3630
50
55
60
65
70
75
80
85
90
95
2K
05
JUL 1950 THROUGH JUL 2009

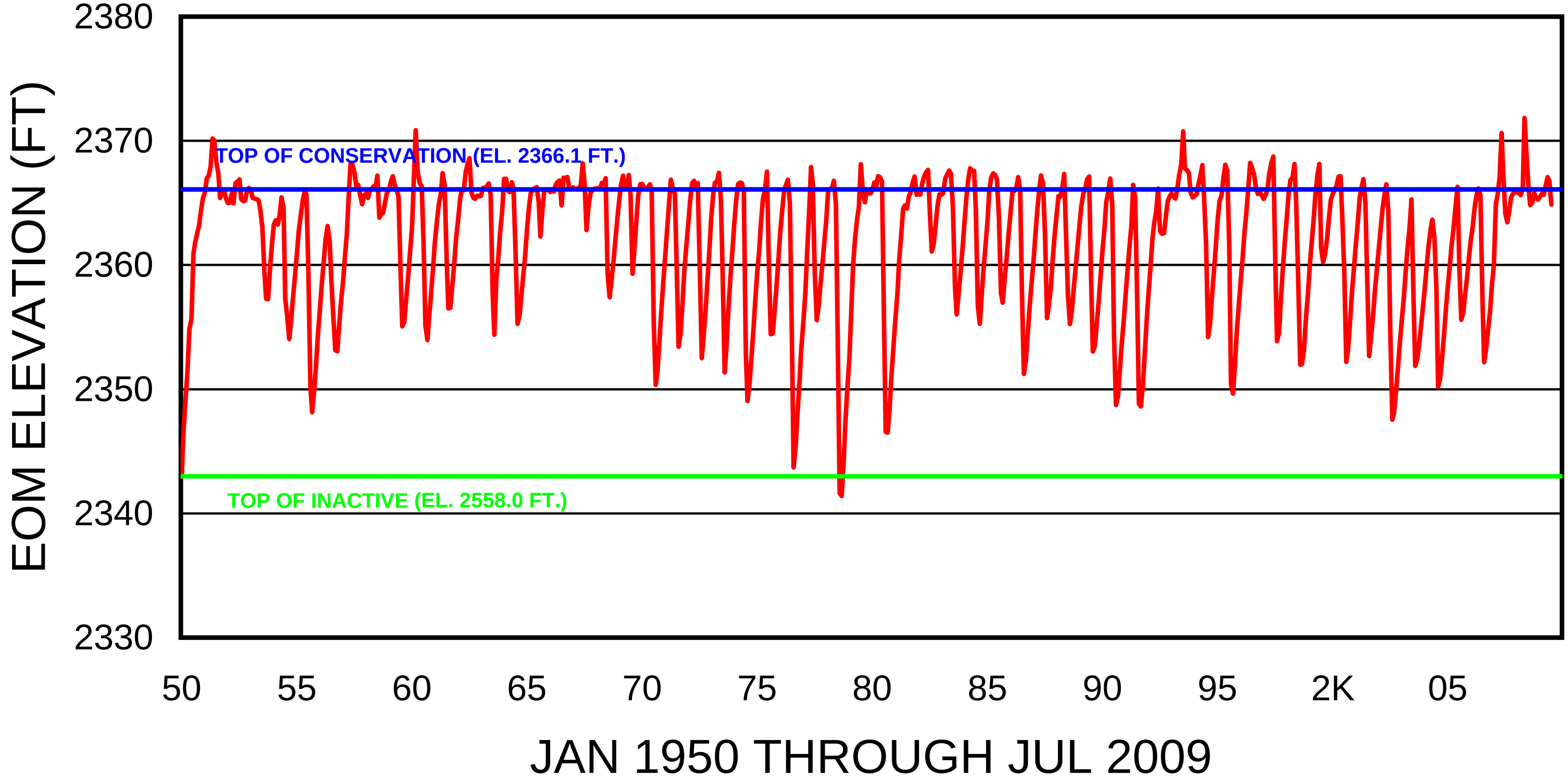

ENDERS RESERVOIR
END OF MONTH ELEVATION
EOM ELEVATION (FT)
3130
3120
3110
3100
3090
3080
3070
TOP OF CONSERVATION (EL. 3112.3 FT)
TOP OF INACTIVE (EL. 3082.4 FT)
50
55
60
65
70
75
80
85
90
95
2K
05
OCT 1950 THROUGH JUL 2009

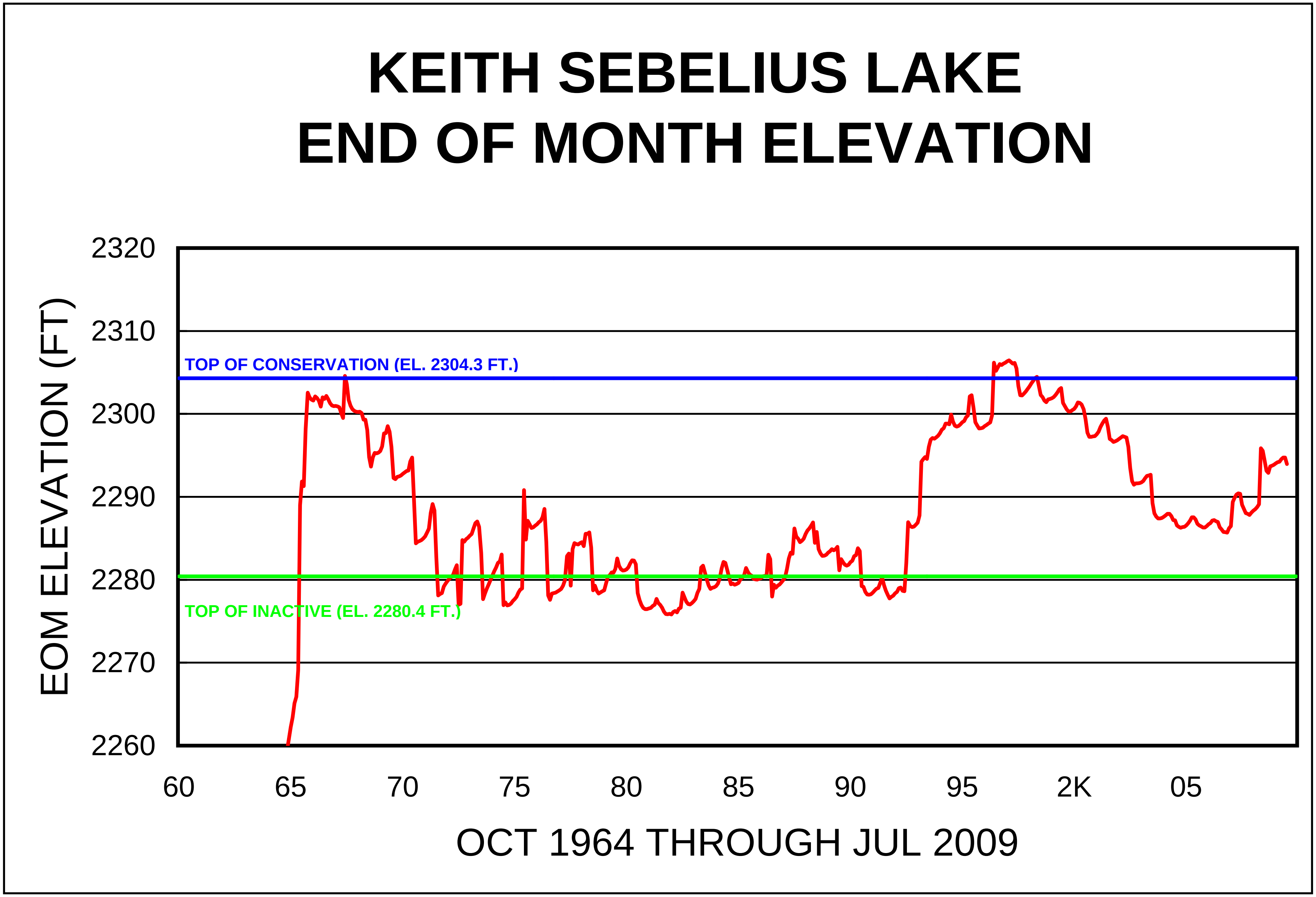

SWANSON LAKE
END OF MONTH ELEVATION
EOM ELEVATION (FT)
2760
2750
2740
2730
2720
2710
TOP OF CONSERVATION (EL. 2752.0 FT.)
TOP OF INACTIVE (EL. 2720.0 FT.)
50
55
60
65
70
75
80
85
90
95
2K
05
NOV 1953 THROUGH JUL 2009

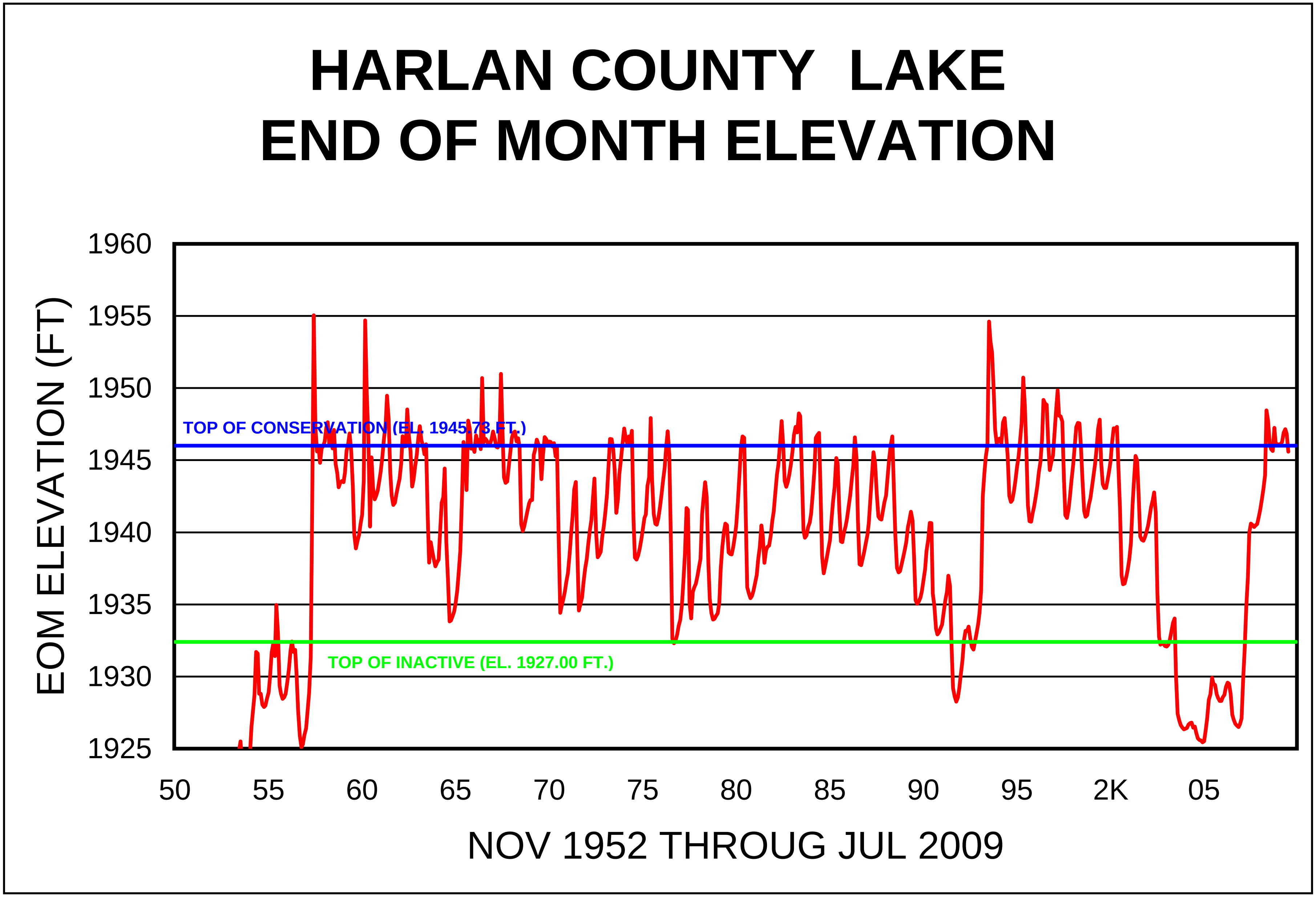
# HUGH BUTLER LAKE
# END OF MONTH ELEVATION



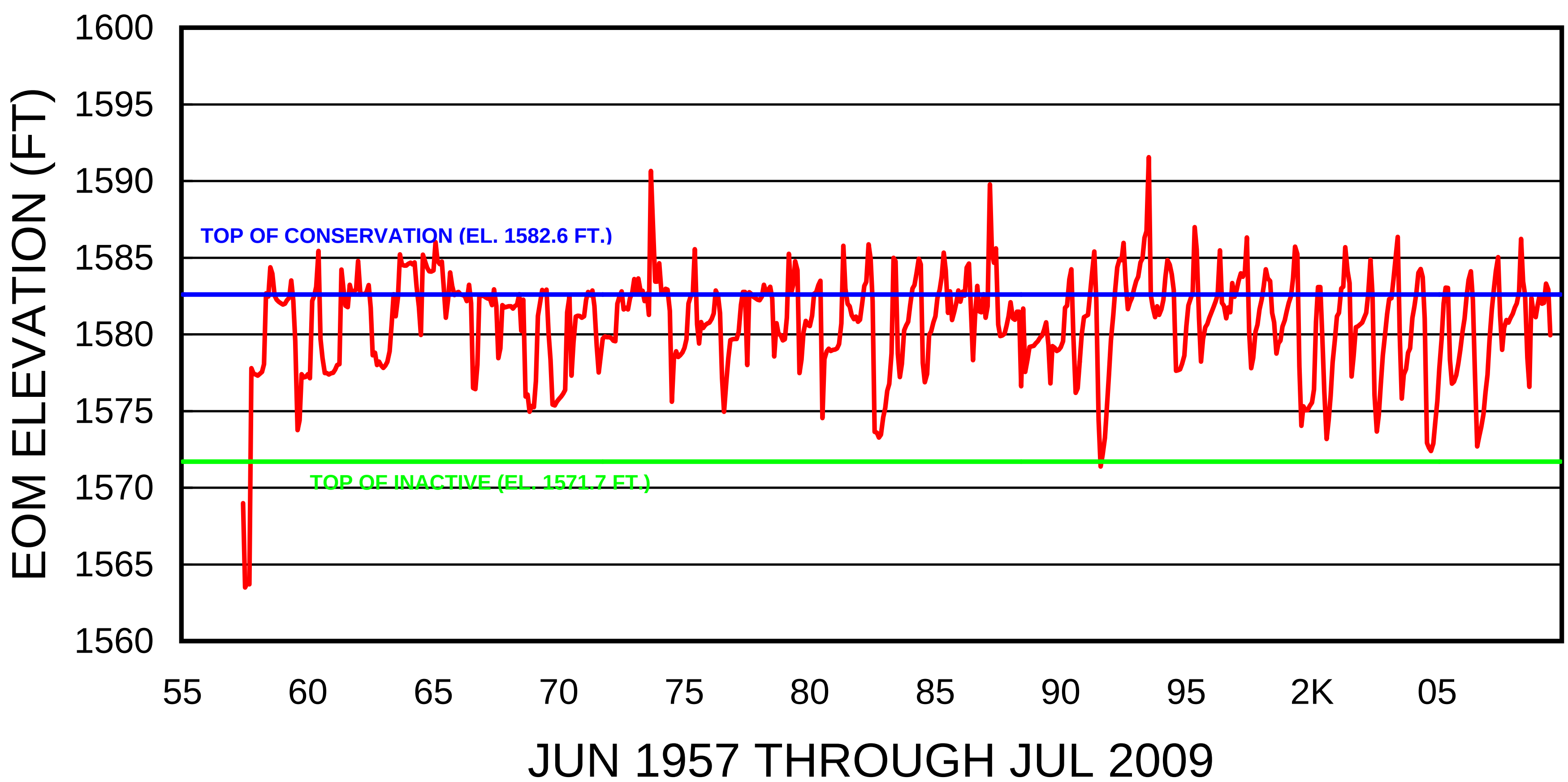
# HARRY STRUNK LAKE
# END OF MONTH ELEVATION




KEITH SEBELIUS LAKE
END OF MONTH ELEVATION
EOM ELEVATION (FT)
2320
2310
2300
2290
2280
2270
2260
TOP OF CONSERVATION (EL. 2304.3 FT.)
TOP OF INACTIVE (EL. 2280.4 FT.)
60
65
70
75
80
85
90
95
2K
05
OCT 1964 THROUGH JUL 2009


HARLAN COUNTY LAKE
END OF MONTH ELEVATION
EOM ELEVATION (FT)
1960
1955
1950
1945
1940
1935
1930
1925
TOP OF CONSERVATION (EL. 1945.73 FT.)
TOP OF INACTIVE (EL. 1927.00 FT.)
50
55
60
65
70
75
80
85
90
95
2K
05
NOV 1952 THROUG JUL 2009

# LOVEWELL RESERVOIR
# END OF MONTH ELEVATION



# ATTACHMENT H

## U.S. GEOLOGICAL SURVEY REPORT
## FOR THE WATER YEAR 2008

Republican River Compact Meeting
Aug 12, 2009 Lincoln, NE

Streamgaging Summary Report
Water Year 2008

U.S. Geological Survey, WRD
Nebraska Water Science Center

**Republican River Basin streamflow-gaging stations with records published by USGS for water year (WY) 2008**

[DCP, data-collection platform; NDNR, Nebraska Department of Natural Resources; USACE, U.S. Army Corps of Engineers; USBR, U.S. Bureau of Reclamation; USGS, U.S. Geological Survey]

| Station number | Station name | Mean discharge ($ft^3$/s) WY 2008 | Mean discharge ($ft^3$/s) Long-term | WY 2008 as percentage of long-term mean | WY 2008 as rank/years (1 highest) | WYs used for long-term mean | Remarks |
|---|---|---|---|---|---|---|---|
| **USGS Compact stations supported by the National Streamflow Information Program (NSIP)** | | | | | | | |
| 06821500 | Arikaree River at Haigler, Nebr | 2.15 | 17.4 | 12.4% | 70/76 | 1933 - 2008 | |
| 06823000 | North Fork Republican River at Colo-Nebr State Line | 29.0 | 42.6 | 68.1% | 65/73 | 1936 - 2008 | |
| 06823500 | Buffalo Creek near Haigler, Nebr | 2.58 | 6.29 | 41.0% | 66/68 | 1941 - 2008 | |
| 06824000 | Rock Creek at Parks, Nebr | 6.55 | 12.2 | 53.7% | 68/68 | 1941 - 2008 | New record low |
| 06827500 | South Fork Republican River near Benkelman, Nebr | 0.30 | 36.4 | 0.8% | 68/71 | 1938 - 2008 | |
| 06835500 | Frenchman Creek at Culbertson, Nebr | 46.7 | 68.6 | 68.1% | 43/58 | 1951 - 2008 | Since Enders Reservoir |
| 06836500 | Driftwood Creek near McCook, Nebr | 3.57 | 8.64 | 41.3% | 54/62 | 1947 - 2008 | |
| 06838000 | Red Willow Creek near Red Willow, Nebr | 16.5 | 12.6 | 131.0% | 09/47 | 1962 - 2008 | Since Hugh Butler Lake |
| 06847500 | Sappa Creek near Stamford, Nebr (USACE funds DCP) | 7.60 | 40.2 | 18.9% | 45/62 | 1947 - 2008 | |
| 06852500 | Courtland Canal at Nebr-Kans State Line (USBR DCP) | 35.8 | 76.8 | 46.6% | 49/54 | 1955 - 2008 | |
| **USGS stations supported by USGS and/or other Federal or State agencies** | | | | | | | |
| 06837000 | Republican River at McCook, Nebr | 57.7 | 131 | 44.0% | 47/54 | 1955 - 2008 | Funded by USBR, NDNR, and USGS |
| 06844500 | Republican River near Orleans, Nebr | 236 | 235 | 100.4% | 22/61 | 1948 - 2008 | Funded by USACE |
| **NDNR stations with USGS/USACE support for DCP, Web display, review, and publishing** | | | | | | | |
| 06828500 | Republican River at Stratton, Nebr | 19.7 | 98.3 | 20.0% | 55/58 | 1951 - 2008 | |
| 06834000 | Frenchman Creek at Palisade, Nebr | 22.5 | 63.3 | 35.5% | 53/58 | 1951 - 2008 | |
| 06843500 | Republican River at Cambridge, Nebr | 174 | 217 | 80.2% | 35/59 | 1950 - 2008 | Since Harry Strunk Lake |
| 06853020 | Republican River at Guide Rock, Nebr | 229 | 266 | 86.1% | 24/58 | 1951 - 2008 | |

EXPLANATION

[green] Indicates that WY 2008 percentage of long-term mean is greater than 100 and that rank is greater than for previous WY
[orange] Indicates that WY 2008 percentage of long-term mean is less than 100 and that rank is less than for previous WY

Online Annual Water Data Reports available at or through
http://wdr.water.usgs.gov
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# ATTACHMENT I

# ENGINEERING COMMITTEE REPORT

# ATTACHMENT J

# CONSERVATION COMMITTEE REPORT

# *REPUBLICAN RIVER BASIN*

## *Fifth Annual Status and Summary Report*

# *STUDY ON THE IMPACTS OF NON-FEDERAL RESERVOIRS AND LAND TERRACING ON BASIN WATER SUPPLIES*

**Prepared by**

**The Republican River Compact Settlement Conservation Committee**
**for**
**The Republican River Compact Administration**

**August 7, 2009**

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## EXECUTIVE SUMMARY

Kansas, Nebraska and Colorado agreed to and the United States Supreme Court approved the Final Settlement Stipulation to settle the Kansas v. Nebraska and Colorado litigation. The Stipulation required a study to determine the quantitative effects of Non-Federal Reservoirs and land terracing practices on water supplies in the Republican River Basin above Hardy, Nebraska.

The study relies primarily on soil water balance models to simulate the impact of terraces and Non-Federal Reservoirs on surface water supply. There are 716 Non-Federal Reservoirs and 2,309,559 acres of terraced land in the study area. The water balance models uses a combination of existing meteorological, soils, and land use data, and data collected as part of these studies specific to small reservoirs and land terraces as input to the water balance models. Various data were collected at 32 reservoir sites and 5 land terraced sites from about September, 2004 through spring 2009.

The design capacity and general condition of the terraces play a significant role in determining the ultimate amount of retention and the apportionment of the retained water. We conducted a study to determine the storage conditions of a sampling of terraces across the basin. A total of 167 fields were surveyed. Based on the fields where the type of terrace has been determined at this time, about eighty percent of the fields are broadbased terraces and twenty percent are flat channel (*i.e.*, conservation bench terraces). The median runoff storage for the broadbased terraces is about 0.5 inches while the flat channel (conservation bench) terraces store about 1.4 inches of runoff.

The Water Erosion Prediction Project (WEPP) model has the ability to simulate changes of infiltration rates. We utilized this ability to predict the variability of hydraulic conductivity within an eco-fallow cropping rotation. A conversion is made to relate hydraulic conductivity to curve numbers and therefore the temporal variability of curve numbers can also be simulated. These simulated values were compared to hydraulic conductivities and curve numbers calculated from field measurements taken at the five locations in southwest Nebraska and northwest Kansas. The WEPP model predicted hydraulic conductivity to range from 4 cm/hr (1.57 inches/hr) following tillage to less than 0.5 cm/hr (0.20 inches/hr) when the soil was frozen. When no tillage had occurred, hydraulic conductivity was approximately 2 cm/hr (0.79 inches/hr). Curve numbers related to the simulated hydraulic conductivity ranged from 60 following tillage to 90 with frozen soil. The curve numbers were approximately 75 during the growing season when no recent tillage had occurred.

The Root Zone Water Quality Model (RZWQM) was used to model the hydrology of the field sites. Thirty-year simulations were carried out at the Colby and Norton, Kansas field sites. Broadbase and conservation bench terraces were modeled at each site. The long-term simulation modeling used the parameters determined through calibration. Over the course of the simulations, 90% or more of the contributing slope runoff was captured by the Colby and Norton broadbase terraces and conservation bench terraces. More ET and deep percolation consistently occurred in the terrace channels than on the contributing slope. The runoff water that was retained on the field as a result of the terraces was used primarily for ET and deep percolation.

At Colby, 80.3% of the runon water retained by the broadbase terrace and 79.4% of the runon water retained by the CBT deep percolated whereas 17.1% of the broadbase terrace retained water and 19.0% of the CBT retained water was used for ET. At Norton, 45.5% of the runon water retained by the broadbase terrace and 47.4% of the runon water retained by the CBT deep percolated while 42.4% of the broadbase terrace retained water and 47.7% of the CBT retained water was used for ET. Deep percolation occurred primarily as a result of specific precipitation events. The ET within the eco-fallow cropping rotation is relatively evenly distributed among the two fallow periods and the wheat and row crop growing periods.

A reservoir water balance simulation model was developed and consists of a gross seepage module and a net seepage module. Data collected a three of the reservoirs were used to calibrate and verify the model. It was observed that contribution to streamflow without the reservoir was significant. With the reservoir in place, streamflow from the reservoir watershed was reduced by 82% to 96%. Of water retained at the reservoir locations during the 4-year study period, from 91% at one reservoir to 94% at another reservoir became gross seepage. The overall result is then that 86% of the retained inflow at one of the reservoirs was accounted for as net seepage. A simple prediction technique was developed to estimate the conversion of reservoir inflow to the amount of overflow and net seepage for other reservoirs in the basin. The characteristics of a reservoir that are important for estimating overflow and net seepage are approximate clay content in the soils at the reservoir site, the average reservoir depth, and the annual moisture deficit defined as the average annual evaporation minus the average annual precipitation.

The estimated net effects of the terraces for the Prairie Dog Creek sub-basin have been refined from previous study estimates. The estimated net effects of the terraces in the Prairie Dog Creek above Keith Sebelius Lake are that streamflow from this part of the sub-basin is reduced by 1,900 acre-feet per year and the net groundwater recharge is reduced by 300 acre-feet per year. The terrace inventory resulted in reducing the amount of runoff that is retained in the terrace channel. Also, observations about transmission losses prompted an increase in losses, especially for the upper portions of this basin.

The study team has identified the tasks for completion of the study so the preliminary results of the study can be transmitted to the RRCA by letter no latter than January 15, 2010.

## INTRODUCTION

On May 26, 1998, Kansas filed suit in the U.S. Supreme Court complaining that the State of Nebraska had violated the Republican River Compact. On January 19, 1999, the Court accepted the lawsuit and assigned Vincent L. McKusick as Special Master. The three original parties to the Compact; Kansas, Nebraska and Colorado became parties to the case and the United States entered the case as *amicus curiae*. In December 2001, the Special Master granted a stay to allow the parties time to attempt to negotiate a settlement. On March 28, 2002, the negotiation teams for Kansas, Nebraska and Colorado signed a Statement of Settlement stating they had negotiated an Agreement in Principle to settle the Kansas v. Nebraska and Colorado litigation. On December 15, 2002, the states completed a Final Settlement Stipulation and the Special Master approved the stipulation in February 2003. The United States Supreme Court, by decree dated May 19, 2003, approved the Final Settlement Stipulation.

The Stipulation required the States, in cooperation with the United States, form a Conservation Committee by January 31, 2003. Further the stipulation required the Conservation Committee to develop a proposed study plan by April 30, 2004, to determine the quantitative effects of Non-Federal Reservoirs and land terracing practices on water supplies in the Republican River Basin above Hardy, Nebraska, including whether such effects can be determined for each of the Designated Drainage Basins (refer to Section VI of the Final Settlement Stipulation).

In January of 2003 each state and the United States appointed individuals to represent them on the Conservation Committee. The Conservation Committee members participated in a series of meeting and conference calls to develop a study plan to quantify the effects of Non-Federal Reservoirs and land terracing practices on water supplies in the Republican River Basin above Hardy, Nebraska. The study plan was transmitted to members of the Republican River Compact Administration (RRCA) on April 30, 2004. A Memorandum of Understanding was also provided with the study plan to identify the responsibilities of each party for funding and completing the study.

Representatives of the Conservation Committee attended the annual Republican River Compact meeting in Burlington, Colorado, on June 8 and 9, 2004, and presented the study plan to the RRCA. The RRCA verbally approved the study plan during the meeting and the signature process for the Memorandum of Understanding formally approving the study proposal was completed on July 27, 2004.

## STUDY PLAN SUMMARY

The study relies primarily on soil water balance models to simulate the impact of terraces and Non-Federal Reservoirs on surface water supply. The study consists of four primary components: 1. Evaluation and modification of existing models, 2. Development of databases, 3. On-the-ground verification, and 4. Application of the water balance and GIS models. A thorough description of the study plan is provided in the Republican River Basin Study Plan proposal on the Impacts of Non-Federal Reservoirs and Land Terracing on Basin Water Supplies dated April 28, 2004.

**PROGRESS SINCE APPROVAL OF STUDY PLAN**

A status report describing the progress made in completing the four primary phases of the study follows:

1. Evaluation and Modification of the Existing Models: KSU is serving as the lead for the portion of the Research Project related to the development of the selected water balance model and for its application to land terraces and Non-Federal Reservoirs in the basin.

The model consists of four parts:

1) A GIS pre-processor framework to define geographical areas, extract characteristics of the areas from GIS coverages such as soils, land use, extent of terracing, applicable meteorological stations, and other information. This pre-processor will generate input data for the water budget simulation model hydrologic response units (HRUs). This phase is under development at UNL.

2) A unit area water budget simulation model capable of receiving input data for individual land-use, soil, conservation practices, and location combinations throughout the basin that will operate on a daily basis for at least 25 years to produce output of daily, monthly and annual water budgets for each applicable HRU. The operation of a terraced field will be done as an HRU as described later in detail. This model is under final development and calibration with recently-obtained data from the five field sites.

*3)* A water budget simulation model of a small reservoir using daily outputs from the applicable HRUs that represent its watershed conditions and reservoir stage-storage-area-discharge relationships as well as estimated seepage loss rate under the surface area of the reservoir. This model has been developed and tested to simulate the operation of a small reservoir on a daily basis to estimate overflow and net seepage from the reservoir. The model has been calibrated and tested on three reservoirs.

4) A post-processor to combine results from the HRU and reservoir simulation models on an areal basis to produce monthly and annual recharge and runoff amounts from the sub-basin. Finally, a simple percent-per-mile transmission loss factor based upon the flowpath-length within the sub-basin will be used to redistribute runoff into infiltration losses to add to recharge and reduce surface runoff from the sub-basin. Interactions and interfacing for data handling are in process. These aspects have been incorporated into an Excel spreadsheet to provide an overall estimate of these effects on surface runoff and groundwater recharge.

A more detailed discussion of the water balance model and modeling approach was included in the Third and Fourth Annual Status Report and additional information is included in Appendix F of this report.

2. Development of Databases: Each state has completed an inventory of the Non-Federal Reservoirs in their portion of the basin. These inventories include data related to reservoir location, size, date constructed, dam height and other reservoir characteristics. The inventories prepared by each state are included as Appendix A.

   GIS mapping of terraced fields within the Republican River basin has been completed based on 2005 and 2006 aerial photography. Digitized mapping provides a database of location and size of each of the terraced fields in the basin. Maps of the terraced lands in the basin are included as Figure 1 and Figure 2 in Appendix E. The distribution of terraced acres and number of fields by sub-basin is also included in Appendix E.

   Soils data from the SSURGO database have been downloaded for all counties in the Republican River Basin and processed to provide data for input to the POTYLD model. The NRCS Conservation Tillage Information Center (CTIC) database on farming practices has also been reviewed and included in the study database.

   Two types of weather data have been assembled. Data from the automated weather data network (AWDN) operated by the High Plains Regional Climate Center and data from the Colorado Agricultural Meteorology network were used to compute reference crop evapotranspiration using the hourly Penman-Monteith method. Nineteen AWDN stations were used across the Republican River Basin. Data from the stations was filtered to remove periods when solar radiation data indicated sensor malfunction and when the difference between daily minimum temperature and the average daily dew point was greater than four degrees Celsius. The filtered reference crop ET data were used to calibrate the Hargreaves equation for the Great Plains for each month. The Hargreaves method only requires the daily maximum and minimum air temperature to estimate reference crop ET. The calibrated Hargreaves method was then used with data from the Cooperative program operated by National Oceanic and Atmospheric Administration and the National Weather Service (NWS). These data are referred to as the NWS data. These records only include the daily maximum and minimum air temperature and the amount of precipitation received for the day. The data for the NWS stations were downloaded from the High Plains Regional Climate Center. The Hargreaves method was used with these data to develop estimates of reference crop ET for the NWS sites. The NWS data were used because a continuous record of data is available after 1950 for the stations.

   Geodatabases have been developed including the location of terraced lands, the delineation of watershed and subwatershed (HUC-10 level) boundaries and the location of waterways and water bodies using the National Hydrographic Dataset (NHD). This base is used to determine the average flow distance for computing transmission losses and for assigning results from POTYLD simulation of individual weather stations to terraced lands and non-federal reservoirs in each subwatershed.

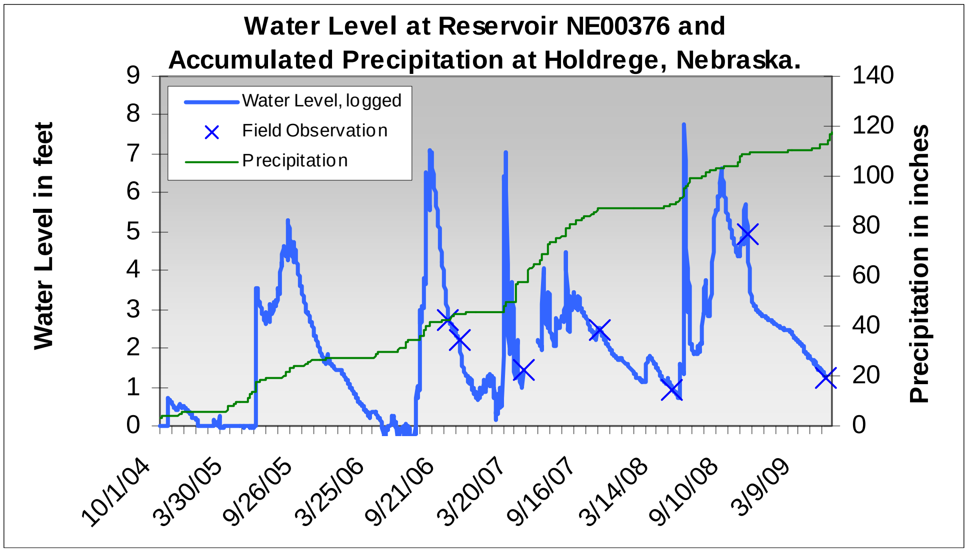
3. On-the-Ground Verification: Initial study efforts were to establish sample monitoring sites in the field for both reservoirs and terraces as a part of the on-the-ground verification. The monitoring sites consist of monitoring at five terrace sites for detailed data collection and monitoring and at 32 reservoir sites for continual remote monitoring and recording of reservoir water levels and water surface area over the study period. Data collection at the reservoir and terrace sites ended during spring 2009.

Reservoirs

Investigation is needed for the non-federal reservoirs to characterize how and when these reservoirs fill and drain. There are 716 non-federal reservoirs in the basin as reported by the States, Appendix A. There are 6 non-federal reservoirs in Colorado, 148 in Kansas, and 562 in Nebraska.

Sample Reservoirs Sites: Colorado, Kansas, and Nebraska selected representative sample reservoir sites for the continuous monitoring of reservoir water level. The sample of 32 reservoir sites was proportioned among the states based on the estimated total number of Non-Federal Reservoirs in the Republican River Basin compared with number of these reservoirs in each respective state. Based on these proportions, 1 reservoir sites were assigned to Colorado, 11 to Kansas, and 20 to Nebraska. The water levels of these reservoirs were monitored from about September 2004 through the spring 2009.

Figure 1 is an example of water level fluctuations for a reservoir in Nebraska and nearby precipitation. This reservoir is located west of Holdrege, Nebraska. The October 2004 through April 2006 precipitation totaled about 28.7 inches, 76 percent of average. Precipitation improved over the next two years. The May 2006 through May 2008 precipitation totaled about 66 inches, nearly 8 inches in April 2007, and 120 percent of average. Precipitation during June 2008 through May 2009 was slightly less than average. Overall, accumulated precipitation for the approximate 41/2 years study period was near average. Maximum storage occurring in the reservoir during the October 2004 through May 2009 observation period was estimated at about 17 acre-feet during May 23, 2008. The reported normal full pool capacity for this reservoir is 20 acre-feet. The estimated drainage area above the reservoir is 1.12 square miles.




Note: Provisional data used for chart.

Figure 1. Example of Water Levels and Accumulated Precipitation for a Reservoir in Nebraska.

Kansas and Nebraska have set up ftp sites to archive the data and to make it available to the Conservation Committee. Kansas has also agreed to archive the data for the Colorado reservoir on their ftp site.

The research team has been concentrating on estimating seepage from the reservoirs, an important, but unquantified part of the daily water balance. Examination of the water level records from the ten sites in Kansas shows that during most of the time between September 2004 when measurements began and April 2007 these reservoirs had little water in them. One reservoir, DPL Hogan near Long Island, Kansas, has had two periods where there was enough good information to allow for estimates of seepage and overflow from the reservoir.

During a 3-hour period on April 5, 2005, overflow occurred. The total amount of runoff on this date was about 6.67 acre-feet (80 acre-inches) or about 1.0 inch from the 82 acre watershed. See Appendix F of the Third and Fourth Annual Status Reports and of this status report for more information about estimating seepage from the non-Federal reservoirs. The overall water balance for the April 5 through August 22, 2005 period is shown in Table 1:

Table 1. – Water Balance for a Non-federal Reservoir in Phillips County, Kansas.

| *Water Balance parameter* | *Water Volume, in acre-feet* | *Water Volume, in acre-inches* |
|---|---|---|
| Runoff | 7.39 | + 88.7 |
| Rainfall | 0.35 | + 4.2 |
| Overflow | 2.33 | - 28.0 |
| Estimated Evaporation | 0.52 | - 6.2 |
| Estimated Seepage | 4.81 | - 57.7 |
| Change in Storage | 0.08 | + 1.0 |

Additional analysis of data on DPL Hogan reservoir through March 2008 shows that it follows the same relationship between daily seepage rate and depth of water as determined from the previous analysis.

For the April 5 through August 22, 2005 period, overflow amounted to 36% of total inflow. Precipitation onto the water surface was small compared to inflow and equaled about 67% of the evaporation from it. Thus, gross seepage was the only way that nearly all of the water retained in the reservoir was lost. Since gross seepage is such an important part of the water budget for these ponds, understanding how much of it might become potential ground-water recharge is important.

Land Terracing

Three separate levels of investigation are needed for land terracing: (1) an overall inventory to determine the number, location and size of all terraced fields in the Republican River basin above Hardy, Nebraska; (2) a survey of a sample set of terraced fields in the basin to acquire information on terrace type, condition and other physical characteristics; and (3) a monitoring program for 5 sample terraced fields for detailed water balance studies.

(1) Terrace Inventory: Mapping of terraced lands is complete based on 2005 and 2006 aerial photography. The mapping identified 2,309,559 acres in the Republican River Basin above Hardy, Nebraska with 220,335 acres in Colorado, 893,263 acres in Kansas, and 1,195,961 acres in Nebraska. Maps of the terraced lands are included as Figure 1 and Figure 2 in Appendix E. Appendix E also contains a tabulation of terraced land acreages by county and sub-basin. The ArcGIS files of the mapping for Colorado and Kansas have been provided to UNL for inclusion in the study database.

(2) Survey of Sample Set of Terraced Fields: The design capacity and general condition of the terraces play a significant role in determining the ultimate amount of retention and the apportionment of the retained water. We conducted a study to determine the storage conditions of a sampling of terraces across the basin. Our initial plan was to randomly select approximately 1% of the fields across the basin to survey to determine the distribution of storage capacity of various types of terraces. We also identified the types of terraces installed across the basin.

The survey was conducted through the use of a survey-grade GPS system that was loaned to the project by the Kansas Department of Water Resources. The GPS system was installed on an all terrain vehicle. The survey-grade GPS provides accurate spatial and vertical resolution of the field topography. The GPS system logs the horizontal location and the elevation within the field. The system was used to define field boundaries and to develop estimates of the storage capacity of two terraces within each field that was surveyed.

A total of 167 fields were surveyed. Eleven fields were surveyed in Colorado, forty-seven in Kansas and 109 fields in Nebraska. Based on the fields where the type of terrace has been determined at this time, about eighty percent of the fields are broadbased terraces and twenty percent are flat channel (*i.e.*, conservation bench terraces). About a quarter of the terraces have been processed and about twenty-five percent are in some phase of processing and/or review. We are currently conducting inspections in the easternmost counties of Nebraska to determine the types of terraces in those counties and their relative condition.

The distribution of the amount of storage available is shown in Figure 2. The results show that the median runoff storage for the broadbased terraces is about 0.5 inches while the flat channel (conservation bench) terraces store about 1.4 inches of runoff on average. The volume of storage was also determined if the terraces had not breached. The ratio of existing to unbreached storage was about 53% for broadbased terraces and 92% for flat channel terraces. Thus it appears that broadbased terraces are much more likely to breach than flat channel terraces. These data are being integrated into the POTYLD modeling phase of the project. A more detailed discussion of the condition survey investigation and results are described in Appendix G.

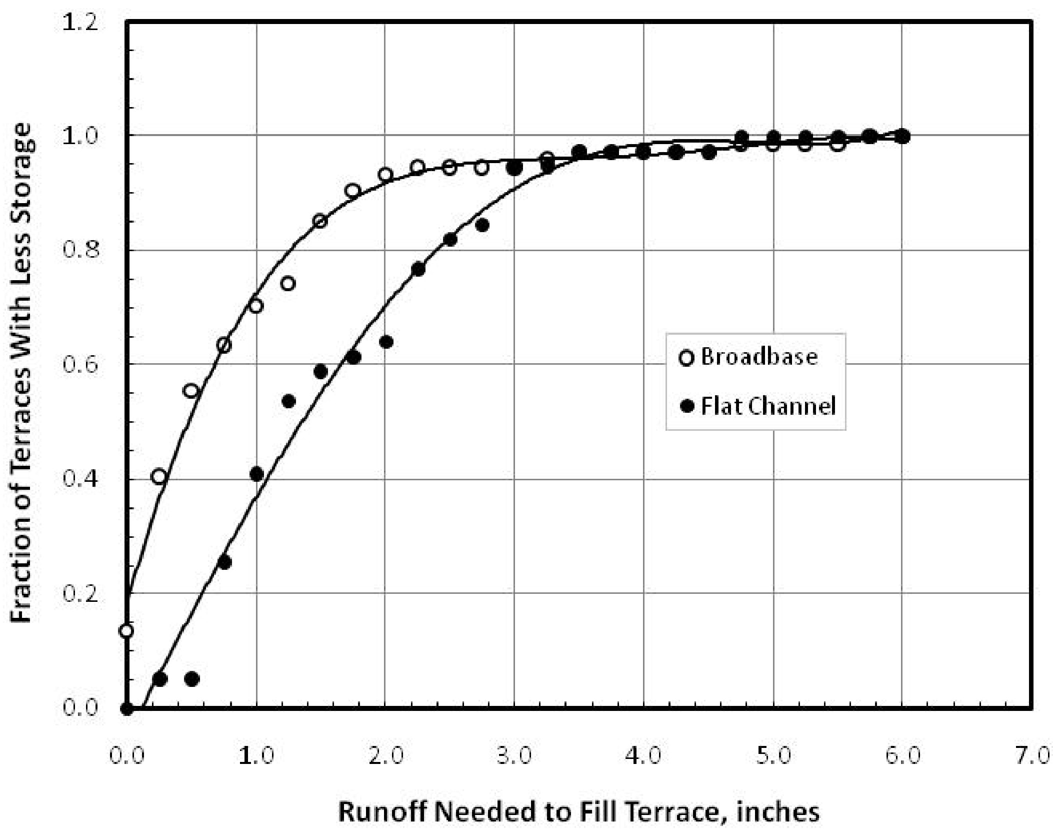



Figure 2. Distribution of storage capacity of surveyed terraces.

(3) Field Research at 5 Terraced Sites: Five sites were selected for the field research on the impact of terraces. The sites include conservation bench terrace systems located near Culbertson, Nebraska and Colby, Kansas; level terrace systems with closed ends located near Curtis, Nebraska and Norton, Kansas; and a level terrace system with open end(s) located near Stamford, Nebraska (Figure 1 of Appendix G).

Data collection equipment has been installed at the five field research terraced sites. Equipment has been installed to measure and record precipitation and reference evapotranspiration at each site. Water level information is also collected in the terrace channel. Volumetric water content of the soil is being collected at various depths in both the contributing area above the terrace channel and in the terraced channel. Soil moisture data is also being collected using matric potential sensors in both the contributing area and in the terrace channel. Soil temperatures are also being collected. Figure 3 indicates the relative location of the contributing area and the terrace channel. The five terraced fields have been monitored for three growing seasons.

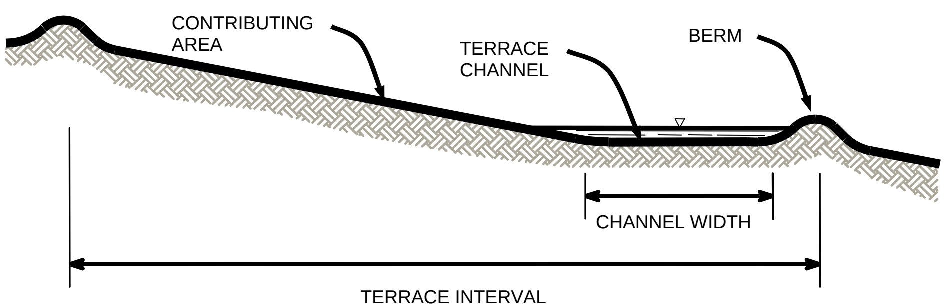



Figure 3. Cross Sectional View of Typical Terraced Land.

A more thorough description of monitoring at the terrace sites and an overview of the data collected has been presented in the Second and Third Annual Report so it is not repeated in this report.

The accuracy of partitioning precipitation into runoff, deep percolation or evapotranspiration from the contributing area and partitioning in the terrace channel depends on estimating the rate of infiltration. In addition the seepage and infiltration rates are related to the field saturated hydraulic conductivity of the soil. We conducted several field and simulation studies to improve our estimates of these quantities for modeling. Our objective was to determine the variability of curve numbers within an eco-fallow cropping system. The POTYLD model used to simulate the water balance of cropping practices depends on the curve number method to estimate infiltration.

The Water Erosion Prediction Project (WEPP) model has the ability to simulate changes of infiltration rates. We utilized this ability to predict the variability of hydraulic conductivity within an eco-fallow cropping rotation. A conversion is made to relate hydraulic conductivity to curve numbers and therefore the temporal variability of curve numbers can also be simulated. Field measurements were made to determine hydraulic conductivity once each year at each of the five studied locations. Curve numbers were also determined for runoff events at each location. These field measurements are used for comparison with WEPP simulations.

The hydraulic conductivity at Colby, Figure 4, decreased due to freezing in the fallow after wheat and wheat phases. The two spikes during the fallow after row crop phase are due to sweep tillage. The curve number is inversely related to the hydraulic conductivity with increasing values during frozen conditions and decreases following tillage. Overall, curve numbers ranged from approximately 60 to 90 during the three-year rotation. This location only had two runoff events during the three years of study. Both runoff events occurred during the fallow after row crop phase. The hydraulic conductivity calculated in the row crop and fallow after wheat was much higher than the simulated values. The hydraulic conductivity calculated for the fallow after row crop phase was for the soil below the tillage layer.

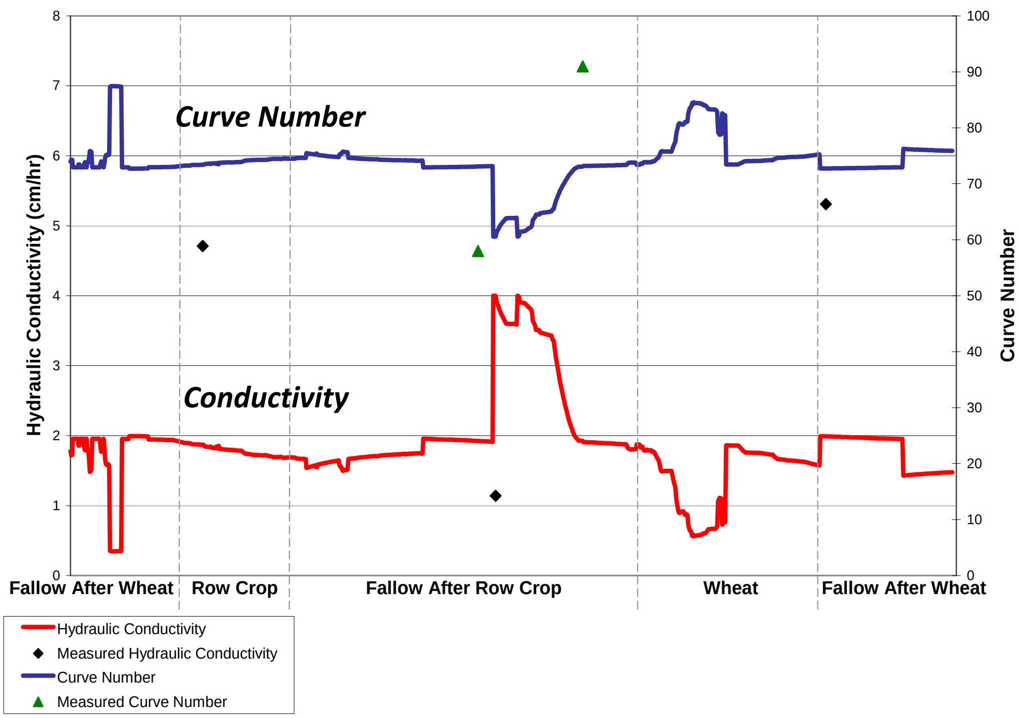



Figure 4. Hydraulic conductivity and curve numbers for the Colby, KS site.

The WEPP model was used to predict the temporal variability of hydraulic conductivity within an eco-fallow rotation. A relationship was developed to convert hydraulic conductivities to curve numbers. These simulated values were compared to hydraulic conductivities and curve numbers calculated from field measurements taken at the five locations in southwest Nebraska and northwest Kansas.

The WEPP model predicted hydraulic conductivity to range from 4 cm/hr (1.57 inches/hr) following tillage to less than 0.5 cm/hr (0.20 inches/hr) when the soil was frozen. When no tillage had occurred, hydraulic conductivity was approximately 2 cm/hr (0.79 inches/hr). Curve numbers related to the simulated hydraulic conductivity ranged from 60 following tillage to 90 with frozen soil. The curve numbers were approximately 75 during the growing season when no recent tillage had occurred.

The Root Zone Water Quality Model (RZWQM), version 2 released on January 6, 2008, was used to model the hydrology of the field sites. The RZWQM model was calibrated with the instrumentation at the Colby south terrace and the Norton lower terrace. After the model was calibrated, 30-year simulations were performed at these two sites. The Colby calibration period was from April 6, 2006 to August 19, 2008 and the Norton calibration period was from January 1, 2005 to December 31, 2007. Input parameters were obtained from data measured at the field sites and from GeoProbe soil core characteristics. The results of the 30-year simulations were used to determine the long-term evapotranspiration, deep percolation and runoff.

The water balance was calculated by volume. As an example, the average annual volume balance for the Norton site is listed in Table 2. As can be seen, the volumes are different between the slopes and the channels; this is because there is more area attributed to the slope than the channel. The broadbase and CBT slopes have different volumes because they have different slope lengths.

Table 2. Volume-based average yearly water balance at the Norton site.

| | Broadbase | | CBT | |
|---|---|---|---|---|
| Quantity | Slope | Channel | Slope | Channel |
| Precipitation ($m^3$) | 21.5 | 10.9 | 20.5 | 13.1 |
| Runoff ($m^3$) | 1.8 | 0.2 | 1.7 | 0.1 |
| Run-on ($m^3$) | 0.0 | 1.8 | 0.0 | 1.7 |
| ET ($m^3$) | 19.9 | 11.1 | 19.0 | 13.4 |
| Evaporation ($m^3$) | 0.0 | 0.1 | 0.0 | 0.1 |
| Deep Percolation ($m^3$) | 0.1 | 1.2 | 0.1 | 1.4 |
| Change in Storage ($m^3$) | -0.023 | 0.013 | -0.022 | 0.004 |

Note: 1 acre-feet equals 1,233 $m^3$.

At Norton, 0.6% of the precipitation falling on the contributing slope resulted in deep percolation. If the extra deep percolation caused by the terrace was spread over the contributing slope and terrace channel, it would result in 2.0 cm per year (0.79 inches/year) of additional percolation in the broadbase channel and 1.7 cm per year (0.67 inches/year) of additional percolation in the CBT. These values are comparable to those obtained by Koelliker (1985). In his research, the CBT field had about 1.6 cm per year (0.63 inches/year) of additional deep percolation, and the field with the level broadbase terrace had about 2.4 cm per year (0.94 inches/year) of additional deep percolation.

Thirty-year simulations with current practices were carried out at the Colby and Norton, Kansas field sites. Broadbase and conservation bench terraces were modeled at each site. The long-term simulation modeling used the parameters determined through calibration. Over the course of the simulations, 90% of the contributing slope runoff was captured by the Colby broadbase terrace, 100% by the Colby CBT, 91% by the Norton broadbase terrace and 95% by the Norton CBT.

More ET and deep percolation consistently occurred in the terrace channels than on the contributing slope. The runoff water that was retained on the field as a result of the terraces was used primarily for ET and deep percolation. At Colby, 80.3% of the runon water retained by the broadbase terrace and 79.4% of the runon water retained by the CBT deep percolated whereas 17.1% of the broadbase terrace retained water and 19.0% of the CBT retained water was used for ET. At Norton, 45.5% of the runon water retained by the broadbase terrace and 47.4% of the runon water retained by the CBT deep percolated while 42.4% of the broadbase terrace retained water and 47.7% of the CBT retained water was used for ET.

Deep percolation occurred primarily as a result of specific precipitation events. At Colby, 49 cm (19.3 inches) of rain fell over a 14-day period resulting in 25.4% of the deep percolation under the CBT during the 30-year simulation. At Norton, 42 cm (16.5 inches) of rain fell over an 8-day period and produced 12.9% of the deep percolation under the broadbase terrace during the 30-year simulation.

The ET within the eco-fallow cropping rotation is relatively evenly distributed among the two fallow periods and the wheat and row crop growing periods. At Colby, the ET of each of the four phases of the rotation ranged from 20 to 28% of the total ET, and at Norton, the ET of each of the four phases of the rotation ranged from 21 to 29% of the total ET. Higher daily ET occurred during the row crop and wheat growing periods, but the fallow periods were longer in duration resulting in similar cumulative amounts of ET.

The field research sites were sampled to a depth of 25 feet using an implement referred to as the GeoProbe. The GeoProbe takes an undisturbed core of soil to a chosen depth. We sampled the field areas (both the contributing area and the terrace channels) in the spring of 2006 and 2009. Analysis of the results of the probing provides a picture of the soil water profile throughout the 25-foot depth. The results show minor variation in the upper portion of the profile, *i.e,* the crop root zone; however, the deeper soil profile is very similar

A more detailed discussion on data collection and simulations to help define the water balance at the terraced sites and using that data to develop input to the POTYLDR water balance model is included in Appendix G.

Stream Transmission Loss

The other aspect of the model development that is under study is transmission losses of streamflow during runoff events. Transmission loss is the quantity of water that enters a stream reach, but that does not flow out of the stream reach as surface flow. Transmission loss is usually associated with evaporation and percolation. The effects have important implications on loss of streamflow and recharge distribution within the basin. So, accounting for them will have effects on where and how terracing and small reservoirs affect both recharge and streamflow within the basin.

A small runoff event occurred from the area above the Ludell, KS stream gauge on Beaver Creek on April 24-26, 2007 that totaled 523 acre-feet of flow. This same event appears to have produced a small flow at the Cedar Bluffs, KS stream gauge on April 24, 2007 a few hours later that totaled 23 acre-feet of flow. Subsequently, the main flow that occurred above Ludell made its way past the Cedar Bluff gauge. The resulting hydrograph at Cedar Bluffs from the inflow from above Ludell passed the Cedar Bluffs gauge on April 25 -28, 2007 and totaled 400 acre-feet. This distance between these two gauges is 40.4 river miles. The volume of flow decrease between the two stations was 523-400 = 123 acre-feet. This amounts to a loss of volume of about 24%.

Jordan (1977) looked at flood flows extensively in Kansas and several of the streams are in the Republican Basin that concluded that the transmission loss in one mile for medium- to large-sized streams in western Kansas averages 2% of the flow volume at the beginning of each mile. Using the same technique as Jordon, the April 24-26 runoff event showed an average of only 0.67% of the hydrograph volume was lost per river mile. Considering the small size of the event and that flow was all within the channel, the lower loss observed here is reasonable. It also leads to the conclusion that transmission losses for in-channel flows are likely to be lower than for floods that have a larger area and greater hydraulic pressures that lead to the greater percentage losses that Jordon's work showed.

A general value of 2% per mile of stream travel has been assumed for the basin. More analysis of recent events found that the losses in the drier areas appear to be higher and the more eastern areas, losses appear to be lower. Losses of as high as 7% were found for the South Fork of the Republican from an event in summer 2008. The distance runoff must travel before it is measured or reported as streamflow greatly affects the amount of surface runoff when transmission losses are high. In the drier areas of the Basin, travel distances are long before measurement or calculations. In the east, the distances are shorter because of the nature of the stream network and Basin configuration.

4. <u>Application of the water balance models</u>**:**

Reservoir

The reservoir simulation model is divided into two modules. A gross seepage module and and a net seepage module. Net seepage is defined as the percolation below the bottom of the rooting zone of the plants that can be expected to grow in the inundation area of the reservoir

Calibration of the gross seepage module was done for the period, April 5 through August 22, 2005, when water levels in the DPL-Hogan reservoir started at spillway level and dropped to less than 0.5 m (19.7 inches). For the calibration period, the average difference in water depth was only 1.3 cm (0.51 inches). The results are similar to the event period presented above with the exception that no more overflow occurred. Gross seepage was computed to be 94% of the inflow retained in the reservoir.

Two reservoirs in Kansas, DCN-Zimb and DRA-Holste, were selected for model verification. The process of model verification involved comparing the model simulation results with measured water level data. The average difference between measured and simulated daily water depth in the DCN-Zimb was 4 cm (1.57 inches) and in the DRA-Holste was 1 cm (0.39 inches). Days with zero depths are included in the averages.

The details of water budget estimation with and without reservoir scenarios for all three reservoirs are presented in the Table 3. It was observed that contribution to streamflow without the reservoir was significant. With the reservoir in place, streamflow from the reservoir watershed was reduced by 82% to 96%. Of water retained at the reservoir locations for during the 4-year study period, from 91% at DCN-Zimb to 94% at DPL-Hogan became gross seepage.

**Table 3. Comparative water input and output with and without reservoir at the three sites during the study period, 2004-07 (4 years).**

| Inputs | All volumes in cubic meters; total for 4-year period. | | | | | |
|---|---|---|---|---|---|---|
| | DPL-Hogan | | DRA-Holste | | DCN-Zimb | |
| | Without reservoir | With reservoir | Without reservoir | With reservoir | Without reservoir | With reservoir |
| Inflow from the watershed | 20,540 | 20,260 | 96,530 | 98,310 | 17,300 | 19,210 |
| Precipitation on water surface | - | 2,550 | - | 9,520 | - | 1,870 |
| **Total** | 20,540 | 22,810 | 96,530 | 107,830 | 17,300 | 21,080 |
| **Outputs** | | | | | | |
| Overflow | 20,540 | 3,640 | 96,530 | 11,750 | 17,300 | 650 |
| Evaporation from water surface | - | 3,080 | - | 8,830 | - | 3,190 |
| Gross seepage | - | 15,690 | - | 74,150 | - | 17,240 |
| Cattle consumption (unknown & small) | - | 0 | - | 0 | - | 0 |
| **Total** | 20,540 | 22,410 | 96,530 | 94,730 | 17,300 | 21,080 |
| Change in streamflow | -16,900 | | -84,780 | | -16,650 | |
| Change in streamflow (%) | -82.2 | | -87.8 | | -96.2 | |
| Increase in gross seepage | 15,690 | | 74,150 | | 17,240 | |

Note: All volumes rounded to nearest 10. 1 acre-feet equals 1,233 $m^3$.

The net seepage module cannot be calibrated directly since there are not any measurements of soil water content. However, judgments can be made about the reasonableness of the results, particularly for the area above the maximum water level which is not inundated. The same 4-year period for DPL-Hogan that was simulated for the gross seepage module was used for this simulation. The net seepage module estimated that a total of 14,750 $m^3$ (11.96 acre-feet) of the gross seepage amount of 15,960 $m^3$ (12.94 acre-feet) for DPL-Hogan moved below the bottom of the rooting zone during the 4-year study period. This amounts to 92% of the gross seepage.

The results of the study for DPL-Hogan show that 94% of the retained inflow became gross seepage and 92% of the gross seepage was calculated to become net seepage. The overall result is then that 86% of the retained inflow was accounted for as net seepage. Finally at the reservoir site, streamflow was reduced by 16,900 $m^3$ (13.70 acre-feet), but net seepage or potential for ground-water recharge was increased by 14,750 $m^3$ (11.96 acre-feet). This results in about a 13% reduction in sum of streamflow plus potential ground-water recharge at the reservoir site.

A simple prediction technique was needed to estimate the conversion of inflow to the amount of overflow and net seepage for other reservoirs in the basin that incorporates the values of several characteristics of a reservoir. Inflow to the reservoir will be estimated using the POTYLDR water budget simulation model. The characteristics of the reservoir that are important for estimating overflow and net seepage are:

a. ACC - approximate clay content in the soils at the reservoir site
b. D- the average reservoir depth defined by reservoir storage volume divided by surface area at the spillway level,
c. AMD - the annual moisture deficit defined as the average annual evaporation minus the average annul precipitation.

The portion of inflow that become overflow and net seepage is estimated using the following equations:

O/I = I/V * ACC’ * D’ * AMD’
NS/I = NS/I * ACC” * D” * AMD”

Where the ‘ are relative factors for O/I and “ denotes relative factors for NS/I. Table 4 shows an example for a reservoir in the eastern portion of the basin. The results may at first look too high because

**Table 4. Example of estimated portion of inflow that becomes overflow and net seepage for a small reservoir**

| | Enter New Reservoir Values Below | | | | | |
|---|---|---|---|---|---|---|
| **EXAMPLE: Predicting for Another Reservoir** | **I/V, - =** | **1.25** | | | | |
| | **ACC, % =** | **28** | | | | |
| **Prediction Equations** | **D, ft =** | **5.0** | | | | |
| **O/I = O/I for Reservoir * ACC' * D' * AMD'** | **AMD, in. =** | **24** | | | | |
| **NS/I = I/V for Reservoir * ACC" * D" * AMD"** | Value for I/V | Relative Factor Effects | | | | |
| | | ACC | D | AMD | **Overall** | |
| | 0.43 | 1.03 | 1.02 | 1.00 | **0.42** | **= O/I** |
| | 0.56 | 0.97 | 1.00 | 1.01 | **0.57** | **= NS/I** |

evaporation losses might be expected to take more of the inflow. That fraction was consistently found to be smaller than expected. The size of the surface area relative to the watershed is small and the results are expressed as net seepage which involves the interaction of the high seepage losses when the reservoirs are full. Evaporation is simply not a very large portion of the water budget for small reservoirs that are seldom very full.
This technique still needs to be tested on some more reservoirs to make sure it is a reasonable approach. For the purposes of determining the overall effects of the 716 reservoirs identified in the Basin, estimates of inflow will be made with the POTYLDR model, reservoir characteristics are available in the inventory provided by the States, and the effects of transmission losses along the channels from the reservoir to the measurement point for streamflow will be estimated. Also, the movement of the net seepage from the reservoir to

groundwater and perhaps as return flow to the surface is needed to predict the net effects for a reservoir

The approximate total watershed area for the 716 reservoirs in square miles is 3,380 for Nebraska, approximately 195 for Colorado, and approximately 1,000 for Kansas for a total of about 4,575 square miles, one-third of the total contributing drainage area in the Republican River Basin above the Hardy, Nebraska stream gage.

## Land Terracing

In the Fourth Annual Status Report of 2008, an overall approach was presented for estimating the effects of land terracing on streamflow and groundwater recharge for the Prairie Dog Creek above Keith Sebelius Lake (590 square miles). Those results estimated an average of about 3,200 acre-ft/yr of reduction in streamflow and about 200 acre-ft/yr increase in ground-water recharge.

Additional information that is needed to apply this approach to other sub-basins include the best estimates of amount of and type of terraces and range of their condition to hold runoff in their storage channel in the sub-basin, the portion of total runoff into the channel that is retained over the long-term and the split of the retained water into potential ground-water recharge and evapotranspiration to determine the field-level water balance. The best estimates of transmission losses in the channel system from the field to the place of streamflow measurement or estimation is needed along with how the alluvial aquifer system distributes runoff into the channel system into recharge of groundwater, delayed return to the stream as baseflow, and runoff water that becomes additional evapotranspiration in the alluvial system. Finally, an estimate of how much, if any, of the ground-water recharge from the terraced field returns as streamflow is needed.

The additional information gathered during the past year, such as the assessment of terrace condition to hold runoff, has allowed refinement of the effects of these land terraces on streamflow and groundwater recharge for Prairie Dog Creek. Table 5 lists the water balance for Prairie Dog Creek above Keith Sebelius Lake.

**Table 5. Water Balance for Prairie Dog Creek above Keith Sebelius Lake**

| | | | |
|---|---|---|---|
| | | Volumes in acre-ft/yr | |
| | Reduction in Runoff at Terraced Field Edge : | 6,500 | |
| | | Losses | Gains |
| | **Evapotranspiration** | | |
| | From terraced fields | | 3,200 |
| | From alluvial valley | 1,000 | |
| **Change in evapotranspiration:** | **2,200 acre-feet** | | |
| | **Streamflow** | | |
| | Direct surface runoff | 1,700 | |
| | Return to stream as baseflow from alluvial system | 300 | |
| | Terrace Recharge that becomes streamflow | | 100 |
| **Change in streamflow:** | **(1,900) acre-feet** | | |
| | **Groundwater** | | |
| | Recharge under terraced fields | | 3,200 |
| | Terrace recharge that becomes streamflow | 100 | |
| | Alluvial aquifer system recharge | 3,400 | |
| **Change in ground water recharge:** | **(300) acre-feet** | | |
| | Overall Totals : | 6,500 | 6,500 |
| | **Water Balance Difference :** | 0 | |
| *(Difference, if any, due to rounding)* | | | |

The results for the Prairie Dog Creek are different than those reported in 2008. The estimated net effects of the terraces are that streamflow from the sub-basin is reduced by 1,900 acre-feet per year and the net groundwater recharge is reduced by 300 acre-feet per year. The terrace inventory resulted in reducing the amount of runoff that is retained in the terrace channel. Also, observations about transmission losses prompted an increase in losses, especially for the upper portions of this basin.

A more detailed discussion on the application of the water balance model, evaluation, and discussion of results is included in Appendix F.

**EXPENDITURES**

The Final Settlement Stipulation specifies that the States and the United States will undertake this study at a cost not to exceed one million dollars of which the United States will be responsible for 75 percent of the cost and each State will be responsible for one third of the remaining 25% ($83,333 per State). The States' portion may be provided entirely through in-kind contributions. If the cost of the study exceeds one million dollars, the United States will be responsible for the entire additional amount.

The Study Plan Proposal of April 28, 2004, specified that the in-kind contributions of the States reported in the status reports would cover the period from April 1 of the previous fiscal year through March 31 of the current fiscal year. However, this status report includes costs for May 1 through April 30 as these costs provide a more up-to-date status. Table 6 shows the expenditures by each entity for each of the study years.

**Table 6. -- Summary of Study Expenditures**

| | ***Study Proposal Development*** | ***Study Expenditure Year***[1] | | | | | |
|---|---|---|---|---|---|---|---|
| | | **2005 Study Yr 1** | **2006 Study Yr 2** | **2007 Study Yr 3** | **2008 Study Yr 4** | **2009 Study Yr 5** | **Total** |
| **Colorado** | $23,820 | $5,625 | $3,744 | Not reported | Not reported | Not reported | 9,369 |
| **Kansas**[3] | 40,009 | 22,307 | 8,193 | 21,644 | 22,129 | Not reported | 74,273 |
| **Nebraska** | 12,938 | 23,219 | 28,023 | 34,846 | 32,453 | Not reported | 118,541 |
| **KSU** | | 0 | 45,400 | 77,121 | 65,920 | 120,605[5] | 309,046 |
| **UNL** | | 0 | 189,400 | 142,406 | 74,120 | 109,849[5] | 515,775 |
| **Reclamation**[4] | | 64,876 | 25,350 | 85,969 | 13,685 | 28,200 | 218,080 |
| **NRCS** | | 0 | 7,125 | 0 | | | |
| Total | | $116,027 | $307,235 | $361,986 | $208,307 | | $1,245,084 |

[1] The Study was approved on July 27, 2004. The Study Expenditure Year for this table is defined as the period from July 27, 2004 through April 30, 2005 for Study Year 1, and May 1 through April 30 for the other study years, unless otherwise noted.
[2] Expenditures for May 1, 2007 thru June 18, 2007.
[3] Expenditures are July 1 through June 30 for 2005 and 2006, July 1 through April 30, 2007, and May 1, 2007 through April 30, 2008.
[4] Expenditures separate from funds provided to KSU and UNL under agreements.
[5] Includes funding through end of study.

Reported study expenditures and obligations totaled $1,245,084.

Colorado – Colorado has provided in-kind contributions toward the study by selecting one reservoir site, assisting with the installation of equipment for monitoring the operation of the reservoir, and by assisting with other work related to the study. Colorado has contributed $9,369 of in-kind services towards the study from the date of approval of the study on July 27, 2004 through April 30, 2006.

Kansas - Kansas Division of Water Resources, Department of Agriculture, has provided staff time, plus expenses in the form of per diem cost for travel, training, installation of instruments and monitoring and maintenance on the instruments on a sample of 11 reservoirs and by assisting with other work related to the study. During 2006, Kansas produced area-capacity tables for each of the 11 dams monitored as part of this study. During 2007, Kansas purchased and supplied a survey grade GPS system to the University of Nebraska staff to use for conducting the terrace condition assessments and an equipment lease cost of $8,000 has been included in contributions by Kansas. Kansas has contributed $74,273 of in-kind services towards the study from the date of approval of the study on July 27, 2004 through April 30, 2008.

Nebraska – Nebraska has provided in-kind contributions toward the study by selecting sites, assisting with the installation of equipment for monitoring the operation of 20 reservoirs, and by assisting with other work related to the study. Nebraska conducts site visits to the 20 reservoir sites at least twice per year to download water level recorder data and to collect water surface perimeter data using GPS. Nebraska has surveyed these (and other non-federal) reservoirs to produce area-capacity tables. Nebraska has contributed $118,541 of in-kind services towards the study from the date of approval of the study on July 27, 2004 through April 30, 2008.

United States
*Reclamation* – Reclamation committed staff time and funding for purchase and installation of equipment related to the larger sample of 32 reservoirs. In addition, Reclamation committed staff time for preparation and administration of the funding and for mapping of terraced fields (terrace inventory) in Colorado and Kansas. Total expenditures by Reclamation for the above work from the time the MOU was signed through July, 2009 were about $218,080.

Reclamation entered into a 5-year agreement with the UNL in early October of 2004 to fund the majority of UNL's role in the study effort. Funding to UNL became available in February of 2005. In March, 2005 Reclamation entered into a 5-year agreement with KSU to fund the majority of their role in the study. According to the agreements, Reclamation has agreed to provide $648,789 to KSU and UNL for the study effort. Reclamation modified the funding agreements in 2007 and in 2009 to include an additional $176,032.

> Kansas State University – Through June, 2009, KSU's Cooperative Agreement expenditures have been about $ 265,000. Reclamation has obligated a total of $309,046 to KSU leaving about $,44,000 of unexpended funds.
>
> University of Nebraska - Through June 30, 2009, UNL's Cooperative Agreement expenditures have totaled about $510,000. Reclamation has obligated a total of $515,775 to UNL leaving about $6,000 of unexpended funds. Obligated funds that are unused in fiscal year 2009 will be available for work in 2010.

*NRCS* – The NRCS committed staff time and travel expenses for the pilot study to identify as-built condition of the terraces and determine present condition. The expenditure for this work was $7,125 during 2006.

**STUDY TIMELINE**

For the first year, July 27, 2004 thru May 30, 2005, progress on the study was on schedule for installation and monitoring of the larger sample of 32 reservoirs but behind schedule on most other aspects of the study by 4-5 months. It was anticipated that only 2-3 months of potential data collection would be lost from the delay in installation of monitoring equipment for the detailed field research. Good progress was made in assembling geographic information needed for the study.

During the second year, June 1, 2005 thru May 30, 2006, the study has fallen further behind schedule, primarily caused by delays on installation of equipment to collect data at the field research sites on detailed information regarding the water balance for the small reservoir and land terrace sites. The Conservation Committee generally believes that good results can be obtained by the planned completion date of the study. Two and one-half to three years of detailed data collection at the reservoir and terrace sites should still provide good information regarding the water balance at the sites.

During the third year, June 1 2006 thru May 30, 2007, the research team expected to apply the model to conditions in the selected test sub-basins, Prairie Dog Creek above Sebelius Lake and Medicine Creek above Harry Strunk Lake by the end of 2006. This activity was not completed because of delays is obtaining an assessment of terraced land conditions in those basins, which has been shown to be an important factor in the water balance of terraces. The original study timeline allowed for calibration of the water balance model until July 1, 2008

During the fourth year, June 1, 2007 thru May 30, 2008, the terrace condition assessment got underway with two of the counties in Nebraska containing the most terraces nearly completed by mid-June 2008. Field data collection at terrace sites has been completed for two of the three years that are typical of ecofallow, common in the Republican River Basin. Preliminary water balance partitioning was completed for example terrace sites. The field data was used along with various simulation models to develop information for adapting the POTYLDR model to represent conditions in the Republican River Basin. The field data collection and adaptation of the POTLYDR model is necessary to improve the partitioning of water into runoff, deep percolation, and evapotranspiration. The POTYLDR model was used to simulate the operation of important land use conditions as representative HRUs in the Prairie Dog Creek basin above Keith Sebelius Lake in Kansas. This evaluation included making estimates of the effects of terracing on streamflow and groundwater recharge for the sub-basin. Model calibration was not completed within the expected timeframe, which will mean less time to develop final model results.

During the fifth year, June 1, 2008 thru July 30, 2009, data collection at the reservoir and land terrace sites continued through the spring 2009. The field work for the assessment of terrace condition was completed. The research team continued to use the process-based models with field data to develop input data for the water balance model. A model to simulate operation of a small reservoir was developed, calibrated, and tested to estimated overflow, and net seepage from the reservoir. The impact of land terraces on water supply for the Prairie Dog Creek subbasin was updated based on new information summarized from the terrace condition assessment and field data during 2009.

**PLANS FOR THE NEXT YEAR**

The study team has identified the following tasks for completion of the study:

1. The States' inventory of Non-federal Reservoirs does not contain all of the data required for the study to assess impact on water supply. Information on drainage area, volume, and depth is missing for some reservoirs in the inventory. The data will either be supplied by the States or a sampling method will be used to estimate the necessary data.
2. Complete processing of the terrace conditions survey data and summarize by sub-basin so it may be used to quantify impacts of terraces on water supply.
3. Determine modeling approach to avoid double accounting of impacts on water supply due to terraces and reservoirs.
4. Finalize reservoir simulation model.
5. Update POTYLDR model calibration and utilize the model to estimate runoff so impacts on runoff can be quantified. Simulations will be made for conditions with no terraces or reservoirs, with terraces but no reservoirs, without terraces but with reservoirs, and with both terraces and reservoirs.
6. Transmit the preliminary results of the study to the RRCA by letter no latter than January 15, 2010.
7. Prepare POTYLDR model users guide, and other study documentation by June 1, 2010.

## REPORTS PRODUCED RELATED TO THE STUDY

1. Ravikumar Choodegowda, Technical Paper presented at the Annual International Meeting of the American Society of Agricultural and Biological Engineers in Reno, NV, June 22, 2009. (Small Reservoir Operations Simulations)

2. Twombly, B. J. 2008. Field scale hydrology of conservation terraces in the Republican River Basin. Master’s thesis, University of Nebraska-Lincoln.

3. Yonts, T.D. 2006. Modeling and monitoring the hydrology of conservation terrace systems. Master’s thesis, University of Nebraska-Lincoln.

4. Smith, T.G. 2009. Temporal variability of hydraulic conductivity and runoff curve numbers for eco-fallow cropping systems. Master’s thesis, University of Nebraska-Lincoln.

# APPENDIX F

DETAILED PROGRESS REPORT
OF
KANSAS STATE UNIVERSITY

# Progress Report for the Period: June 15, 2008 —July 24, 2009

***Electronic file: Progress Report July 2009.doc (Word document)***

Cooperative Agreement Between The Bureau of Reclamation and Kansas State University: Modeling and Field Experimentation to Determine the Effects of Land Terracing and Non-Federal Reservoirs on Water Supplies in the Republican River Basin Above Hardy, Nebraska

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Kansas State University Responsibilities:

**a.** Lead the effort to evaluate existing water balance modeling methods and improvement of those models. At least three models will be studied to determine the most reliable methods. The following sections describe the work done so far.

## Water Budget Model Evaluations:

In cooperation with the University of Nebraska-Lincoln, three water budget models were evaluated and the **POTYLDR** (**POT**ential **Y**ie**LD** Model **R**evised) developed by Kansas State University (Koelliker 1994 and 1998) will serve as the basic framework for the water budget simulation model.

## The Overall Modeling Approach for this Project

The KSU and UNL teams met several more times to work on details of this project. Also, we have shared information and data as needed via e-mail and ftp procedures. The development of the computer simulation model has been a continuing topic that has received considerable attention.

The total model will consist of four parts *(Current information is presented after each item)*:

1) A GIS pre-processor framework to define geographical areas, extract characteristics of the areas from GIS coverages such as soils, land use, extent of terracing, applicable meteorological stations, and other information that can be put in GIS format. This pre-processor will generate input data for the

water budget simulation model hydrologic response units (HRUs).
*This phase is still under development at UNL.*

2) A unit area water budget simulation model capable of receiving input data for individual land-use, soil, conservation practices, and location combinations throughout the basin that will operate on a daily basis for at least 25 years to produce output of daily, monthly and annual water budgets for each applicable HRU. The operation of a terraced field will be done as an HRU as described later in detail.

   *This model is still under final development and calibration with recently-obtained data from the five field sites and will be operational by August 15, 2009. Results from the field study along with previous simulation work for the area form the basis for overall estimates for terraced land that are presented later in this report.*

3) A water budget simulation model of a small reservoir using daily outputs from the applicable HRUs for that represent its watershed conditions and reservoir stage-storage-area-discharge relationships as well as estimated seepage loss rate under the surface area of the reservoir.

   *We have developed and tested a model to simulate the operation of a small reservoir on a daily basis to estimate overflow and net seepage from the reservoir. The model has been calibrated and tested on three reservoirs. This is described in detail later.*

4) A GIS post-processor to combine results from the HRU and reservoir simulation models on an areal basis to produce monthly and annual recharge and runoff amounts from the sub-basin. Finally, a simple percent-per-mile transmission loss factor based upon the flowpath-length within the sub-basin will be used to redistribute runoff into infiltration losses to add to recharge and reduce surface runoff from the sub-basin. The GIS pre-processor and post-processor aspects of the project are being led by the Nebraska cooperators of this project. Interactions and interfacing for data handling are in process.

   *Based upon results of previous work and best estimates, we have incorporated this aspect into an Excel spreadsheet to provide an overall estimate of these effects on surface runoff and groundwater recharge.*

# Small Reservoir Operations Simulations

*Following are the slightly modified contents of a technical paper presentation prepared by doctoral candidate, Ravikumar Choodegowda, with input from his co-authors on the study team. It was presented at the Annual International Meeting of the American Society of Agricultural and Biological Engineers in Reno, NV on June 22, 2009.*

For this work, three sensor-monitored reservoirs were selected. They are all in Kansas – DPL-Hogan, DCN-Zimb and DRA-Holste. These three were selected because of a more continuous presence of water and we were more familiar with their watershed characteristics and we have followed their operations most closely. They also represent a range of different precipitation and land-use characteristics.

We examined the water level record which is influenced by the factors that include reservoir characteristics of stage-storage--area and stage-discharge relationships, site soil characteristics, precipitation on and evaporation from the free-water surface area, and water used from it along with the change in depth to estimate the daily seepage amount by calculating a daily water balance. Input parameters include inflow from the watershed area and precipitation onto the free-surface area. Outflow parameters include evaporation from the free-water surface, seepage, overflow through the spillway and water use from the reservoir. Change in storage volume was determined by using the change in depth and the stage-storage relationship. Seepage (S), $m^3$, was estimated by summing the daily values using following relation:

$$S = P + I - E - O \pm \Delta S \quad (1)$$

Where,

P = Precipitation from the nearest reporting station times free-water surface area, $m^3$

I = Inflow (sum of runoff and drainage), $m^3$

E = Weighted $ET_o$ for the nearest station(s) times free-water surface area, $m^3$

O =Estimated overflow from recorded water level and spillway characteristics, $m^3$

$\Delta S$ = Change in storage of the reservoir, $m^3$

For the daily water balance, the first sensor record after 12:00 a.m. was used as the daily water level in the reservoir. It was observed from the water level data that inflow was only occasional and uncertain and precipitation occurred only about one day in five. Seepage and evaporation, however, were known to occur each day. Water used from the reservoirs was limited to consumption by livestock and we determined it to be minimal and it has not been included in our analysis. This resulted in more unknowns than relationships to determine seepage and inflow independently. Therefore, we had to examine the water level record carefully to estimate seepage. On days with no inflow or precipitation, seepage could be estimated by change in depth minus evaporation and seepage. Evaporation was assumed to be equal to $ET_o$. On days with inflow that produced an increase in water depth that was more than would result from precipitation minus evaporation and seepage, inflow was estimated by adjusting the seepage amount such that it remained a reasonable amount compared to the preceding day unless there were large inflows. Then, the amount of seepage had to be estimated by our best judgment. Overflow amounts, when they occurred were determined by examining the hourly water-level record and the stage-discharge relationship. This new approach was less than satisfying methodology but it was the only approach that the field data would allow. We believe, however, this approach is providing reasonably good results for the operation of these reservoirs.

***Reservoir Simulation Model Development***

The reservoir simulation model is divided in to two modules – a gross seepage module and a net seepage module.

**Gross seepage module**

The gross seepage module solves Equation 1 on a daily basis and requires daily data inputs of inflow from the drainage area, precipitation, and evaporation.

**User-specified inputs**

The reservoir characteristics of stage-area and stage-storage relationships are input in a step-wise fashion since we want to estimate gross seepage at various locations within the reservoir storage area. To estimate gross seepage at different depths, the reservoir storage area is divided into 14 level sections or stages (Fig. 1). The measured reservoir stage-storage and stage-area relationships for one of the three reservoirs studied are compared graphically with the relationships used in the gross seepage module in Figure 2. Since the reservoir is modeled with 14 level sections the user must define the height from the bottom of the reservoir and surface area for each level section. Also, estimated daily seepage rate in cm/day at 0.3 m or less of head ($S_0$) for each level is needed. To account for the influence of water head on seepage rate for level (Si, i =1 to 14) a default exponent of 0.25 on the head of water greater than 0.30 m ($h_L$) over the each level section is used.

$$\text{If } h_L > 0.3 \text{ m, then } S_i = S_0 * h_L^{\;0.25} \qquad (2)$$

For the entire modeling process, seepage and infiltration are assumed to move only vertically resulting in only one-dimensional soil-water movement.

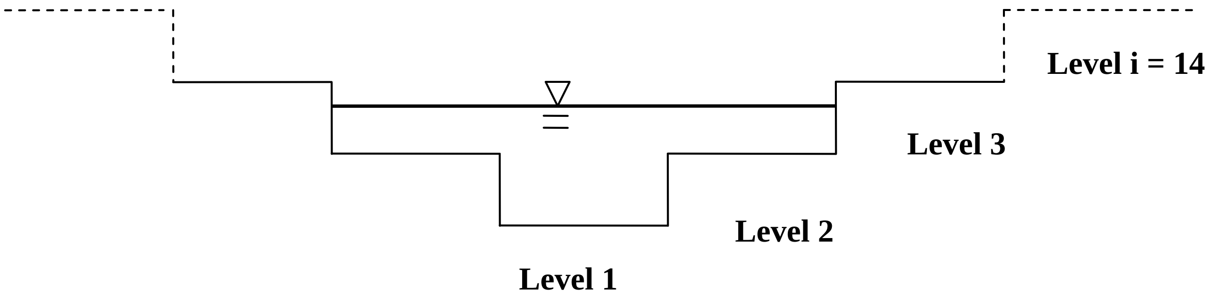



**Figure 1. Reservoir representation of level sections to estimate gross seepage rates for different depths and areas.**

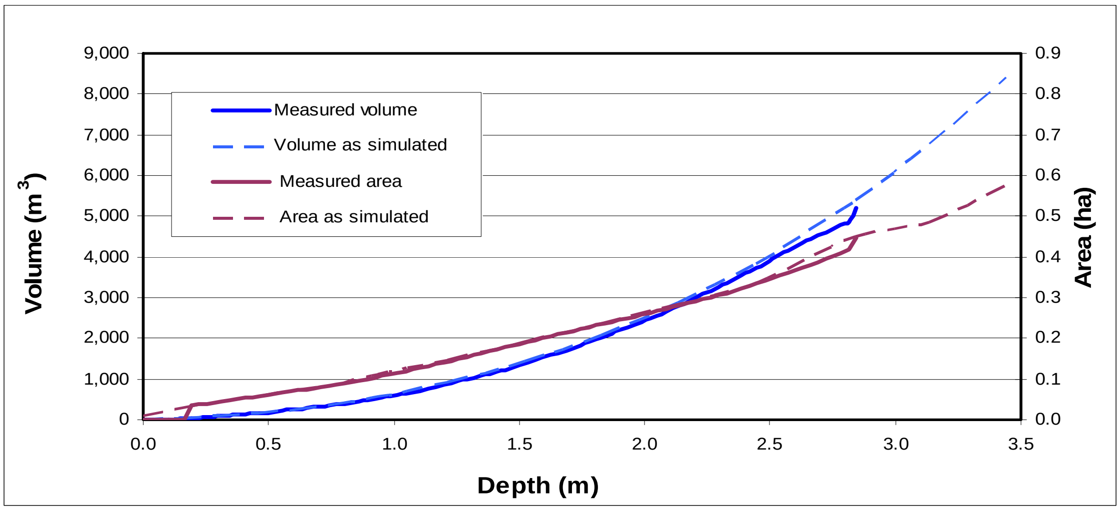



**Figure 2. Measured stage–storage and stage-area relationships for the reservoir, DPL-Hogan and as represented in the inputs to the gross seepage module.**

The model begins with an initial depth of water in the reservoir and it performs the daily water balance on a volumetric basis. Precipitation onto the reservoir water-surface area and inflow from the watershed area are the inputs and evaporation from the free-water surface, overflow through the spillway and seepage volume from each level section are the outputs of the reservoir water budget. The seepage rate calculation is based upon depth of inundation of each level section. Those level sections that are not inundated at the beginning of the day are assumed to contribute runoff at the same volume per unit area rate as the watershed whenever inflow occurs. $ET_0$ was used as the estimated evaporation from the free-water surface. Weighted average of $ET_0$ values from nearby stations of Scandia and Colby were used. Precipitation data from the nearest meteorological station was used. The model reads all inputs in the beginning of the day and updates the depth in the reservoir at the beginning of each day by taking the level at the end of the previous day and adding the input of inflow and precipitation and estimates the new water level and any overflow to determine which level sections are inundated. Then, it calculates seepage from each level and evaporation from the reservoir water surface area. Finally, it calculates the depth at the end of the day after removing seepage and evaporation losses and the proceeds to the next day. The details of the module operation are presented in the Figure 3.

**Overflow calculation**

The maximum depth or capacity of reservoir to hold water was based on the location of the spillway. The spillway location for the module is at the height of the $13^{th}$ level section. Partitioning between overflow through the spillway and temporary storage above the spillway is used to estimate the overflow volume and the average water depth for those days with overflow.

**Seepage calculations**

Seepage through each level section is estimated after checking the water depth in the reservoir. If the level is not inundated, no seepage occurs. For those level sections that are inundated, estimated seepage rates are calculated using Equation 2.

Two separate output files are generated from the gross seepage module. One of them prints a daily water budget that lists gross seepage from each of the 14 levels, precipitation, $ET_0$, inflow depth, and reservoir level which are used as input to the net seepage module. The other output is a monthly water budget for the reservoir that can be used to estimate the effect of the reservoir on streamflow and potential ground water recharge with and without the reservoir.

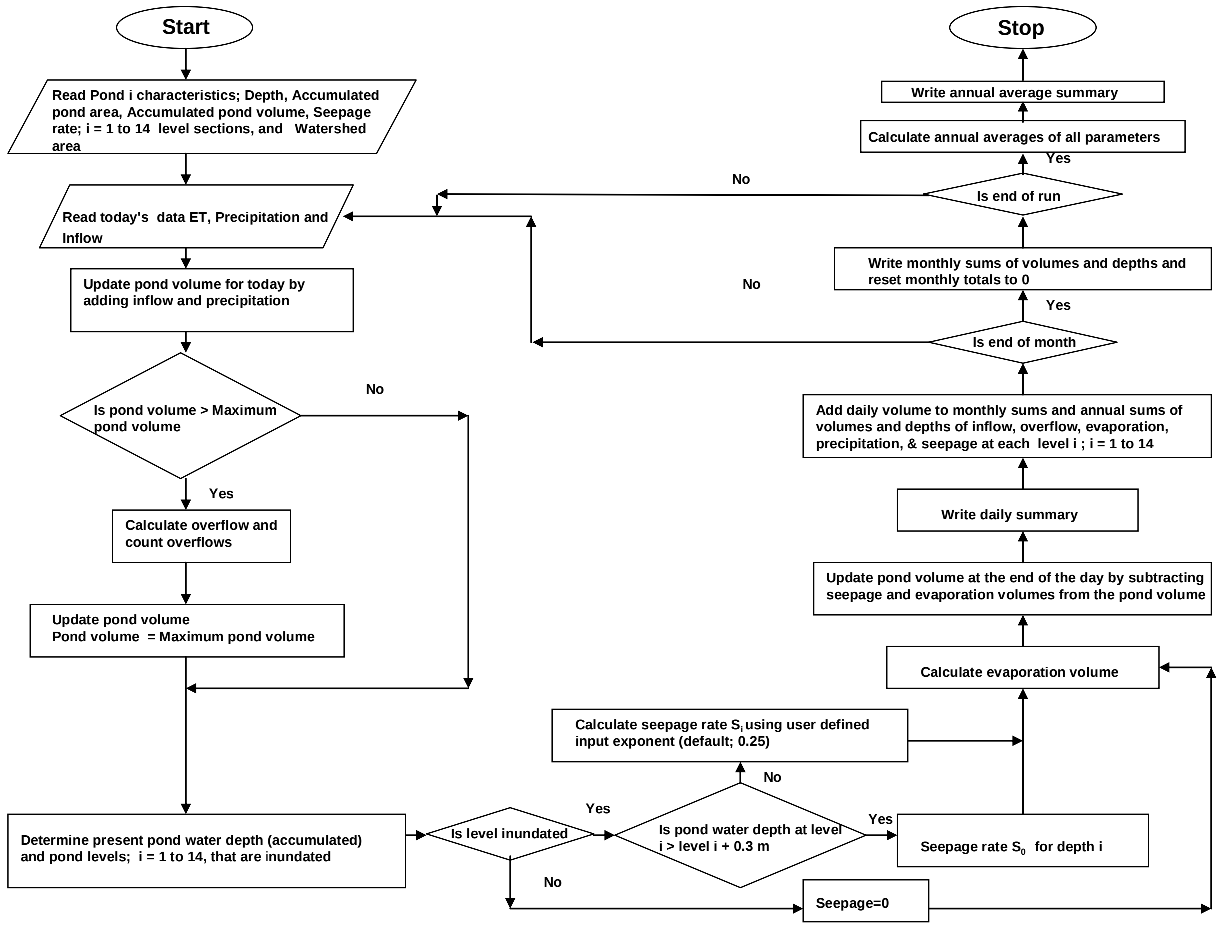



**Figure 3. The general algorithm for gross seepage module**

## Net seepage module

The net seepage module is designed to simulate net seepage, defined as the percolation below the bottom of the rooting zone of the plants that can be expected to grow on each of the 14 levels of the reservoir. A flowchart for it is shown in Figure 4. The soil profile on each level is divided vertically into three zones. They are the top of the upper zone (TUZ) equal to 10.2 cm, the bottom of the upper zone (BUZ) equal to 20.3 cm, and the lower zone (LZ) that has thickness of 120 cm (Fig. 5). The TUZ receives water from infiltration from precipitation when not inundated and seepage when inundated and loses water only by bare soil evaporation and runoff when not inundated and by percolation to the BUZ whenever the water content of the TUZ exceeds field capacity (FC). The BUZ receives percolated water from the TUZ and loses water by actual evapotranspiration (AET) when conditions are suitable for plant growth and by percolation to the LZ whenever the water content exceeds FC. The LZ receives percolated

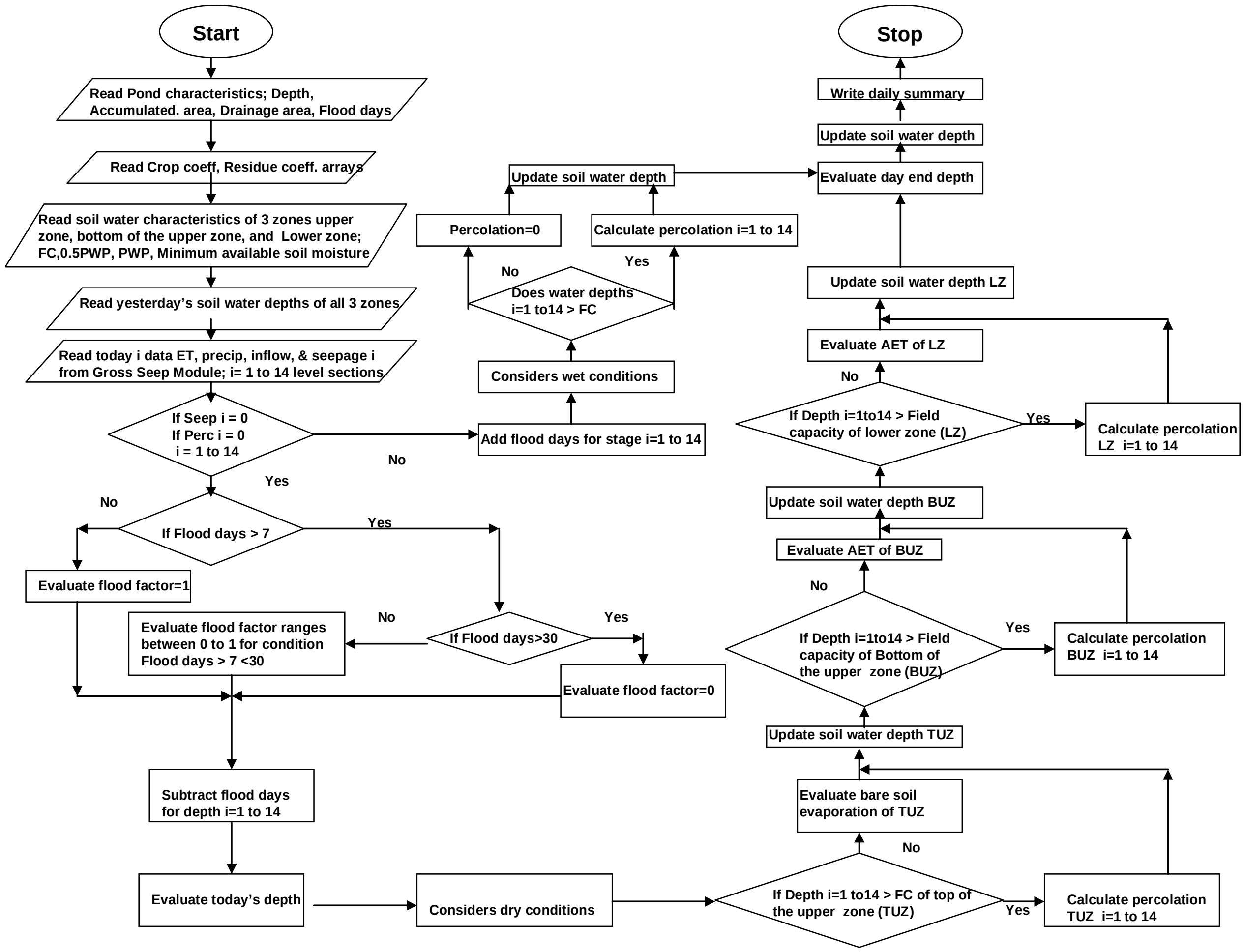



**Figure 4. The general algorithm for net seepage module.**

water from the BUZ and loses water by AET when conditions are suitable for plant growth and by percolation out of the LZ whenever the water content exceeds 90% of field capacity. Water is assumed not to move up to the layer above it and back from percolation that moves below the LZ.

There are three distinct scenarios we can expect in modeling vertical soil water movement. First, whenever a level is inundated, no bare soil evaporation or transpiration occurs from that level.

The second scenario is when inundation affects plant transpiration and actual evapotranspiration (AET) is multiplied by transpiration factor (TF). During inundation there is no transpiration from plants on the particular level because the gross seepage module calculates water loss by evaporation from all inundated areas equal to $ET_o$.

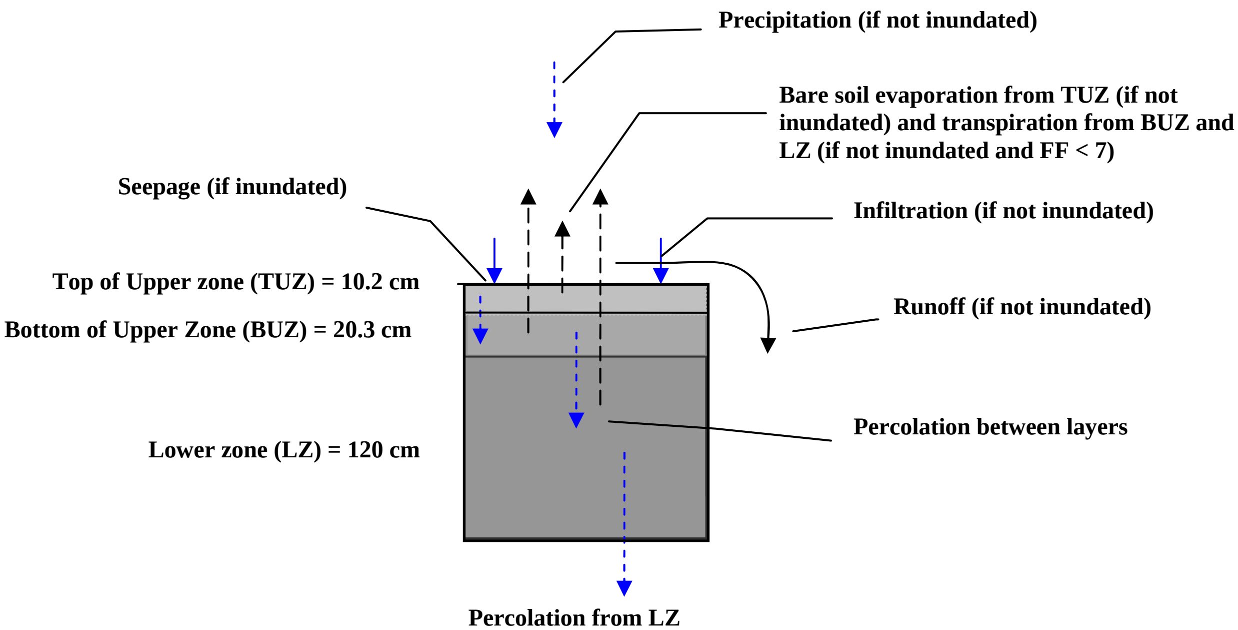



**Figure 5. Assumptions made for vertical movement of water in the soil profile for net seepage module.**

Each day inundation continues on level, a flood factor (FF) equal to the total number of days the particular level has been inundated, to a maximum of 60 days, accumulates. If FF is less than 7 days, then TF=1 and transpiration resumes at the full rate for the day as soon as inundation ceases. When inundation ceases, FF is reduced by 1 each day until it reaches 0. When the FF greater than 30 days, TF=0. When the FF is more than 7 and less than 30 days, TF is calculated for the day by,

$$TF = \frac{(30-7)-(FF-7)}{(30-7)} \tag{3}$$

Third, during the periods when inundation is not occurring and FF is less than 8, TF=1.

### Bare soil evaporation calculation

Soil water evaporation occurs whenever a level is not inundated. It is described by the two-stage process found in FAO Irrigation and Drainage Paper 56 (Allen et al., 1998). The first-stage, when the soil is wet, evaporation occurs at a constant rate equal to the amount of $ET_o$ that reaches the surface. Second-stage evaporation occurs when the hydraulic properties of soil limit the evaporation rate. This stage occurs when the available soil water (ASW) falls below a threshold limit. The process uses soil-water content characteristics that are equivalent to about a 10-cm layer of soil. Thus, we use a thickness of 10.2 cm for TUZ. When water content is above FC, all excess water percolates to the BUZ at the end of each day. When ASW content is above 70% of FC, water continues to be lost at the rate of $ET_o$ that reaches the soil surface. Between 70% FC down to a water content of 50% of permanent of wilting point (PWP), the rate of evaporation is reduced linearly from 100% of the rate of $ET_o$ reaching the surface down to 0%. The amount of $ET_o$ reaching the bare soil surface is reduced by a residue factor (RF) and by the monthly water-use-coefficient (WUC) times TF.

**Actual evapotranspiration**

The portion of $ET_o$ left after what was used for bare soil evaporation, $ET_{rem}$, is applied to the monthly WUC times TF to estimate actual evapotranspiration (AET) from the BUZ and LZ each day,

$$AET = ET_{rem} * WUC * TF * SWC \quad (4)$$

Where,

SWC = the soil water coefficient

SWC is 1.0 when the ASM is greater than 30% of FC and reduces linearly to 0 at PWP.

The amount of AET taken from BUZ is 20% of the total when SWC is 1.0. If the SWC of the BUZ is less than 1.0, then AET from the BUZ is reduced by the SWC. The amount of AET that remains after subtracting the amount satisfied by the BUZ is passed to the LZ where it is satisfied as much as possible based up the SWC of the LZ.

Finally, at the end of each day the water content in each soil layer is updated.

Output from the net seepage module is monthly estimates of the water balance for each of the 14 levels in the reservoir. In particular, it produces the percolation below the LZ and the percent net seepage which is calculated as the percolation below the LZ divided by the gross seepage into the particular level.

***Gross Seepage Model Calibration and Verification***

The gross seepage module was first calibrated by applying it to the reservoir, DPL-Hogan. Then, two other reservoirs, DCN-Zimb and DRA-Holste, were operated with the modules to examine visually how well results from the module agreed with their observed water depths during the measurement period.

## Results and Discussion

Figure 6 shows the measured water level in DPL-Hogan reservoir, located in northwest Phillips County, Kansas, from October 25, 2004 through October 02, 2007. This reservoir provided us the best record of continuous water level with respect to time from which we could perform an inspection of its operation on a daily basis to get estimates of average seepage rates. The exact date of construction of the dam is unknown, but it was probably in the 1960's. The watershed area is 32.5 ha and its soil is characterized as Uly, Penden silt loam in hydrologic soil group B (NRCS, 2008). Land use in the watershed area is characterized by pastured rangeland with about five percent average slopes. The storage volume in the reservoir at the 6.1-m wide earthen spillway level of 4,860 equal to 1.65 cm over its watershed area. The reservoir surface area at spillway level is 0.41ha. Annual precipitation at the nearest station, Long Island, Kansas averages 62 cm, and weighted annual $ET_o$ between the two nearest locations, Colby and Scandia, KS averages 130 cm. The reservoir was one of two water sources for about 30 cattle in the approximately 80-ha fenced area around the reservoir. Cattle were in the area only during the growing season. Total water consumption was estimated to be small, on the order of 100 $m^3$, and well within the uncertainty of our other assumptions, so we did not include it in our balance calculations.

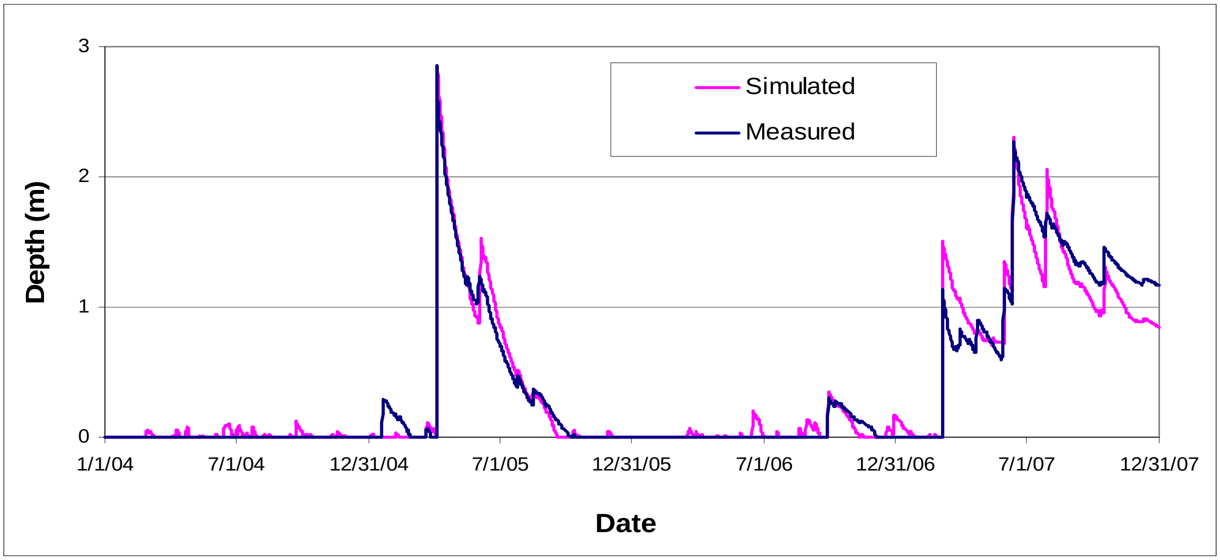



**Figure 6. Continuous measured water depth record and simulated water depth for DPL-Hogan during study period, 2004-07.**

***Examination of the Water Level Record to Estimate Daily Gross Seepage***

Since seepage and evaporation are continuous whenever there was water impounded in a reservoir, the sum of the two could be reasonably estimated on most days. In the study area, average annual values of $ET_o$ agree reasonably well with the average annual evaporation from small reservoirs provided by the USDA NRCS as shown on p. 45 in Viessman et al. (1977) of about 135 cm. Since we had $ET_o$ values available on a daily basis, we used them directly to estimate daily evaporation. So, daily $ET_o$ was added to the daily loss of water level during days with no precipitation or inflow to estimate seepage using Equation 1.

One large inflow event on April 5, 2005 from a 9.5-cm rainfall event that produced an estimated 9,300 $m^3$ of runoff filled the reservoir and produced an estimated overflow of 3,640 $m^3$. This event and the subsequent period with essentially no more inflow provided us with the opportunity to observe seepage rates for the full range of depths for the reservoir. The results of this inspection of the daily water-level record for DPL-Hogan to estimate daily seepage are shown in Figure 7.

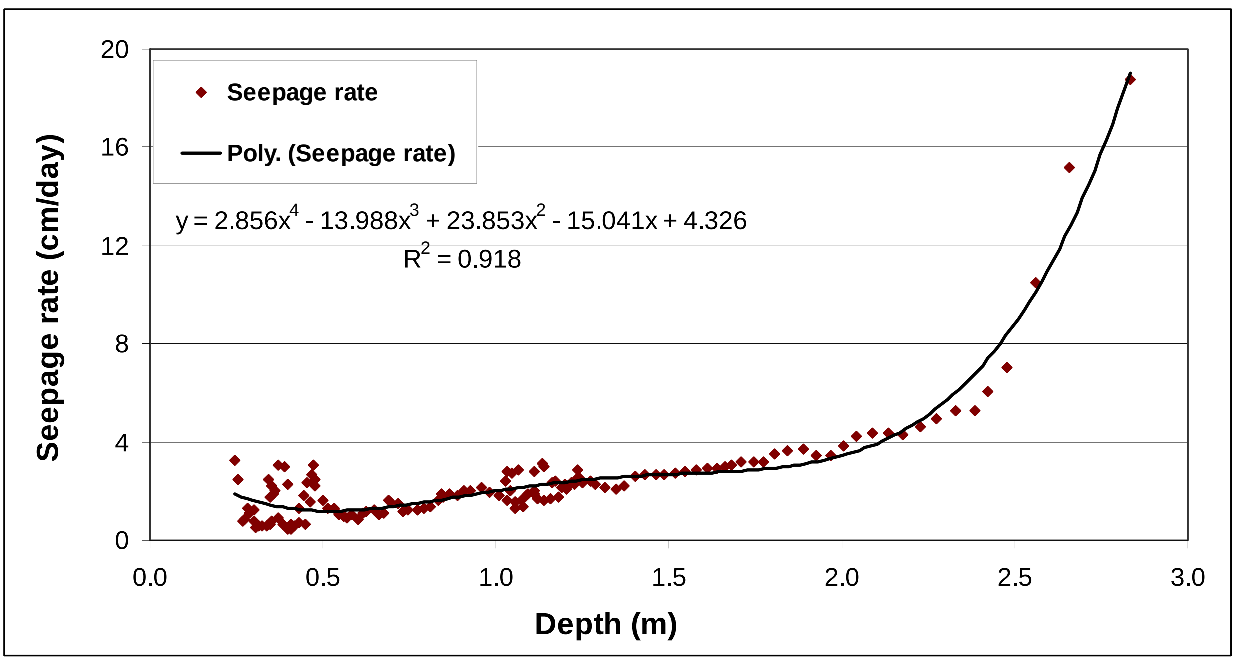



**Figure 7. Calculated daily seepage rate versus depth of the reservoir DPL- Hogan.**

Clearly, the average seepage rate decreased as the water level in the reservoir decreased. We believe the high rate of seepage is mostly from higher rates of infiltration into the sides of the reservoir that are only infrequently inundated and probably due somewhat to the additional hydraulic head on the bottom parts of the reservoir. The graph of daily seepage rate shows quite a bit of scatter, but considering that water levels were measured to the nearest 0.01-ft (0.3-cm) that amount approached the daily seepage rate when the reservoir level was less than half the full depth. So, any fluctuations in values were quite large compared to calculated seepage amounts. Also, precipitation differences between at the reporting station located about 5 km to the north of the site likely contributed additional fluctuations in the daily seepage rates. Below about one meter depth seepage averaged near 0.4 cm/day.

***Examination of the Water Level Record to Estimate Inflow***

Once seepage rates were determined as above, those rates were used as inputs to Equation 1 as the accepted values along with the daily precipitation and $ET_o$, then the daily amount of inflow could be solved for as the only unknown. The resulting water balance for the period, April 5 to August 22, 2005 is shown in Table 1. For this period, overflow amounted to 36% of total inflow. Precipitation onto the water surface was small compared to inflow and equaled about 67% of the evaporation from it. Thus, gross seepage was the only way that nearly all of the water retained in the reservoir was lost. Since gross seepage is such an important part of the water budget for these ponds, understanding how much of it might become potential ground-water recharge is important.

**Table 1. Water balance for DPL-Hogan for the period, April 5 to August 22, 2005**

| **Inputs** | All volumes in cubic meters* |
|---|---|
| Inflow from the watershed | 10,040 |
| Precipitation on water surface | 430 |
| **Total** | 10,470 |
| **Outputs** | |
| Overflow | 3,640 |
| Evaporation from water surface | 640 |
| Gross seepage | 6,100 |
| Cattle consumption (unknown & small) | 0 |
| **Total** | 10,380 |
| Change in storage | 100 |

*All volumes rounded to nearest 10.

***Calibration of Gross Seepage Module***

Calibration was done for the period, April 5 through August 22, 2005, when water levels in the DPL-Hogan reservoir started at spillway level and dropped to less than 0.5 m. Daily values of precipitation, $ET_o$, inflow, and measured water depth were input along with the reservoir characteristics represented by the 14 level sections which included their height above the bottom, surface area and estimated seepage rate at 0.3-m of hydraulic head. Outputs of water level in the reservoir from each run were compared visually with the measured record of water depth and the average difference between measured depth and simulated depth was calculated. For the calibration period, the average difference in water depth was only 1.3 cm.

To improve the fit between measured and simulated depths, we changed the standard seepage rates for some of the sections slightly in combination with the exponent on the head term. We did increase the seepage rates a bit for the higher levels in the reservoir. The 0.25 exponent, however, gave us the best fit. Finally, we show a comparison of simulated water depths with measured for the period of record in Figure 6.

Table 2 includes the water balance for DPL-Hogan for the 4-year calibration period. The results are similar to the event period presented above with the exception that no more overflow occurred. Gross seepage was computed to be 94% of the inflow retained in the reservoir.

***Verification of Gross Seepage Module***

The other two reservoirs DCN-Zimb and DRA-Holste were selected for model verification. The process of model verification involved comparing the model simulation results with measured water level data.

**Description of the reservoirs**

**DCN-Zimb**

This reservoir is located in the western Cheyenne County, Kansas. Precipitation data, obtained from the nearest station St.Francis 8NW, located 6 km from the reservoir, was used. Annual average precipitation is 46 cm. DCN-Zimb has a watershed area of 29.9 ha with average land slope of 7 percent. One third of the drainage area is cropland with level-closed end terraces is poor condition and the remaining two thirds is grazed pasture/range. Soils are characterized as Colby silt loam with good permeability of about

15.24 cm/day. $ET_o$ was taken as 97% of the Colby station or 126 cm. The reservoir surface area at spillway level is 0.48 ha.

**Table 2. Simulated water balance for the three reservoirs used for the study, 2004-07.**

| **Inputs** | All volumes in cubic meters* | | |
|---|---|---|---|
| | DPL-Hogan | DRA-Holste | DCN-Zimb |
| Inflow from the watershed | 19,600 | 96,310 | 19,210 |
| Precipitation on water surface | 2,560 | 9,480 | 1,870 |
| **Total** | 22,160 | 105,790 | 21,080 |
| **Outputs** | | | |
| Overflow | 3,370 | 24,820 | 650 |
| Evaporation from water surface | 3,080 | 8,060 | 3,190 |
| Gross seepage | 15,700 | 72,920 | 17,240 |
| Cattle consumption (unknown & small) | 0 | 0 | 0 |
| **Total** | 22,150 | 105,800 | 21,080 |
| Change in storage | -43 | 0 | 0 |
| Delta difference | -32 | 0 | 0 |
| Delta difference in % | -0.1 | 0.0 | 0.0 |

*All volumes rounded to nearest 10.

**DRA-Holste**

DRA-Holste is located in the Rawlins County and has a watershed area of 174 ha. Precipitation data was obtained from the nearest station at Atwood 8SSE, located 10 km from the reservoir. Annual average precipitation is 55 cm. Soils (types) at the site have good permeability of 0.50 to 15.24 cm/day. Land use in the watershed area is characterized by pastured rangeland. A weighted average of $ET_o$ between Colby, KS and Scandia, KS was used for the site. The reservoir surface area at spillway level is 1.83 ha.

Figures 8 and 9 show the comparison of measured and simulated water depths during the field measurement period. The average difference between measured and simulated daily water depth in the DCN-Zimb was 4 cm and in the DRA-Holste was 1 cm. Days with zero depths are included in the averages. Finally, Table 2 shows the simulated water balance for these two reservoirs.

***Effect of Reservoirs on Streamflow and Gross Seepage at the Reservoir Site***

The details of water budget estimation with and without reservoir scenarios for all three reservoirs are presented in the Table 3. It was observed that contribution to streamflow without

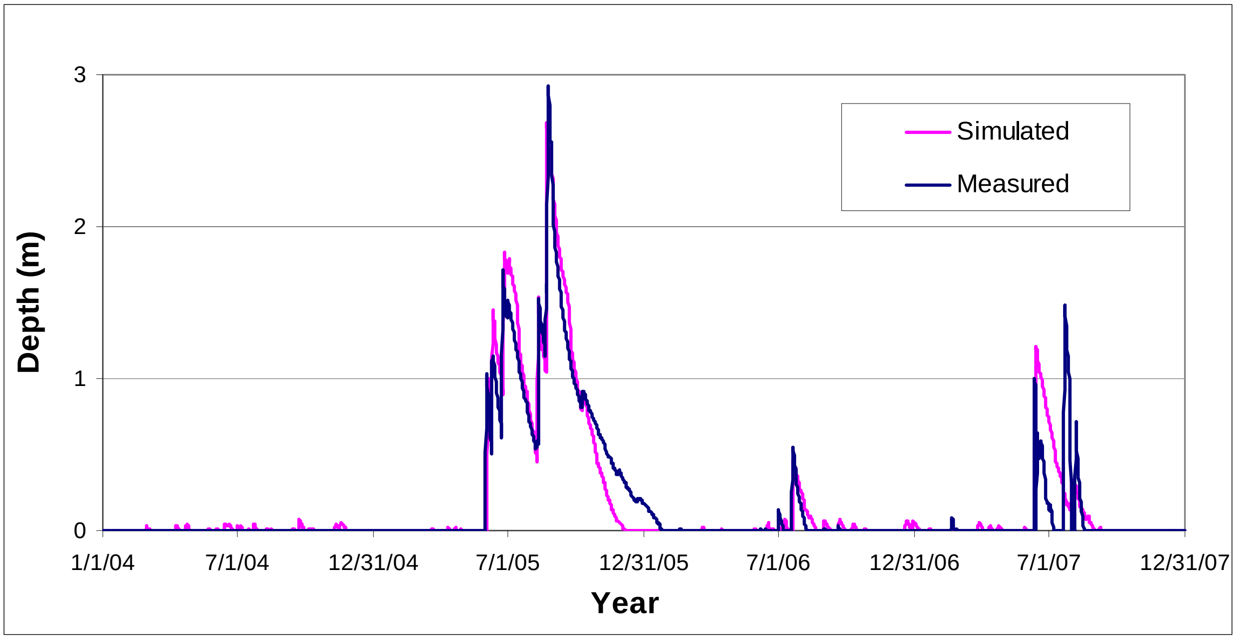



**Figure 8. Simulated versus observed water depth comparison of the reservoir DCN-Zimb, 2004-07.**

the reservoir was significant. With the reservoir in place, streamflow from the reservoir watershed was reduced by 82% to 96%. Of water retained at the reservoir locations for during the 4-year study period, from 91% at DCN-Zimb to 94% at DPL-Hogan became gross seepage.

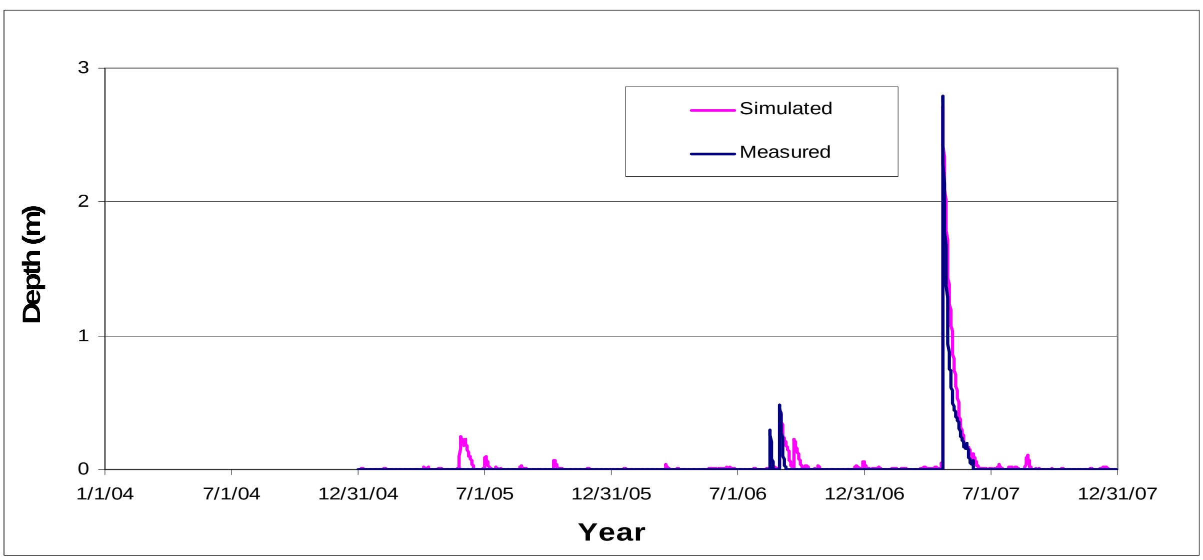



**Figure 9. Simulated versus observed water depth comparison of the reservoir, DRA-Holste, 2004-07.**

### *Estimating Net Seepage*

The net seepage module cannot be calibrated directly since we do not have any measurements of soil water content. However, we can make judgments about the reasonableness of the results, particularly for Level 14 which is above the maximum water level which is not inundated. For the purposes of this work, we present results for DPL-Hogan to show what results were found for the reservoir and for various levels within the reservoir. The same 4-year period that was simulated for the gross seepage module was used for this simulation. Because of the amount of change in the soil water content of the 120-cm deep soil profile, results for net seepage may affected by slightly by the change in storage.

**Table 3. Comparative water input and output with and without reservoir at the three sites during the study period, 2004-07 (4 years).**

| Inputs | All volumes in cubic meters* | | | | | |
|---|---|---|---|---|---|---|
| | DPL-Hogan | | DRA-Holste | | DCN-Zimb | |
| | Without reservoir | With reservoir | Without reservoir | With reservoir | Without reservoir | With reservoir |
| Inflow from the watershed | 20,540 | 20,260 | 96,530 | 98,310 | 17,300 | 19,210 |
| Precipitation on water surface | - | 2,550 | - | 9,520 | - | 1,870 |
| **Total** | 20,540 | 22,810 | 96,530 | 107,830 | 17,300 | 21,080 |
| **Outputs** | | | | | | |
| Overflow | 20,540 | 3,640 | 96,530 | 11,750 | 17,300 | 650 |
| Evaporation from water surface | - | 3,080 | - | 8,830 | - | 3,190 |
| Gross seepage | - | 15,690 | - | 74,150 | - | 17,240 |
| Cattle consumption (unknown & small) | - | 0 | - | 0 | - | 0 |
| **Total** | 20,540 | 22,410 | 96,530 | 94,730 | 17,300 | 21,080 |
| Change in streamflow | -16,900 | | -84,780 | | -16,650 | |
| Change in streamflow (%) | -82.2 | | -87.8 | | -96.2 | |
| Increase in gross seepage | 15,690 | | 74,150 | | 17,240 | |

*All volumes rounded to nearest 10.

Table 4 shows the simulated 4-year average water balance for the 14 different levels within the reservoir. Recall that Level 14 is above the maximum water level and represents the level where no seepage is added. Figure 10 compares gross and net seepage graphically for the 14 levels. It shows that both gross and net seepage were maximum in Levels between 5 to 7, and it was lower in the lower and upper levels.

Level 1 has a lower net seepage percentage because it has a lower seepage rate that reduces gross seepage when it was inundated and also, when precipitation onto the pond occurred when the reservoir was empty all precipitation was accounted for in the inflow for the day. Thus, precipitation on Level 1 is 0. Since Level 1 was usually affected by the FF on any day with precipitation added a day to the FF. This resulted in more of the $ET_0$ being used by bare soil evaporation that resulted in more of the gross seepage being lost from Level 1. In the upper levels, net seepage was less at middle levels because when events occurred, more of the gross seepage was used to fill the soil profile because they were usually drier than the middle levels.

The net seepage module estimated that a total of 14,750 $m^3$ of the gross seepage amount of 15,960 $m^3$ for DPL-Hogan moved below the LZ during the 4-year study period. This amounts to 92% of the gross seepage.

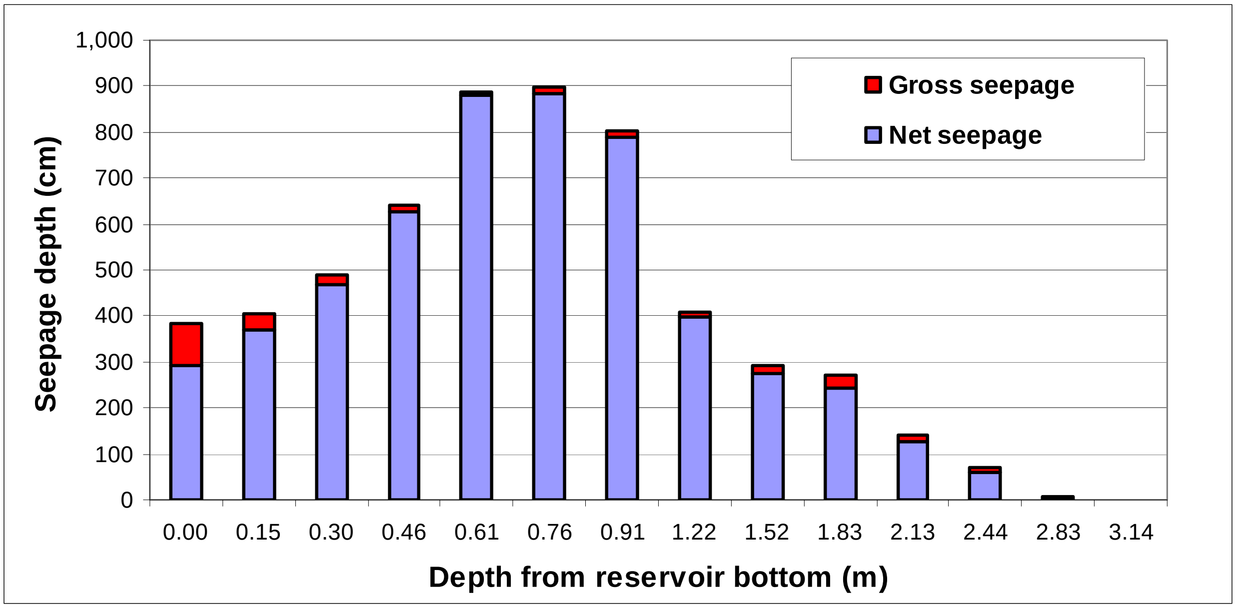



**Figure 10. Simulated gross and net seepage at different depths of the reservoir DPL-Hogan, 2004-07.**

**Table 4. Water balance predicted by the net seepage module at different levels in the reservoir DPL- Hogan, 2004-07 (4 years).**

| Levels | Depth above bottom (m) | Gross seepage (cm) | P [a] (cm) | Net seepage [b] (cm) | Bare soil evaporation (cm) | AET (cm) | Runoff (cm) | Change in soil water (cm) | Net seepage [b] (%) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 384 | 0 | 292 | 46 | 27 | 0 | 19 | 76 |
| 2 | 0.15 | 404 | 116 | 371 | 73 | 56 | 0 | 19 | 92 |
| 3 | 0.30 | 489 | 135 | 467 | 78 | 59 | 0 | 19 | 96 |
| 4 | 0.46 | 641 | 146 | 627 | 80 | 60 | 0 | 19 | 98 |
| 5 | 0.61 | 888 | 153 | 879 | 82 | 61 | 0 | 19 | 99 |
| 6 | 0.76 | 898 | 156 | 885 | 87 | 62 | 0 | 19 | 99 |
| 7 | 0.91 | 805 | 169 | 791 | 95 | 70 | 0 | 19 | 98 |
| 8 | 1.22 | 410 | 198 | 398 | 110 | 81 | 0 | 18 | 97 |
| 9 | 1.52 | 294 | 219 | 276 | 117 | 106 | 1 | 13 | 94 |
| 10 | 1.83 | 272 | 227 | 247 | 120 | 123 | 1 | 7 | 91 |
| 11 | 2.13 | 145 | 236 | 129 | 122 | 123 | 1 | 5 | 89 |
| 12 | 2.44 | 76 | 244 | 66 | 123 | 124 | 2 | 5 | 86 |
| 13 | 2.83 | 15 | 245 | 5 | 124 | 124 | 2 | 5 | 35 |
| 14 | 3.14 | 0 | 255 | 0 | 124 | 121 | 5 | 5 | - |

[a] Precipitation on to the soil surface when level was not inundated. For level l (bottom of the reservoir), all precipitation was accounted for as inflow.

[b] All percolation out of Lower Zone

***Effect of DPL-Hogan Reservoir on Streamflow and Net Seepage at the Reservoir Site***

The combined results of the study results for DPL-Hogan show that 94% of the retained inflow became gross seepage and 92% of the gross seepage was calculated to become net seepage out of the LZ. The overall result is then that 86% of the retained inflow was accounted for as net seepage. Finally at the reservoir site, streamflow was reduced by 16,900 $m^3$, but net seepage or potential for ground-water recharge was increased by 14,750 $m^3$. This results in about a 13% reduction in sum of streamflow plus potential ground-water recharge at the reservoir site. Of course, the reservoir did provide other benefits for some water supply for cattle, a minor flood control benefit, and perhaps some erosion control and recreation uses.

## Conclusions

This work showed that it is possible to estimate daily seepage for a small reservoir from daily water level measurement provided reasonable estimates of precipitation and $ET_o$ are available to use when inspecting the water level record. More than 90% of the retained water in the reservoirs was calculated to be lost as seepage out of the reservoir. Over a 4-year study period, between 82 and 96% of inflow to the reservoirs was retained.

The gross seepage module method approach used to simulate the operation of a typical reservoirs located in the Republican River Basin gave a satisfactory result for gross seepage amounts. Representing the reservoir as a series of 14 level sections helped account for the different seepage rates within the reservoir area. Hydraulic head effect on the seepage rate for the various levels was found to be best represented by applying a power of 0.25 to the head above each level when the total head was greater than 0.3 m. The gross seepage module predicted good agreement between measured and simulated water levels in three reservoirs.

A net seepage module was developed and applied to estimate how much of the gross seepage might be expected to move through the rooting depth of plants in the reservoir storage area and become potential ground-water recharge using a water budget method on each of the 14 level sections assuming only vertical water movement. With a 1.5-m rooting depth, 92% of the gross seepage was estimated to be net seepage below the rooting depth and potential ground-water recharge.

Finally at the reservoir site, DPL-Hogan, streamflow was reduced by 16,900 $m^3$, but net seepage or potential for ground-water recharge was increased by 14,750 $m^3$**.** This results in about a 13% reduction in sum of streamflow and potential ground-water recharge at the reservoir site. The effect of the reservoir on downstream surface water supply and ground-water recharge that might have occurred in the alluvial stream system depends upon several factors that beyond the scope of this paper and these factors complicate considerably the aggregated effect of all of the 716 reservoirs in the entire study area.

# Extending the Results of Small Reservoir Operations Simulations

The main source of water to the reservoir is the runoff (inflow) from the watershed area. To assess the effect of inflow on outflows of net seepage and overflow, the amount of inflow was changed to test the performance of the model. The original average annual inflow for the long run was changed by 25-percent steps to +100% to -75% at a time. The simulation was run for each changed input. The net seepage and overflows were used as the indicators to draw conclusions.

In the same way the seepage rate was changed for all levels of the reservoir. The seepage rate was changed in increments of 25% between 75% less up to 200% more.

The depth of the reservoir was altered so that surface area changed but the volume remained the same for the new depth.

Lower zone soil depth is one of the crucial assumptions made to estimate AET and net seepage. To examine its effect, the original lower zone soil depth of 120 cm was changed. During the development of the model, lower zone depth was decided on by looking into the root zone depth. The inspections in the reservoir location indicated that, there were perennial grass and weed growth. It was assumed that, to facilitate these plants to extract water, a 120-cm lower zone depth was selected. Lower zone soil depths were changed to 0.2 m increments from 0.2 m to 2.4 m.

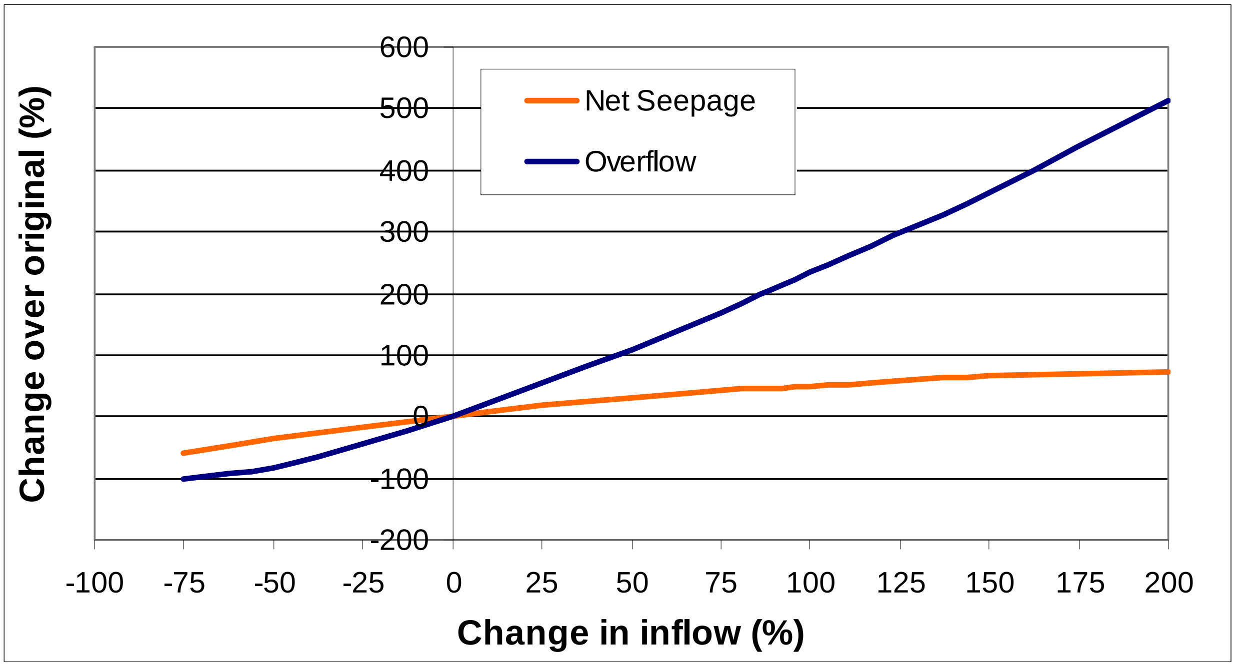
While developing the modules, evaporation from the water surface area, and evapotranspiration from the plants was assumed to be on par with the grass reference evapotranspiration. The $ET_0$ for this assumption was obtained from the nearest two stations and the distance-weighted value was used for the simulation. To test the effect of this assumption, original $ET_0$ was changed in increments of 25% between 75% lower to 200% above the original daily values.

## Results and Discussion

Results of the simulation run for inputs of inflow change from the watershed area, reservoir depth, seepage rate, thickness of the lower zone soil depth of the 14 level sections and evaporation from water surface are discussed in this chapter. The simulation was run for historical weather data from the year 1971 to 2007.

The results of effect of inflow on net seepage and overflow are shown in the Figure 11.

**Figure 11. Relative change in net seepage and overflow as affected by change in inflow of reservoir DPL-Hogan, 1971-2007.**




It was observed that, by reducing inflow by 50%, net seepage and overflow were reduced by 30% and 83%, respectively. When inflow was increased by 100% net seepage was increased by 47% and overflow by 234%. This indicated that, the net seepage was less sensitive compare to overflow. More inflow results in more water retained in the reservoir more of the time to increase seepage, but it also resulted in less storage volume for subsequent inflows, so overflow increased substantially.

The effect of altered seepage rate is shown in the Figure 12. The net seepage was increasing by increasing the seepage rate whereas overflow showed opposite trend. This is because, as the seepage rate increased storage volume and enhanced storage volume for subsequent inflow. The increased seepage increased percolation, too. The opposite trend was being found in overflow. The increased seepage rate reduced overflow. Note, however, relative effects for changes in seepage are much less than for inflow changes.

In another test conducted, the lower zone soil depth was changed in the net seepage module to understand its effect on outputs. The results are presented in the Figure 13. The net seepage was decreased as the depth increased. This is because of increase in depth increases water storage capacity of the soil layer and more water is required to fill the soil column before percolation out of the zone occurs.

**Figure 12. Relative change in net seepage and overflow as affected by change in seepage rate of reservoir DPL-Hogan, 1971-2007.**

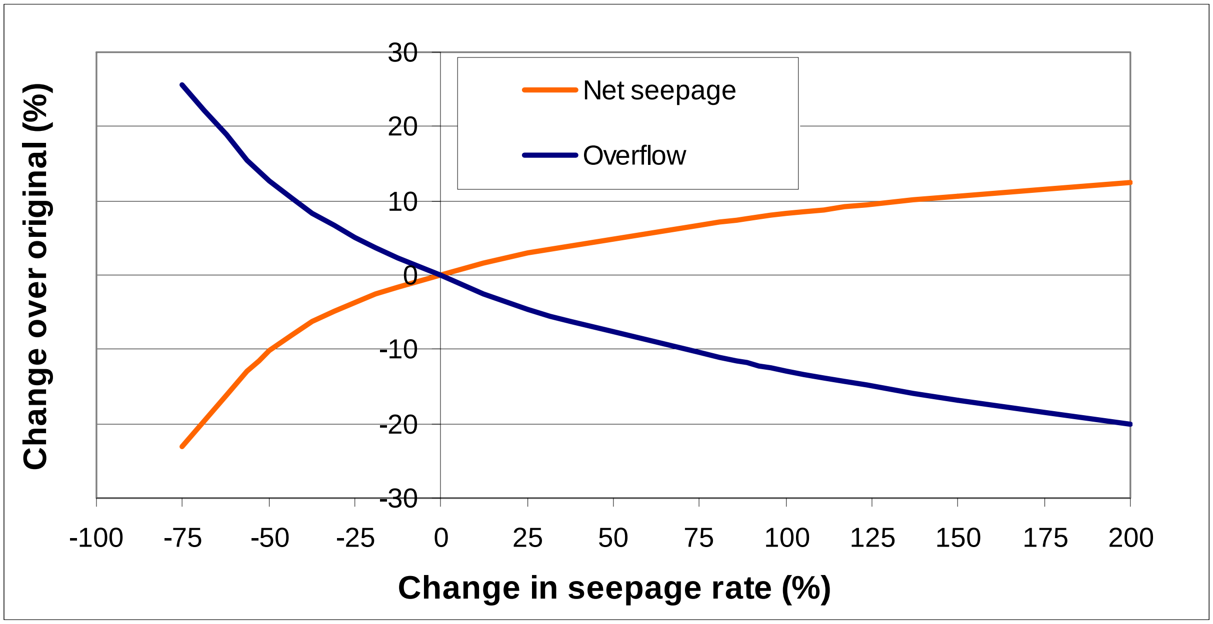
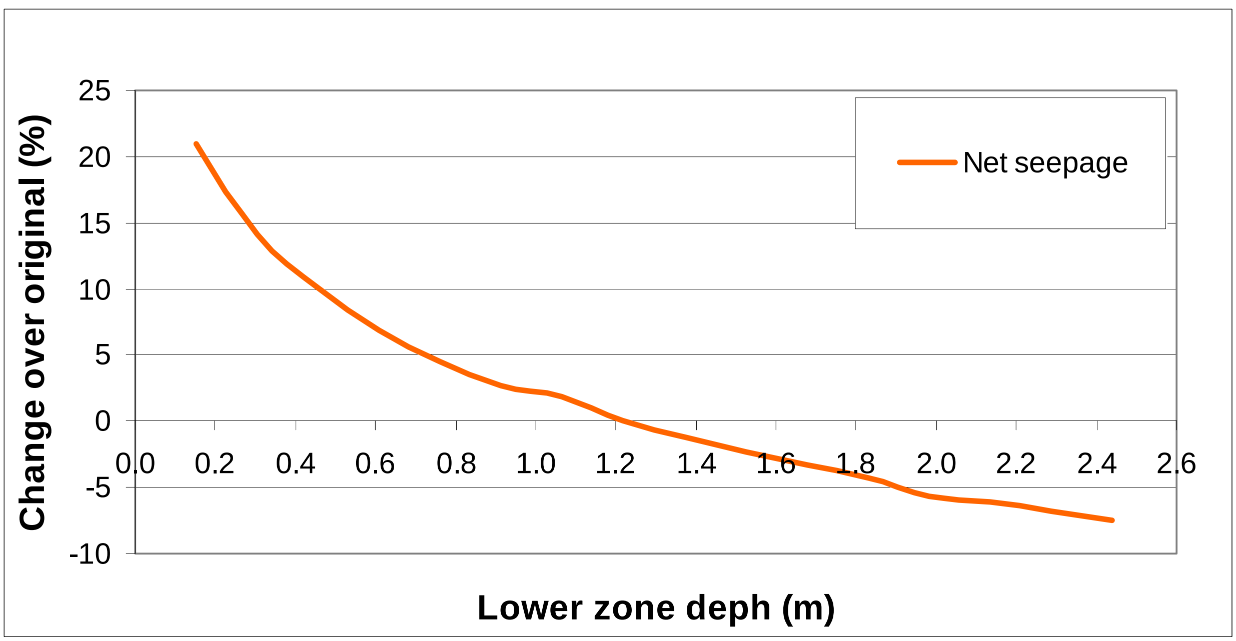
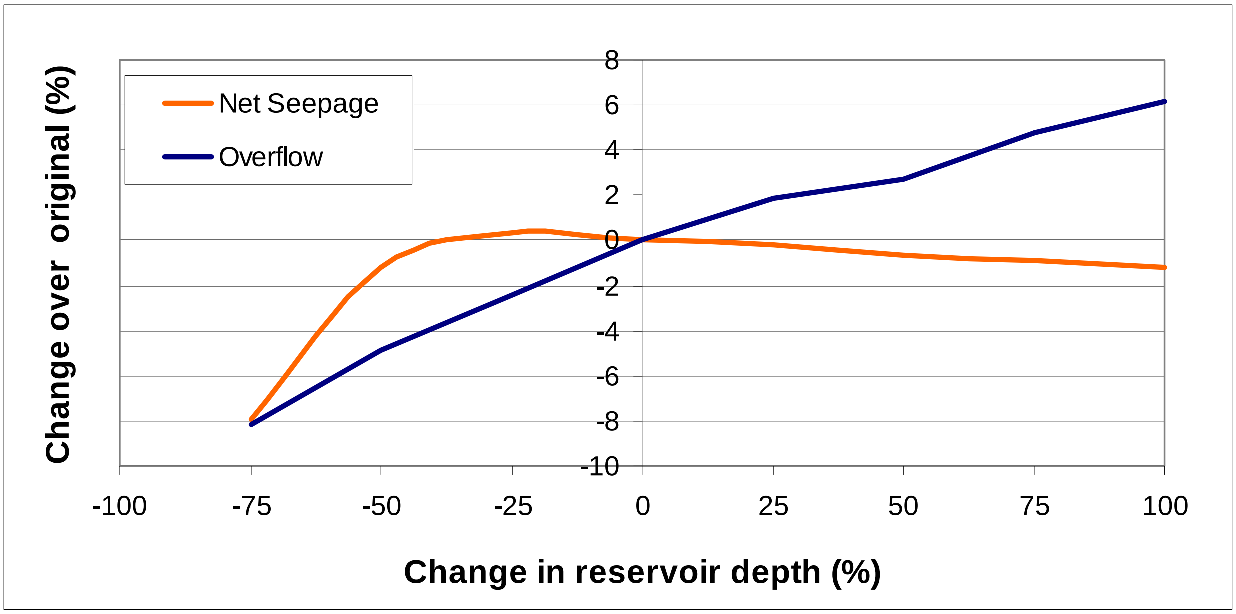



**Figure 13. Relative change in net seepage as affected by lower zone soil depth of reservoir DPL-Hogan, 1971-2007**




The influence of change in depth and surface area on net seepage and overflow is shown in the figure 14. The results showed that, there was limited impact on both net seepage and overflow. However, overflow was more sensitive than the net seepage. As the depth was reduced, the surface area increased to accommodate the storage volume, which increased evaporation from the water surface. And therefore, this resulted in a reduction of both net seepage and overflow. This led to more water stored with a smaller surface area for evaporation and seepage and this encouraged more overflow and net seepage. Again, relative changes are rather small compared to inflow effects.

**Figure 14. Relative change in net seepage and overflow as affected by change in depth of reservoir DPL-Hogan, 1971-2007.**




When evapotranspiration was increased to test its effect on the outputs, both parameters were shown a decrease in trend (Figure 15). Compared to overflow, net seepage was more sensitive to changed scenario. It may be due to change in more bare soil evaporation and AET soil water content. Reservoir evaporation was less of factor which shows up as the small change in overflows.

Since average annual inflow volume compared to reservoir volume(IV) was found to be so important by these analyses, he have prepared a graph that illustrates the effect of I/V on the fractions of the inflow that becomes overflow and net seepage (see Figure 16).

**Figure 15. Relative change net seepage and overflow as affected by reference evapotranspiration rate of reservoir DPL-Hogan, 1971-2007.**

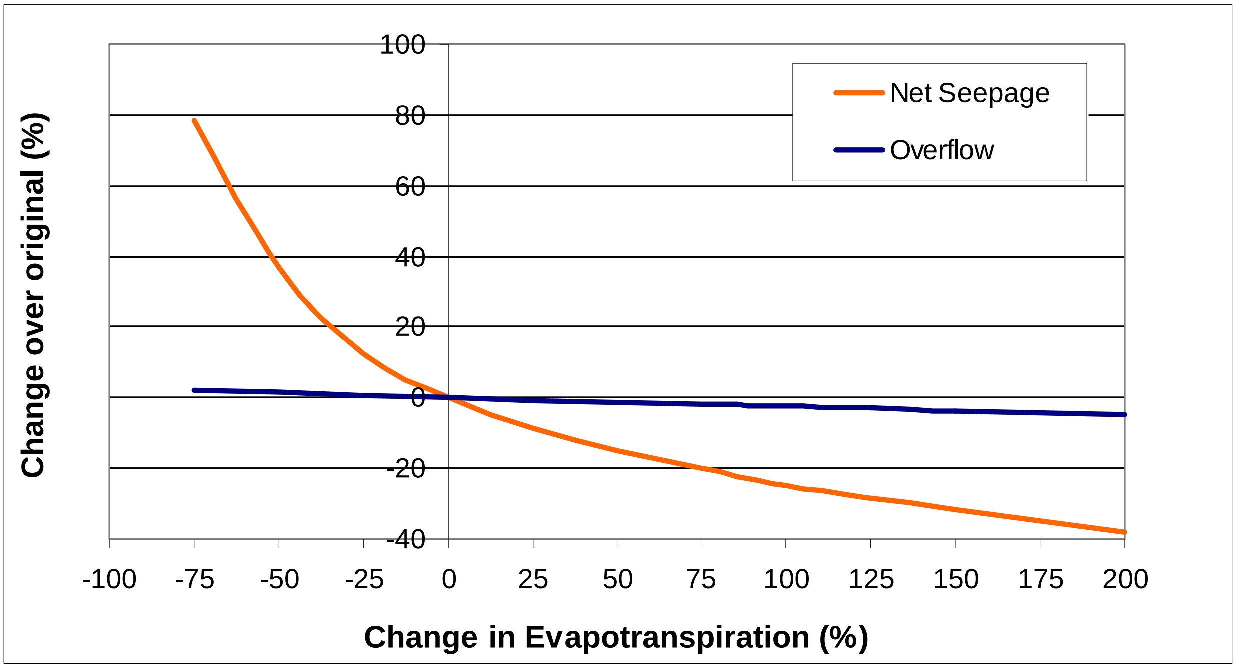
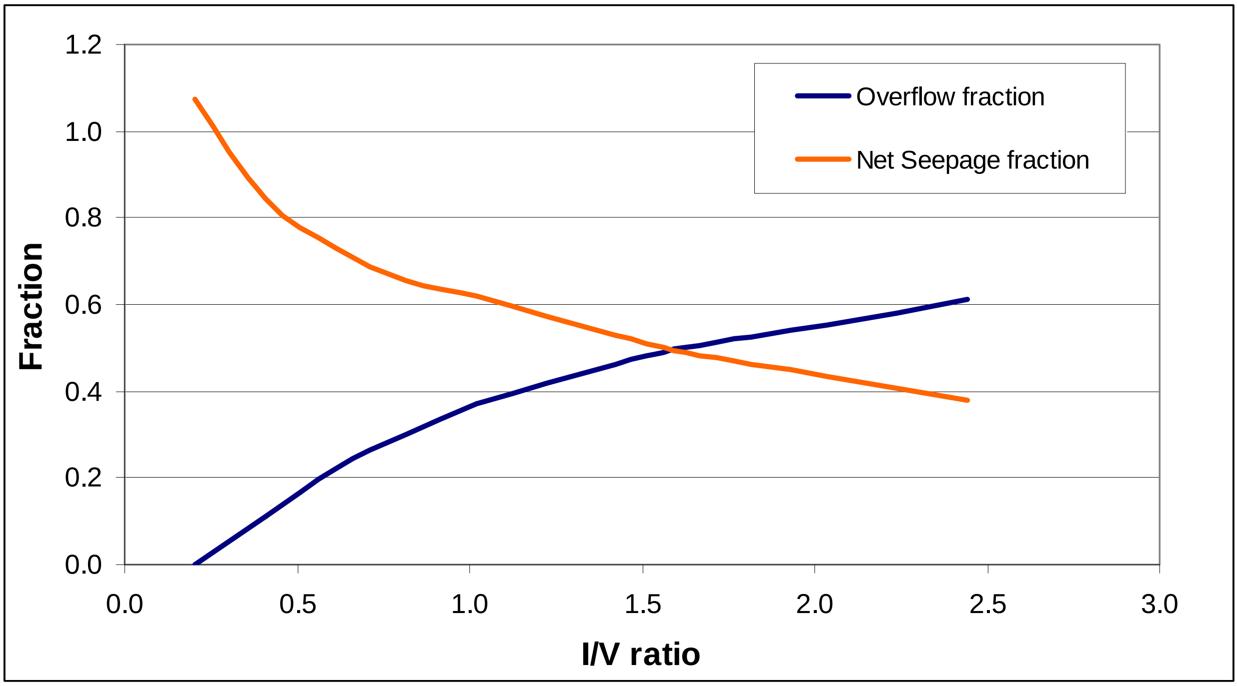



**Figure 16. Effect of average annual inflow volume/reservoir volume (I/V) on overflow and net seepage of reservoir DPL-Hogan, 1971-2007.**



## Development of a Prediction Technique for Other Reservoirs

The results of the sensitivity analysis provide basic information to develop a prediction technique to use to estimate the amount of overflow and net seepage for other reservoirs in the basin by using the results to develop a simple relationship to incorporate the values of several characteristics of a reservoir to estimate its conversion of inflow into overflow and net seepage at the reservoir location.

First, the results of the sensitivity analyses for DPL-Hogan were converted into tabular form as shown in Table 5 and the conditions for that reservoir were assigned a value of 100% for each of the four factors about the reservoir considered most important to describe the relationship between annual overflow and net seepage for the reference reservoir and the other variables of importance.

1) The average annual inflow volume from the watershed compared to reservoir storage volume (I/V) at spillway level provides the relative capacity of the reservoir to retain inflow.
2) The relative seepage rate from the reservoir affects the amount of seepage loss. We chose to use an estimate of the approximate clay content (ACC) in the soils at the reservoir site as a measure of the relative seepage rate. DEPL-Hogan had a lower seepage rate than the other two reservoirs used above. We found that the soil types at the sites showed DPL-Hogan to have the highest clay content at about 30%. The relative hydraulic conductivity of soils can be estimated by using the technique described by Saxton et al. (1986). We used that relationship to estimate the relative seepage rate relationship for other reservoirs.
3) Average reservoir depth (D) defined by reservoir storage volume divided by surface area at spillway level is the third factor. The depth has a minor effect, but it is included in the predictors.
4) Finally, since the net loss of water by evaporation from the reservoir surface is the difference between evaporation and precipitation onto the surface, the term annual moisture deficit (AMD) is used instead of just evaporation. AMD is the average annual evaporation minus the average annual precipitation. Average annual reference evaporation for Long Island, KS is 51.2 inches and normal annual precipitation is 24.0 inches and this produces an AMD of 27 inches.

**Table 5. Effects of several reservoir and watershed characteristics on the portion of inflow that becomes overflow and net seepage for a small reservoir in the Republican River Basin (see Excel file, Reservoir Characteristics Analysis.xls).**

| Reference Reservoir Characteristics | |
|---|---|
| Site Identifier | DPL-Hogan |
| Location: | Phillips County, KS |
| Watershed Area, acres: | 81.0 |
| Average Annual Runoff, inches: | 0.5 |
| Storage Volume at Permanent Spillway, acre-ft: | 4.0 |
| Surface Area at Permanent Spillway, acres: | 1.1 |
| Maximum Water Depth, feet | 9.3 |
| Weighted Average Seepage Rate, in./day | 0.4 |
| Reservoir Soils Approximate Clay Content (ACC), % | 30 |
| Average Reservoir Depth (D), feet: | 3.6 |
| Watershed Area:Reservoir Surface Area Ratio: | 72 |
| Average Annual Precipitation (P), inches: | 24.0 |
| Average Annual Small Lake Evaporation (E), inches: | 51.2 |
| Average Annual Moisture Deficit (AMD) = E-P), inches: | 27.2 |
| Average Annual Inflow Volume from Watershed, ac-ft | 3.5 |

| **Percent of Reference Reservoir Value:** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
|---|---|---|---|---|---|---|---|
| **Annual Inflow Volume/Reservoir Volume (I/V):** | **0.20** | **0.41** | **0.61** | **0.81** | **1.01** | **1.22** | **1.62** |
| **Overflow Volume/Inflow Volume Ratio (O/I):** | **0.00** | **0.11** | **0.22** | **0.29** | **0.37** | **0.42** | **0.51** |
| **Net Seepage Volume/Inflow Volume Ratio (NS/I):** | **0.99** | **0.88** | **0.75** | **0.67** | **0.63** | **0.58** | **0.49** |

| **Percent of Reference Reservoir Value:** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
|---|---|---|---|---|---|---|---|
| ***Approximate* Clay Content in Reservoir Soils (ACC), % :** | **40** | **38** | **34** | **30** | **27** | **25** | **22** |
| **Overflow Volume/Inflow Volume Ratio (O/I):** | **0.36** | **0.32** | **0.30** | **0.29** | **0.28** | **0.27** | **0.25** |
| **Net Seepage Volume/Inflow Volume Ratio (NS/I):** | **0.52** | **0.60** | **0.65** | **0.67** | **0.69** | **0.70** | **0.73** |
| **ACC' = Relative Factor Effect for ACC on O/I :** | **1.13** | **1.11** | **1.06** | **1.00** | **0.96** | **0.91** | **0.87** |
| **ACC" = Relative Factor Effect for ACC on NS/I :** | **0.90** | **0.91** | **0.95** | **1.00** | **1.02** | **1.05** | **1.09** |

| **Percent of Reference Reservoir Value:** | **25** | **50** | **75** | **100** | **125** | **150** | **200** |
|---|---|---|---|---|---|---|---|
| **Average Reservoir Depth (Volume/Surface Area) (D), feet :** | **0.90** | **1.80** | **2.70** | **3.60** | **4.50** | **5.40** | **7.20** |
| **Overflow Volume/Inflow Volume Ratio (O/I):** | **0.27** | **0.27** | **0.28** | **0.29** | **0.29** | **0.30** | **0.31** |
| **Net Seepage Volume/Inflow Volume Ratio (NS/I):** | **0.62** | **0.66** | **0.67** | **0.67** | **0.67** | **0.66** | **0.66** |
| **D' = Relative Factor Effect for D on O/I :** | **1.20** | **1.11** | **1.05** | **1.00** | **0.97** | **0.95** | **0.91** |
| **D" = Relative Factor Effect for D on NS/I :** | **0.96** | **0.98** | **0.99** | **1.00** | **1.01** | **1.01** | **1.02** |

| **Percent of Reference Reservoir Value:** | **70** | **80** | **90** | **100** | **110** | **125** | **150** |
|---|---|---|---|---|---|---|---|
| **Average Annual Moisture Deficit (AMD), inches :** | **20** | **22** | **24** | **27** | **30** | **34** | **41** |
| **Overflow Volume/Inflow Volume Ratio (O/I):** | **0.31** | **0.30** | **0.29** | **0.29** | **0.29** | **0.30** | **0.30** |
| **Net Seepage Volume/Inflow Volume Ratio (NS/I):** | **0.70** | **0.69** | **0.68** | **0.67** | **0.65** | **0.61** | **0.56** |
| **AMD' = Relative Factor Effect for AMD on O/I :** | **1.00** | **1.00** | **1.00** | **1.00** | **1.00** | **0.99** | **0.99** |
| **AMD" = Relative Factor Effect for AMD on NS/I :** | **1.09** | **1.07** | **1.03** | **1.00** | **0.98** | **0.94** | **0.89** |

Using the results of the sensitivity analyses that are shown in Table 5 in tabular form shows the relative effect of each of the four factors on the estimate portion of inflow that becomes overflow and net seepage. To make prediction of the amounts for other reservoirs easier, the tabular values were fitted to equations of that other values could be calculated directly. The four graphs are show in Figures 17-20. Clearly, I/V is the most important factor of the four. The equations of fit on the graphs show the relative effects of the four variables on the operation of the reservoirs and ones with substantial change show high $R^2$-values .

**Figure 17.**

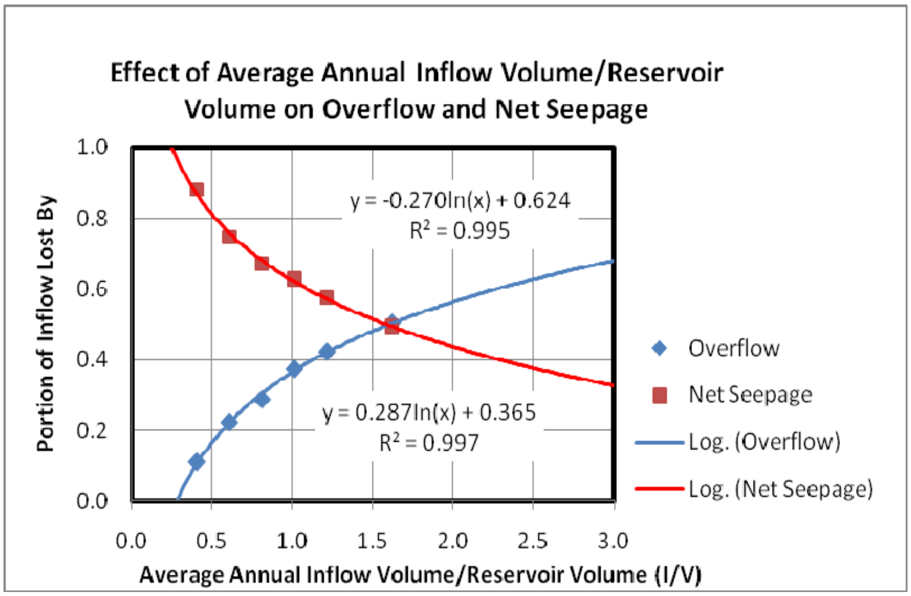



**Figure 18.**

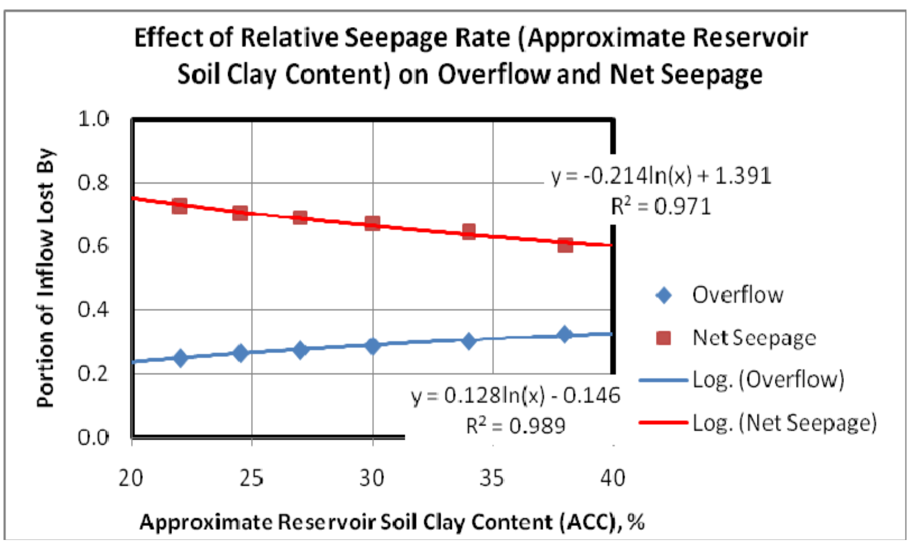


**Figure 19.**

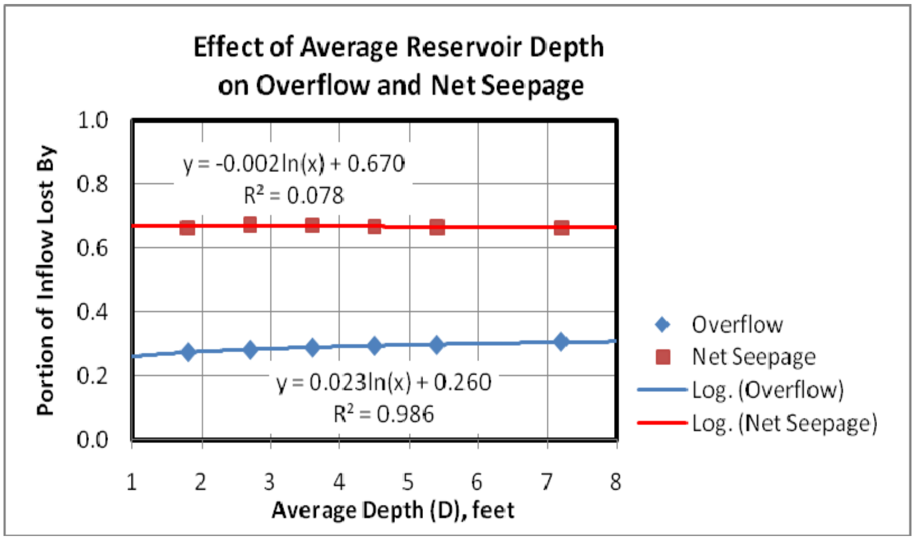
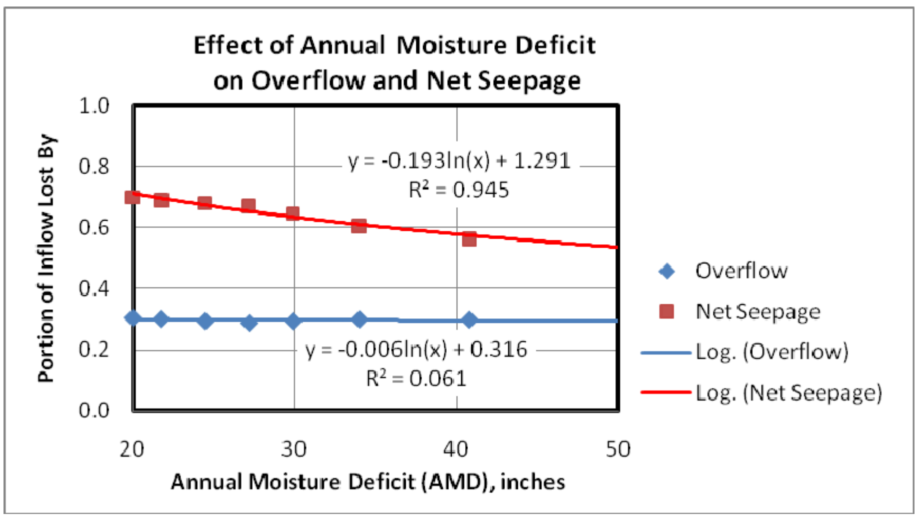



**Figure 20.**




.

To calculate the best estimate of the portion of inflow that become overflow and net seepage is done by using the following equations:

O/I = I/V * ACC' * D' * AMD'

NS/I = NS/I * ACC" * D" * AMD"

Where the ' are relative factors for O/I and " denotes relative factors for NS/I. Table 6 e shows an example for a reservoir in the eastern portion of the basin. A spreadsheet is available to perform these calculations. The results may at first look too high because

**Table 6. Example of estimated portion of inflow that becomes overflow and net seepage for a small reservoir (see Excel file, Reservoir Characteristics Analysis.xls).**

**EXAMPLE: Predicting for Another Reservoir**

**Prediction Equations**

**O/I = O/I for Reservoir * ACC' * D' * AMD'**

**NS/I = I/V for Reservoir * ACC" * D" * AMD"**

| Enter New Reservoir Values Below | |
|---|---|
| I/V, - = | 1.25 |
| ACC, % = | 28 |
| D, ft = | 5.0 |
| AMD, in. = | 24 |

| Value for I/V | Relative Factor Effects: ACC | D | AMD | Overall | |
|---|---|---|---|---|---|
| 0.43 | 1.03 | 1.02 | 1.00 | 0.42 | = O/I |
| 0.56 | 0.97 | 1.00 | 1.01 | 0.57 | = NS/I |
| This * | This * | This * | This * | = Result | |

evaporation losses might be expected to take more of the inflow. That fraction was consistently found to be smaller than we expected. The size of the surface area relative to the watershed is small and the results are expressed as net seepage which involves the interaction of the high seepage losses when the reservoirs are full. Evaporation is simply not a very large portion of the water budget for small reservoirs that are seldom very full. This technique still needs to be tested on some more reservoirs to make sure it is a reasonable approach. For the purposes of determining the overall effects of the 716 reservoirs identified in the Basin, good estimates of inflow, reservoir characteristics, and the effects of transmission losses along the channels from the reservoir to the measurement point for streamflow are needed. Also, the movement of the net seepage from the reservoir to groundwater and perhaps as return flow to the surface is needed to predict the net effects for a reservoir. This information is largely lacking and collective judgment or more fieldwork will be needed to make those determinations.

## Final Thoughts

The approximate total watershed area for the 716 reservoirs is square miles is 3,380 for Nebraska, 1,130 for Colorado, and ______ for Kansas (maybe 1,000) for a total of about 5,500 square miles one-third of the total contributing drainage area in the Republican River Basin above the Hardy, NE stream gage. The characteristics of the individual reservoirs as to their I/V characteristics vary so widely that additional effort will be necessary to them in order to make reasonable estimates of their effects.

## Estimation of the Effects of Land Terracing Approach and an Overall Estimate

In our 2008 report, we presented an overall approach for estimating the effects of land terracing on streamflow and groundwater recharge for the Prairie Dog Creek above Keith Sebelius Lake (590 square miles). Those results estimated an average of about 3,200 acre-ft/yr of reduction in streamflow and about 200 acre-ft/yr increase in ground-water recharge.

Additional information that is needed to apply this technique to other sub-basins include the best estimates of amount of and type of terraces and range of their condition to hold runoff in their storage channel in the sub-basin, the portion of total runoff into the channel that is retained over the long-term and the split of the retained water into potential ground-water recharge and evapotranspiration to determine the field-level water balance. The best estimates of transmission losses in the channel system from the field to the place of streamflow measurement or estimation is needed along with how the alluvial aquifer system distributes runoff into the channel system into recharge of groundwater, delayed return to the stream as baseflow, and runoff water that becomes additional evapotranspiration in the alluvial system. Finally, an estimate of how much, if any, of the ground-water recharge from the terraced field returns as streamflow is needed.

This approach has been incorporated into an Excel spreadsheet that can be applied to an area from part of a sub-basin to the entire Basin to make estimates of the average effects of land terracing. Of course, it could be applied for a shorter time period provided the estimated values needed were available for the period. For purposes of getting an estimate for the entire Basin, the file: Approximate Field-Level Effect of on Runoff and Recharge From Terraces (annual report).xls is provided as a part of this report. The file is a total of three pages, so I have not attempted to format into this report for the sake of time. This spreadsheet has been set up to be such that best values for which there are only estimates can be inserted and the effects on change in streamflow and ground-water are immediately updated in the results. Following is a narrative of the spreadsheet.

For purposes of this narrative, the reader should have a paper copy of the spreadsheet (See Appendix A) or the spreadsheet open on a computer. Location on the file will be described by the Row numbers on the left-hand side of the page. At the top of the sheet in the right-hand portion on Rows 3-7 is the overall results section that can remain in view while scrolling the remainder of the spreadsheet to the various section. Also, notice that on the file, values that may be changed are in blue in italics. Of course, other parts can be changed, too, but they contain formulas or narrative that should not need the user's attention.

The terrace information contains the number of acres of terraced land for the particular area to be evaluated in Row 5. The percent of that terraced land that is above a terrace ridge is needed since areas below the lowest terrace is assumed to be unaffected from the perspective to the overall water balance effect. This value is in the 80 to 90 percent range.

In Rows 11-14, the type of terrace is important because to water storage capacity is affected substantially. Results from the terrace condition inventory are revealing that the condition of terraces within each type various considerably by their capacity to retain water. The remaining table values of estimates are from my interpretation of the terrace inventory preliminary results.

Extending the values for the terrace inventory, Rows 19-22 contain my estimates of the average annual runoff between terraces and my estimates of the amount of the runoff that would be runoff from each type of terrace based upon their water storage capability.

In Rows 25-30, calculations of the amount of overflow by terrace type and condition are made. The calculations take into account the amount and type of terrace and the condition of each type. Individual values in the table are the fractional amount of terraces in the exceedance probability table between two consecutive values and the average overflow depth for that fraction expressed in acre-feet. Then, values are summed to get the estimate by terrace type. To the right is the estimate of the amount of runoff with no terraces on the land.

Next, the estimates of the effects of transmission losses are estimated to account for the effects of less runoff entering the stream channels in the area are needed in Rows 37-40. Estimates of transmission losses by terrace type are used. In the lower precipitation regions of the Basin, storage-type terraces are used and there, too, transmission losses are higher. A general value of 2% per mile of stream travel has been assumed for the basin. More analysis of recent events found that the losses in the drier areas appear to be higher and the more eastern areas, losses appear to be lower. Losses of as high as 7% were found for the South Fork of the Republican from an event in Summer 2008. The distance runoff must travel before it is measured or reported as streamflow greatly affects the amount of surface runoff when transmission losses are high. In the drier areas of the Basin, travel distances are long before measurement or calculations. In the east, the distances are shorter because of the nature of the stream network and Basin configuration. Runoff that is retained in the field by terraces either becomes percolation below the rooting depth of plants grown in the terrace storage areas or evapotranspiration. In Rows 51-54, the portion of runoff that becomes percolation is calculated from estimates of the percent of runoff that goes to percolation. Here, estimates are provided that are based upon simulations and field from the field sites and previous work. The calculations n the table are simply the percentage estimates applied to the depth of field runoff minus overflow calculated previously. Again, amount of terraces, terrace type and terrace condition are used to calculate the volume of percolation in Rows 57-62.

After the percolation volumes are calculated, the estimated additional evapotranspiration is determined by subtracting the amount of percolation from the amount of runoff retained by the terraces.

In Rows 88-90, the user must specify how the alluvial valley system will allocate surface runoff into water that become additional evapotranspiration from water stored in the soil during runoff events that can be withdrawn by plants, to usable groundwater for use, and to water that is subsequently returned to the stream following high discharge events. Because there is less runoff into the stream system, these amounts of water are actually losses within the stream system.

Finally, it is possible that water that percolates from the terrace channels will eventually become an input to streamflow and might reach the outlet of a sub-basin or a measurement point. The user can provide an estimate of this as a percent of the total additional recharge caused by the terraces in the area under consideration.

Lastly, in Rows 100-118, the results of the various parts of the calculations are put into a net overall water balance for the estimates to show the gains and losses in evapotranspiration, streamflow, and groundwater to the area under consideration to provide the user with a way to see the values as gains and losses for the system.

**b.** Lead the effort to modify and apply a version of the selected water balance model to the land terraces and non-Federal reservoirs in the basin.

Most of the progress on this task is described above.

**c.** Select and administer postdoctoral research assistant(s), graduate assistant(s), and/or undergraduate student assistant(s) to complete Research Project effort.

Personnel working on this project at this time are Koelliker, 30% time, and Ravikumar Choodegowda, a 50% time doctoral graduate student. Dr. Phil Barnes, a research-extension engineer in our department, is working with us on the field work aspects of this project. He has worked closely with our Nebraska colleagues in securing and setting up and instrumenting our terraced fields. His total time commitment is about 5%. Mr. Choodegowda will defend his final dissertation on July 27, 2009. If successful, he will return to this faculty position at the University of Bangalore as soon as feasible.

**d.** Collaborate with UNL on modeling efforts and field work involved with monitoring a small sample of land terraces and non-Federal reservoirs.

Collaboration continues but as a slower pace than we would like due to the many aspects to be finalized. We have much of the information that is needed, time to get it processed, analyzed, and formed into final products is needed. We will continue until we are finished, but that will be beyond the original 5-year timeframe of the agreement.

**e.** Provide an update on the Research Project activities to Reclamation and the Conservation Committee by May 1st and December 1st of each year. The update due by May 1 will allow the Conservation Committee time to review the update and brief the RRCA at their annual meeting normally scheduled in June of each year.

This report is my 2009 update on most of our work. I have attempted to get an estimate for terracing effects on the Basin as a whole for terracing. I did not have time to get an estimate for reservoirs as of this report deadline. I would like to have that estimate by the time of the Basin Commission meeting. I hope to get help from the Conservation Committee at our meeting on August 4 with some of the data that I am not ready to make estimates on at this time.

**f.** Lead in the preparation of a final report on or before June 1, 2009 that summarizes the results of the Research Project and addresses items a, b, c, and d included under B.6. Deliverable Products.

A final report will be delivered when the work is complete. This deadline has passed, but our work is continuing as best we can do with what remains to be accomplished.

## Assessment of Progress on This Agreement:

Work on the project is proceeding. Koelliker has been spending more time on the work than originally expected. My appointment and the nature of the work make this a better way to proceed. My doctoral student has completed his modeling on the operations of small reservoirs which has been a big contribution. The details of modeling of land terraces and now making revisions to more effectively represent the reservoirs have been the major focuses for the most of the past year and now needs to be modified a bit to fit with the field data that is being provided. We are still working on datasets of weather and climate data.

Resources for completing this major watershed simulation effort are limited. We will try to make the most of them, but if this work should become a basis for decisions affecting the Republican Rive Compact agreements, then the level of detail at which we are forced to work because of limited financial resources are likely not sufficient.

Finally, as of May 2010, Koelliker will retire from his permanent position at Kansas State University. He will continue to work on this project until that time if necessary as a part of his 0.3-time phased retirement appointment.

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## Appendix A

Printout of Excel spreadsheet:

Approximate Field-Level Effect on Runoff and Recharge From Terraces (annual report).xls

Not included here. The file has been sent electronically. It can be printed and included in a hardcopy.

## Location: Upper Reach of Prairie Dog Creek above Sebelius Lake (20%)

**NOTE: ALL Values in *BOLD* are estimates that can be changed and the net effects will update.**

| | Terrace information |
|---|---|
| Total terraced fields, acres: | ***35,000*** |
| Portion of terraced fields above lowest terrace ridge, % : | ***85*** |
| Total terraced land contributing to channel, acres: | 29,750 |

| **Average net effects** | **acre-ft/yr** |
|---|---|
| **Change in evapotranspiration** | **400** |
| **Change in streamflow** | **(300)** |
| **Change in ground-water recharge** | **(200)** |
| *(Difference, if any, due to rounding)* **Total :** | **(100)** |

### Terrace Inventory Results

| Terraces by type | | Exceedance probability of water storage depth (inches) in the channel, % | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **100** | **70** | **60** | **50** | **35** | **20** | **15** |
| Conservation bench, % : | ***25*** | ***0.00*** | ***0.20*** | ***0.30*** | ***0.50*** | ***0.80*** | ***1.00*** | ***1.50*** |
| Level, closed-end conventional, % : | ***75*** | ***0.00*** | ***0.10*** | ***0.20*** | ***0.44*** | ***0.75*** | ***1.00*** | ***1.20*** |
| Level, open-end conventional, % : | ***-*** | ***0.00*** | ***0.02*** | ***0.10*** | ***0.15*** | ***0.20*** | ***0.25*** | ***0.25*** |
| Graded, % : | ***-*** | ***0.00*** | ***0.01*** | ***0.02*** | ***0.03*** | ***0.03*** | ***0.03*** | ***0.03*** |
| Total, % : | 100 | | | | | | | |

### Field-Edge Runoff Reduction Calculations

| Estimated runoff from field area without terraces, in. | | Average annual estimated overflow from terraced fields, inches | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conservation bench | ***0.75*** | ***0.60*** | ***0.38*** | ***0.30*** | ***0.15*** | ***0.08*** | ***0.04*** | ***0.00*** |
| Level, closed-end conventional | ***0.75*** | ***0.71*** | ***0.45*** | ***0.38*** | ***0.25*** | ***0.15*** | ***0.05*** | ***0.00*** |
| Level, open-end conventional | ***-*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** |
| Graded | ***-*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** | ***0.00*** |

| | Sum | Incremental average annual estimated overflow from terrace type, acre-feet | | | | | | | Runoff without from land without terraces but with same land uses |
|---|---|---|---|---|---|---|---|---|---|
| Conservation bench | 100 | 91 | 21 | 14 | 10 | 5 | 1 | 0 | 500 |
| Level, closed-end conventional | 500 | 324 | 77 | 58 | 55 | 28 | 2 | 0 | 1,400 |
| Level, open-end conventional | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| Graded | - | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - |
| Total estimated runoff at field boundary, acre-ft/yr : | 600 | *NOTE: All final volumes in acre-ft are rounded to the nearest 100.* | | | | | | Total = | 1,900 acre-ft/yr |
| | | Field edge difference in runoff, acre-ft/yr : | | | | | 1,300 | | |

### Transmission Losses of Runoff Calculations

| | With Terraces: Trans. loss/mile, percent | Average channel distance, miles | Portion of overflow at field passed, - | Est. trans. loss for runoff, acre-feet | Average streamflow at sub-basin outlet, acre-ft/yr | Without Terraces: Trans. loss/mile, percent | Average channel distance, miles | Portion of overflow at field passed, - | Est. trans. loss for runoff, acre-feet | Average streamflow at sub-basin outlet, acre-ft/yr |
|---|---|---|---|---|---|---|---|---|---|---|
| Conservation bench | ***3.5*** | ***80*** | 0.06 | 100 | - | 3.5 | 50 | 0.17 | 400 | 100 |
| Level, closed-end conventional | ***3.5*** | ***80*** | 0.06 | 500 | - | 3.5 | 50 | 0.17 | 1,200 | 200 |
| Level, open-end conventional | ***-*** | ***40*** | 1.00 | - | - | 0.0 | 40 | 1.00 | - | - |
| Graded | ***-*** | ***20*** | 1.00 | - | - | 0.0 | 30 | 1.00 | - | - |
| | | | Total = | 600 | - | | | Total = | 1,600 | 300 |

| | Without | With | Difference |
|---|---|---|---|
| Estimated DECREASE in amount of measurable streamflow directly attributable to terracing by reduction in surface runoff, acre-ft/yr = | 300 | - | 300 |
| Estimated DECREASE in transmission losses directly attributable to terracing by reduction in surface runoff, acre-ft/yr = | 1,600 | 600 | 1,000 |

## Location: Upper Reach of Prairie Dog Creek above Sebelius Lake (20%)



### Percolation Increases Calculations

| | Retained runoff to percolation, percent | Average annual estimated additional percolation over the field, inches | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conservation Bench | *50* | 0.08 | 0.19 | 0.23 | 0.30 | 0.34 | 0.36 | 0.38 |
| Level, closed-end conventional | *50* | 0.02 | 0.15 | 0.19 | 0.25 | 0.30 | 0.35 | 0.38 |
| Level, open-end conventional | *40* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Graded | *40* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | Sum | Incremental average annual estimated percolation from terrace type, acre-feet | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conservation Bench | 200 | 24 | 13 | 16 | 30 | 32 | 11 | 35 |
| Level, closed-end conventional | 400 | 47 | 31 | 41 | 77 | 90 | 34 | 105 |
| Level, open-end conventional | - | - | - | - | - | - | - | - |
| Graded | - | - | - | - | - | - | - | - |
| Estimated total additional percolation under terraced fields, acre-ft/yr : | 600 | | | | | | | |

*NOTE: All final volumes in acre-ft are rounded to the nearest 100.*

### Evapotranspiration Increases Calculations

| | Retained runoff to evapotranspiration, percent | Average annual estimated additional evapotranspiration over the field, inches | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conservation Bench | 50 | 0.08 | 0.19 | 0.23 | 0.30 | 0.34 | 0.36 | 0.38 |
| Level, closed-end conventional | 50 | 0.02 | 0.15 | 0.19 | 0.25 | 0.30 | 0.35 | 0.38 |
| Level, open-end conventional | 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Graded | 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | Sum | Estimated avg. incremental additional evapotranspiration from terrace type, acre-ft/yr | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Conservation Bench | 200 | 24 | 13 | 16 | 30 | 32 | 11 | 35 |
| Level, closed-end conventional | 400 | 47 | 31 | 41 | 77 | 90 | 34 | 105 |
| Level, open-end conventional | - | - | - | - | - | - | - | - |
| Graded | - | - | - | - | - | - | - | - |
| Estimated total additional evapotranspiration from terraced fields, acre-ft/yr : | 600 | | | | | | | |

*NOTE: All final volumes in acre-ft are rounded to the nearest 100.*

## Location: Upper Reach of Prairie Dog Creek above Sebelius Lake (20%)



**Estimates of the Interactions in the Alluvial System Caused by Reduction in Transmission Loss Volume Resulting for Less Upstream Runoff**

Estimated Reduction in Transmission Loss Volume, acre-ft/yr : 1,000 (from PAGE 1)

| Assignment of Reductions in Transmission Loss to Different Components | Percent | Volume, acre-ft/yr |
|---|---|---|
| Evapotranspiration in alluvial valley from soil storage, %: | *20* | 200 |
| Groundwater recharge to usable aquifer system, %: | *80* | 800 |
| Return to stream as baseflow, %: | - | - |
| Total, % : | 100 | 1,000 |

*NOTE: All final volumes in acre-ft are rounded to the nearest 100.*

| Terrace Recharge That Becomes Streamflow | Percent | Volume, acre-ft/yr |
|---|---|---|
| Portion of groundwater recharge under terraces that becomes streamflow at measurement point, %: | *0* | 0 |

### Net Overall Water Balance Effect

| | Volumes in acre-ft/yr | |
|---|---|---|
| Reduction in Runoff at Terraced Field Edge : | 1,300 | |
| | Losses | Gains |
| **Evapotranspiration** | | |
| From terraced fields | | 600 |
| From alluvial valley | 200 | |
| **Streamflow** | | |
| Direct surface runoff | 300 | |
| Return to stream as baseflow from alluvial system | 0 | |
| Terrace Recharge that becomes streamflow | | 0 |
| **Groundwater** | | |
| Recharge under terraced fields | | 600 |
| Terrace recharge that becomes streamflow | 0 | |
| Alluvial aquifer system recharge | 800 | |
| Overall Totals : | 1,300 | 1,200 |
| **Water Balance Difference :** | -100 | |
| *(Difference, if any, due to rounding)* | | |

| Average net effects | | acre-ft/yr |
|---|---|---|
| Change in evapotranspiration | | 400 |
| Change in streamflow | | (300) |
| Change in ground-water recharge | | (200) |
| *(Difference, if any, due to rounding)* | Total : | (100) |

# APPENDIX G

DETAILED PROGRESS REPORT
OF
UNIVERSITY OF NEBRASKA-LINCOLN

**PROGRESS REPORT**

# *Modeling and Field Experimentation to Determine the Effects of Land Terracing and Non-Federal Reservoirs on Water Supplies in the Republican River Basin Above Hardy, Nebraska*

Cooperative Agreement No. 05EC601962

**Reporting Period**: May, 2008 – July 2009

**Principal Investigator**: Derrel Martin
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## PROJECT OBJECTIVES

This joint project between the University of Nebraska-Lincoln, Kansas State University and the Bureau of Reclamation involves the following responsibilities:

1. Field experimentation to quantify the water balance for representative terraced land sites and small non-federal reservoirs. Subprojects include:
   a. Installation, calibration and maintenance of monitoring equipment.
   b. Identification of suitable monitoring sites.
   c. Collection of water balance data from representative sites.
   d. Processing and summarizing research results.
   e. Limited studies to estimate transmission losses in ephemeral streams and channels.

2. Modification, calibration and verification of simulation models used to predict the effects of reservoirs and terraces on subwatersheds that provide water to the riparian area adjacent to the Republican River.

3. Development of databases required to simulate the water balance of subwatersheds.

4. Development of a Geographic Information System to process input data for simulation models and simulation results to enhance understanding of depletive effects of terraces and reservoirs.

5. Conduct simulations to develop comparisons between conditions with and without terraces and small reservoirs.

6. Integration of model results, supporting data and programs into a project report.

## TERRACE RESEARCH

### Field Water Balance

Five field sites were selected to research the impact of terraces. The sites include two conservation bench (*i.e.*, flat channel) terrace systems located near Culbertson, Nebraska and Colby, Kansas; two broadbase (level) terrace systems with closed ends located near Curtis, Nebraska and Norton, Kansas; and one broadbase (level) terrace system with open end(s) located near Stamford, Nebraska (Figure 1).

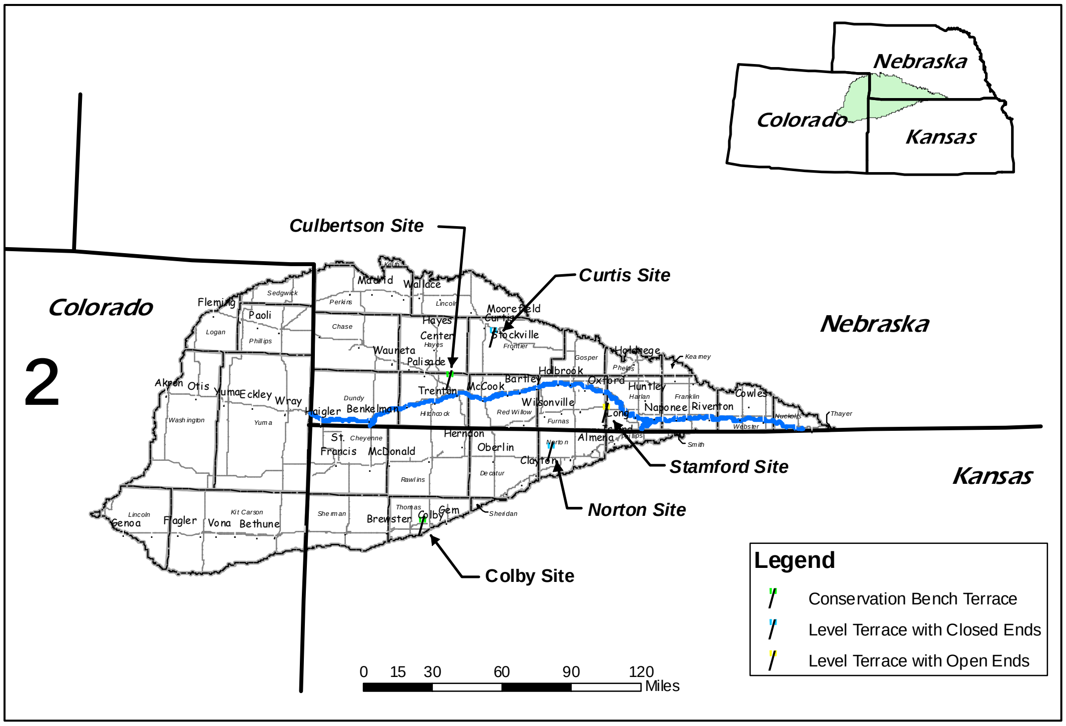


Figure 1. Location of terraced field research sites.

Precipitation in the western Great Plains is often insufficient to produce acceptable crop yields every year. Historically, the traditional cropping practice was a wheat-fallow rotation producing one winter wheat crop every-other year. This rotation allowed a 14-month fallow period for soil moisture accumulation; however, only about 25% of the precipitation during the fallow period was actually stored in the future crop root zone (Peterson and Westfall 1996). Ecofallow was developed to enhance the fraction of the precipitation that is stored (*i.e.*, the fallow efficiency). Ecofallow cropping is an intensification of the traditional wheat-fallow rotation that produces two crops in three years with a summer annual row crop such as corn or grain sorghum rotated with winter wheat. The timing of the two fallow periods and crops of this rotation system provides a better fallow efficiency than traditional wheat-fallow rotations (Peterson et al. 1996). Figure 2 shows the sequence of the ecofallow cropping system.

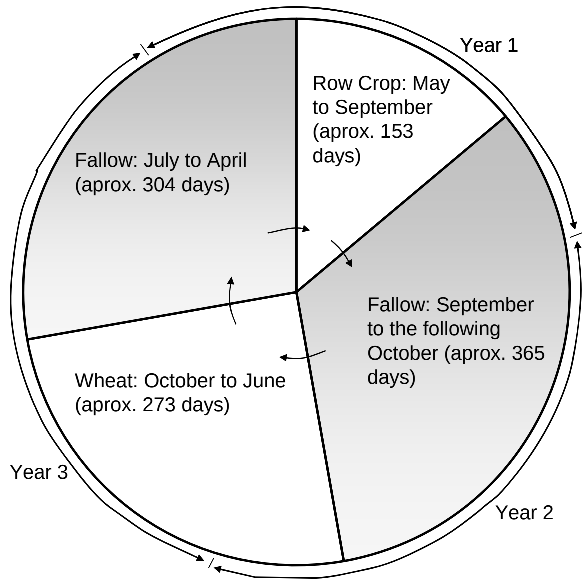


Figure 2. Ecofallow cropping sequence (Twombly 2008; Baumhardt and Anderson 2006)

The water cycle components that we are monitoring are illustrated in Figure 3. Terrace systems capture runoff water from the upland contributing area and temporarily store the water in the terrace channel. Terrace systems with closed ends retain the water in the channel until it infiltrates or is used as evapotranspiration (ET). Other types of terraces are open on the ends to allow water to slowly flow from the terrace. Runoff from the contributing area may exceed the storage capacity of the channel for large storms and some water may overtop the terrace end or ridge. A significant portion of the water that overtops terraces, or that flows from the ends of open-ended terraces, will likely end up in streams; however, some of the water also seeps into dry channels between the field and the stream. Water that stays in the terrace channel can be used by crops or percolate below the root zone of crops grown in the channel. Deep percolation ultimately reaches the local groundwater where it may (1) return to the stream as baseflow, (2) be pumped for irrigation or (3) be stored in the ground water system. Our goal is to determine the amount of water that runs into terrace channels and to partition the captured water into either deep percolation or evapotranspiration. We are also estimating the amount of deep percolation, evapotranspiration and runoff for the contributing areas.

The following instrumentation has been installed at the sites to measure:

- Rainfall rate and amount using 8-inch diameter tipping bucket rain gauges,
- Alfalfa reference evapotranspiration (ET) using a Model E atmometer,
- Inflow into terrace channels using water level loggers,
- Outflow from terraces with open ends is measured with a velocity-area meter, and
- Soil water in and below the crop root zone is monitored with the various instruments.

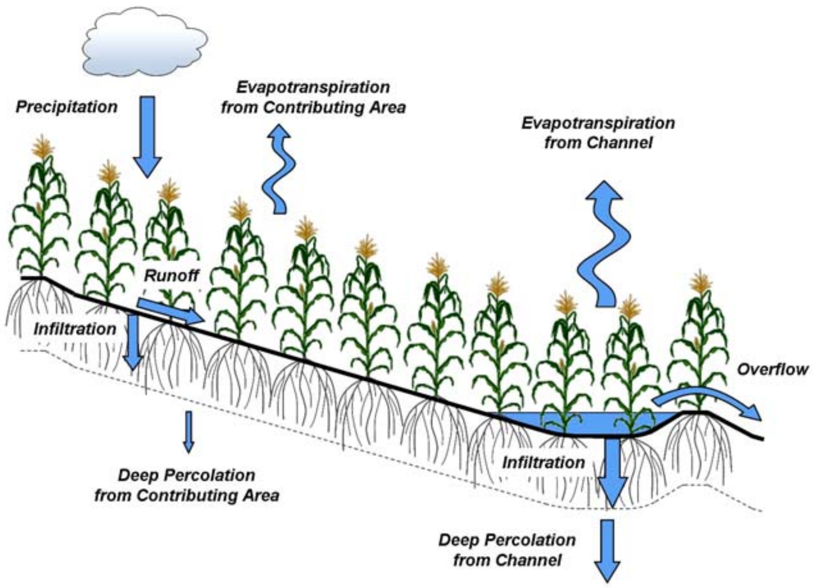


Figure 3. Water balance components of terraced land.

Data from the field sensors were continuously stored in data loggers. The data from the loggers were downloaded during monthly field visits. Equipment was installed by the spring of 2006 and the fields have been monitored for three growing seasons.

The dominant soil series mapped at each location by the Natural Resource Conservation Service (2009) are listed in Table 1. Hydraulic conductivity values from the NRCS are included in Table 1 along with the particle size distributions for soil samples taken in 2006. All soils were formed in loess parent material in an upland landscape setting.

All study sites were in a no-till ecofallow cropping rotation during each of the three years of the study (Table 2). Sweep tillage was performed on the Colby and Curtis sites during the fallow period after the row crop. The Stamford site was tilled with a disk prior to drilling wheat. The Norton and Culbertson sites were in a no-till system. Colby was the only site to utilize sorghum in the rotation; all other sites produced corn during the row crop phase.

Precipitation was recorded by tipping bucket rain gauges located at each site. The recorded precipitation shown in Table 3 was obtained from the High Plains Regional Climate Center. The average annual precipitation and recorded rainfall is listed in Table 3. Only Curtis, NE in 2006 and Colby, KS in 2007 received less than average precipitation. Curtis, NE was considerably above average in 2007 and 2008 as were Norton, KS and Stamford, NE in 2008.

The five study sites all have terraces in place to control soil erosion and pond water in the channels for infiltration. The type of terrace used at each site is shown in Table 4. The Colby, KS and Curtis, NE locations utilize a terrace with a wide flat channel that spreads runoff water over a large area for increased infiltration. The other three sites have level broadbase terraces. The terraces at Curtis, NE and Norton, KS have closed ends to contain runoff on the field, whereas, the Stamford, NE site has terraces that are open on the ends to allow water to drain from the channel.

Table 1. Characteristics of soils at the research sites.

| Location | Soil Series | $K_{sat}$ (cm/hr)[1] | Sand (%) | Silt (%) | Clay (%) |
|---|---|---|---|---|---|
| Colby, KS | Ulysses | 3.2 | 20 | 60 | 20 |
| Culbertson, NE | Blackwood | 3.2 | 25 | 55 | 20 |
| Curtis, NE | Holdrege | 3.3 | 27 | 53 | 20 |
| Norton, KS | Holdrege | 3.2 | 21 | 54 | 25 |
| Stamford, NE | Holdrege | 3.3 | 22 | 56 | 22 |

1. From NRCS web soil survey (NRCS, 2009).

Table 2. Crops harvested at each location.

| Location | 2006 Crop | 2007 Crop | 2008 Crop |
|---|---|---|---|
| Colby, KS | Sorghum | Fallow | Wheat |
| Culbertson, NE | Wheat | Corn | Fallow |
| Curtis, NE | Corn | Fallow | Wheat |
| Norton, KS | Wheat | Corn | Fallow |
| Stamford, NE | Fallow | Wheat | Corn |

Table 3. Average annual and recorded precipitation.

| Location | Average annual precipitation (cm)† | Recorded precipitation (cm) † | | |
|---|---|---|---|---|
| | | 2006 | 2007 | 2008 |
| Colby, KS | 48.8 | 53.6 | 46.2 | 52.3 |
| Culbertson, NE | 50.3 | 51.8 | 61.7 | 56.9 |
| Curtis, NE | 53.3 | 45.7 | 80.6 | 78.7 |
| Norton, KS | 57.8 | 70.0 | 62.6 | 85.3 |
| Stamford, NE | 56.6 | 69.5 | 68.6 | 84.4 |

† SCS, 1970, 1974, 1977, 1978, 1980, and HPRCC, 2009

Table 4. Type of terrace at each research site.

| Location | Type of Terrace |
|---|---|
| Colby, KS | Conservation Bench (flat channel) |
| Culbertson, NE | Conservation Bench (flat channel) |
| Curtis, NE | Level Broadbase w/ Closed Ends |
| Norton, KS | Level Broadbase w/ Closed Ends |
| Stamford, NE | Level Broadbase w/ Open Ends |

## Simulating Terrace Performance

Runoff from contributing areas and infiltration of runoff is modeled using the NRCS Curve Number method in the POTYLD model. In addition the seepage and infiltration rates are related to the field saturated hydraulic conductivity of the soil. We conducted several field and simulation studies to improve our estimates of these quantities for modeling. Our objective was to determine the variability of curve numbers within an ecofallow cropping system.

### Curve Numbers for Ecofallow

The curve number method was developed by the Soil Conservation Service, now the Natural Resources Conservation Service (NRCS), for estimation of runoff from storm rainfall (Ponce and Hawkins 1996). The method uses precipitation depth and a term called maximum potential retention to determine the amount of runoff. The maximum potential retention is inversely related to the curve number. The curve number varies from 0-100 where 100 is an impervious surface. Tables of curve numbers have been developed by the NRCS (2004) for various conditions. The method historically included an adjustment for antecedent moisture condition, AMC. A dry condition corresponded with AMC-I, AMC-II for average conditions, and for wetter conditions AMC-III is used. This was based on the idea that the rainfall during the previous 5 days was the cause for variability in runoff predictions. In recent studies, it has been discovered that prior rainfall does not explain all of the variability (Woodward et al. 2002). Recent versions of the National Engineering Handbook from the NRCS have removed this previous 5-day rainfall adjustment. The new terminology is antecedent runoff condition (NRCS 2004). This attempts to include all effects that cause variability in runoff prediction.

Crop residue has been shown to decrease curve numbers by 5-10% (Onstad and Otterby 1979; Rawls et al. 1980). Hauser and Jones (1991) derived curve numbers for a conservation tillage system with a wheat-sorghum-fallow rotation. The study site was in a semi-arid climate in the southern High Plains. Each phase of the rotation was analyzed separately and compared to SCS handbook curve numbers. It was determined that the handbook value for wheat was accurate at 80, but the number for sorghum needed to be increased to 82. The larger discrepancy was with the fallow values. The handbook value for fallow with good conservation methods is 90 while the curve numbers derived from their study were 77 and 82 for fallow after wheat and fallow after sorghum respectively. Steichen (1983) also studied curve numbers for the wheat-sorghum-fallow rotation. Three levels of tillage were used for comparison: no-till, stubblemulch, and clean tillage. The study found that the curve numbers estimated from the SCS handbook accurately predicted runoff under all three conditions. The SCS adjustments for crop residue cover adequately accounted for the increase in infiltration for the observed conditions.

We conducted a study to determine the temporal variability of runoff curve numbers within an ecofallow cropping system. Five sites located on silt loam soils with conservation terraces were monitored for three years to obtain rainfall-runoff information for each of the four phases of the rotation. The curve numbers were calculated using the log-normal method used by Hjelmfelt (1991). The curve numbers of 85 and 84 for the fallow after row crop and fallow after wheat phases of the rotation, respectively, match well with the NRCS (2004) tabulated value for fallow of 83. However, the curve number of 85 calculated for the row crop phase was higher than the tabulated value of 75. Also, the tabulated curve number for wheat of 72 was much lower than the value obtained from these data of 92. This is most likely due to using all runoff events in the analysis instead of removing smaller precipitation events. There were significant differences between curve numbers obtained for the phases. The curve number for the wheat phase of the rotation was found to be significantly higher than the curve numbers for the two fallow periods.

**Variability of Hydraulic Conductivity**

The objective of this portion of the project was to determine the temporal variability of field saturated hydraulic conductivity in an ecofallow cropping system. The infiltration rate of a soil is related to saturated hydraulic conductivity, $K_s$. Infiltration under different cropping systems, including ecofallow, was studied by Shaver et al. (2002). That study analyzed soil sorptivity with Smith's (1999) method using a single ring infiltrometer from long-term no-till plots in wheat-fallow, wheat-corn-fallow, and continuous cropping. They found no differences between infiltration rates under the different cropping systems. The study reported a sorptivity value for wheat-corn-fallow of 0.21 $cm/s^{1/2}$.

We measured the field saturated hydraulic conductivity on all field sites one time each year for three years. Six tests were performed in each contributing slope. A randomization procedure was used to choose the quadrant in which the test would be performed. Wheel tracks and crop rows were also taken into consideration. The tests performed during row crop growing seasons and fallow after row crops were divided evenly between wheel tracks rows, non-wheel track rows, and crop rows. One out of three tests performed in fallow after wheat was located in a wheel track. Following sweep tillage at Colby, KS and Curtis, NE in 2007, tests were performed below the tillage zone.

Hydraulic conductivity was measured using a variation on the method proposed by Smith (1999) for a single ring infiltrometer. Rings 15 cm in diameter were driven 10 cm into the soil. A coffee filter was placed into the ring to prevent damage to the soil surface as water was added. The filter but was removed immediately after ponding. One dimensional flow was maintained by only ponding water to a depth of 1-2 cm. The elapsed time required for the water to infiltrate until approximately ½ of the soil surface was exposed was recorded. The test method varied in the depth of water applied as the study progressed. In 2006, one cm of water was ponded but if infiltration was occurring rapidly a second cm was added. In 2007 a consistent depth of 1.5 cm was used for each test. In 2008, the depth of 1.5 cm was used but after 3 minutes of infiltration, excess water was removed until half of the surface was exposed. Soil samples, 5.375 cm in diameter and 6 cm long, were taken adjacent to the ring infiltrometers for determination of bulk density and initial moisture content.

Because measurements were not taken in each phase at each location each year, there may be differences in the rainfall prior to infiltration tests. This may bias a measurement higher when less rainfall was received prior to the infiltration tests or it may be lower if a high amount of precipitation had occurred. A procedure was developed to remove the effect of rainfall impact energy on hydraulic conductivity and to produce adjusted curves similar to that one used by the WEPP model from Risse (1994).

The original calculated hydraulic conductivity was not significantly different between the three phases of the rotation that were measured. However, precipitation prior to infiltration tests was thought to affect the measured values. A curve was developed to adjust hydraulic conductivity depending on the amount of precipitation recorded during the 90 days prior to measurement. The adjusted hydraulic conductivity values were different between the phases of the rotation. The hydraulic conductivity for the fallow after wheat phase was significantly higher with a value of 3.54 cm/hr than for the row crop phase at 1.13 cm/hr and the fallow after row crop at 1.41 cm/hr.

**Using WEPP to Predict Variability**

The Water Erosion Prediction Project (WEPP) model has the ability to simulate changes of infiltration rates. We utilized this ability to predict the variability of hydraulic conductivity within an ecofallow cropping rotation. A conversion is made to relate hydraulic conductivity to curve numbers and therefore the temporal variability of curve numbers can also be simulated. Field measurements were made to determine hydraulic conductivity once each year at each of the five studied locations. Curve numbers were also determined for runoff events at each location. These field measurements are used for comparison with WEPP simulations.

The weather files utilized by the WEPP model were compiled using weather data obtained from the High Plains Regional Climate Center (HPRCC) and supplemented with rainfall information recorded at each research site. The HPRCC data were recorded by National Weather Service cooperative observer locations. A tipping bucket rain gauge was also installed at each research site (Yonts 2006). It collected precipitation in 0.04 mm tipping events. The collection area had a 20 cm diameter. Each 0.04 mm tipping event was recorded by a HOBO datalogger that also recorded the time at which it occurred. The rain gauges were installed in late March and removed in late November; therefore precipitation from snowfall was not recorded. The high and low temperatures and winter precipitation from the HPRCC data were used with the rainfall recorded at each site as inputs in to WEPP's CLIGEN weather simulator. This created the weather file to be used in each simulation.

The WEPP model has the option of either using a constant hydraulic conductivity or a time-variable hydraulic conductivity. The time-variable hydraulic conductivity method was chosen to predict the changes in hydraulic conductivity and, therefore, curve numbers. This method uses an exponential decay equation developed by Risse et al (1995):

$$K_e = K_b \left[ MA + (1-MA)\, e^{-C \times KEcum \times \left(1-\frac{rr}{4}\right)} \right]$$

where $K_e$ is the effective hydraulic conductivity, $K_b$ is a baseline conductivity following tillage, MA is the maximum adjustment to conductivity, C is a soil stability factor, KEcum is the cumulative rainfall energy and rr is the random roughness following tillage.

A single storm was used to predict runoff with various hydraulic conductivities. This runoff was used to calculate curve numbers. The storm used was a 100-year return period storm for Colby, KS. It had a total storm depth of 10.6 cm. A surface storage of 0.1 cm was assumed, as a wetting front suction of 17 cm and $\Delta\theta$ equal to 0.27. The relationship is shown in Figure 4.

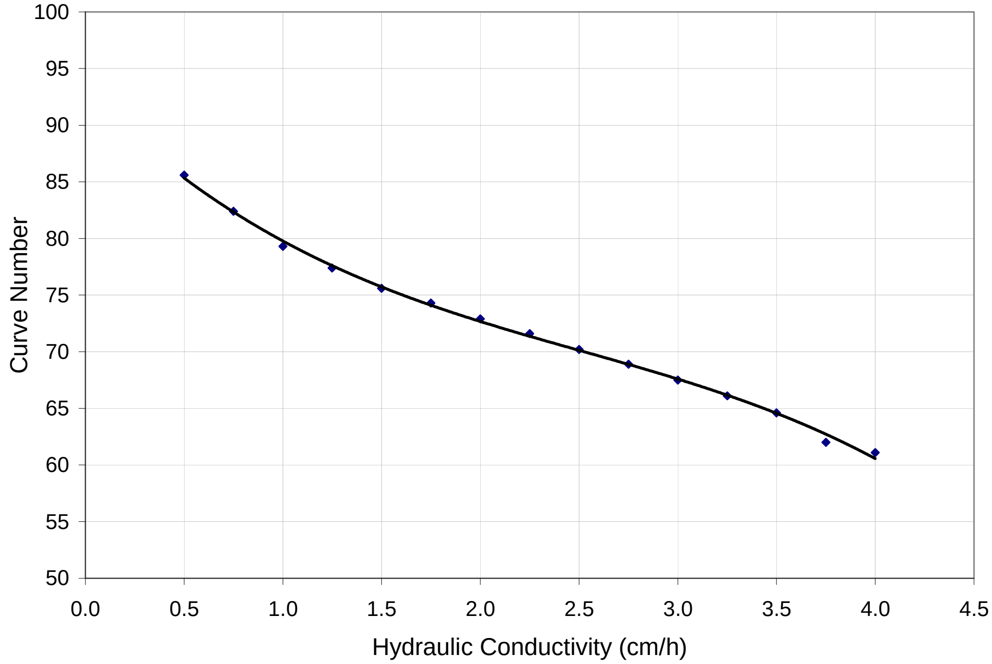


Figure 4. Hydraulic conductivity/curve number relationship.

Data from the field terraces were used to determine runoff for evaluating the predicted curve number method. Level logger pressure transducers made by Solinst were installed to record ponded water depth in each channel (Yonts 2006). The transducers were hung from a chain attached to the cap on top of a 5.1 cm schedule 40 PVC pipe standing vertical in the lowest point in the channel. The pipe had many holes drilled into it to allow water to pass through freely. The transducers were hung below the soil surface to ensure that small depths of ponded water would be recorded. A 15-minute recording interval was utilized. Another pressure transducer was installed at each site to measure atmospheric pressure. The transducers in the channels could then be compensated to remove the effects of changes in atmospheric pressure. All pressure transducers were installed in late March and removed in late November. Runoff from snowfall was not recorded.

The level broadbase terraces with open ends at the Stamford, NE site could not be monitored with pressure transducers. Instead, flumes were installed with velocity-area sensors to record runoff information. Plywood sheets were laid in the channel to create a flume that was level in the center section and the outer sections were inclined to match the dimensions of the existing channel. The plywood was attached to cinder blocks buried below the soil surface. Other plywood was inserted vertically on both the upstream and downstream sides of the flume to prevent water from flowing under the flume. The terraces were surveyed with a global positioning system (GPS) mounted on an all-terrain vehicle. The survey-grade GPS was used by driving transects parallel to the channel at various positions along the slope. A software program was used to analyze the survey information obtained by the GPS. A relationship was developed between the depth and the volume of water in the channel. Also, a relationship was made between the depth and the surface area of the water in the channel.

The length of the terrace berm is shown in Table 5. The areas of each terrace were also calculated using this survey information. This is the land area between the berm of the terrace above and the berm of the terrace being studied. The maximum volume that each terrace could contain before the berm over-topped was also calculated. The maximum volume that each terrace could store and the area contributing to the channel were used to calculate the depth of runoff required to fill the channel (Table 5).

Table 5. Terrace properties.

| Location | Length (m) | Area ($m^2$) | Maximum Volume ($m^3$) | Depth of Runoff to Fill the Channel (cm) |
|---|---|---|---|---|
| Colby, KS | 215 | 12842 | 697 | 5.43 |
| Culbertson, NE Upper | 788 | 70685 | 1044 | 1.48 |
| Culbertson, NE Lower | 619 | 55384 | 1895 | 3.42 |
| Curtis, NE Upper | 327 | 10842 | 108 | 0.99 |
| Curtis, NE Lower | 399 | 13155 | 529 | 4.02 |
| Norton, KS Upper | 1037 | 47310 | 3064 | 6.47 |
| Norton, KS Lower | 1526 | 67405 | 3689 | 5.47 |
| Stamford, NE Upper | | | | |
| Stamford, NE Lower | | | | |

Data for the 15-minute recording intervals was used to compute the runoff depth:

$$Runoff\ Depth = \frac{(\Delta\ Channel\ Volume) - (Rainfall\ Volume) - (Infiltration\ Volume)}{(Contributing\ Area)}$$

The change in channel volume is the difference in the volume of water in the channel between transducer readings. The rainfall volume accounts for the rainfall that falls directly onto ponded water in the terrace channel. Rainfall volume was computed as:

$$Rainfall\ Volume = (Depth\ of\ Rainfall) \times (Surface\ Area\ of\ Ponded\ Water\ in\ the\ Channel)$$

The infiltration volume is the water that infiltrated from the ponded water in the channel. A uniform rate of 1.0 cm/hr was used for infiltration. The volume that infiltrated for each 15-minute interval was calculated using:

$$\text{Infiltration Volume} = (\text{Surface Area of Ponded Water in the Channel}) \times (K_s \times t)$$

where Ks = 1.0 cm/hr and t = 0.25 hr. The contributing area from which the runoff for each interval originates also changes with depth of water in the channel. As the water in the channel increases, the amount of exposed land decreases. The contributing area was calculated for each interval as:

$$\text{Contributing Area} = (\text{Total Area of Terrace}) - (\text{Surface Area of Ponded Water in the Channel})$$

The sum of the interval runoff depths provides the total storm runoff depth. This runoff depth was used for calculating curve number values.

The curve number method predicts runoff using the precipitation depth, initial abstraction, and maximum potential retention:

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)}$$

where $I_a$ is an initial abstraction ratio related to $S$, $P$ is the precipitation depth, and $S$ is the maximum potential retention. The maximum potential retention was calculated using the precipitation and runoff depths for each storm (Hawkins 1973):

$$S = 5\left[P + 2Q - \left(4Q^2 + 5PQ\right)^{1/2}\right]$$

This relationship assumes that the initial abstraction equals the historical value where $I_a = 0.2S$.

Two methods were used to calculate curve numbers from the maximum potential retention derived from rainfall and runoff information. First, the log-normal method developed by Hjelmfelt (1991) was used. The basis of this method is that maximum potential retention is log-normally distributed. It uses the assumption that the median of the maximum potential retention values, $S$, corresponds to the ARC-II curve number. This median calculated as the mean of the logarithms of the maximum potential retention. This median was used to calculate the corresponding curve number with the following equation (Lamont, et al., 2008):

$$CN = \frac{25400}{254 + S}$$

<u>Results</u>

The hydraulic conductivity results from WEPP simulations and the corresponding curve numbers are shown in Figures 5 through 9. The field measurements from which hydraulic conductivities were calculated are also shown to compare to WEPP simulations. The resulting curve numbers from runoff producing events are shown for each site as well.

The hydraulic conductivity at Colby (Figure 5) decreased due to freezing in the fallow after wheat and wheat phases. The two spikes during the fallow after row crop phase are due to sweep tillage. The curve number is inversely related to the hydraulic conductivity with increasing values during frozen conditions and decreases following tillage. Overall, curve numbers ranged from approximately 60 to 90 during the three-year rotation. This location only had two runoff events during the three years of study. Both runoff events occurred during the fallow after row crop phase. The hydraulic conductivity calculated in the row crop and fallow after wheat was much higher than the simulated values. The hydraulic conductivity calculated for the fallow after row crop phase was for the soil below the tillage layer.

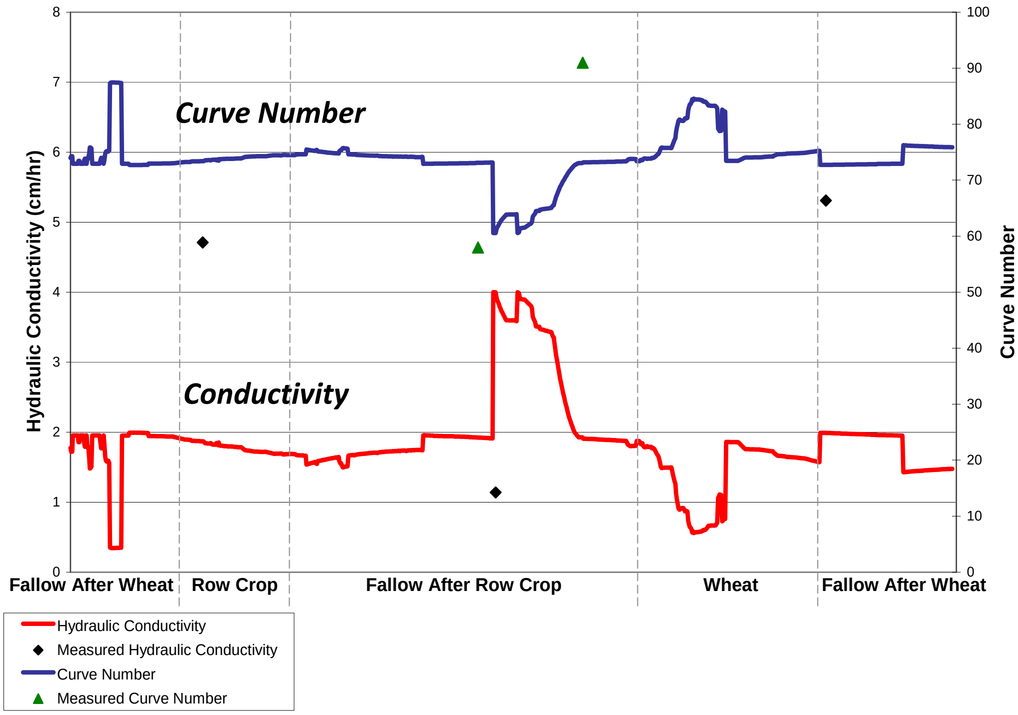


Figure 5. Hydraulic conductivity and curve numbers for the Colby, KS site.

The simulated hydraulic conductivity for the Culbertson, NE site is shown in Figure 6. This site experienced no tillage during the study so the baseline hydraulic conductivity was never reached. The hydraulic conductivity seemed to be consistent in each phase of the rotation at approximately 2 cm/hr. This results in a consistent curve number of approximately 75. Again, the frost periods can be seen as periods of low hydraulic conductivity and high curve numbers.

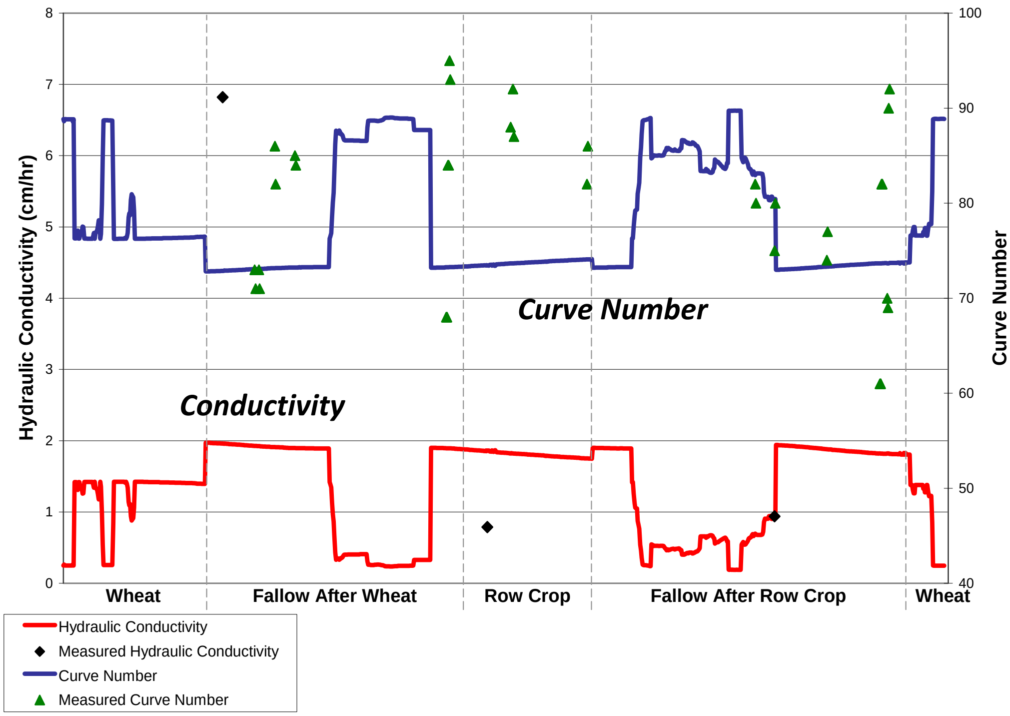


Figure 6. Hydraulic conductivity and curve numbers for the Culbertson, NE site.

Figure 7 shows the results of a WEPP simulation for the Curtis, NE site. This location, similar to the Colby, KS site, experienced two sweep tillage events during the fallow after row crop phase. These events are reflected in the sharp increases in hydraulic conductivity and decreases in curve number. The simulated hydraulic conductivity matches well with the calculated values. The measured curve numbers are higher than those calculated from the simulated hydraulic conductivity. This is most likely due to the fact that the upper terrace that was monitored at Curtis overtopped in 2007 and made a cut in the berm. This reduced the usable runoff events to the smaller events that didn't overtop the cut berm and smaller events usually result in larger curve numbers. Overall, the curve numbers range from approximately 60 to 90 while hydraulic conductivity ranges from less than 0.5 cm/hr during the winter to the baseline hydraulic conductivity of 4 cm/hr.

The results from the WEPP simulation for the Norton, KS site are shown in Figure 8. No tillage was performed at this site during the three years of this study. The hydraulic conductivity of the row crop phase appears to be lower than that of the other three phase of the rotation. The measured hydraulic conductivity value for the fallow after wheat phase is much higher than the simulated values.

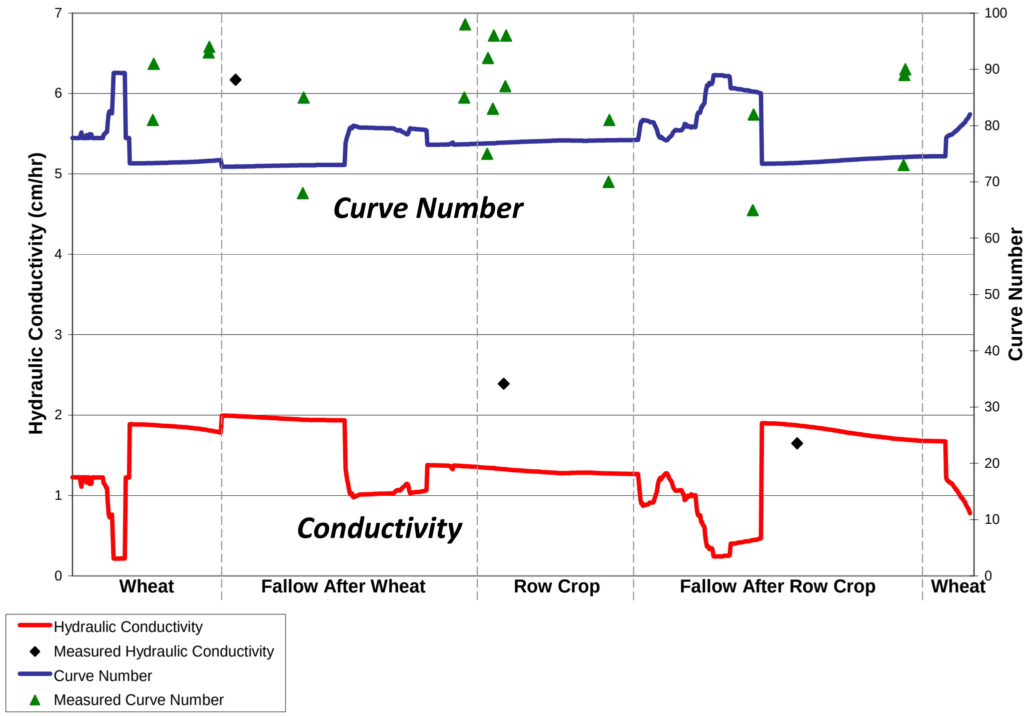


Figure 7. Hydraulic conductivity and curve numbers for the Curtis, NE site.

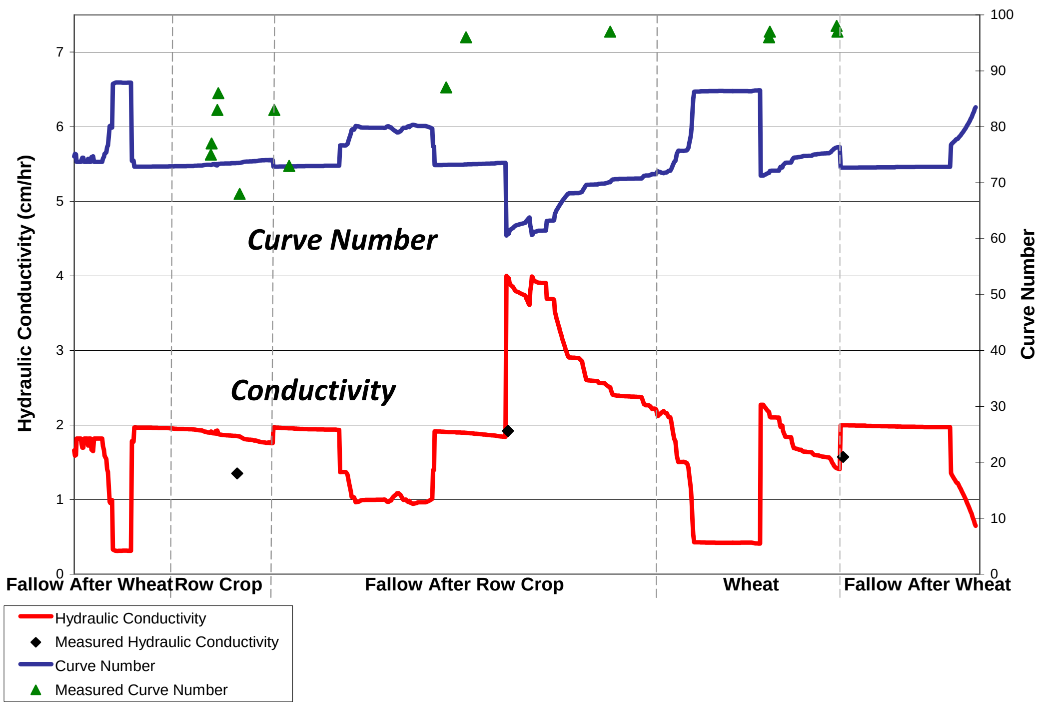


Figure 8. Hydraulic conductivity and curve numbers for the Norton, KS site.

Figure 9 shows the results of the simulation from the WEPP model for the Stamford, NE site. This site was tilled prior to planting wheat which caused the WEPP model to increase hydraulic conductivity to the baseline value of 4 cm/hr. Overall the hydraulic conductivity predicted by WEPP matched the measured values well. Simulated hydraulic conductivities ranged from less than 0.5 cm/hr to 2 cm/hr when no tillage had occurred. The curve numbers related to this simulated hydraulic conductivity ranged from 60 following tillage to 90 when the soil was frozen.

<u>Summary</u>

The WEPP model was used to predict the temporal variability of hydraulic conductivity within an ecofallow rotation. A relationship was developed to convert hydraulic conductivities to curve numbers. These simulated values were compared to hydraulic conductivities and curve numbers calculated from field measurements taken at five locations in southwest Nebraska and northwest Kansas.

The WEPP model predicted hydraulic conductivity to range from 4 cm/hr following tillage to less than 0.5 cm/hr when the soil was frozen. When no tillage had occurred, hydraulic conductivity was approximately 2 cm/hr. Curve numbers related to the simulated hydraulic conductivity ranged from 60 following tillage to 90 with frozen soil. The curve numbers were approximately 75 during the growing season when no recent tillage had occurred.

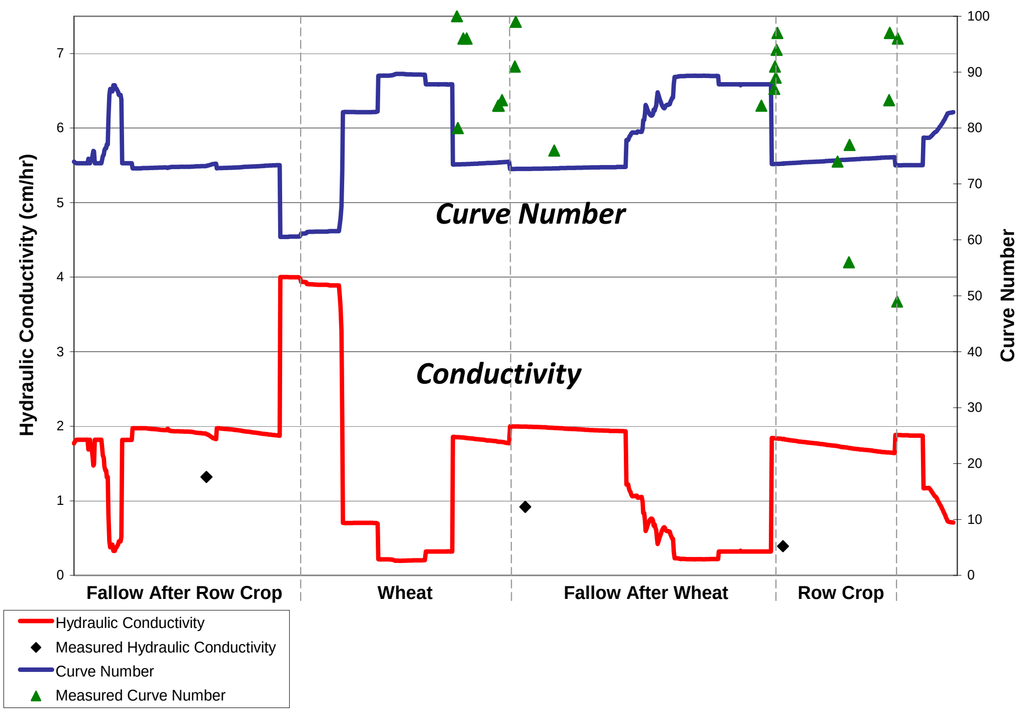


Figure 9. Hydraulic conductivity and curve numbers for the Stamford, NE site.

## Root Zone Water Quality Model

The Root Zone Water Quality Model (RZWQM) (Ahuja et al., 2000) version 2 released on January 6, 2008 was used to model the hydrology of the field sites. The RZWQM model was calibrated with the instrumentation at the Colby south terrace and the Norton lower terrace. After the model was calibrated, 30-year simulations were performed at these two sites. The Colby calibration period was from April 6, 2006 to August 19, 2008 and the Norton calibration period was from January 1, 2005 to December 31, 2007. Input parameters were obtained from data measured at the field sites and from GeoProbe soil core characteristics.

Weather files can be generated within RZWQM or developed from collected data. Three weather files are used: breakpoint rainfall, meteorological, and snow. The meteorological files include daily maximum and minimum air temperature, average wind speed, shortwave solar radiation, pan evaporation, and relative humidity. These files were developed using a combination of data measured in the field and at nearby locations.

RZWQM is a point model, so water quantities are expressed as depths. RZWQM was applied twice, once for the contributing slope and once for the terrace channel. We assumed that no water ran off the terrace channel. In the field, there may be some movement within the channel itself because it may not be perfectly level, but for the modeled situation, level channels were assumed. The same weather files were used for both scenarios except for the snow weather file where the fraction of snowmelt infiltrating can be included.

Once the model was calibrated, 30-year simulation scenarios were set up for the Norton and Colby sites. The results of the 30-year simulations were used to determine the long-term ET, deep percolation and runoff. The soil properties, initial conditions, and management practices determined while calibrating the sites were used in the long-term simulations. Fields were assumed to be farmed using no-till. We assumed that the crops in the terrace channel did not drown even though field observations indicate that some crop drowning occurs during wet years.

An average of several cross-sections for the terrace was used. Yonts (2006) surveyed the terraces for the Colby and Norton sites and provided several cross sections along the terraces. At Norton, a curved line was used to fit the channel survey data rather than a triangular shape. Figures 10 and 11 show the averaged cross sections for Colby and Norton, respectively. The survey data points used in making the cross sections are also shown in the figures.

Each 30-year simulation covers ten cycles of the ecofallow rotation. The simulation was actually run for a total of 39 years to allow the effect of the initial conditions to dampen out. Figures 12 and 13 show the cumulative ET for the terrace channel and the contributing area for Colby and Norton, respectively. The cumulative ET in the channel is for the deepest point in the channel.

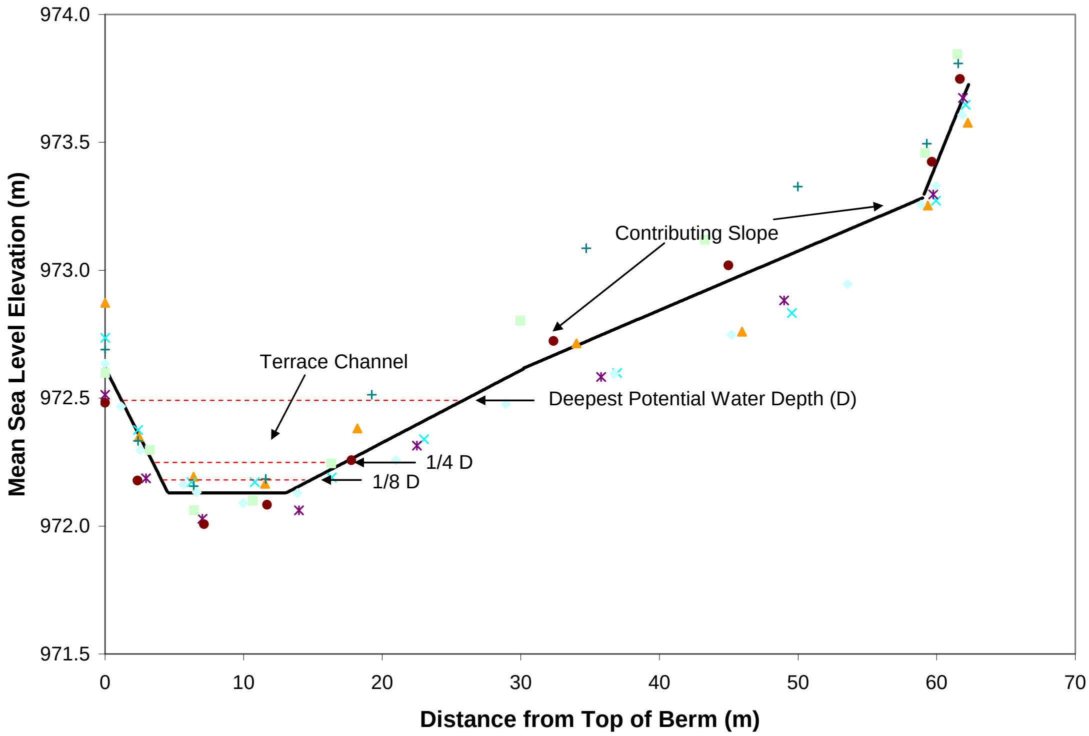


Figure 10. Average cross section for the Colby terrace (conservation bench terrace).

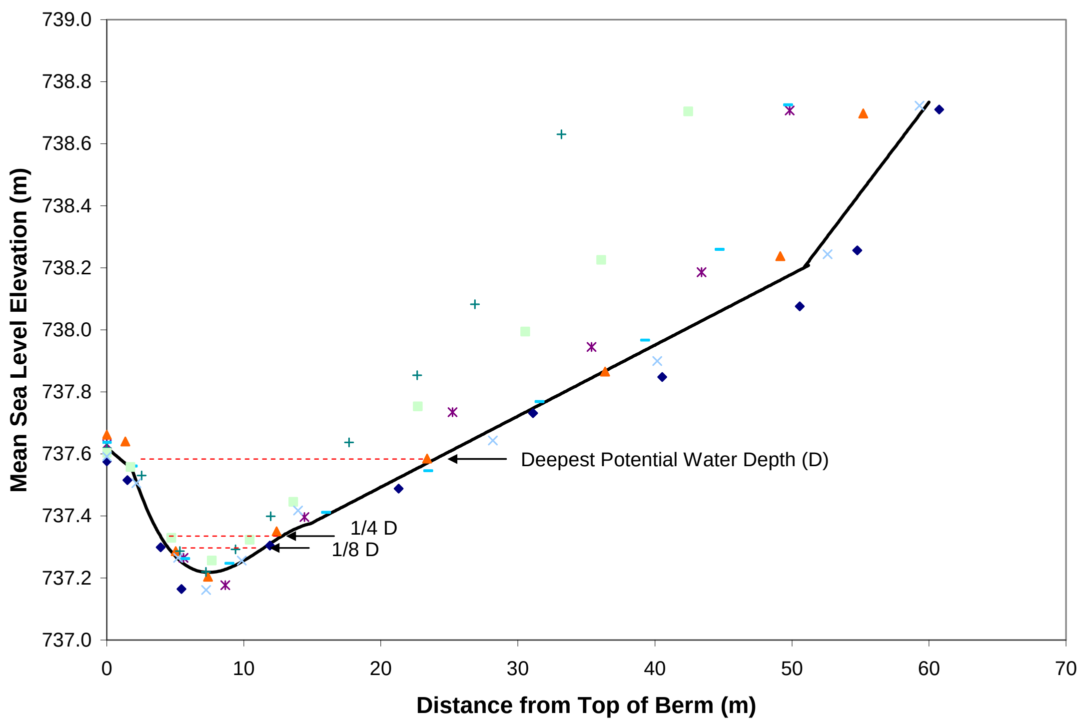


Figure 11. Average cross section for the Norton terrace (broadbase terrace).

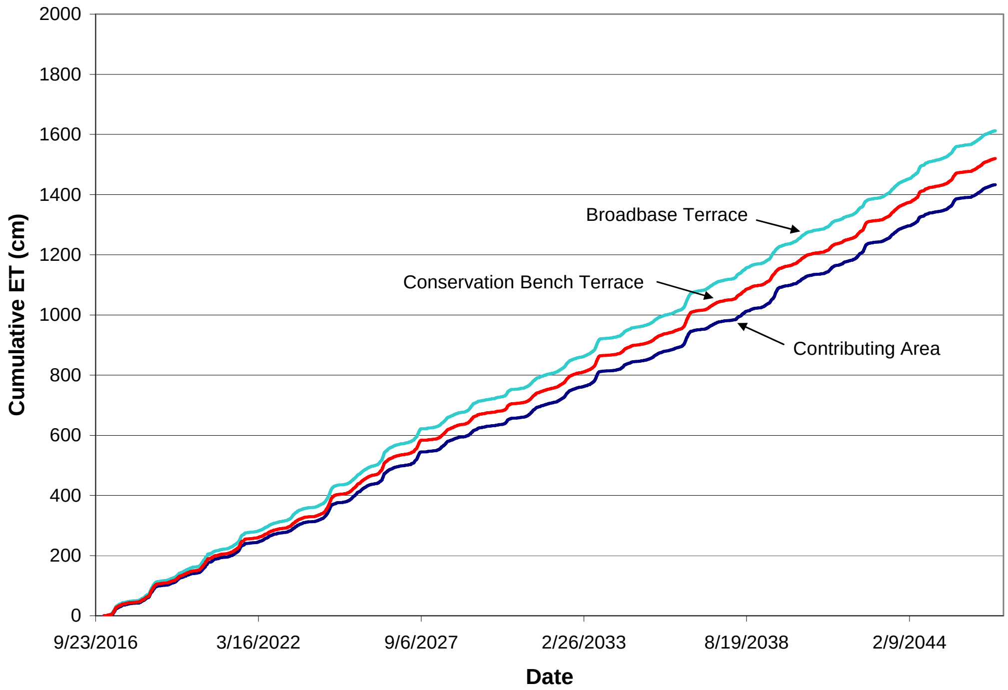


Figure 12. Modeled evapotranspiration at the Colby site. Terrace channel data is for the deepest point in the channel.

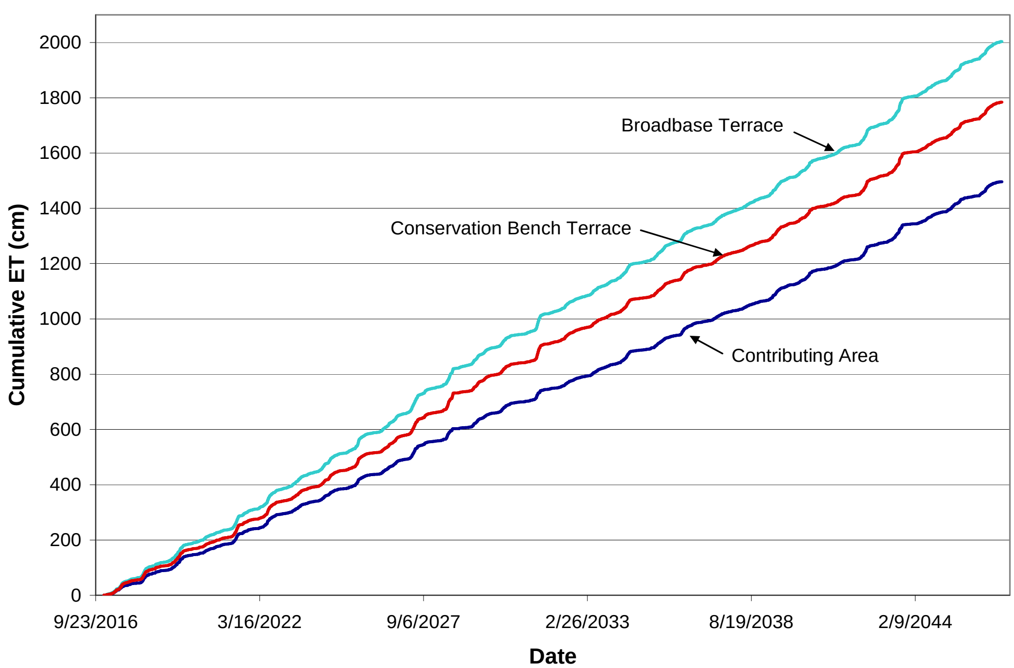


Figure 13. Modeled evapotranspiration at the Norton site. Terrace channel data is for the deepest point in the channel.

Figures 14 and 15 show the cumulative deep percolation at Colby and Norton, respectively. This deep percolation is actually the cumulative amount of water moving downward at 203 cm. Water moved upward during some time periods resulting in negative water flux or deep percolation. This can especially be seen in the contributing slope deep percolation. The deep percolation in the channel is for the deepest point in the channel. At Norton the cumulative deep percolation for the contributing area is close to zero and does not show up for much of the time period.

Deep percolation was very episodic. The most significant event was for weather data represented by 2039 at Colby and 2042 at Norton. At Colby, 14.1% of the broadbase and 25.4% of the CBT 30-year deep percolation occurred over a 37 day period from May 30 to July 5, 2039. About 49 cm of rain fell from May 27 to June 10 resulting in this deep percolation. Grain sorghum was planted in the field at the beginning of this time period. At Norton, 12.9% of the broadbase and 15.4% of the CBT 30-year deep percolation occurred over a 42 day period from June 18 to July 29, 2042. This deep percolation was a result of 42 cm of rain coming in four storms from June 10 to 18. The field was cropped to wheat during the deep percolation period.

Figures 12 to 15 show a time series of the contributing area and a time series of the terrace channel at its deepest point. However, especially for the broadbase terrace, the deepest point is just a small portion of the channel. It was desired to obtain an averaged depth of stored water, ET, or deep percolation across the channel and not just the deepest point. Both terraces were constructed with a lower section in the berm where the channel will drain if it fills with water. This drain is generally next to the edge of the field so if the terrace is overtopped it will only wash out at the edge of the field. The average cross-sections shown in Figures 10 and 11 represent the deepest potential water depth. This is the place along the terrace berm that has the lowest elevation. The deepest water possible is 30 cm at Colby and 32.2 cm at Norton.

To estimate the storage, ET, and deep percolation along the sides of the channels, the model was run several more times with the terrace channel setup except that run-on water depth corresponded to a quarter and an eighth of the deepest spot in the channel. Once these extra scenarios were run the cumulative depth of storage, ET, and deep percolation were plotted giving a profile of these processes along the channel. These profiles were integrated to calculate the total volume of water either stored (or lost from storage), evaporated or percolated for each meter of channel length. Figures 16 and 17 are examples of these profiles.

Once the total volume of water movement in each meter of channel length was known, the water balance was calculated. The volume of water in the terrace channel, calculated by integrating the ET, evaporation, deep percolation, or storage profile, was divided by the top width of the terrace channel to obtain an average depth within the terrace channel.

The water balance was also calculated by volume. To convert the depth to volume in the terrace channels, the contributing area depths were multiplied by the length of the contributing slope which was taken to be the horizontal distance from the top of the terrace berm to the top of the berm on the terrace above minus the width of channel. The depths for the terrace channel were likewise multiplied by width of terrace channel. The average annual volume balance at the two sites is listed in Tables 7 and 8. As can be seen, the volumes are different between the slopes and the channels; this is because there is more area attributed to the slope than the channel. The broadbase and CBT slopes have different volumes because they have different slope lengths.

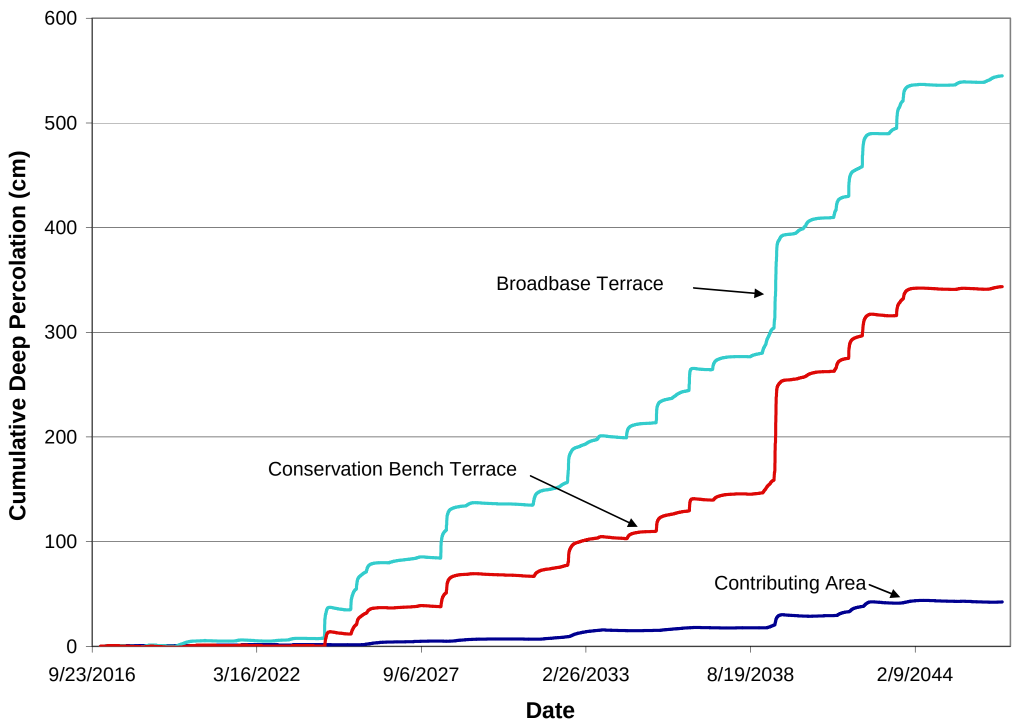


Figure 14. Deep percolation at 203 cm at the Colby site. Terrace channel data is for the deepest point in the channel.

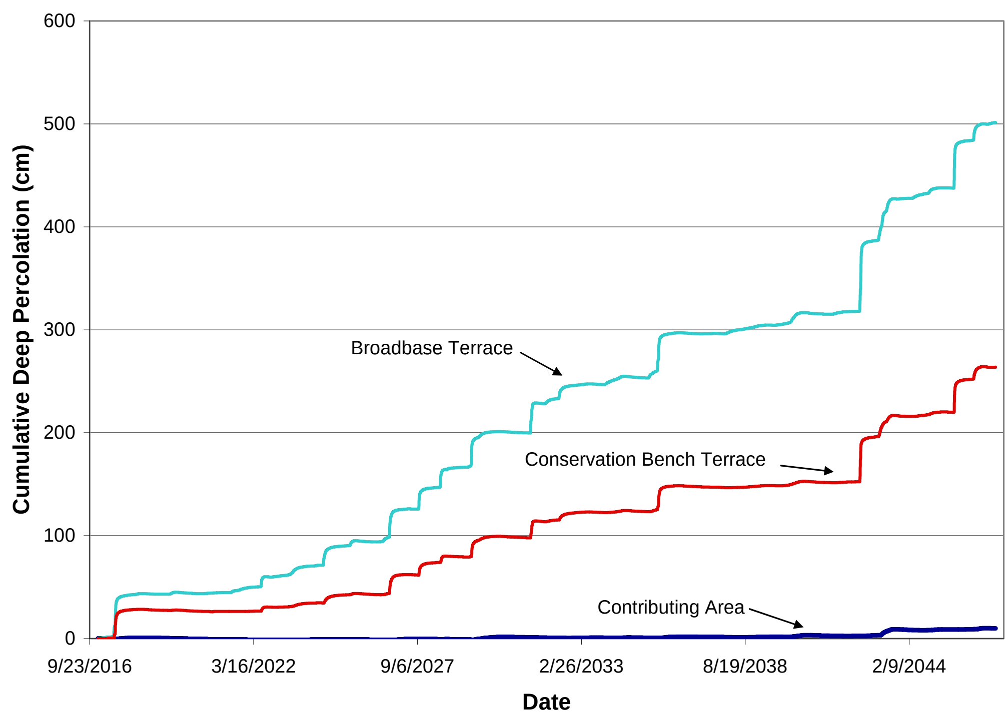


Figure 15. Deep percolation at 203 cm at the Norton site. Terrace channel data is for the deepest point in the channel.

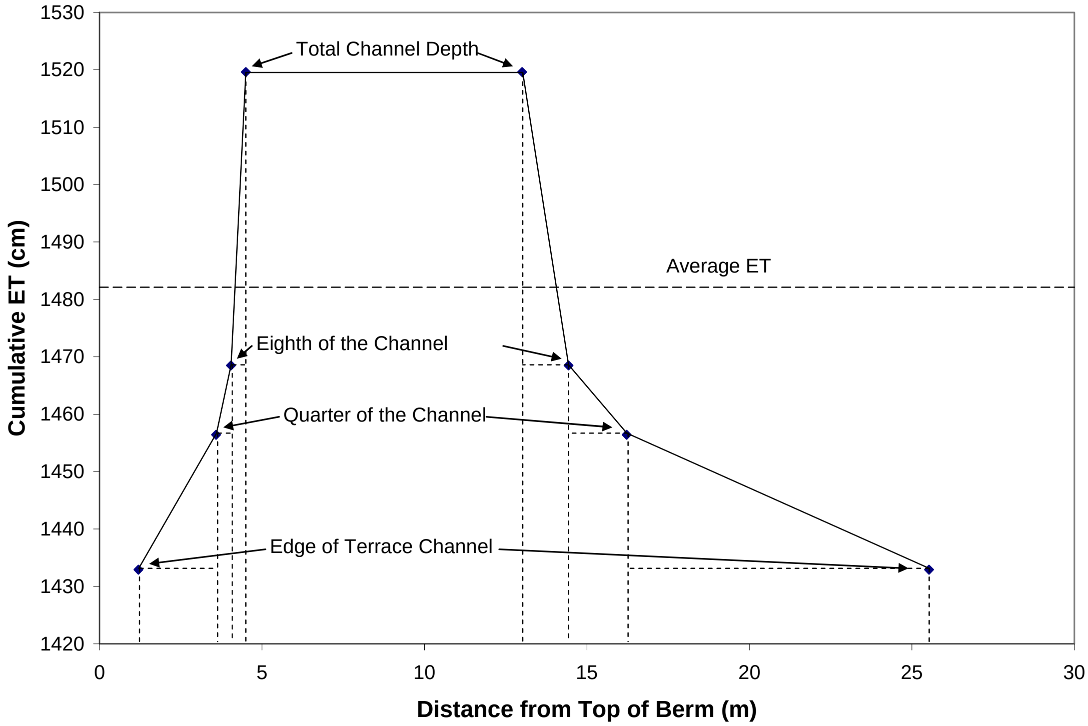


Figure 16. Thirty-year ET profile in the CBT channel at the Colby site.

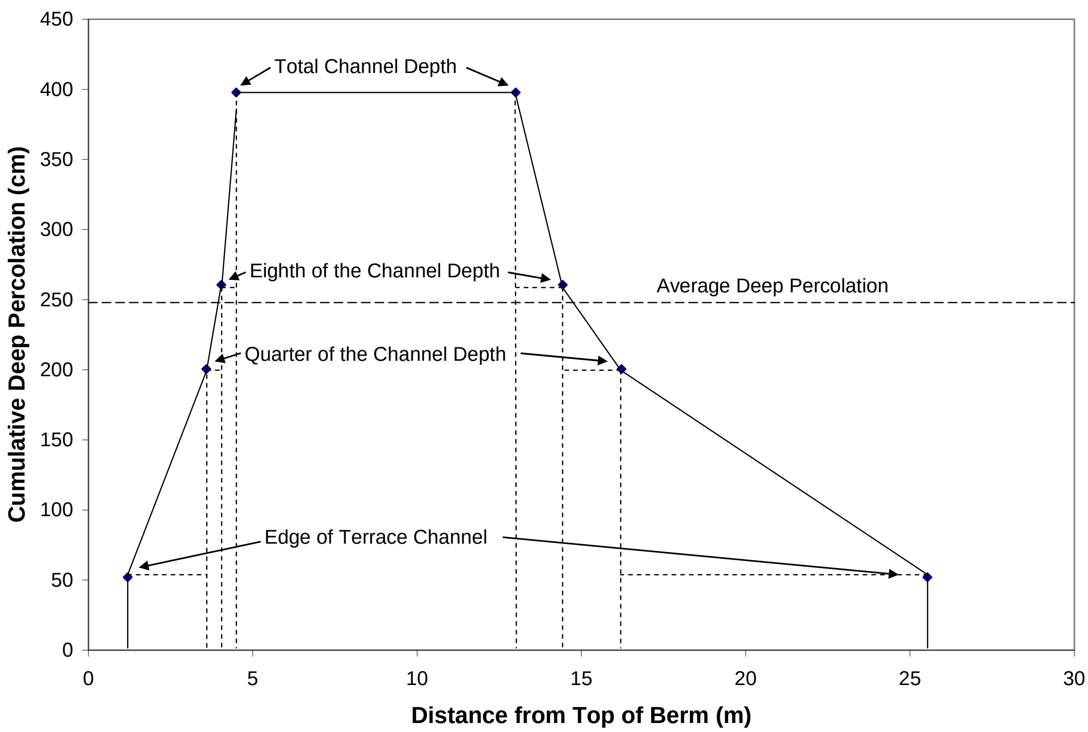


Figure 17. Thirty-year deep percolation profile in the CBT channel at the Colby site.

Table 7. Volume-based average yearly water balance at the Colby site.

| Quantity | Broadbase | | CBT | |
|---|---|---|---|---|
| | Slope | Channel | Slope | Channel |
| Precipitation ($m^3$) | 20.7 | 10.5 | 19.8 | 12.6 |
| Runoff ($m^3$) | 1.3 | 0.1 | 1.3 | 0.0 |
| Run-on ($m^3$) | 0.0 | 1.3 | 0.0 | 1.3 |
| ET ($m^3$) | 19.0 | 9.9 | 18.2 | 12.0 |
| Evaporation ($m^3$) | 0.0 | 0.1 | 0.0 | 0.1 |
| Deep Percolation ($m^3$) | 0.6 | 1.8 | 0.5 | 2.0 |
| Change in Storage ($m^3$) | 0.021 | -0.005 | 0.020 | -0.006 |

Table 8. Volume-based average yearly water balance at the Norton site.

| Quantity | Broadbase | | CBT | |
|---|---|---|---|---|
| | Slope | Channel | Slope | Channel |
| Precipitation ($m^3$) | 21.5 | 10.9 | 20.5 | 13.1 |
| Runoff ($m^3$) | 1.8 | 0.2 | 1.7 | 0.1 |
| Run-on ($m^3$) | 0.0 | 1.8 | 0.0 | 1.7 |
| ET ($m^3$) | 19.9 | 11.1 | 19.0 | 13.4 |
| Evaporation ($m^3$) | 0.0 | 0.1 | 0.0 | 0.1 |
| Deep Percolation ($m^3$) | 0.1 | 1.2 | 0.1 | 1.4 |
| Change in Storage ($m^3$) | -0.023 | 0.013 | -0.022 | 0.004 |

At Colby, 2.7% of the precipitation falling on the contributing slope resulted in deep percolation. If the extra deep percolation caused by the terrace was spread over the contributing slope and terrace channel, it would result in 2.1 cm per year of additional percolation in the broadbase terrace and 2.3 cm per year of additional percolation in the CBT. At Norton, 0.6% of the precipitation falling on the contributing slope resulted in deep percolation. If the extra deep percolation caused by the terrace was spread over the contributing slope and terrace channel, it would result in 2.0 cm per year of additional percolation in the broadbase channel and 1.7 cm per year of additional percolation in the CBT. These values are comparable to those obtained by Koelliker (1985). In his research, the CBT field had about 1.6 cm per year of additional deep percolation, and the field with the level broadbase terrace had about 2.4 cm per year of additional deep percolation.

The simulation results were also used to determine the ET and deep percolation that occurs during each phase of the crop rotation as shown in Figures 18 to and 19. The terrace channel had more ET than the contributing slope except when fallow followed wheat at Colby. Deep percolation was always higher in the terrace channel than the contributing slope. The deep percolation shown in Figures 20 and 21 had large ranges in the exceedance probabilities. This is a result of the episodic nature of deep percolation.

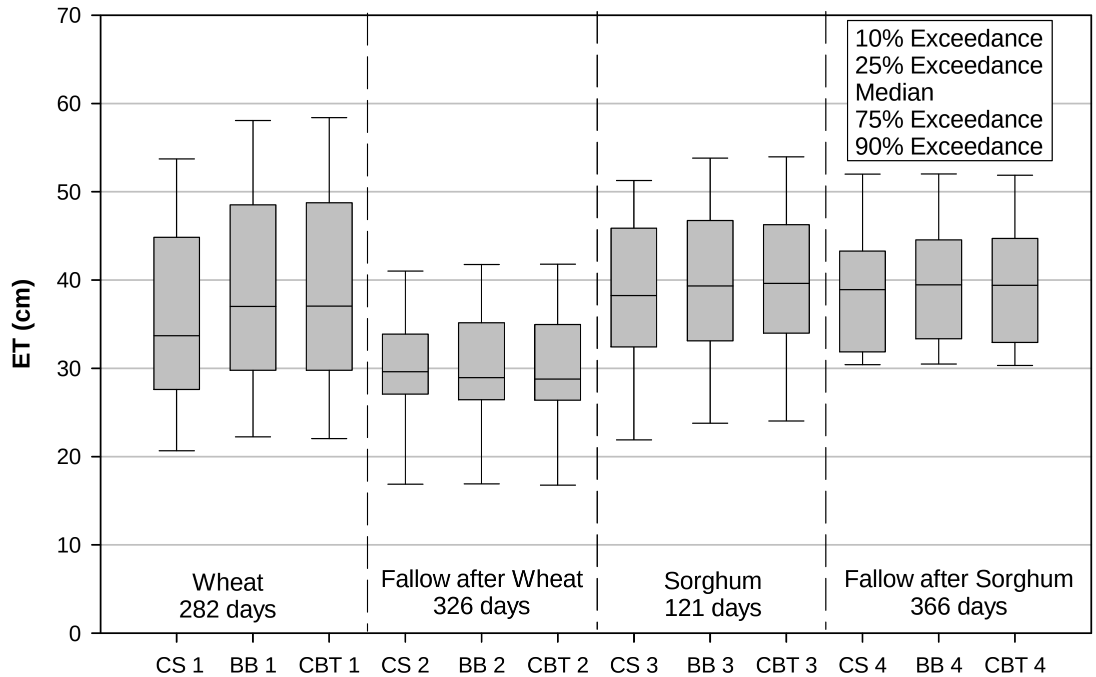


Figure 18. Colby ET compared between the contributing slopes and terrace channels. The terrace channel ET is the average across the channel (CS denotes contributing slope, BB is for broadbased terraces and CBT is for conservation bench terraces).

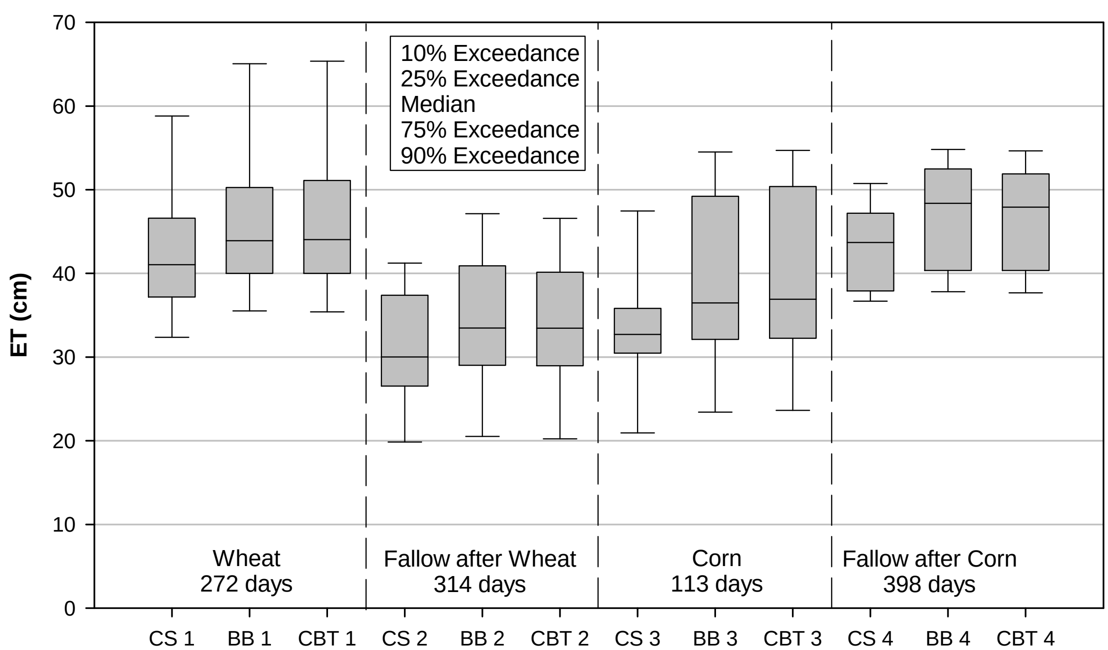


Figure 19. Norton ET compared between the contributing slopes and terrace channels. The terrace channel ET is the average across the channel (CS denotes contributing slope, BB is for broadbased terraces and CBT is for conservation bench terraces).

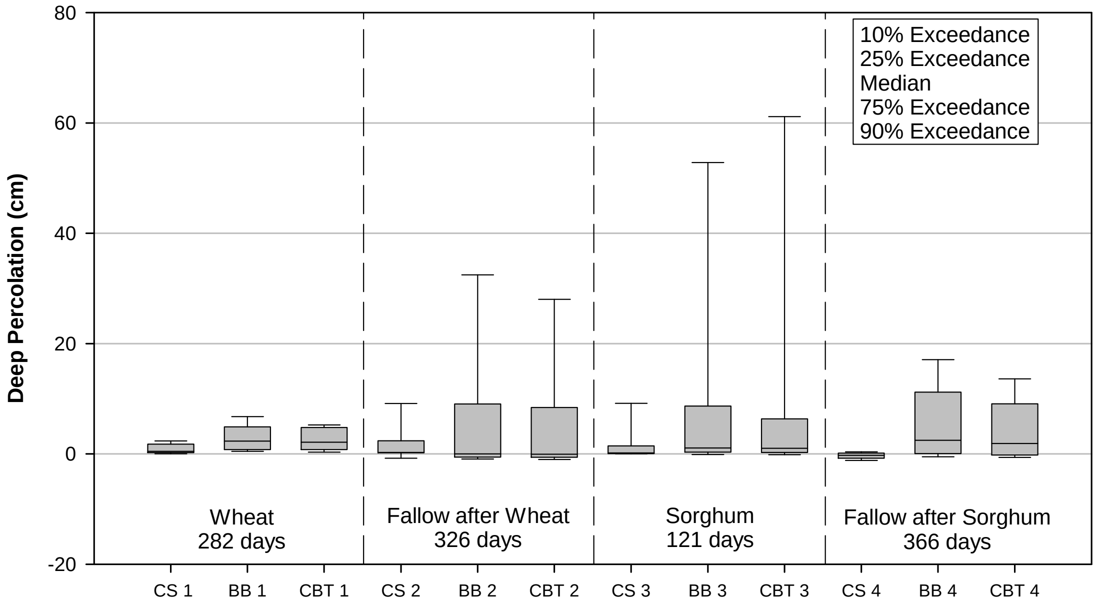


Figure 20. Colby deep percolation compared between the contributing slopes and terrace channels. The terrace channel deep percolation is the average across the channel (CS denotes contributing slope, BB is for broadbased terraces and CBT is for conservation bench terraces).

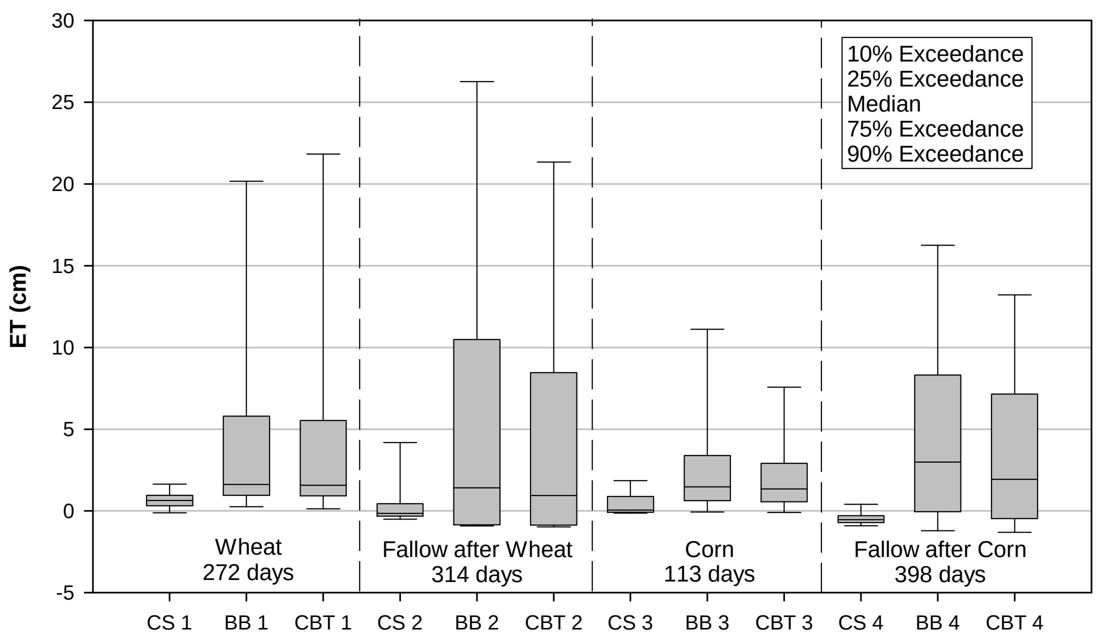


Figure 21. Norton deep percolation compared between the contributing slopes and terrace channels. The terrace channel deep percolation is the average across the channel (CS denotes contributing slope, BB is for broadbased terraces and CBT is for conservation bench terraces).

Summary and Conclusions

Thirty-year simulations were carried out at the Colby and Norton, Kansas field sites. Broadbase and conservation bench terraces were modeled at each site. The long-term simulation modeling used the parameters determined through calibration. The Colby broadbase terrace retained 2.7 cm of runoff water per year, and the Colby CBT terrace retained 2.8 cm of runoff per year. The Norton broadbase terrace retained 2.9 cm of runoff water per year, and the Norton CBT terrace retained 3.5 cm of runoff per year. Over the course of the simulations, 90% of the contributing slope runoff was captured by the Colby broadbase terrace, 100% by the Colby CBT, 91% by the Norton broadbase terrace and 95% by the Norton CBT.

More ET and deep percolation consistently occurred in the terrace channels than on the contributing slope. The runoff water that was retained on the field as a result of the terraces was used primarily for ET and deep percolation. At Colby, 80.3% of the runon water retained by the broadbase terrace and 79.4% of the runon water retained by the CBT deep percolated whereas 17.1% of the broadbase terrace retained water and 19.0% of the CBT retained water was used for ET. At Norton, 45.5% of the runon water retained by the broadbase terrace and 47.4% of the runon water retained by the CBT deep percolated while 42.4% of the broadbase terrace retained water and 47.7% of the CBT retained water was used for ET.

Deep percolation occurred primarily as a result of specific precipitation events. At Colby, 49 cm of rain fell over a 14-day period resulting in 25.4% of the deep percolation under the CBT during the 30-year simulation. At Norton, 42 cm of rain fell over an 8-day period and produced 12.9% of the deep percolation under the broadbase terrace during the 30-year simulation.

The ET within the ecofallow cropping rotation is relatively evenly distributed among the two fallow periods and the wheat and row crop growing periods. At Colby, the ET of each of the four phases of the rotation ranged from 20 to 28% of the total ET, and at Norton, the ET of each of the four phases of the rotation ranged from 21 to 29% of the total ET. Higher daily ET occurred during the row crop and wheat growing periods, but the fallow periods were longer in duration resulting in similar cumulative amounts of ET

## GeoProbe Results

The field research sites were sampled to a depth of 25 feet using an implement referred to as the GeoProbe. The GeoProbe takes an undisturbed core of soil to a chosen depth. We sampled the field areas (both the contributing area and the terrace channels) in the spring of 2006 and 2009. Analysis of the results of the probing provides a picture of the soil water profile throughout the 25-foot depth. An example of the soil water profile at the Curtis site for the land that contributes runoff into the upper of the two terraces studied is shown in Figure 22. The results show minor variation in the upper portion of the profile, *i.e*, the crop root zone; however, the deeper soil profile is very similar. We are analyzing the remaining profiles to understand the variability of soil water in the vadose zone over time.

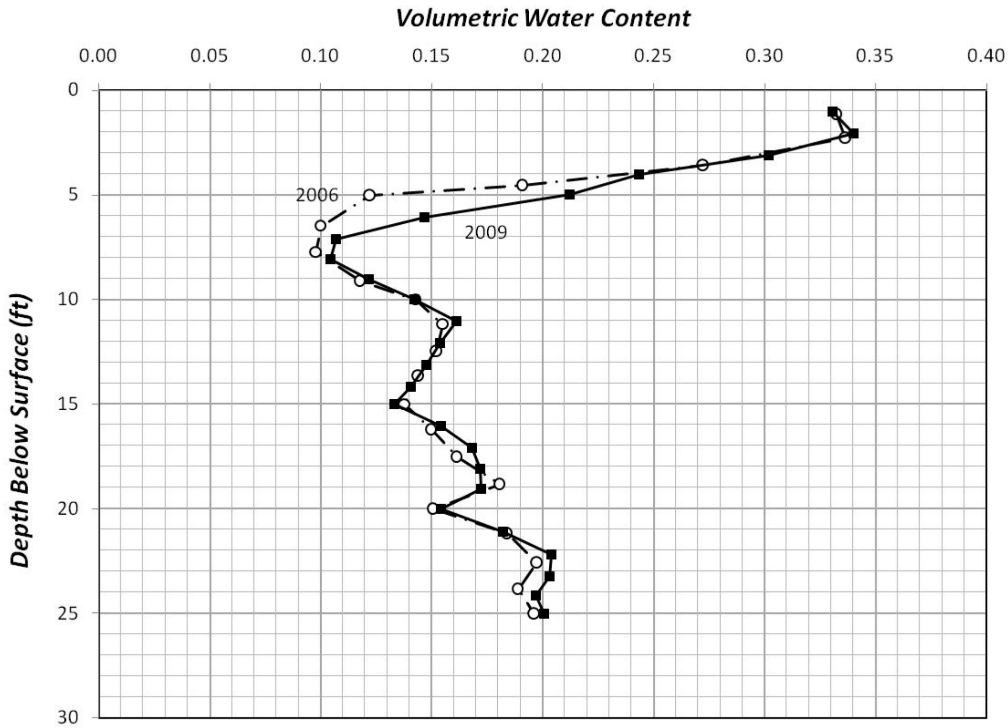


Figure 22. Soil water profiles for the upper contributing area at the Curtis site.

## Terrace Condition Survey

The locations of terraced fields across the Republican Basin have been digitized. When combined with the results of field experiments we will be able to provide estimates of the distribution of water retained by terraces. However, the design capacity and general condition of the terraces play a significant role in determining the ultimate amount of retention and the apportionment of the retained water. We conducted a study to determine the storage conditions of a sampling of terraces across the basin. Our initial plan was to randomly select approximately 1% of the fields across the basin to survey to determine the distribution of storage capacity of various types of terraces. We also identified the types of terraces installed across the basin.

The survey was conducted through the use of a survey-grade GPS system that was loaned to the project by the Kansas Department of Water Resources. The GPS system was installed on an all terrain vehicle. The survey-grade GPS provides accurate spatial and vertical resolution of the field topography. The GPS system logs the horizontal location and the elevation within the field. We are using the system to define field boundaries and to develop estimates of the storage capacity of two terraces within each field that is surveyed.

An application to a field owned by a producer cooperating with the field experiments will illustrate the process. The aerial photograph for the field is given in Figure 23. As the figure illustrates there are seven terraces in the field. For this field the ATV was driven around the boundary of the field as indicated by the open diamonds in Figure 24. The ridge of each terrace was also driven to determine the location and layout of individual terraces. The resulting relative topographic map for the field is shown in Figure 24. The topographic map helps characterize the field but it is not helpful in determining the storage capacity of the terraces.

To determine the storage capacity we drove seven paths parallel to two terraces in each field as illustrated in Figure 25. The first path is on the back slope of the terrace, the second path is along the terrace ridge, the third path is along the front slope of the terrace, the fourth path is in the bottom of the channel of the terrace, the fifth path is along the cut slope of the terrace, the sixth path is along the toe of the contributing area and the final path is along the contributing area that was not affected by terrace construction. The paths for the survey of the third terrace in the field are illustrated in Figure 26.

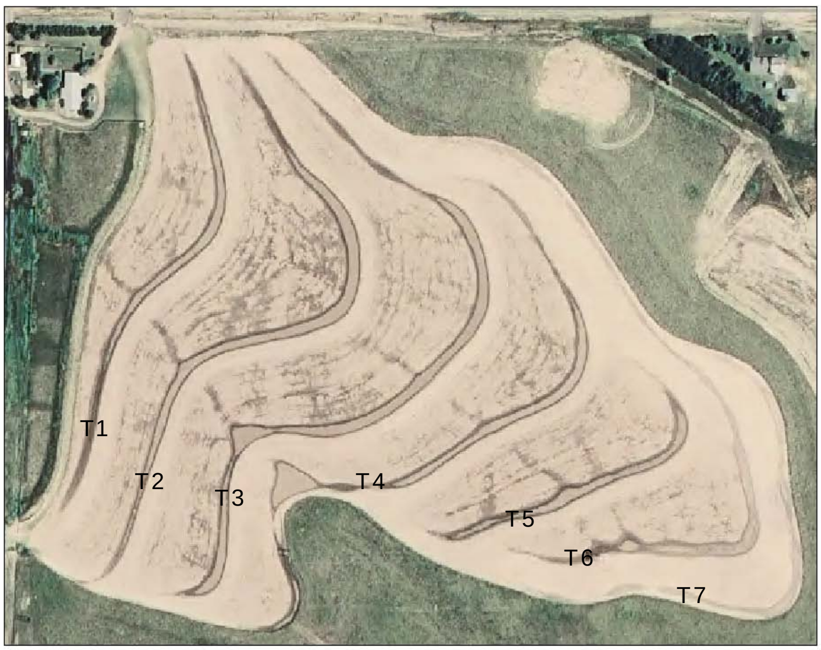


Figure 23. FSA digital photograph of a terraced field used to illustrate the use of a field-grade GPS system to characterize field conditions and terrace storage.

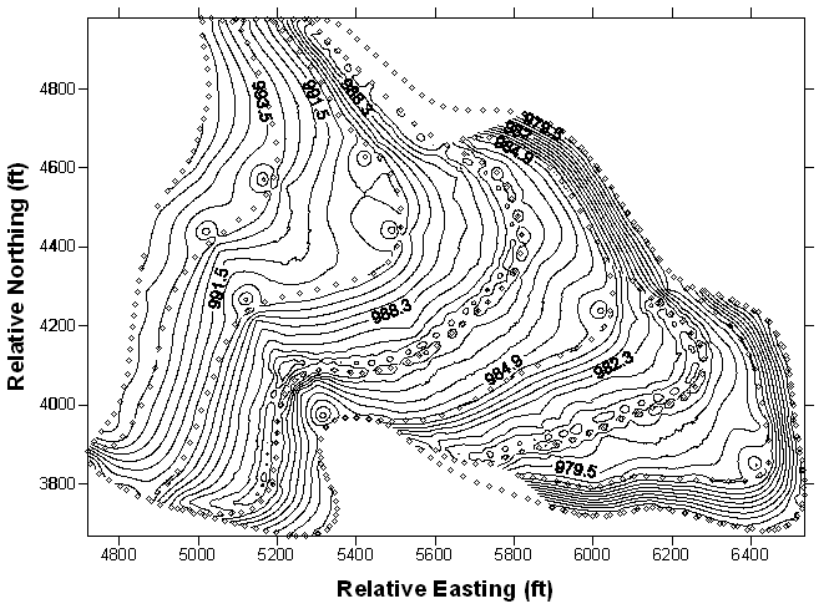


Figure 24. Relative topographic map of the producer's field as developed from driving the paths in the field depicted by the open diamonds.

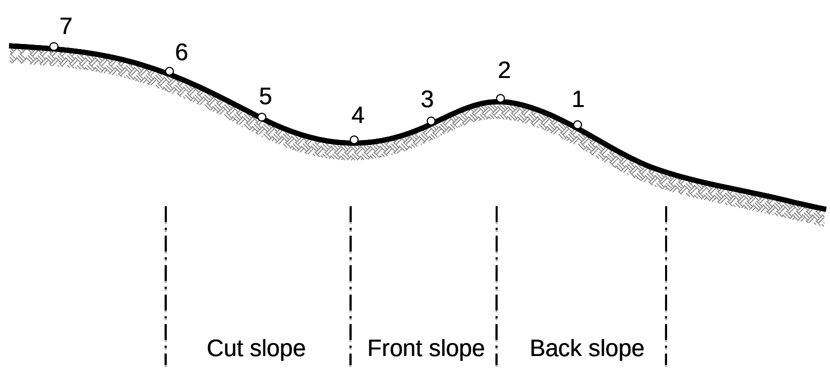


Figure 25. Location of survey lines relative to the cross-sectional profile of a terraced field.

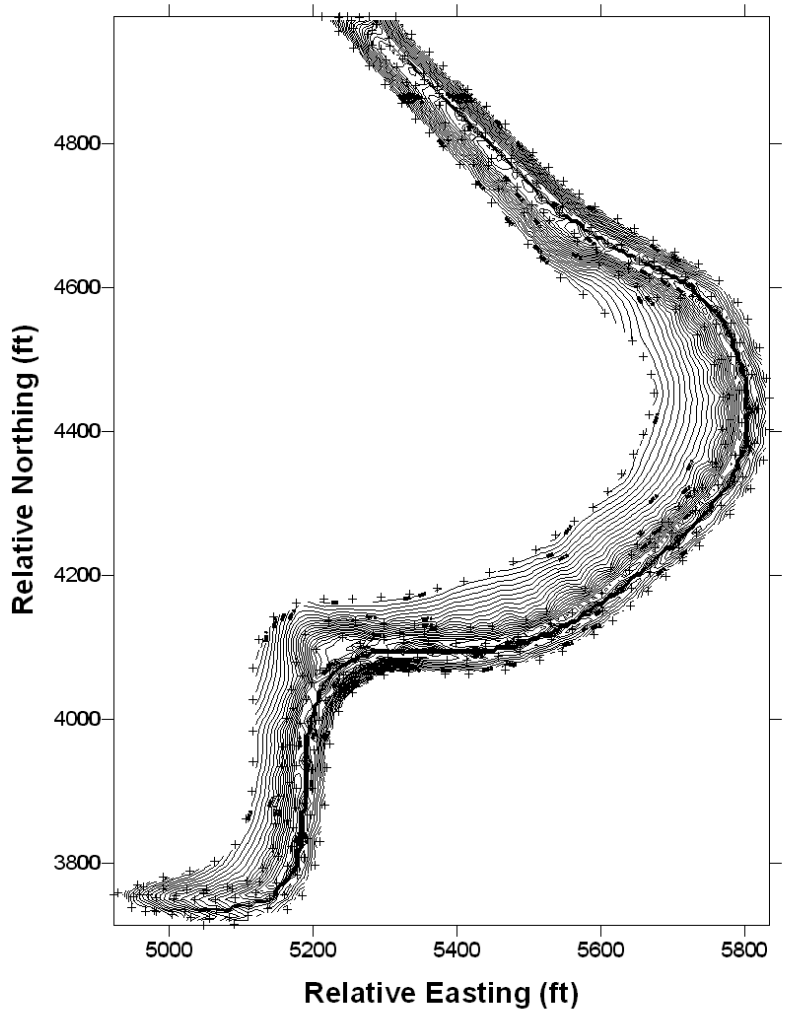


Figure 26. Topography for the third terrace in a cooperator's field.

The survey data from the GPS system are entered into the Surfer® program to process the elevation data into topographic data. The topographic data are being analyzed to determine the amount of water that can be stored in the terrace channel. The storage capacity is determined for two representative terraces in sampled fields. If the terrace ridge or the ends of the terrace have been breached the elevations of the eroded zone is measured to use in determining the maximum water elevation in the terrace channel. The amount of storage per terrace is computed as the fill for the terrace channel based on the seven paths described above.

The digitized locations of terraced fields in each county were used to draw a random sample of fields for investigation. A second sample was also drawn as an alternate to provide backup if a selected field could not be surveyed. We contacted land owners and producers to gain permission for the survey.

A total of 167 fields were surveyed with the distribution shown in Table 9. Eleven fields were surveyed in Colorado, forty-seven in Kansas and 109 fields in Nebraska. Based on the fields were the type of terrace has been determined at this time, about eighty percent of the fields are broadbased terraces and twenty percent are flat channel (*i.e.,* conservation bench terraces). About a quarter of the terraces have been processed with the Surfer routine and about twenty-five percent are in some phase of processing and/or review. We are currently conducting inspections in the easternmost counties of Nebraska to determine the types of terraces in those counties and their relative condition. Results of the processing of the two terrace types are summarized in Tables 10 and11.

Table 9. Summary of terraces surveyed in the Republican River Basin.

| State | County | Fields Surveyed | Fields Processed | Fields In Progress | Terrace Type | | |
|---|---|---|---|---|---|---|---|
| | | | | | Broadbase | Flat Channel | Unknown[1] |
| Colorado | Kit Carson | 4 | | 1 | 3 | 1 | |
| Colorado | Lincoln | 1 | | | 1 | | |
| Colorado | Logan | 1 | | | 1 | | |
| Colorado | Phillips | 1 | 1 | | | 1 | |
| Colorado | Washington | 2 | | | 1 | 1 | |
| Colorado | Yuma | 2 | | | 2 | | |
| Kansas | Cheyenne | 6 | 3 | 3 | 5 | 1 | |
| Kansas | Decatur | 8 | 6 | 1 | 2 | 5 | 1 |
| Kansas | Norton | 11 | | 9 | 6 | 1 | 4 |
| Kansas | Phillips | 7 | | 3 | 6 | | 1 |
| Kansas | Rawlins | 13 | 3 | | 10 | 3 | |
| Kansas | Thomas | 2 | | | 2 | | |
| Nebraska | Frontier | 20 | 5 | 4 | 16 | 2 | 2 |
| Nebraska | Furnas | 34 | 11 | 12 | 27 | 1 | 6 |
| Nebraska | Harlan | 11 | 5 | 6 | 4 | 2 | 5 |
| Nebraska | Hayes | 9 | 2 | 3 | 5 | 2 | 2 |
| Nebraska | Hitchcock | 16 | 5 | 1 | 5 | 6 | 5 |
| Nebraska | Red Willow | 19 | 6 | 1 | 16 | 2 | 1 |
| Total | | 167 | 47 | 44 | 112 | 28 | 27 |

1. If the data sheet provided by the surveyor did not indicate a terrace type, it was assumed to be unknown until later analysis.

Table 10. Summary of broadbase terraces analyzed.

| County | Total Field Area (ac) | Number Of Terraces | Average Terrace Area (ac) | Average Internal Terrace Area (ac) | Average Terrace Length (ft) | Field Slope (%) | Average Terrace Spacing (ft) | Average Vertical Interval (ft) | Terrace Type | Terrace Condition | Terrace Id | Maximum Storage Volume ($ft^3$) | Runoff Needed To Fill Terrace (In) | Maximum Unbreached Terrace Volume ($ft^3$) | Runoff Needed To Fill Terrace If Unbreached (In) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cheyenne | 15.7 | 4 | 3.4 | 3.52 | 1100.4 | 7.25 | 138.7 | 9.8 | broadbase closed | excellent | 2 | 14887.0 | 1.11 | 14887.0 | 1.11 |
| | | | | | | | | | | | 4 | 807.9 | 0.07 | 4707.3 | 0.41 |
| Cheyenne | 7.0 | 78.9 | 8.0 | 5.55 | 1614.4 | 1.86 | 272.6 | 4.1 | broadbase partial closure | good | 2 | 16500.9 | 0.46 | 16500.9 | 0.46 |
| | | | | | | | | | | | 4 | 11353.7 | 0.27 | 11353.7 | 0.27 |
| Decatur | 3.0 | 45.1 | 8.6 | 1.39 | 1711.2 | 1.35 | 280.2 | 3.0 | partical closure | poor | 1 | 17767.4 | 0.48 | 34979.2 | 0.94 |
| Frontier | 48.6 | 10 | 3.96 | 4.21 | 1570.2 | 3.15 | 104.4 | 3.5 | broadbase closed | good | 3 | 2050.5 | 0.28 | 5167.2 | 0.71 |
| | | | | | | | | | | | 6 | 1782.5 | 0.26 | 4432.9 | 0.65 |
| | | | | | | | | | | | 9 | 14151.8 | 0.95 | 30727.7 | 2.06 |
| Frontier | 27.1 | 11 | 2.20 | 2.24 | 1046.4 | 4.70 | 93.7 | 4.3 | old broadbase partial closure | non-functional | 3 | 3673.8 | 0.60 | 8683.4 | 1.42 |
| | | | | | | | | | | | 6 | 10088.6 | 1.10 | 12442.9 | 1.36 |
| | | | | | | | | | | | 9 | 1075.7 | 0.15 | 4632.2 | 0.65 |
| Frontier | 22.3 | 8 | 2.16 | 2.29 | 992.5 | 4.51 | 100.7 | 4.3 | broadbase | non-functional | 2 | 0.0 | 0.00 | 3293.3 | 0.31 |
| Frontier | 30.5 | 3 | 6.44 | 6.44 | 1844.3 | 3.55 | 205.1 | 5.4 | broadbase partial closure | poor | 1 | NA | NA | 7711.3 | 0.70 |
| Frontier | 52.6 | 11 | 3.85 | 4.14 | 1307.7 | 2.96 | 135.0 | 3.8 | broadbase closed | excellent | 3 | 31342.3 | 3.32 | 31342.3 | 3.32 |
| | | | | | | | | | | | 6 | 23806.8 | 1.44 | 23806.8 | 1.44 |
| | | | | | | | | | | | 9 | 15985.6 | 0.91 | 53258.7 | 3.04 |
| Furnas | 77.6 | 12 | 5.80 | 6.57 | 1332.7 | 4.58 | 147.5 | 8.7 | broadbase (except terrace 12 - steep backslope) partial closure | excellent | 3 | 18682.6 | 1.03 | 18682.6 | 1.03 |
| | | | | | | | | | | | 6 | 19547.3 | 0.73 | 30749.7 | 1.14 |
| | | | | | | | | | | | 9 | 5561.5 | 0.44 | 17413.5 | 1.37 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Furnas | 126.4 | 13 | 6.40 | 6.39 | 1980.4 | 3.06 | 132.8 | 4.3 | broadbase partial closure | poor | 3 | 14136.1 | 0.67 | 18082.1 | 0.86 |
| | | | | | | | | | | | 6 | NA | NA | 13725.5 | 0.38 |
| | | | | | | | | | | | 9 | 19889.6 | 0.54 | 30322.0 | 0.82 |
| Furnas | 13.9 | 3 | 2.35 | 2.60 | 1047.5 | 3.70 | 102.4 | 3.6 | broadbase closed | excellent | 2 | 13692.1 | 1.26 | 15917.8 | 1.47 |
| Furnas | 21.4 | 2 | 5.14 | 4.86 | 2068.1 | 2.79 | 102.3 | 3.0 | broadbase partial closure | poor | 2 | 19738.3 | 1.00 | 40091.2 | 2.04 |
| Furnas | 56.6 | 2 | 2.39 | 1.08 | 691.7 | 2.04 | 68.2 | 3.1 | - | - | 1 | 930.3 | 0.07 | 6731.3 | 0.50 |
| Furnas | 57.7 | 9 | 5.30 | 5.69 | 1650.3 | 2.84 | 148.3 | 4.0 | broadbase partial closure | poor to non-functional | 2 | 191.9 | 0.01 | 3391.4 | 0.23 |
| | | | | | | | | | | | 7 | 2503.3 | 0.09 | 13440.0 | 0.47 |
| Furnas | 29.9 | 10 | 2.40 | 2.53 | 761.3 | 2.83 | 145.3 | 3.9 | broadbase partial closure | good | 2 | 1520.2 | 0.18 | 1520.2 | 0.18 |
| | | | | | | | | | | | 4 | 740.9 | 0.06 | 2340.8 | 0.18 |
| | | | | | | | | | | | 6 | 635.6 | 0.11 | 1830.7 | 0.31 |
| Furnas | 1.79 | 3 | 0.49 | 0.61 | 439.7 | 11.20 | 59.9 | 5.4 | broadbase closed | excellent | 2 | 2743.3 | 1.49 | 3170.1 | 1.72 |
| Furnas | 5.75 | 5 | 0.58 | 0.69 | 421.0 | 11.50 | 68.8 | 6.9 | broadbase closed | good | 2 | 399.7 | 0.21 | 1334.4 | 0.70 |
| | | | | | | | | | | | 4 | 2389.8 | 0.81 | NA | NA |
| Furnas | 15.2 | 3 | 3.29 | 4.12 | 1078.0 | 2.58 | 166.7 | 3.4 | broadbase closed | excellent | 2 | 21935.2 | 1.48 | 25353.7 | 1.71 |
| Furnas | 3.87 | 1 | 1.50 | 0.00 | 628.6 | NA | NA | NA | broadbase partial closure | good | 1 | 0.0 | 0.00 | 4222.3 | 0.78 |
| Furnas | 116.5 | 11 | 9.10 | 9.64 | 2125.6 | 3.58 | 194.7 | 6.7 | flat channel partial closure | poor (new terraces in good condition) | 3 | 66953.4 | 1.95 | 95770.7 | 2.79 |
| | | | | | | | | | | | 6 | 73978.3 | 1.59 | 73978.3 | 1.59 |
| | | | | | | | | | | | 9 | 40515.5 | 1.32 | 51240.3 | 1.67 |
| Furnas | 8.73 | 3 | 1.64 | 2.06 | 779.3 | 4.23 | 118.0 | 3.9 | broadbase closed | nearly new or excellent | 2 | 20571.4 | 3.22 | 20571.4 | 3.22 |
| Furnas | 19.0 | 9 | 1.20 | 1.52 | 910.8 | 9.44 | 67.0 | 5.6 | broadbase closed | good | 2 | 979.2 | 0.29 | 3116.5 | 0.92 |
| | | | | | | | | | | | 5 | 2091.3 | 0.25 | 9078.6 | 1.09 |
| Furnas | 5.13 | 9 | 0.51 | 0.51 | 250.8 | 5.43 | 84.9 | 4.8 | broadbase partial closure | non-functional | 4 | 165.7 | 0.06 | 872.2 | 0.30 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Furnas | 5.10 | 6 | 0.61 | 0.56 | 586.4 | 8.35 | 58.4 | 3.8 | broadbase partial closure | good | 2 | 4769.9 | 1.35 | 11010.9 | 3.12 |
| Furnas | 4.26 | 3 | 1.01 | 1.27 | 470.6 | 4.70 | 115.8 | 4.4 | broadbase partial closure | good | 2 | 191.8 | 0.06 | 1343.1 | 0.39 |
| Furnas | 39.0 | 8 | 3.46 | 3.55 | 1235.5 | 3.29 | 128.8 | 4.0 | broadbase partial closure | poor | 2 | 1793.9 | 0.09 | 10298.6 | 0.51 |
| | | | | | | | | | | | 5 | 78.1 | 0.01 | 3957.7 | 0.33 |
| Furnas | 8.49 | 2 | 3.67 | 0.00 | 1361.7 | 4.65 | 162.5 | 5.5 | closed | nearly new or excellent | 1 | 14706.3 | 1.79 | 14706.3 | 1.79 |
| Furnas | 43.0 | 13 | 2.40 | 2.38 | 957.7 | 3.88 | 113.9 | 4.2 | broadbase partial closure | good | 3 | 2068.6 | 0.15 | 4403.0 | 0.32 |
| | | | | | | | | | | | 6 | 298.6 | 0.04 | 1987.3 | 0.26 |
| | | | | | | | | | | | 9 | NA | NA | NA | NA |
| Harlan | 75.8 | 4 | 12.28 | 13.43 | 1932.8 | 1.04 | 427.2 | 2.9 | flat channel partial closure | nearly new or excellent | 1 | 150423.5 | 4.69 | 170332.7 | 5.31 |
| | | | | | | | | | | | 3 | 248319.4 | 5.70 | 270464.8 | 6.21 |
| Harlan | 25.9 | 5 | 4.60 | 4.81 | 868.0 | 1.55 | 226.8 | 3.6 | broadbase partial closure | poor | 2 | 18186.4 | 1.69 | NA | NA |
| | | | | | | | | | | | 4 | 21311.5 | 0.82 | 44065.5 | 1.69 |
| Harlan | 9.30 | 4 | 1.40 | 1.71 | 884.9 | 10.60 | 85.8 | 7.2 | - | - | 2 | 1818.1 | 0.29 | 5376.3 | 0.85 |
| | | | | | | | | | | | 4 | 2845.3 | 0.39 | 3700.3 | 0.51 |
| Harlan | 13.0 | 1 | 9.87 | 0.00 | 922.7 | NA | NA | NA | broadbase partial closure | good | 1 | 0.0 | 0.00 | NA | NA |
| Harlan | 4.70 | 3 | 1.08 | 1.51 | 672.6 | 9.49 | 93.2 | 6.6 | terrace 1&2 - broadbase terrace 3 - gradient grass waterway | good | 3 | 0.0 | 0.00 | NA | NA |
| Harlan | 56.0 | 4 | 3.24 | 3.60 | 989.8 | 2.57 | 156.6 | 3.7 | - | - | 2 | 17201.4 | 1.75 | 32133.8 | 3.28 |
| | | | | | | | | | | | 4 | 0.0 | 0.00 | NA | NA |
| Harlan | 35.3 | 2 | 14.50 | 14.54 | 1819.7 | 2.21 | 359.4 | 4.0 | broadbase partial closure | good | 1 | 0.0 | 0.00 | NA | NA |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hayes | 85.6 | 8 | NA | 7.83 | 2326.0 | NA | NA | 4.1 | broadbase partial closure | good | 3 | NA | NA | NA | NA |
| | | | | | | | | | | | 6 | 7187.4 | 0.50 | 7187.4 | 0.50 |
| Hayes | 21.3 | 5 | 3.14 | 3.63 | 1265.5 | 5.39 | 117.4 | 5.8 | broadbase partial closure | excellent to good | 2 | 4732.5 | 0.50 | 13482.3 | 1.42 |
| | | | | | | | | | | | 4 | 1414.8 | 0.09 | 29532.0 | 1.77 |
| Red Willow | 102.3 | 9 | 9.80 | 9.17 | 2294.0 | 1.91 | 199.9 | 3.6 | broadbase partial closure | good | 3 | 42393.0 | 1.75 | 1999.9 | 2.73 |
| | | | | | | | | | | | 5 | 20059.5 | 0.55 | 1995.2 | 0.57 |
| Red Willow | 26.6 | 3 | 6.22 | 5.41 | 1265.7 | 2.95 | 237.1 | 6.3 | flat channel closed | excellent | 2 | 34675.8 | 1.44 | 59349.4 | 2.46 |
| Red Willow | 60.8 | 10 | 2.93 | 3.11 | 1179.5 | 3.41 | 130.3 | 3.7 | broadbase partial closure | poor | 3 | 482.3 | 0.05 | 2744.6 | 0.26 |
| Red Willow | 112.1 | 23 | 4.13 | 4.24 | 1436.6 | 2.81 | 128.3 | 3.5 | broadbase partial closure | good | 3 | 38496.4 | 2.16 | 38496.4 | 2.16 |
| | | | | | | | | | | | 6 | 12104.7 | 1.28 | 12104.7 | 1.28 |
| | | | | | | | | | | | 9 | 2791.2 | 0.21 | 16053.1 | 1.23 |
| Red Willow | 33.8 | 8 | 3.51 | 3.83 | 1357.6 | 3.15 | 132.1 | 3.5 | broadbase partial closure | good | 2 | 6430.1 | 0.53 | 8328.1 | 0.69 |
| | | | | | | | | | | | 4 | 3381.6 | 0.22 | 8428.9 | 0.54 |

Table 11. Summary of flat-channel terraces analyzed.

| County | Total Field Area (ac) | Number Of Terraces | Average Terrace Area (ac) | Average Internal Terrace Area (ac) | Average Terrace Length (ft) | Field Slope (%) | Average Terrace Spacing (ft) | Average Vertical Interval (ft) | Terrace Type | Terrace Condition | Terrace Id | Maximum Storage Volume ($ft^3$) | Runoff Needed To Fill Terrace (In) | Maximum Unbreached Terrace Volume ($ft^3$) | Runoff Needed To Fill Terrace If Unbreached (In) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phillips | 63.4 | 5 | 7.8 | 7.7 | 1260 | 1.61% | 351 | 4.2 | flat channel | good | 2 | 49420 | 1.21 | 49420 | 1.21 |
| | | | | | | | | | | | 4 | 13619 | 0.61 | 13619 | 0.61 |
| Cheyenne | 85.9 | 4 | 9.8 | 13.4 | 1761 | 1.42% | 249 | 4.4 | flat channel | excellent | 1 | 50137 | 1.37 | 50137 | 1.37 |
| | | | | | | | | | | | 4 | 44452 | 0.95 | 44452 | 0.95 |
| Decatur | 72.3 | 5 | 11.1 | 11.2 | 1958 | 1.94% | 274 | 5.2 | flat channel | excellent | 2 | 170766 | 2.13 | 170766 | 2.13 |
| | | | | | | | | | | | 4 | 398 | 0.03 | 398 | 0.03 |
| Decatur | 51.7 | 7 | 4.8 | 4.8 | 1198 | 2.99% | 259 | 5.5 | flat channel | good | 3 | 26975 | 1.42 | 26975 | 1.42 |
| | | | | | | | | | | | 6 | 79782 | 2.02 | 79782 | 2.02 |
| Decatur | 79.4 | 5 | 11.9 | 13.0 | 1877 | 1.51% | 312 | 4.2 | flat channel | good | 2 | 58226 | 0.88 | 58226 | 0.88 |
| | | | | | | | | | | | 4 | 20687 | 0.63 | 20687 | 0.63 |
| Decatur | 87.4 | 9 | 8.1 | 8.1 | 2556 | 2.37% | 136 | 3.5 | flat channel | excellent | 2 | 25321 | 0.81 | 25321 | 0.81 |
| | | | | | | | | | broadbase | | 6 | 23369 | 0.73 | 23369 | 0.73 |
| | | | | | | | | | broadbase | | 9 | 10564 | 1.10 | 10564 | 1.10 |
| Decatur | 32.6 | 5 | 4.0 | 4.0 | 909 | 2.22% | 248 | 5.2 | flat channel | good | 2 | 9549 | 0.58 | 9549 | 0.58 |
| | | | | | | | | | | | 4 | 17980 | 0.91 | 17980 | 0.91 |
| Rawlins | 48.4 | 5 | 6.8 | 7.2 | 1412 | 4.35% | 246 | 9.1 | flat channel | excellent | 2 | 28860 | 1.08 | 28860 | 1.08 |
| | | | | | | | | | | | 4 | 87279 | 2.80 | 99476 | 3.19 |
| Rawlins | 153.0 | 3 | 42.6 | 0.0 | 2988 | 0.71% | 609 | 4.4 | flat channel | good | 2 | 130058 | 0.77 | 130058 | 0.77 |
| Rawlins | 158.3 | 9 | 14.1 | 15.2 | 2385 | 1.11% | 265 | 2.5 | flat channel | non-functional | 6 | 32519 | 0.52 | 32519 | 0.52 |
| Frontier | 27.0 | 6 | 3.3 | 2.8 | 896 | 3.03% | 191 | 5.0 | flat channel | good | 3 | 10586 | 0.62 | 28684 | 1.68 |
| | | | | | | | | | | | 5 | 32675 | 2.89 | 32675 | 2.89 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Frontier | 84.1 | 9 | 8.1 | 7.8 | 1571 | 1.94% | 243 | 4.4 | flat channel | excellent | 2 | 84925 | 2.24 | 84925 | 2.24 |
| | | | | | | | | | | | 4 | 63769 | 2.36 | 63769 | 2.36 |
| | | | | | | | | | | | 8 | 58299 | 1.88 | 58299 | 1.88 |
| Hayes | 69.6 | 8 | 6.0 | 6.5 | 1388 | 2.61% | 207 | 5.3 | flat channel | good to excellent | 3 | 39305 | 2.14 | 39305 | 2.14 |
| | | | | | | | | | | | 6 | 31457 | 0.87 | 54501 | 1.51 |
| Hitchcock | 100.9 | 7 | 10.5 | 11.1 | 2106 | 2.28% | 226 | 5.1 | flat channel | excellent | 3 | 73187 | 2.01 | 143523 | 3.95 |
| | | | | | | | | | | | 6 | 173371 | 3.38 | 173371 | 3.38 |
| Hitchcock | 24.3 | 3 | 3.2 | 4.1 | 815 | 1.37% | 209 | 2.9 | flat channel | poor | 2 | 526 | 0.04 | 3933 | 0.32 |
| Hitchcock | 96.4 | 7 | 12.4 | 12.0 | 2121 | 3.43% | 314 | 7.4 | flat channel | excellent | 3 | 136729 | 2.97 | 136729 | 2.97 |
| | | | | | | | | | | | 6 | 119063 | 2.60 | 119063 | 2.60 |
| Hitchcock | 54.3 | 7 | 6.0 | 6.5 | 1060 | 1.11% | 261 | 2.9 | flat channel | good | 3 | 14738 | 0.56 | 14738 | 0.56 |
| | | | | | | | | | | | 6 | 13827 | 0.65 | 13827 | 0.65 |
| Hitchcock | 48.1 | 4 | 7.3 | 5.5 | 1075 | 2.79% | 324 | 6.7 | flat channel | poor to good | 2 | 57899 | 1.06 | 57899 | 1.06 |
| | | | | | | | | | | | 4 | 15477 | 1.13 | 15477 | 1.13 |
| Red Willow | 100.7 | 7 | 7.9 | 8.2 | 1515 | 2.68% | 243 | 6.1 | flat channel | excellent | 3 | 164348 | 4.73 | 164348 | 4.73 |
| | | | | | | | | | | | 6 | 75413 | 2.41 | 75413 | 2.41 |
| | | | | | | | | | | | 8 | 62415 | 2.78 | 62415 | 2.78 |
| Red Willow | 26.6 | 3 | 5.8 | 4.8 | 1266 | 3.73% | 210 | 6.3 | flat channel | excellent | 2 | 33834 | 1.58 | 57571 | 2.68 |

The amount of ruoff that can be stored in the channel is listed in Tables 10 and 11for the broadbased and flat channel (*i.e.*, conservation bench) terraces. The distribution of the amount of storage available is shown in Figure 27. The results show that the average runoff storage for the broadbased terraces is about 0.5 inches while the flat channel (conservation bench) terraces store about 1.4 inches of runoff on average. The volume of storage was also determined if the terraces had not breached. The ratio of existing to unbreached storage was about 53% for broadbased terraces and 92% for flat channel terraces. Thus it appears that broadbased terraces are much more likely to breach than flat channel terraces. These data are being integrated into the POTYLD modeling phase of the project.

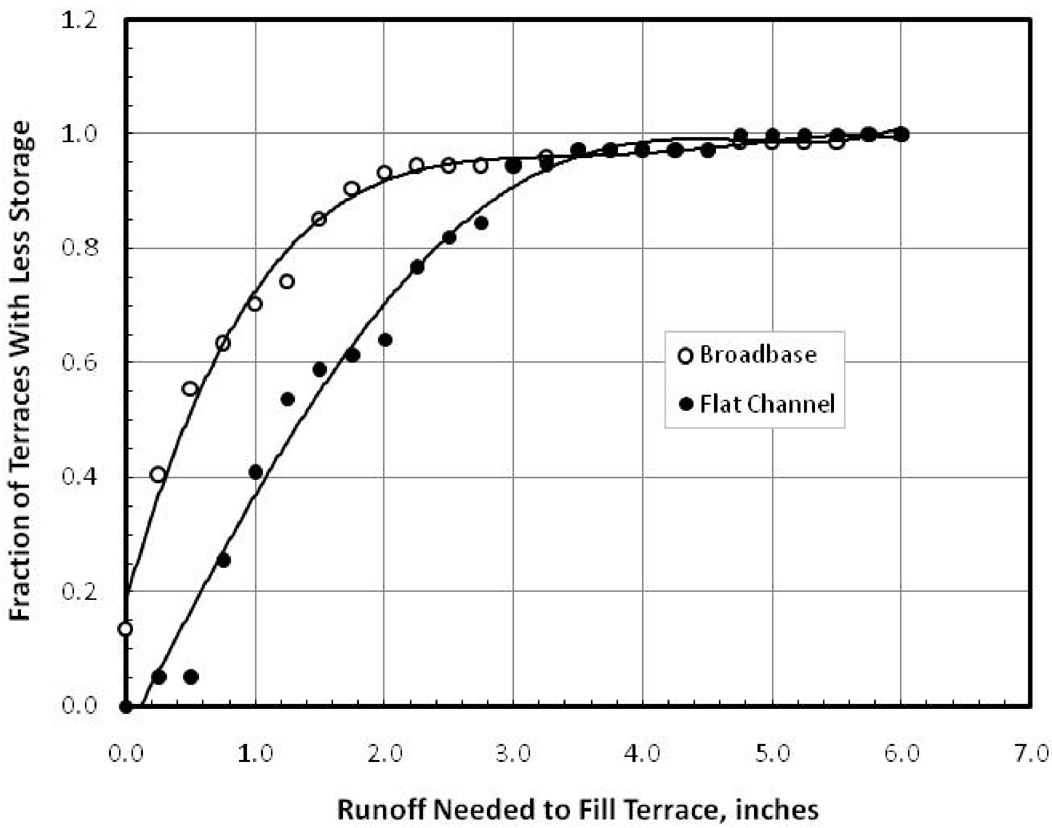


Figure 27. Distribution of storage capacity of surveyed terraces.

# DATABASE DEVELOPMENT

## Weather Data

Two types of weather data have been assembled. Data from the automated weather data network (AWDN) operated by the High Plains Regional Climate Center and data from the Colorado Agricultural Meteorology network were used to compute reference crop evapotranspiration using the hourly Penman-Monteith method. Nineteen AWDN stations were used across the Republican River Basin. Data from the stations was filtered to remove periods when solar radiation data indicated sensor malfunction and when the difference between daily minimum temperature and the average daily dew point was greater than four degrees Celsius. The filtered reference crop ET data were used to calibrate the Hargreaves equation for the Great Plains for each month. The Hargreaves method only requires the daily maximum and minimum air temperature to estimate reference crop ET. The calibrated Hargreaves method was then used with data from the Cooperative program operated by NOAA and the National Weather Service (NWS). These data are referred to as the NWS data. These records only include the daily maximum and minimum air temperature and the amount of precipitation received for the day. The data for the NWS stations were downloaded from the High Plains Regional Climate Center. The Hargreaves method was used with these data to develop estimates of reference crop ET for the NWS sites shown in Figure 28 The NWS data were used because a continuous record of data is available after 1950 for the stations. These data are available for use in the POTYLD model.

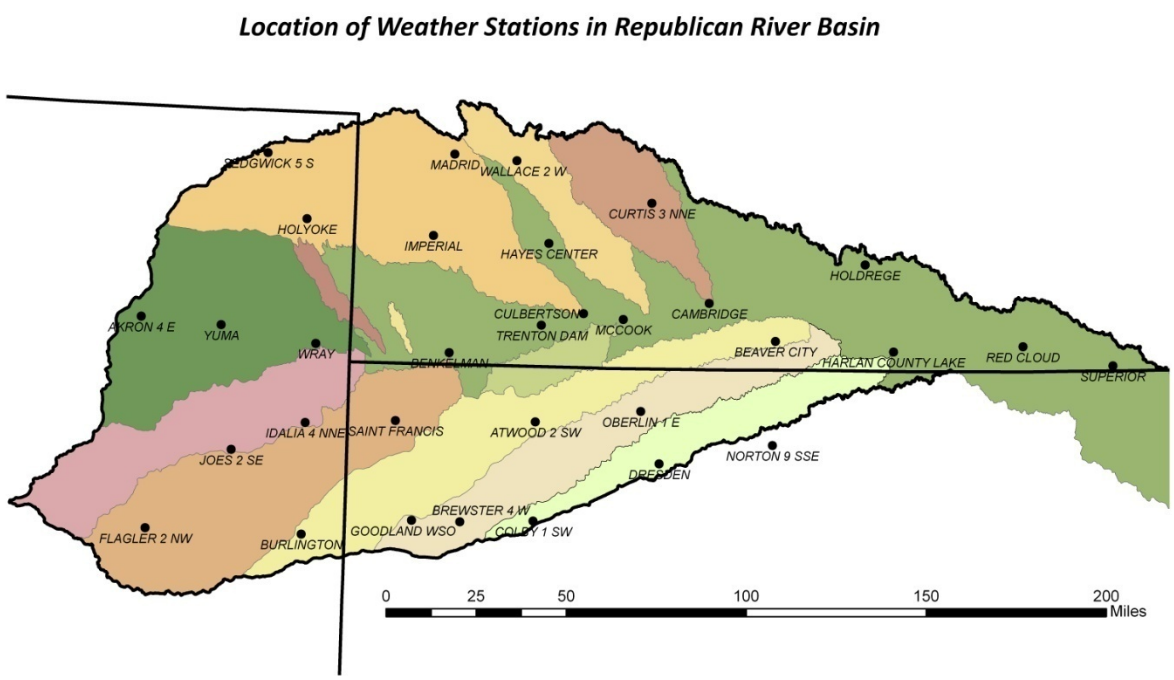


Figure 28. Location of NWS weather stations for simulation of terrace and reservoir impacts.

**GIS Datasets**

Geodatabases have been developed including the location of terraced lands, the delineation of watershed and subwatershed (HUC-10 level) boundaries and the location of waterways and water bodies using the National Hydrographic Dataset (NHD) as shown in Figure 29. This base is used to determine the average flow distance for computing transmission losses and for assigning results from POTYLD simulation of individual weather stations to terraced lands and non-federal reservoirs in each subwatershed.

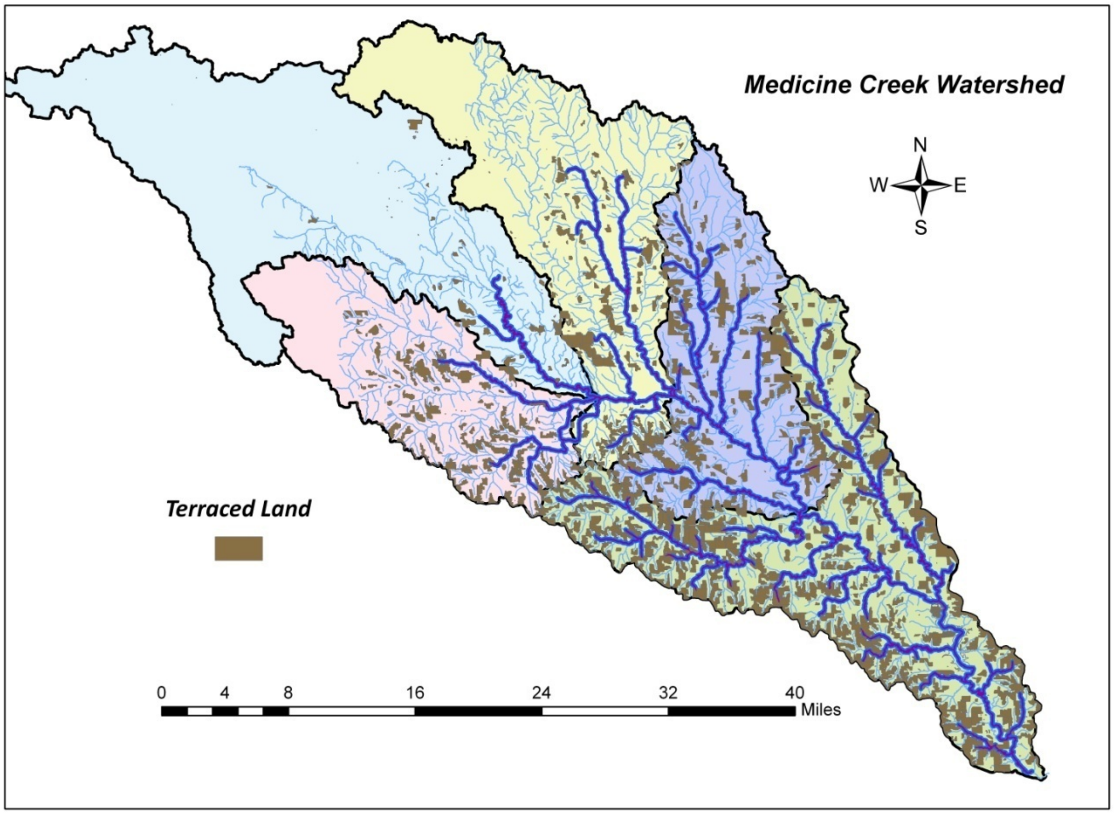


Figure 29. Example watershed map for the Medicine Creek Watershed.

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# ATTACHMENT K

## RESOLUTION PROPOSED BY COLORADO
*Regarding the*
COMPACT COMPLIANCE PIPELINE
AUGUST 12, 2009

# RESOLUTION BY THE REPUBLICAN RIVER COMPACT ADMINISTRATION REGARDING APPROVAL OF COLORADO'S AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES SUBMITTED UNDER SUBSECTION III.B.1.k OF THE FINAL SETTLEMENT STIPULATION

August 12, 2009

**Whereas,** the States of Kansas, Nebraska, and Colorado entered into a Final Settlement Stipulation ("FSS") as of December 15, 2002, to resolve pending litigation in the United States Supreme Court regarding the Republican River Compact ("Compact") in the case of *Kansas v. Nebraska and Colorado,* No. 126 Original;

**Whereas,** the FSS was approved by the United States Supreme Court on May 19, 2003;

**Whereas**, the State of Colorado's Computed Beneficial Consumptive Use of the waters of the Republican River Basin exceeded Colorado's Compact Allocation using the five-year running average to determine Compact compliance from 2003 through 2007, as provided in Subsection IV.D of the FSS;

**Whereas**, the Republican River Water Conservation District is a water conservation district created by Colorado statute to assist the State of Colorado to comply with the Compact;

**Whereas,** the Republican River Water Conservation District, acting by and through its Water Activity Enterprise ("RRWCD WAE"), has contracted to acquire fifteen Compact Compliance Wells in the Republican River Basin in Colorado for the sole purpose of offsetting stream depletions in order to comply with the State of Colorado's Compact Allocations;

**Whereas**, the RRWCD WAE has contracted to purchase groundwater rights in the Republican River Basin within Colorado and proposes to pump the historical consumptive use of all or some of these water rights from the Compact Compliance Wells into a pipeline and deliver that water into the North Fork of the Republican River near the Colorado/Nebraska State Line to offset stream depletions in order to comply with Colorado's Compact Allocations ("Colorado Compact Compliance Pipeline");

**Whereas,** the States of Kansas, Nebraska, and Colorado adopted a Moratorium on New Wells in Subsection III.A of the FSS, with certain exceptions set forth in subsection III.B of the FSS;

**Whereas**, Subsection III.B.1.k of the FSS provides that the Moratorium shall not apply to wells acquired or constructed by a State for the sole purpose of offsetting stream depletions in order to comply with its Compact Allocations, provided that such wells shall not cause any new net depletion to stream flow either annually or long term;

**Whereas**, Subsection III.B.1.k of the FSS further provides that augmentation plans and related accounting procedures submitted under this Subsection III.B.1.k shall be approved by the Republican River Compact Administration ("RRCA") prior to implementation;

**Whereas,** Subsection I.F of the FSS also provides that: "The RRCA may modify the RRCA Accounting Procedures, or any portion thereof, in any manner consistent with the Compact and this Stipulation;" and

**Whereas**, the State of Colorado and the RRWCD WAE have submitted an augmentation plan and related accounting procedures to account for water delivered to the North Fork of the Republican River for the purpose of offsetting stream depletions in order to comply with Colorado's Compact Allocations.

**Now, therefore,** it is hereby resolved that the RRCA approves the augmentation plan and the related accounting procedures submitted by the State of Colorado and the RRWCD WAE under Subsection III.B.1.k of the FSS, subject to the terms and conditions set forth herein. The augmentation plan is described in the application submitted by the State of Colorado and the RRWCD WAE, which is attached hereto as Exhibit 1. The related accounting procedures are included in the revised RRCA Accounting Procedures and Reporting Requirements ("revised RRCA Accounting Procedures"), which are attached hereto as Exhibit 2. This approval of the augmentation plan and the related accounting procedures shall be subject to the following terms and conditions:

1. The average annual historical consumptive use of the groundwater rights that will be diverted at the Compact Compliance Wells shall be as determined by the Colorado Ground Water Commission pursuant to its rules and regulations, provided that the average annual historical consumptive use of the groundwater rights listed on Exhibit 3 shall not exceed the 1998-2007 average annual amounts shown on Exhibit 3. Annual diversions during any calendar year under the groundwater rights included in the augmentation plan shall be limited to the total average annual historical consumptive use of the rights, except as provided in paragraph 3 below.

2. Net depletions from the Colorado Compact Compliance Wells shall be computed by the RRCA Groundwater Model and included in Colorado's Computed Beneficial Consumptive Use of groundwater pursuant to paragraph III.D.1 of the revised RRCA Accounting Procedures. Groundwater pumping from the Compact Compliance Wells shall be measured by totalizing flow meters, and the measured groundwater pumping from such wells shall be included in the base "run" of the RRCA Groundwater Model in accordance with paragraph III.D.1 of the revised RRCA Accounting Procedures.

3. Diversions from any individual Compact Compliance Well shall be limited to no more than 2,500 acre feet per year. Banking of groundwater shall be permitted in accordance with the rules and regulations of the Colorado Ground Water Commission, subject to the limit on Augmentation Water Supply Credit in paragraph 4 below.

4. The Augmentation Water Supply Credit due to deliveries from the Colorado Compact Compliance Pipeline that will be applied against the Computed Beneficial Consumptive Use of water to offset stream depletions in order to comply with Colorado's Compact Allocations during any calendar year shall be limited as follows:

   <u>Calculation of Projected Augmentation Water Supply Delivery to Determine the Limit on Augmentation Water Supply Credit</u>

   Each year, using the procedures described below, Colorado will determine the Projected Augmentation Water Supply Delivery ("Projected Delivery") for the upcoming accounting year (the "subject accounting year") to estimate the volume of Augmentation Water Supply that will be delivered from the Colorado Compact Compliance Pipeline during the subject accounting year, with a minimum annual delivery of 4,000 acre-feet. The RRWCD WAE will begin deliveries from the Colorado Compact Compliance Pipeline during the subject accounting year based on the Projected Delivery, but actual deliveries will be adjusted during the course of the year based on hydrologic and climatic conditions and the need to offset stream depletions in order to comply with Colorado's Compact Allocations, subject to the limit on the Augmentation Water Supply Credit set forth below.

   The steps to determine the Projected Delivery and the limit on the Augmentation Water Supply Credit are as follows:

   A. Step 1. By March 31st of each year, Colorado will calculate Colorado's total Allocation and Colorado's Computed Beneficial Consumptive Use ("CBCU") for the previous accounting year using the procedures described in the revised RRCA Accounting Procedures, but using preliminary data where necessary.

   B. Step 2. Colorado will determine the Projected Delivery, which shall be the largest annual deficit or difference between Colorado's total annual Allocation and Colorado's CBCU during the 10 accounting years immediately preceding the subject accounting year; provided, however, that accounting years in which Colorado's total annual Allocation exceeds Colorado's CBCU shall not be used in determining the Projected Delivery.

   C. Step 3. The Colorado RRCA Member shall provide notice of the Projected Delivery determination to the Kansas and Nebraska RRCA Members by April 1 of each year.

D. Step 4. The Augmentation Water Supply Credit for the subject accounting year shall be limited to the Projected Delivery plus 4,000 acre-feet, or 140% of the Projected Delivery, whichever is greater.

Examples of how this limitation shall be applied are attached as Exhibit 4.

5. The preliminary design for the Colorado Compact Compliance Pipeline is described in the application attached hereto as Exhibit 1. The State of Colorado and the RRWCD WAE shall submit the final design for the Colorado Compact Compliance Pipeline to the RRCA and any changes to the final design after the Colorado Compliance Pipeline has been constructed. If the final design or changes to the final design of the Colorado Compliance Pipeline as constructed differ from the preliminary design in a way that would materially change the location of the Compact Compliance Wells or the river outlet structure, the RRCA may modify the terms and conditions of this approval.

6. The RRWCD WAE may acquire additional groundwater rights to be pumped through the Compact Compliance Wells upon the terms and conditions of this resolution. The State of Colorado and the RRWCD WAE shall file a notice with the RRCA identifying the additional groundwater rights and the historical consumptive use of the groundwater rights. The RRCA members shall have sixty days from the date the notice is given to review the information. If no objection is made within sixty days from the date the notice is given, the additional groundwater rights may be pumped through the Compact Compliance Wells upon the terms and conditions of this resolution. If an objection is made by any RRCA member, the objection shall be shall be given in writing to the RRWCD WAE within 60 days from the date the notice is given and the notice shall be treated as an application for approval of an augmentation plan and related accounting procedures under Subsection III.B.1.k of the FSS and the State of Colorado and the RRWCD WAE may submit any additional information to address the objection.

7. The approval of this augmentation plan and the related accounting procedures shall not govern the approval of any future proposed augmentation plan and related accounting procedures submitted by any other State under Subsection III.B.1.k of the FSS.

8. The approval of this augmentation plan and the related accounting procedures shall not waive any State's rights to seek damages from any other State for violations of the Compact or the FSS subsequent to December 15, 2002.

9. Except for the approval of the augmentation plan and the related accounting procedures as provided herein, nothing in this Resolution shall relieve the State of Colorado from complying with the obligations set forth in the Compact or FSS.

Approved by the RRCA this 12th day of August, 2009.

| | |
|---|---|
| Brian Dunnigan, P.E.<br>Nebraska Member<br>Chairman, RRCA | date |
| David Barfield, P.E.<br>Kansas Member | date |
| Dick Wolfe, P.E.<br>Colorado Member | date |

**EXHIBIT 1 TO ATTACHMENT K**

*Application for Approval of an*
*Augmentation Plan and Related Accounting Procedures*

*The Republican River Compact Compliance Pipeline*

Submitted by the

State of Colorado

And the

Republican River Water Conservation District
Acting by and through its
Water Activity Enterprise

March 2008.

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

Bill Ritter, Jr.
Governor

Harris D. Sherman
Executive Director

Dick Wolfe, P.E.
Director/State Engineer

# APPLICATION FOR APPROVAL OF AN AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES UNDER SUBSECTION III.B.I.K. OF THE FINAL SETTLEMENT STIPULATION IN KANSAS V. NEBRASKA AND COLORADO, NO. 126, ORIGINAL

## The Republican River Compact Compliance Pipeline

**Submitted by**

**The State of Colorado**
**And**
**The Republican River Water Conservation District, acting by and through its Water Activity Enterprise**

**March 2008**

STATE OF COLORADO
DIVISION OF WATER RESOURCES
1313 Sherman Street, Room 818
Denver, Colorado 80203
(303) 866-3581

| | |
|---|---|
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| Colorado Engineer Advisor | Ken Knox |

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## LIST OF TABLES (follow text)



## LIST OF FIGURES (follow Tables)

# 1.0 INTRODUCTION

## 1.1. The Republican River Compact Compliance Pipeline

Subsection III.B.1.k of the Final Settlement Stipulation in *Kansas v. Nebraska and Colorado*, No. 126, Original (U.S. Sup. Court) allows the acquisition or construction of wells for the purpose of offsetting stream depletions in order to comply with a State's Compact Allocations. Subsection III.B.1.k states that these wells "shall not cause any new net depletion to stream flow either annually or long-term." It further states: "The determination of net depletions from these Wells will be computed by the RRCA Groundwater Model and included in the State's Computed Beneficial Consumptive Use. Augmentation plans and related accounting procedures submitted under this Subsection III.B.1.k shall be approved by the RRCA [Republican River Compact Administration] prior to implementation."

The Republican River Water Conservation District (RRWCD) was formed in 2004 to assist the State of Colorado to comply with the Compact, and the RRWCD, acting through its Water Activity Enterprise (WAE), has entered into contracts to purchase rights to ground water located north of the North Fork of the Republican River in the Republican River Basin in Colorado. These rights have an historical consumptive use of approximately 15,000 acre-feet per year. The RRWCD WAE is currently in the process of completing the engineering design of a 12.7 mile Compact Compliance Pipeline to deliver this water to the North Fork of the Republican River to offset stream depletions in order to comply with Colorado's Compact Allocations. The general location of the compact compliance pipeline is shown in Figure 1. The design is scheduled for completion in August of this year. Selection of the construction contractor is anticipated to be finalized by the first of October and construction on the pipeline and related facilities will commence in November. Construction of the pipeline is scheduled for completion of June of 2009 and approximately 11,000 ac-ft will be delivered between June and December to allow Colorado to meet its compact obligation in 2009.

The RRWCD WAE has applied for, and received preliminary approval, a $60.6 million loan from the Colorado Water Conservation Board Water Project Construction Fund to purchase these rights to and to construct the Compact Compliance Pipeline to offset stream depletions in order to comply within Colorado's Compact Allocations.

The State of Colorado on behalf of the RRWCD WAE requests that the RRCA approve an augmentation plan and related accounting procedures described in this application under Subsection III.B.1.k of the Final Settlement Stipulation for the Republican River Compact Compliance Pipeline.

### 1.2. Project Sponsor – The Republican River Water Conservation District, acting by and through its Water Activity Enterprise

The RRWCD is managed and controlled by a 15-member board of directors comprised of one member appointed by the county commissioners of each of the seven counties wholly or partially within the RRWCD, one member appointed by the boards of the seven ground water management districts within the RRWCD, and one member appointed by the Colorado Ground Water Commission. The RRWCD Board of Directors established the RRWCD Water Activity Enterprise (WAE) in October 2004.

The RRWCD Board of Directors imposed a use fee on the diversion of water within the District of $5.50 per assessed irrigated acre on diversions of ground water for irrigation use by post-compact wells within the District. The RRWCD Board recently increased the use fee to $14.50 per assessed irrigated acre to pay for the Republican River Compact Compliance Pipeline. There are approximately 500,500 assessed irrigated acres in the basin irrigated by post-compact wells and the RRWCD fee will generate approximately $7.3 million per year for operating expenses and to pay back the loans used to acquire the water rights and construct the compact compliance pipeline.

The RRWCD WAE uses a portion of the revenues collected from use fees to provide local cost-sharing for federal programs designed to retire irrigated acreage in the basin, including the Republican River Conservation Reserve Enhancement Program (CREP) and the Environmental Quality Improvement Program (EQIP). To date, approximately 30,000 irrigated acres have been voluntarily retired in the basin under CREP and EQIP, or approximately five percent (5%) of the irrigated acreage in the basin. An amendment to the Republican River CREP designed to retire an additional 30,000 irrigated acres has been submitted to the U.S. Department of Agriculture for approval. The RRWCD WAE has committed to provide local cost-sharing for a second Republican River CREP amendment that is proposed to retire an additional 30,000 acres. The CREP program is an important part of the RRWCD efforts to implement conservation measures in the basin to reduce groundwater pumping in Colorado to assist in meeting compact compliance obligations.

The RRWCD is located in northeastern Colorado and includes all of Yuma and Phillips Counties and those portions of Kit Carson, Lincoln, Logan, Sedgwick, and Washington Counties that overlie the Ogallala Aquifer. The RRWCD encompasses about 7,761 square miles or about 7.5% of Colorado's 104,247 square miles. There is currently about 545,000 irrigated acres within the Ogallala Aquifer in Colorado with 500,500 irrigated acres located within the RRWCD boundaries. With the exception of approximately 3,000 acres irrigated by surface water, virtually all the acreage in the basin is irrigated with ground water from the Ogallala Aquifer. A map of the RRWCD boundaries is shown in Figure 2.

## 2.0 AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES

The State of Colorado has exceeded its compact allocation by approximately 11,000 ac-ft/yr for period of 2003-2007. In order to comply with the State of Colorado's Compact Allocations, the RRWCD WAE has entered into contracts to acquire ground water rights that were historically used for irrigation in the Republican River Basin. The location of the lands that were historically irrigated with the water rights acquired by the RRWCD WAE is shown in Figures 3 and 4.

The RRWCD WAE will change the use of these existing rights and consolidate these rights at fifteen existing Republican River Compact Compliance Wells (Compact Compliance Wells) that will be used for the sole purpose of offsetting stream depletions in order to comply with the State of Colorado's Compact Allocations. Initially only eight of the wells will be active with an additional seven existing wells that will serve as backup if additional well capacity in needed in the future. The locations of the 15 wells are shown in Figure 4 (wells A1 through A8 are the initial wells, and the wells numbered B1 through B7 are the backup wells).

The compact compliance wells are located in the area of the Ogallala Aquifer in Colorado that has the greatest saturated thickness. The wells typically have 250 to 300 feet of saturated thickness. The well field is also located in the sand hills region of Colorado that has the highest recharge rates of any location in the Republican River Basin.

The Computed Beneficial Consumptive Use of the compact compliance wells, specifically the ground water impacts of these wells upon the stream system, will be determined by use of the RRCA Groundwater Model as the difference in streamflows using two runs of the model that is consistent with Section III.D.1 of the Republican River Compact Administration Accounting Procedures and Reporting Requirements.

The historical consumptive use of the rights that will be diverted at the Compact Compliance Wells was determined based on irrigation system and pump efficiency tests, power records, and crop records for ten year period from 1998 to 2007 as summarized in Table 1. The procedures for changing the use of existing rights to designated ground water based on historical consumptive use are established in the current Colorado Ground Water Commission rules. The Compact Compliance Wells will cause no new net depletions because pumping will be limited to the historical consumptive use of the existing rights.

The pumping under this plan for augmentation will be limited to the historical consumptive use of existing groundwater rights as determined by the Colorado Ground Water Commission pursuant to its rules and regulations, which permit banking of ground water once a change has been based on historical consumptive use. Pumping from the Compact Compliance Wells will be metered and included in the RRCA Groundwater Motel. The groundwater pumped by the Compact Compliance Wells will be delivered by a pipeline to the North Fork of the Republican River a short distance upstream from the streamflow gage at the Colorado-Nebraska state line (USGS gaging station number 06823000, North Fork Republican River at the Colorado-Nebraska State Line). The augmentation discharge will be measured and subtracted from the gaged flow of the North Fork of the Republican River to calculate the Annual Virgin Water Supply. The augmentation discharge to the North Fork of the Republican River from the Compact Consumptive Pipeline will be the Augmentation Credit for the purpose of offsetting stream depletions to comply with the State of Colorado's Compact Allocations and shall be counted as a credit/offset against the Computed Beneficial Consumptive use of water allocated to Colorado

## 3.0 ENGINEERING ANALYSIS FOR THE COMPACT COMPLIANCE PIPELINE

Approximately 11,000 acre-feet of water per year needs to be supplied by the compact compliance pipeline to meet Colorado's Compact obligation. The initial capacity of the main trunk of the pipeline will be 15,000 acre-feet per year using a nine-month delivery season. The pipeline is being designed so that it will be capable of delivering up to 25,000 ac-ft/yr by adding a pumping facility to deliver the water under a higher pressure.

### 3.1. Water Quality

All of the streamflow in the North Fork of the Republican River, with the exception of the occasional rainstorm event, is derived from groundwater inflow from the Ogallala Aquifer. The compact compliance pipeline will deliver groundwater from the Ogallala aquifer to the North Fork of the Republican River at the state line. Table 2 presents the ground water quality of the Ogallala aquifer relative to the water quality standards for the North Fork of the Republican River, as published by the Colorado Water Quality Control Commission. The water quality of the Ogallala Aquifer meets or exceeds drinking water standards. This is to be expected because the groundwater management districts in Colorado carefully monitor the water quality in the Ogallala Aquifer since the groundwater supplies agriculture uses along with domestic, municipal, and industrial uses. Thus, the water quality of ground water for the Republican River Compact Compliance Pipeline is appropriate for delivery to the North Fork of the Republican River to offset stream depletions.

### 3.2. Pipeline Design

The RRWCD WAE contracted with GEI Consultants to perform a preliminary feasibility study for the design of a compact compliance pipeline. The $50,000 study was completed in January of 2008. Based on the recommendations in this report, the RRWCD WAE has contracted with GEI Consultants to proceed with the final design of the compact compliance pipeline. The final design of the compact compliance pipeline is scheduled to be completion in August of 2008 and is budgeted to cost approximately $1 million dollars.

The preliminary design of the Republican River Compact Compliance Pipeline has been completed and is summarized in the following paragraphs. This summary is based on the preliminary design and the design refinements made in the last two months. The final design is currently under way and the general description included in this report will probably somewhat in the next few months as the design is finalized.

The well field to pump the water will consist of 8 wells numbered A1 through A8 as shown in Figure 4. The design of the pipeline will also allow for an additional 7 wells numbered B1 through B7 in Figure 4. These 7 additional wells will not initially be connected to the pipeline, but are available for future use if needed.

Water pumped from the individual wells will be collected in a series of pipes that will vary in size from 12” to 18” and the water will then be conveyed to a 1 million gallon re-regulating storage tank. The storage tank will provide reserve capacity allowing the main pipeline to operate for 2 hours at two-thirds capacity with no inflow to the tank from the well field. The storage tank will also provide protection of the main pipeline from surge and negative pressures that could develop if the main pipeline were connected directly to the well field collection system.

From the storage tank the water will flow by gravity through the main water 36-inch diameter conveyance pipeline approximately 12.7 miles to the North Fork of the Republican River following the general alignment shown on Figure 3. Releases from the tank will be regulated by a valve located near the tank, and an ultra-sonic flow meter will be provided approximately 30 feet downstream of the release valve. The main conveyance pipeline will be designed so that a pump could be added at the outlet of the storage tank to increase the capacity of the pipeline to approximately 25,000 ac-ft/yr in the future.

At this time, the most likely type of pipe material is PVC. The pipeline will be buried with minimum cover of three feet above the crown of the pipe. To assure integrity, the pipe will be properly bedded prior to filling the trench with well-compacted backfill. Access manholes, air release valves, and drain valves will be provided at appropriate locations along the pipeline, as determined during the final design and confirmed during construction.

Table 3 contains summaries of the preliminary cost estimates developed by GEI during the preliminary feasibility study for the Compact Compliance Pipeline project. The final cost estimates will be dependent upon the final design and the bids received by the contractors. The key milestone dates discussed in previous sections of this report are summarized Table 4. Achieving this schedule will enable full delivery of water to begin in the latter part of June 2009. The project should be able to deliver close to 11,000 acre-feet of water in by year-end 2009.

## 4.0 REQUEST FOR APPROVAL

The State of Colorado on behalf of the RRWCD WAE requests that RRCA approve an augmentation plan and related accounting procedures described above under Subsection III.B.1.k of the Final Settlement Stipulation for the Republican River Compact Compliance Pipeline.

# EXHIBIT 2 TO ATTACHMENT K

Proposed Changes to the

*Republican River Compact Administration*
*Accounting Procedures and Reporting Requirements*

Revised July 27, 2005
Updated November 7, 2008
Colorado Proposal, Updated January 26, 2009.

# Republican River Compact Administration

## ACCOUNTING PROCEDURES

## AND

## REPORTING REQUIREMENTS

Revised July 27, 2005

Updated November 7, 2008

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Colorado Proposal
Updated January 26, 2009

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## I. Introduction

This document describes the definitions, procedures, basic formulas, specific formulas, and data requirements and reporting formats to be used by the RRCA to compute the Virgin Water Supply, Computed Water Supply, Allocations, Imported Water Supply Credit, Augmentation Water Supply Credit, and Computed Beneficial Consumptive Use. These computations shall be used to determine supply, allocations, use and compliance with the Compact according to the Stipulation. These definitions, procedures, basic and specific formulas, data requirements and attachments may be changed by consent of the RRCA consistent with Subsection I.F of the Stipulation. This document will be referred to as the RRCA Accounting Procedures. Attached to these RRCA Accounting Procedures as Figure 1 is the map attached to the Compact that shows the Basin, its streams and the Basin boundaries.

## II. Definitions

The following words and phrases as used in these RRCA Accounting Procedures are defined as follows:

**Additional Water Administration Year -** a year when the projected or actual irrigation water supply is less than 130,000 Acre-feet of storage available for use from Harlan County Lake as determined by the Bureau of Reclamation using the methodology described in the Harlan County Lake Operation Consensus Plan attached as Appendix K to the Stipulation.

**Allocation(s):** the water supply allocated to each State from the Computed Water Supply;

**Annual:** yearly from January 1 through December 31;

**Augmentation Plan:** a detailed program used by a State to offset stream depletions in order to comply with its Compact Allocations. An Augmentation Plan shall be approved by the RRCA prior to implementation in accordance with Subsection III.B.1.k of the Stipulation;

**Augmentation Water Supply:** the water supply developed through the acquisition or construction of wells for the sole purpose of offsetting stream depletions in order to comply with a State's Compact Allocations in conformance with an Augmentation Plan;

**Augmentation Water Supply Credit:** the amount of water measured and discharged to the stream flow of a Designated Drainage Basin due to the acquisition or construction of wells for the purpose of offsetting stream depletions to comply with a States' Compact Allocation in conformance with an Augmentation Plan. The Augmentation Water Supply Credit of a State shall not be included in the Virgin Water Supply in the Designated Drainage Basin and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State;

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**Basin:** the Republican River Basin as defined in Article II of the Compact;

**Beneficial Consumptive Use:** that use by which the Water Supply of the Basin is consumed through the activities of man, and shall include water consumed by evaporation from any reservoir, canal, ditch, or irrigated area;

**Change in Federal Reservoir Storage:** the difference between the amount of water in storage in the reservoir on December 31 of each year and the amount of water in storage on December 31 of the previous year. The current area capacity table supplied by the appropriate federal operating agency shall be used to determine the contents of the reservoir on each date;

**Compact:** the Republican River Compact, Act of February 22, 1943, 1943 Kan. Sess. Laws 612, codified at Kan. Stat. Ann. § 82a-518 (1997); Act of February 24, 1943, 1943 Neb. Laws 377, codified at 2A Neb. Rev. Stat. App. § 1-106 (1995), Act of March 15, 1943, 1943 Colo. Sess. Laws 362, codified at Colo. Rev. Stat. §§ 37-67-101 and 37-67-102 (2001); Republican River Compact, Act of May 26, 1943, ch. 104, 57 Stat. 86;

**Computed Beneficial Consumptive Use:** for purposes of Compact accounting, the stream flow depletion resulting from the following activities of man:

> Irrigation of lands in excess of two acres;
> Any non-irrigation diversion of more than 50 Acre-feet per year;
> Multiple diversions of 50 Acre-feet or less that are connected or otherwise combined to serve a single project will be considered as a single diversion for accounting purposes if they total more than 50 Acre-feet;
> Net evaporation from Federal Reservoirs;
> Net evaporation from Non-federal Reservoirs within the surface boundaries of the Basin;
> Any other activities that may be included by amendment of these formulas by the RRCA;

**Computed Water Supply:** the Virgin Water Supply less the Change in Federal Reservoir Storage in any Designated Drainage Basin, and less the Flood Flows;

**Designated Drainage Basins:** the drainage basins of the specific tributaries and the Main Stem of the Republican River as described in Article III of the Compact. Attached hereto as Figure 3 is a map of the Sub-basins and Main Stem;

**Dewatering Well:** a Well constructed solely for the purpose of lowering the groundwater elevation;

**Federal Reservoirs:**

> Bonny Reservoir

Swanson Lake
Enders Reservoir
Hugh Butler Lake
Harry Strunk Lake
Keith Sebelius Lake
Harlan County Lake
Lovewell Reservoir

**Flood Flows:** the amount of water deducted from the Virgin Water Supply as part of the computation of the Computed Water Supply due to a flood event as determined by the methodology described in Subsection III.B.1.;

**Gaged Flow:** the measured flow at the designated stream gage;

**Guide Rock:** a point at the Superior-Courtland Diversion Dam on the Republican River near Guide Rock, Nebraska; the Superior-Courtland Diversion Dam gage plus any flows through the sluice gates of the dam, specifically excluding any diversions to the Superior and Courtland Canals, shall be the measure of flows at Guide Rock;

**Historic Consumptive Use:** that amount of water that has been consumed under appropriate and reasonably efficient practices to accomplish without waste the purposes for which the appropriation or other legally permitted use was lawfully made;

**Imported Water Supply**: the water supply imported by a State from outside the Basin resulting from the activities of man;

**Imported Water Supply Credit:** the accretions to stream flow due to water imports from outside of the Basin as computed by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State, except as provided in Subsection V.B.2. of the Stipulation and Subsections III.I. – J. of these RRCA Accounting Procedures;

**Main Stem**: the Designated Drainage Basin identified in Article III of the Compact as the North Fork of the Republican River in Nebraska and the main stem of the Republican River between the junction of the North Fork and the Arikaree River and the lowest crossing of the river at the Nebraska-Kansas state line and the small tributaries thereof, and also including the drainage basin Blackwood Creek;

**Main Stem Allocation:** the portion of the Computed Water Supply derived from the Main Stem and the Unallocated Supply derived from the Sub-basins as shared by Kansas and Nebraska;

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**Meeting(s):** a meeting of the RRCA, including any regularly scheduled annual meeting or any special meeting;

**Modeling Committee:** the modeling committee established in Subsection IV.C. of the Stipulation;

**Moratorium**: the prohibition and limitations on construction of new Wells in the geographic area described in Section III. of the Stipulation;

**Non-federal Reservoirs:** reservoirs other than Federal Reservoirs that have a storage capacity of 15 Acre-feet or greater at the principal spillway elevation;

**Northwest Kansas:** those portions of the Sub-basins within Kansas;

**Replacement Well:** a Well that replaces an existing Well that a) will not be used after construction of the new Well and b) will be abandoned within one year after such construction or is used in a manner that is excepted from the Moratorium pursuant to Subsections III.B.1.c.-f. of the Stipulation;

**RRCA**: Republican River Compact Administration, the administrative body composed of the State officials identified in Article IX of the Compact;

**RRCA Accounting Procedures:** this document and all attachments hereto;

**RRCA Groundwater Model**: the groundwater model developed under the provisions of Subsection IV.C. of the Stipulation and as subsequently adopted and revised through action of the RRCA;

**State:** any of the States of Colorado, Kansas, and Nebraska;

**States:** the States of Colorado, Kansas and Nebraska;

**Stipulation:** the Final Settlement Stipulation to be filed in *Kansas v. Nebraska and Colorado*, No. 126, Original, including all Appendices attached thereto;

**Sub-basin**: the Designated Drainage Basins, except for the Main Stem, identified in Article III of the Compact. For purposes of Compact accounting the following Sub-basins will be defined as described below:

> North Fork of the Republican River in Colorado drainage basin is that drainage area above USGS gaging station number 06823000, North Fork Republican River at the Colorado-Nebraska State Line,

Arikaree River drainage basin is that drainage area above USGS gaging station number 06821500, Arikaree River at Haigler, Nebraska,

Buffalo Creek drainage basin is that drainage area above USGS gaging station number 06823500, Buffalo Creek near Haigler, Nebraska,

Rock Creek drainage basin is that drainage area above USGS gaging station number 06824000, Rock Creek at Parks, Nebraska,

South Fork of the Republican River drainage basin is that drainage area above USGS gaging station number 06827500, South Fork Republican River near Benkelman, Nebraska,

Frenchman Creek (River) drainage basin in Nebraska is that drainage area above USGS gaging station number 06835500, Frenchman Creek in Culbertson, Nebraska,

Driftwood Creek drainage basin is that drainage area above USGS gaging station number 06836500, Driftwood Creek near McCook, Nebraska,

Red Willow Creek drainage basin is that drainage area above USGS gaging station number 06838000, Red Willow Creek near Red Willow, Nebraska,

Medicine Creek drainage basin is that drainage area above the Medicine Creek below Harry Strunk Lake, State of Nebraska gaging station number 06842500; and the drainage area between the gage and the confluence with the Main Stem,

Sappa Creek drainage basin is that drainage area above USGS gaging station number 06847500, Sappa Creek near Stamford, Nebraska and the drainage area between the gage and the confluence with the Main Stem; and excluding the Beaver Creek drainage basin area downstream from the State of Nebraska gaging station number 06847000 Beaver Creek near Beaver City, Nebraska to the confluence with Sappa Creek,

Beaver Creek drainage basin is that drainage area above State of Nebraska gaging station number 06847000, Beaver Creek near Beaver City, Nebraska, and the drainage area between the gage and the confluence with Sappa Creek,

Prairie Dog Creek drainage basin is that drainage area above USGS gaging station number 06848500, Prairie Dog Creek near Woodruff, Kansas, and the drainage area between the gage and the confluence with the Main Stem;

Attached hereto as Figure 2 is a line diagram depicting the streams, Federal Reservoirs and gaging stations;

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**Test hole:** a hole designed solely for the purpose of obtaining information on hydrologic and/or geologic conditions;

**Trenton Dam**: a dam located at 40 degrees, 10 minutes, 10 seconds latitude and 101 degrees, 3 minutes, 35 seconds longitude, approximately two and one-half miles west of the town of Trenton, Nebraska;

**Unallocated Supply**: the "water supplies of upstream basins otherwise unallocated" as set forth in Article IV of the Compact;

**Upstream of Guide Rock, Nebraska:** those areas within the Basin lying west of a line proceeding north from the Nebraska-Kansas state line and following the western edge of Webster County, Township 1, Range 9, Sections 34, 27, 22, 15, 10 and 3 through Webster County, Township 2, Range 9, Sections 34, 27 and 22; then proceeding west along the southern edge of Webster County, Township 2, Range 9, Sections 16, 17 and 18; then proceeding north following the western edge of Webster County, Township 2, Range 9, Sections 18, 7 and 6, through Webster County, Township 3, Range 9, Sections 31, 30, 19, 18, 7 and 6 to its intersection with the northern boundary of Webster County. Upstream of Guide Rock, Nebraska shall not include that area in Kansas east of the 99° meridian and south of the Kansas-Nebraska state line;

**Virgin Water Supply:** the Water Supply within the Basin undepleted by the activities of man;

**Water Short Year Administration:** administration in a year when the projected or actual irrigation water supply is less than 119,000 acre feet of storage available for use from Harlan County Lake as determined by the Bureau of Reclamation using the methodology described in the Harlan County Lake Operation Consensus Plan attached as Appendix K to the Stipulation.

**Water Supply of the Basin** or **Water Supply within the Basin:** the stream flows within the Basin, excluding Imported Water Supply;

**Well:** any structure, device or excavation for the purpose or with the effect of obtaining groundwater for beneficial use from an aquifer, including wells, water wells, or groundwater wells as further defined and used in each State's laws, rules, and regulations.

## III. Basic Formulas

The basic formulas for calculating Virgin Water Supply, Computed Water Supply, Imported Water Supply, Allocations and Computed Beneficial Consumptive Use are set forth below. The results of these calculations shall be shown in a table format as shown in Table 1.

| Basic Formulas for Calculating Virgin Water Supply, Computed Water Supply, Allocations and Computed Beneficial Consumptive Use |
|---|

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| | | |
|---|---|---|
| Sub-basin VWS | = | Gage + All CBCU – AWS +ΔS – IWS |
| Main Stem VWS | = | Hardy Gage – Σ Sub-basin gages + All CBCU in the Main Stem +ΔS – IWS |
| CWS | = | VWS - Δ S – FF |
| Allocation for each State in each Sub-basin And Main Stem | = | CWS x % |
| State's Allocation | = | Σ Allocations for Each State |
| State's CBCU | = | Σ State's CBCUs in each Sub-basin and Main Stem |

Abbreviations:

AWS = Augmentation Water Supply Credit
CBCU = Computed Beneficial Consumptive Use
FF = Flood Flows
Gage = Gaged Flow
IWS = Imported Water Supply Credit
CWS = Computed Water Supply
VWS = Virgin Water Supply
% = the ratio used to allocate the Computed Water Supply between the States. This ratio is based on the allocations in the Compact
Δ S = Change in Federal Reservoir Storage

## A. Calculation of Annual Virgin Water Supply

### 1. Sub-basin calculation:

The annual Virgin Water Supply for each Sub-basin will be calculated by adding: a) the annual stream flow in that Sub-basin at the Sub-basin stream gage designated in Section II., b) the annual Computed Beneficial Consumptive Use above that gaging station, and c) the Change in Federal Reservoir Storage in that Sub-basin; and from that total subtract any Imported Water Supply Credit and any Augmentation Water Supply Credit. The Computed Beneficial Consumptive Use will be calculated as described in Subsection III. D. Adjustments for flows diverted around stream gages and for Computed Beneficial Consumptive Uses in the Sub-basin between the Sub-basin stream gage and the confluence of the Sub-basin tributary and the Main Stem shall be made as described in Subsections III. D. 1 and 2 and IV. B.

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**2. Main Stem Calculation:**

The annual Virgin Water Supply for the Main Stem will be calculated by adding: a) the flow at the Hardy gage minus the flows from the Sub-basin gages listed in Section II, b) the annual Computed Beneficial Consumptive Use in the Main Stem, and c) the Change in Federal Reservoir Storage from Swanson Lake and Harlan County Lake; and from that total subtract any Imported Water Supply Credit for the Main Stem. Adjustments for flows diverted around Sub-basin stream gages and for Computed Beneficial Consumptive Uses in a Sub-basin between the Sub-basin stream gage and the confluence of the Sub-basin tributary and the Mains Stem shall be made as described in Subsections III. D. 1 and 2 and IV.B.,

**3. Imported Water Supply Credit Calculation:**

The amount of Imported Water Supply Credit shall be determined by the RRCA Groundwater Model. The Imported Water Supply Credit of a State shall not be included in the Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water allocated to that State. Currently, the Imported Water Supply Credits shall be determined using two runs of the RRCA Groundwater Model:

a. The “base” run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the current accounting year turned “on.” This will be the same “base” run used to determine groundwater Computed Beneficial Consumptive Uses.

b. The “no NE import” run shall be the run with the same model inputs as the base run with the exception that surface water recharge associated with Nebraska’s Imported Water Supply shall be turned “off.”

The Imported Water Supply Credit shall be the difference in stream flows between these two model runs. Differences in stream flows shall be determined at the same locations as identified in Subsection III.D.1.for the “no pumping” runs.
Should another State import water into the Basin in the future, the RRCA will develop a similar procedure to determine Imported Water Supply Credits.

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**4. Augmentation Water Supply Credit:**

The amount of Augmentation Water Supply Credit shall be the quantity of water delivered to the stream flow of a Designated Drainage Basin and shall be measured and subtracted from the Gaged Flow of the Designated Drainage Basin to calculate the Annual Virgin Water Supply. The Augmentation Water Supply Credit of a State shall not be included in the Annual Virgin Water Supply and shall be counted as a credit/offset against the Computed Beneficial Consumptive Use of water

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allocated to that State.

## B. Calculation of Computed Water Supply

On any Designated Drainage Basin without a Federal Reservoir, the Computed Water Supply will be equal to the Virgin Water Supply of that Designated Drainage Basin minus Flood Flows.

On any Designated Drainage Basin with a Federal Reservoir, the Computed Water Supply will be equal to the Virgin Water Supply minus the Change in Federal Reservoir Storage in that Designated Drainage Basin and minus Flood Flows.

### 1. Flood Flows

If in any calendar year there are five consecutive months in which the total actual stream flow[1] at the Hardy gage is greater than 325,000 Acre-feet, or any two consecutive months in which the total actual stream flow is greater than 200,000 Acre-feet, the annual flow in excess of 400,000 Acre-feet at the Hardy gage will be considered to be Flood Flows that will be subtracted from the Virgin Water Supply to calculate the Computed Water Supply, and Allocations. The Flood Flow in excess of 400,000 Acre-feet at the Hardy gage will be subtracted from the Virgin Water Supply of the Main Stem to compute the Computed Water Supply unless the Annual Gaged Flows from a Sub-basin were in excess of the flows shown for that Sub-basin in Attachment 1. These excess Sub-basin flows shall be considered to be Sub-basin Flood Flows.

If there are Sub-basin Flood Flows, the total of all Sub-basin Flood Flows shall be compared to the amount of Flood Flows at the Hardy gage. If the sum of the Sub-basin Flood Flows are in excess of the Flood Flow at the Hardy gage, the flows to be deducted from each Sub-basin shall be the product of the Flood Flows for each Sub-basin times the ratio of the Flood Flows at the Hardy gage divided by the sum of the Flood Flows of the Sub-basin gages. If the sum of the Sub-basin Flood Flows is less than the Flood Flow at the Hardy gage, the entire amount of each Sub-basin Flood Flow shall be deducted from the Virgin Water Supply to compute the Computed Water Supply of that Sub-basin for that year. The remainder of the Flood Flows will be subtracted from the flows of the Main Stem.

## C. Calculation of Annual Allocations

[1] These actual stream flows reflect Gaged Flows after depletions by Beneficial Consumptive Use and change in reservoir storage above the gage.

Article IV of the Compact allocates 54,100 Acre-feet for Beneficial Consumptive Use in Colorado, 190,300 Acre-feet for Beneficial Consumptive Use in Kansas and 234,500 Acre-feet for Beneficial Consumptive Use in Nebraska. The Compact provides that the Compact totals are to be derived from the sources and in the amounts specified in Table 2.

The Allocations derived from each Sub-basin to each State shall be the Computed Water Supply multiplied by the percentages set forth in Table 2. In addition, Kansas shall receive 51.1% of the Main Stem Allocation and the Unallocated Supply and Nebraska shall receive 48.9% of the Main Stem Allocation and the Unallocated Supply.

## D. Calculation of Annual Computed Beneficial Consumptive Use

### 1. Groundwater

Computed Beneficial Consumptive Use of groundwater shall be determined by use of the RRCA Groundwater Model. The Computed Beneficial Consumptive Use of groundwater for each State shall be determined as the difference in streamflows using two runs of the model:

The “base” run shall be the run with all groundwater pumping, groundwater pumping recharge, and surface water recharge within the model study boundary for the current accounting year “on”.

The “no State pumping” run shall be the run with the same model inputs as the base run with the exception that all groundwater pumping and pumping recharge of that State shall be turned “off.”

An output of the model is baseflows at selected stream cells. Changes in the baseflows predicted by the model between the “base” run and the “no-State-pumping” model run is assumed to be the depletions to streamflows. i.e., groundwater computed beneficial consumptive use, due to State groundwater pumping at that location. The values for each Sub-basin will include all depletions and accretions upstream of the confluence with the Main Stem. The values for the Main Stem will include all depletions and accretions in stream reaches not otherwise accounted for in a Sub-basin. The values for the Main Stem will be computed separately for the reach above Guide Rock, and the reach below Guide Rock.

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### 2. Surface Water

The Computed Beneficial Consumptive Use of surface water for irrigation and non-irrigation uses shall be computed by taking the diversions from the river and subtracting the return flows to the river resulting from those diversions, as described in Subsections IV.A.2.a.-d. The Computed Beneficial Consumptive Use of surface water from Federal Reservoir and Non-Federal Reservoir evaporation shall be the net reservoir evaporation from the reservoirs, as described in Subsections IV.A.2.e.-f.

For Sub-basins where the gage designated in Section II. is near the confluence with the Main Stem, each State's Sub-basin Computed Beneficial Consumptive Use of surface water shall be the State's Computed Beneficial Consumptive Use of surface water above the Sub-basin gage. For Medicine Creek, Sappa Creek, Beaver Creek and Prairie Dog Creek, where the gage is not near the confluence with the Main Stem, each State's Computed Beneficial Consumptive Use of surface water shall be the sum of the State's Computed Beneficial Consumptive Use of surface water above the gage, and its Computed Beneficial Consumptive Use of surface water between the gage and the confluence with the Main Stem.

## E. Calculation to Determine Compact Compliance Using Five-Year Running Averages

Each year, using the procedures described herein, the RRCA will calculate the Annual Allocations by Designated Drainage Basin and total for each State, the Computed Beneficial Consumptive Use by Designated Drainage Basin and total for each State and the Imported Water Supply Credit and the Augmentation Water Supply Credit that a State may use for the preceding year. These results for the current Compact accounting year as well as the results of the previous four accounting years and the five-year average of these results will be displayed in the format shown in Table 3.

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## F. Calculations To Determine Colorado's and Kansas's Compliance with the Sub-basin Non-Impairment Requirement

The data needed to determine Colorado's and Kansas's compliance with the Sub-basin non-impairment requirement in Subsection IV.B.2. of the Stipulation are shown in Tables 4.A. and B.

## G. Calculations To Determine Projected Water Supply

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**1. Procedures to Determine Water Short Years**

The Bureau of Reclamation will provide each of the States with a monthly or, if requested by any one of the States, a more frequent update of the projected or actual irrigation supply from Harlan County Lake for that irrigation season using the methodology described in the Harlan County Lake Operation Consensus Plan, attached as Appendix K to the Stipulation. The steps for the calculation are as follows:

Step 1. At the beginning of the calculation month (1) the total projected inflow for the calculation month and each succeeding month through the end of May shall be added to the previous end of month Harlan County Lake content and (2) the total projected 1993 level evaporation loss for the calculation month and each succeeding month through the end of May shall then be subtracted. The total projected inflow shall be the 1993 level average monthly inflow or the running average monthly inflow for the previous five years, whichever is less.

Step 2. Determine the maximum irrigation water available by subtracting the sediment pool storage (currently 164,111 Acre-feet) and adding the summer sediment pool evaporation (20,000 Acre-feet) to the result from Step 1.

Step 3. For October through January calculations, take the result from Step 2 and using the Shared Shortage Adjustment Table in Attachment 2 hereto, determine the preliminary irrigation water available for release. The calculation using the end of December content (January calculation month) indicates the minimum amount of irrigation water available for release at the end of May. For February through June calculations, subtract the maximum irrigation water available for the January calculation month from the maximum irrigation water available for the calculation month. If the result is negative, the irrigation water available for release (January calculation month) stays the same. If the result is positive the preliminary irrigation water available for release (January calculation month) is increased by the positive amount.

Step 4. Compare the result from Step 3 to 119,000 Acre-feet. If the result from Step 3 is less than 119,000 Acre-feet Water Short Year Administration is in effect.

Step 5. The final annual Water-Short Year Administration calculation determines the total estimated irrigation supply at the end of June (calculated in July). Use the result from Step 3 for the end of May irrigation release estimate, add the June computed inflow to Harlan County Lake and subtract the June computed gross evaporation loss from Harlan County Lake.

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### 2. Procedures to Determine 130,000 Acre Feet Projected Water Supply

To determine the preliminary irrigation supply for the October through June calculation months, follow the procedure described in steps 1 through 4 of the "Procedures to determine Water Short Years" Subsection III. G. 1. The result from step 4 provides the forecasted water supply, which is compared to 130,000 Acre-feet. For the July through September calculation months, use the previous end of calculation month preliminary irrigation supply, add the previous month's Harlan County Lake computed inflow and subtract the previous month's computed gross evaporation loss from Harlan County Lake to determine the current preliminary irrigation supply. The result is compared to 130,000 Acre-feet.

## H. Calculation of Computed Water Supply, Allocations and Computed Beneficial Consumptive Use Above and Below Guide Rock During Water-Short Administration Years.

For Water-Short-Administration Years, in addition to the normal calculations, the Computed Water Supply, Allocations, Computed Beneficial Consumptive Use and Imported Water Supply Credits, and Augmentation Water Supply Credits shall also be calculated above Guide Rock as shown in Table 5C. These calculations shall be done in the same manner as in non-Water-Short Administration years except that water supplies originating below Guide Rock shall not be included in the calculations of water supplies originating above Guide Rock. The calculations of Computed Beneficial Consumptive Uses shall be also done in the same manner as in non-Water-Short Administration years except that Computed Beneficial Consumptive Uses from diversions below Guide Rock shall not be included. The depletions from the water diverted by the Superior and Courtland Canals at the Superior-Courtland Diversion Dam shall be included in the calculations of Computed Beneficial Consumptive Use above Guide Rock. Imported Water Supply Credits and Augmentation Water Supply Credits above Guide Rock, as described in Sub-section III.I., may be used as offsets against the Computed Beneficial Consumptive Use above Guide Rock by the State providing the Imported Water Supply Credits or Augmentation Water Supply Credits

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The Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage shall be determined by taking the difference in stream flow at Hardy and Guide Rock, adding Computed Beneficial Consumptive Uses in the reach (this does not include the Computed Beneficial Consumptive Use from the Superior and Courtland Canal diversions), and subtracting return flows from the Superior and Courtland Canals in the reach. The Computed Water Supply above Guide Rock shall be determined by subtracting the Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage from the total Computed Water Supply. Nebraska's Allocation above Guide Rock shall be determined by subtracting 48.9% of the Computed Water Supply of the Main Stem reach between Guide Rock and the Hardy gage from Nebraska's total Allocation.

Nebraska's Computed Beneficial Consumptive Uses above Guide Rock shall be determined by subtracting Nebraska's Computed Beneficial Consumptive Uses below Guide Rock from Nebraska's total Computed Beneficial Consumptive Use.

**I. Calculation of Imported Water Supply Credits During Water-Short Year Administration Years.**

Imported Water Supply Credit during Water-Short Year Administration years shall be calculated consistent with Subsection V.B.2.b. of the Stipulation.

The following methodology shall be used to determine the extent to which Imported Water Supply Credit, as calculated by the RRCA Groundwater Model, can be credited to the State importing the water during Water-Short Year Administration years.

**1. Monthly Imported Water Supply Credits**

The RRCA Groundwater Model will be used to determine monthly Imported Water Supply Credits by State in each Sub-basin and for the Main Stem. The values for each Sub-basin will include all depletions and accretions upstream of the confluence with the Main Stem. The values for the Main Stem will include all depletions and accretions in stream reaches not otherwise accounted for in a Sub-basin. The values for the Main Stem will be computed separately for the reach 1) above Harlan County Dam, 2) between Harlan County Dam and Guide Rock, and 3) between Guide Rock and the Hardy gage. The Imported Water Supply Credit shall be the difference in stream flow for two runs of the model: a) the "base" run and b) the "no State import" run.

During Water-Short Year Administration years, Nebraska's credits in the Sub-basins shall be determined as described in Section III. A. 3.

**2. Imported Water Supply Credits Above Harlan County Dam**

Nebraska's Imported Water Supply Credits above Harlan County Dam shall be the sum of all the credits in the Sub-basins and the Main Stem above Harlan County Dam.

**3. Imported Water Supply Credits Between Harlan County Dam and Guide Rock During the Irrigation Season**

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a. During Water-Short Year Administration years, monthly credits in the reach between Harlan County Dam and Guide Rock shall be determined as the differences in the stream flows between the two runs at Guide Rock.

b. The irrigation season shall be defined as starting on the first day of release of water from Harlan County Lake for irrigation use and ending on the last day of release of water from Harlan County Lake for irrigation use.

c. Credit as an offset for a State's Computed Beneficial Consumptive Use above Guide Rock will be given to all the Imported Water Supply accruing in the reach between Harlan County Dam and Guide Rock during the irrigation season. If the period of the irrigation season does not coincide with the period of modeled flows, the amount of the Imported Water Supply credited during the irrigation season for that month shall be the total monthly modeled Imported Water Supply Credit times the number of days in the month occurring during the irrigation season divided by the total number of days in the month.

**4. Imported Water Supply Credits Between Harlan County Dam and Guide Rock During the Non-Irrigation Season**

a. Imported Water Supply Credit shall be given between Harlan County Dam and Guide Rock during the period that flows are diverted to fill Lovewell Reservoir to the extent that imported water was needed to meet Lovewell Reservoir target elevations.

b. Fall and spring fill periods shall be established during which credit shall be given for the Imported Water Supply Credit accruing in the reach. The fall period shall extend from the end of the irrigation season to December 1. The spring period shall extend from March 1 to May 31. The Lovewell target elevations for these fill periods are the projected end of November reservoir level and the projected end of May reservoir level for most probable inflow conditions as indicated in Table 4 in the current Annual Operating Plan prepared by the Bureau of Reclamation.

c. The amount of water needed to fill Lovewell Reservoir for each period shall be calculated as the storage content of the reservoir at its target elevation at the end of the fill period minus the reservoir content at the start of the fill period plus the amount of net evaporation during this period minus White Rock Creek inflows for the same period.

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d. If the fill period as defined above does not coincide with the period of modeled flows, the amount of the Imported Water Supply Credit during the fill period for that month shall be the total monthly modeled Imported Water Supply Credit times the number of days in the month occurring during the fill season divided by the total number of days in the month.

e. The amount of non-imported water available to fill Lovewell Reservoir to the target elevation shall be the amount of water available at Guide Rock during the fill period minus the amount of the Imported Water Supply Credit accruing in the reach during the same period.

f. The amount of the Imported Water Supply Credit that shall be credited against a State's Consumptive Use shall be the amount of water imported by that State that is available in the reach during the fill period or the amount of water needed to reach Lovewell Reservoir target elevations minus the amount of non-imported water available during the fill period, whichever is less.

### 5. Other Credits

Kansas and Nebraska will explore crediting Imported Water Supply that is otherwise useable by Kansas.

## J. Calculations of Compact Compliance in Water-Short Year Administration Years

During Water-Short Year Administration, using the procedures described in Subsections III.A-D, the RRCA will calculate the Annual Allocations for each State, the Computed Beneficial Consumptive Use by each State, the Imported Water Supply Credit, and the Augmentation Water Supply Credit that a State may use to offset Computed Beneficial Consumptive Use in that year. The resulting annual and average values will be calculated as displayed in Tables 5 A-C and E.

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If Nebraska is implementing an Alternative Water-Short-Year Administration Plan, data to determine Compact compliance will be shown in Table 5D. Nebraska’s compliance with the Compact will be determined in the same manner as Nebraska’s Above Guide Rock compliance except that compliance will be based on a three-year running average of the current year and previous two year calculations. In addition, Table 5 D. will display the sum of the previous two-year difference in Allocations above Guide Rock and Computed Beneficial Consumptive Uses above Guide Rock minus any Imported Water Credits and compare the result with the Alternative Water-Short-Year Administration Plan’s expected decrease in Computed Beneficial Consumptive Use above Guide Rock.  Nebraska will be within compliance with the Compact as long as the three-year running average difference

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in Column 8 is positive and the sum of the previous year and current year deficits above Guide Rock are not greater than the expected decrease in Computed Beneficial Consumptive Use under the plan.

## IV. Specific Formulas

### A. Computed Beneficial Consumptive Use

#### 1. Computed Beneficial Consumptive Use of Groundwater:

The Computed Beneficial Consumptive Use caused by groundwater diversion shall be determined by the RRCA Groundwater Model as described in Subsection III.D.1.

#### 2. Computed Beneficial Consumptive Use of Surface Water:

The Computed Beneficial Consumptive Use of surface water shall be calculated as follows:

a) Non-Federal Canals

Computed Beneficial Consumptive Use from diversions by non- federal canals shall be 60 percent of the diversion; the return flow shall be 40 percent of the diversion

b) Individual Surface Water Pumps

Computed Beneficial Consumptive Use from small individual surface water pumps shall be 75 percent of the diversion; return flows will be 25 percent of the diversion unless a state provides data on the amount of different system types in a Sub-basin, in which case the following percentages will be used for each system type:

| | |
|---|---|
| Gravity Flow. | 30% |
| Center Pivot | 17% |
| LEPA | 10% |

c) Federal Canals

Computed Beneficial Consumptive Use of diversions by Federal canals will be calculated as shown in Attachment 7. For each Bureau of

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Reclamation Canal the field deliveries shall be subtracted from the diversion from the river to determine the canal losses. The field delivery shall be multiplied by one minus an average system efficiency for the district to determine the loss of water from the field. Eighty-two percent of the sum of the field loss plus the canal loss shall be considered to be the return flow from the canal diversion. The assumed field efficiencies and the amount of the field and canal loss that reaches the stream may be reviewed by the RRCA and adjusted as appropriate to insure their accuracy.

d) Non-irrigation Uses

Any non-irrigation uses diverting or pumping more than 50 acre-feet per year will be required to measure diversions. Non-irrigation uses diverting more than 50 Acre-feet per year will be assessed a Computed Beneficial Consumptive Use of 50% of what is pumped or diverted, unless the entity presents evidence to the RRCA demonstrating a different percentage should be used.

e) Evaporation from Federal Reservoirs

Net Evaporation from Federal Reservoirs will be calculated as follows:

(1) Harlan County Lake, Evaporation Calculation

April 1 through October 31:

Evaporation from Harlan County Lake is calculated by the Corps of Engineers on a daily basis from April 1 through October 31. Daily readings are taken from a Class A evaporation pan maintained near the project office. Any precipitation recorded at the project office is added to the pan reading to obtain the actual evaporation amount. The pan value is multiplied by a pan coefficient that varies by month. These values are:

| | |
|---|---|
| March | .56 |
| April | .52 |
| May | .53 |
| June | .60 |
| July | .68 |
| August | .78 |
| September | .91 |

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October 1.01

The pan coefficients were determined by studies the Corps of Engineers conducted a number of years ago. The result is the evaporation in inches. It is divided by 12 and multiplied by the daily lake surface area in acres to obtain the evaporation in Acre-feet. The lake surface area is determined by the 8:00 a.m. elevation reading applied to the lake's area-capacity data. The area-capacity data is updated periodically through a sediment survey. The last survey was completed in December 2000.

November 1 through March 31

During the winter season, a monthly total evaporation in inches has been determined. The amount varies with the percent of ice cover. The values used are:

HARLAN COUNTY LAKE

Estimated Evaporation in Inches
Winter Season -- Monthly Total

PERCENTAGE OF ICE COVER

| | 0% | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 0.88 | 0.87 | 0.85 | 0.84 | 0.83 | 0.82 | 0.81 | 0.80 | 0.78 | 0.77 | 0.76 |
| FEB | 0.90 | 0.88 | 0.87 | 0.86 | 0.85 | 0.84 | 0.83 | 0.82 | 0.81 | 0.80 | 0.79 |
| MAR | 1.29 | 1.28 | 1.27 | 1.26 | 1.25 | 1.24 | 1.23 | 1.22 | 1.21 | 1.20 | 1.19 |
| OCT | 4.87 | | | NO ICE | | | | | | | |
| NOV | 2.81 | | | NO ICE | | | | | | | |
| DEC | 1.31 | 1.29 | 1.27 | 1.25 | 1.24 | 1.22 | 1.20 | 1.18 | 1.17 | 1.16 | 1.14 |

The monthly total is divided by the number of days in the month to obtain a daily evaporation value in inches. It is divided by 12 and multiplied by the daily lake surface area in acres to obtain the evaporation in Acre-feet. The lake surface area is determined by the 8:00 a.m. elevation reading applied to the lake's area-capacity data. The area-capacity data is updated periodically through a sediment survey. The last survey was completed in December 2000.

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To obtain the net evaporation, the monthly precipitation on the lake is subtracted from the monthly gross evaporation. The monthly precipitation is calculated by multiplying the sum of the month's daily precipitation in inches by the average of the end of the month lake surface area for the previous month and the end of the month lake surface area for the current month in acres and dividing the result by 12 to obtain the precipitation for the month in acre feet.

The total annual net evaporation (Acre-feet) will be charged to Kansas and Nebraska in proportion to the annual diversions made by the Kansas Bostwick Irrigation District and the Nebraska Bostwick Irrigation District during the time period each year when irrigation releases are being made from Harlan County Lake. For any year in which no irrigation releases were made from Harlan County Lake, the annual net evaporation charged to Kansas and Nebraska will be based on the average of the above calculation for the most recent three years in which irrigation releases from Harlan County Lake were made. In the event Nebraska chooses to substitute supply for the Superior Canal from Nebraska's allocation below Guide Rock in Water-Short Year Administration years, the amount of the substitute supply will be included in the calculation of the split as if it had been diverted to the Superior Canal at Guide Rock.

(2) Evaporation Computations for Bureau of Reclamation Reservoirs

The Bureau of Reclamation computes the amount of evaporation loss on a monthly basis at Reclamation reservoirs. The following procedure is utilized in calculating the loss in Acre-feet.

An evaporation pan reading is taken each day at the dam site. This measurement is the amount of water lost from the pan over a 24-hour period in inches. The evaporation pan reading is adjusted for any precipitation recorded during the 24-hour period. Instructions for determining the daily pan evaporation are found in the "National Weather Service Observing Handbook No. 2 – Substation Observations." All dams located in the Kansas River Basin with the exception of Bonny Dam are National Weather Service Cooperative Observers. The daily evaporation pan readings are totaled at the end of each month and converted to a "free water surface" (FWS) evaporation, also referred to as "lake" evaporation. The FWS evaporation is determined by multiplying the observed pan evaporation by a coefficient of .70 at each of the reservoirs. This coefficient can be affected by several factors including water and air

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temperatures. The National Oceanic and Atmospheric Administration (NOAA) has published technical reports describing the determination of pan coefficients. The coefficient used is taken from the "NOAA Technical Report NWS 33, Map of coefficients to convert class A pan evaporation to free water surface evaporation". This coefficient is used for the months of April through October when evaporation pan readings are recorded at the dams. The monthly FWS evaporation is then multiplied by the average surface area of the reservoir during the month in acres. Dividing this value by twelve will result in the amount of water lost to evaporation in Acre-feet during the month.

During the winter months when the evaporation pan readings are not taken, monthly evaporation tables based on the percent of ice cover are used. The tables used were developed by the Corps of Engineers and were based on historical average evaporation rates. A separate table was developed for each of the reservoirs. The monthly evaporation rates are multiplied by the .70 coefficient for pan to free water surface adjustment, divided by twelve to convert inches to feet and multiplied by the average reservoir surface area during the month in acres to obtain the total monthly evaporation loss in Acre-feet.

To obtain the net evaporation, the monthly precipitation on the lake is subtracted from the monthly gross evaporation. The monthly precipitation is calculated by multiplying the sum of the month's daily precipitation in inches by the average of the end of the month lake surface area for the previous month and the end of the month lake surface area for the current month in acres and dividing the result by 12 to obtain the precipitation for the month in acre feet.

f) Non-Federal Reservoir Evaporation:

For Non-Federal Reservoirs with a storage capacity less than 200 Acre-feet, the presumptive average annual surface area is 25% of the area at the principal spillway elevation. Net evaporation for each such Non-Federal Reservoir will be calculated by multiplying the presumptive average annual surface area by the net evaporation from the nearest climate and evaporation station to the Non-Federal Reservoir. A State may provide actual data in lieu of the presumptive criteria.

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Net evaporation from Non-Federal Reservoirs with 200 Acre-feet of storage or greater will be calculated by multiplying the average annual surface area (obtained from the area-capacity survey) and the net evaporation from the nearest evaporation and climate station to the reservoir. If the average annual surface area is not available, the Non-Federal Reservoirs with 200 Acre-feet of storage or greater will be presumed to be full at the principal spillway elevation.

**B. Specific Formulas for Each Sub-basin and the Main Stem**

All calculations shall be based on the calendar year and shall be rounded to the nearest 10 Acre-feet using the conventional rounding formula of rounding up for all numbers equal to five or higher and otherwise rounding down.

Abbreviations:

| | |
|---|---|
| AWS | = Augmentation Water Supply Credit |
| CBCU | = Computed Beneficial Consumptive Use |
| CWS | = Computed Water Supply |
| D | = Non-Federal Canal Diversions for Irrigation |
| Ev | = Evaporation from Federal Reservoirs |
| EvNFR | = Evaporation from Non-Federal Reservoirs |
| FF | = Flood Flow |
| GW | = Groundwater Computed Beneficial Consumptive Use (includes irrigation and non-irrigation uses) |
| IWS | = Imported Water Supply Credit from Nebraska |
| M&I | = Non-Irrigation Surface Water Diversions (Municipal and Industrial) |
| P | = Small Individual Surface Water Pump Diversions for Irrigation |
| RF | = Return Flow |
| VWS | = Virgin Water Supply |
| c | = Colorado |
| k | = Kansas |
| n | = Nebraska |
| ΔS | = Change in Federal Reservoir Storage |
| % | = Average system efficiency for individual pumps in the Sub-basin |
| % BRF | = Percent of Diversion from Bureau Canals that returns to the stream |
| ### | = Value expected to be zero |

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### 3. North Fork of Republican River in Colorado [2]

| | |
|---|---|
| CBCU Colorado | = 0.6 x Haigler Canal Diversion Colorado + 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc |
| CBCU Kansas | = GWk |
| CBCU Nebraska | = 0.6 x Haigler Canal Diversion Nebraska + GWn |
| | Note: The diversion for Haigler Canal is split between Colorado and Nebraska based on the percentage of land irrigated in each state |
| VWS | = North Fork of the Republican River at the State Line, Stn. No. 06823000 + CBCUc + CBCUk + CBCUn + Nebraska Haigler Canal RF– IWS -AWS |
| | Note: The Nebraska Haigler Canal RF returns to the Main Stem |
| CWS | = VWS - FF |
| Allocation Colorado | = 0.224 x CWS |
| Allocation Nebraska | = 0.246 x CWS |
| Unallocated | = 0.53 x CWS |

### 4. Arikaree River [2]

| | |
|---|---|
| CBCU Colorado | = 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc |
| CBCU Kansas | = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk |
| CBCU Nebraska | = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn |
| VWS | = Arikaree Gage at Haigler Stn. No. 06821500 + CBCUc + CBCUk + CBCUn – IWS |

[2] The RRCA will investigate whether return flows from the Haigler Canal diversion in Colorado may return to the Arikaree River, not the North Fork of the Republican River, as indicated in the formulas. If there are return flows from the Haigler Canal to the Arikaree River, these formulas will be changed to recognize those returns.

CWS = VWS - FF

Allocation Colorado = 0.785 x CWS

Allocation Kansas = 0.051 x CWS

Allocation Nebraska = 0.168 x CWS

Unallocated =-0.004 x CWS

**5. Buffalo Creek**

CBCU Colorado = 0.6 x Dc + % x Pc + 0.5 x M&In + EvNFRc + GWc

CBCU Kansas = GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Buffalo Creek near Haigler Gage Stn. No. 06823500 + CBCUc + CBCUk + CBCUn – IWS

CWS = VWS - FF

Allocation Nebraska = 0.330 x CWS

Unallocated = 0.670 x CWS

**6. Rock Creek**

CBCU Colorado = GWc

CBCU Kansas = GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Rock Creek at Parks Gage Stn. No. 06824000 + CBCUc + CBCUk + CBCUn – IWS

CWS = VWS - FF

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Allocation Nebraska = 0.400 x CWS

Unallocated = 0.600 x CWS

**7. South Fork Republican River**

CBCU Colorado = 0.6 x Hale Ditch Diversion + 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + Bonny Reservoir Ev + GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = South Fork Republican River near Benkelman Gage Stn. No. 06827500 + CBCUc + CBCUk + CBCUn + ΔS Bonny Reservoir – IWS

CWS = VWS - ΔS Bonny Reservoir - FF

Allocation Colorado = 0.444 x CWS

Allocation Kansas = 0.402 x CWS

Allocation Nebraska = 0.014 x CWS

Unallocated = 0.140 x CWS

**8. Frenchman Creek in Nebraska**

CBCU Colorado = GWc

CBCU Kansas = GWk

CBCU Nebraska = Culbertson Canal Diversions x (1-%BRF) + Culbertson Extension x (1-%BRF) + 0.6 x Champion Canal Diversion + 0.6 x Riverside Canal Diversion + 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + Enders Reservoir Ev + GWn

VWS = Frenchman Creek in Culbertson, Nebraska Gage Stn. No.

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06835500 + CBCUc + CBCUk + CBCUn + 0.17 x Culbertson Diversion RF + Culbertson Extension RF + ΔS Enders Reservoir – IWS

Note: 17% of the Culbertson Diversion RF and 100% of the Culbertson Extension RF return to the Main Stem

CWS = VWS - ΔS Enders Reservoir – FF

Allocation Nebraska = 0.536 x CWS

Unallocated = 0.464 x CWS

**9. Driftwood Creek**

CBCU Colorado = GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + GWn

VWS = Driftwood Creek near McCook Gage Stn. No. 06836500 + CBCUc + CBCUk + CBCUn – 0.24 x Meeker Driftwood Canal RF - IWS

Note: 24 % of the Meeker Driftwood Canal RF returns to Driftwood Creek

CWS = VWS – FF

Allocation Kansas = 0.069 x CWS

Allocation Nebraska = 0.164 x CWS

Unallocated = 0.767 x CWS

**10. Red Willow Creek in Nebraska**

CBCU Colorado = GWc

CBCU Kansas = GWk

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| | |
|---|---|
| CBCU Nebraska | = 0.1 x Red Willow Canal CBCU + 0.6 x Dn + % x Pn + 0.5 x M&In + EvNFRn + 0.1 x Hugh Butler Lake Ev + GWn<br><br>Note:<br>Red Willow Canal CBCU = Red Willow Canal Diversion x (1- % BRF)<br><br>90% of the Red Willow Canal CBCU and 90% of Hugh Butler Lake Ev charged to Nebraska's CBCU in the Main Stem |
| VWS | = Red Willow Creek near Red Willow Gage Stn. No. 06838000 + CBCUc + CBCUk + CBCUn + 0.9 x Red Willow Canal CBCU + 0.9 x Hugh Butler Lake Ev + 0.9 xRed Willow Canal RF + ΔS Hugh Butler Lake – IWS<br><br>Note: 90% of the Red Willow Canal RF returns to the Main Stem |
| CWS | = VWS - ΔS Hugh Butler Lake - FF |
| Allocation Nebraska | = 0.192 x CWS |
| Unallocated | = 0.808 x CWS |

**11. Medicine Creek**

| | |
|---|---|
| CBCU Colorado | = GWc |
| CBCU Kansas | = GWk |
| CBCU Nebraska | = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn<br><br>Note: Harry Strunk Lake Ev charged to Nebraska's CBCU in the Main Stem.<br><br>CU from Harry Strunk releases in the Cambridge Canal is charged to the Main stem (no adjustment to the VWS |

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formula is needed as this water shows up in the Medicine Creek gage).

VWS = Medicine Creek below Harry Strunk Lake Gage Stn. No. 06842500 + CBCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage + Harry Strunk Lake Ev + ΔS Harry Strunk Lake– IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS - ΔS Harry Strunk Lake - FF

Allocation Nebraska = 0.091 x CWS

Unallocated = 0.909 x CWS

**12. Beaver Creek**

CBCU Colorado = 0.6 x Dc + % x Pc + 0.5 x M&Ic + EvNFRc + GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn

VWS = Beaver Creek near Beaver City gage Stn. No. 06847000 + BCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage – IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS – FF

Allocation Colorado = 0.200 x CWS

Allocation Kansas = 0.388 x CWS

Allocation Nebraska = 0.406 x CWS

Unallocated = 0.006 x CWS

**13. Sappa Creek**

CBCU Colorado = GWc

CBCU Kansas = 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + GWk

CBCU Nebraska = 0.6 x Dn above and below gage + % x Pn above and below gage + 0.5 x M&In above and below gage + EvNFRn above and below gage + GWn

VWS = Sappa Creek near Stamford gage Stn. No. 06847500 – Beaver Creek near Beaver City gage Stn. No. 06847000 + CBCUc + CBCUk + CBCUn – 0.6 x Dn below gage - % x Pn below gage – 0.5 * M&In below gage - EvNFRn below gage – IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS - FF

Allocation Kansas = 0.411 x CWS

Allocation Nebraska = 0.411 x CWS

Unallocated = 0.178 x CWS

**14. Prairie Dog Creek**

CBCU Colorado = GWc

CBCU Kansas = Almena Canal Diversion x (1-%BRF) + 0.6 x Dk + % x Pk + 0.5 x M&Ik + EvNFRk + Keith Sebelius Lake Ev + GWk

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CBCU Nebraska = 0.6 x Dn below gage + % x Pn below gage + 0.5 x M&In below gage + EvNFRn + GWn below gage

VWS = Prairie Dog Creek near Woodruff, Kansas USGS Stn. No. 06848500 + CBCUc + CBCUk + CBCUn - 0.6 x Dn below gage - % x Pn below gage - 0.5 x M&In below gage - EvNFRn below gage + ΔS Keith Sebelius Lake – IWS

Note: The CBCU surface water terms for Nebraska which occur below the gage are added in the VWS for the Main Stem

CWS = VWS- ΔS Keith Sebelius Lake - FF

Allocation Kansas = 0.457 x CSW

Allocation Nebraska = 0.076 x CWS

Unallocated = 0.467 x CWS

**15. The North Fork of the Republican River in Nebraska and the Main Stem of the Republican River between the junction of the North Fork and the Arikaree River and the Republican River near Hardy**

CBCU Colorado = GWc

CBCU Kansas =
(Deliveries from the Courtland Canal to Kansas above Lovewell) x (1-%BRF)
+ Amount of transportation loss of Courtland Canal deliveries to Lovewell that does not return to the river, charged to Kansas
+ (Diversions of Republican River water from Lovewell Reservoir by the Courtland Canal below Lovewell) x (1-%BRF)
+ 0.6 x Dk
+ % x Pk
+ 0.5 x M&Ik
+ EvNFRk
+ Harlan County Lake Ev charged to Kansas
+ Lovewell Reservoir Ev charged to the Republican River

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+ GWk

CBCU Nebraska =
Deliveries from Courtland Canal to Nebraska lands x (1- %BRF)
+ Superior Canal x (1- %BRF)
+ Franklin Pump Canal x (1- %BRF)
+ Franklin Canal x (1- %BRF)
+ Naponee Canal x (1- %BRF)
+ Cambridge Canal x (1- %BRF)
+ Bartley Canal x (1- %BRF)
+ Meeker-Driftwood Canal x (1- %BRF)
+ 0.9 x Red Willow Canal CBCU
+ 0.6 x Dn
+ % x Pn
+ 0.5 x M&In
+ EvNFRn
+ 0.9 x Hugh Butler Lake Ev
+ Harry Strunk Lake Ev
+ Swanson Lake Ev
+ Harlan County Lake Ev charged to Nebraska
+ GWn

Notes:
The allocation of transportation losses in the Courtland Canal above Lovewell between Kansas and Nebraska shall be done by the Bureau of Reclamation and reported in their "Courtland Canal Above Lovewell" spreadsheet. Deliveries and losses associated with deliveries to both Nebraska and Kansas above Lovewell shall be reflected in the Bureau's Monthly Water District reports. Losses associated with delivering water to Lovewell shall be separately computed.

Amount of transportation loss of the Courtland Canal deliveries to Lovewell that does not return to the river, charged to Kansas shall be 18% of the Bureau's estimate of losses associated with these deliveries.

Red Willow Canal CBCU = Red Willow Canal Diversion x (1- % BRF)

10% of the Red Willow Canal CBCU is charged to Nebraska's CBCU in Red Willow Creek sub-basin

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10% of Hugh Butler Lake Ev is charged to Nebraska's CBCU in the Red Willow Creek sub-basin

None of the Harry Strunk Lake EV is charged to Nebraska's CBCU in the Medicine Creek sub-basin

VWS =

Republican River near Hardy Gage Stn. No. 06853500
- North Fork of the Republican River at the State Line, Stn. No. 06823000
- Arikaree Gage at Haigler Stn. No. 06821500
- Buffalo Creek near Haigler Gage Stn. No. 06823500
- Rock Creek at Parks Gage Stn. No. 06824000
-South Fork Republican River near Benkelman Gage Stn. No. 06827500
- Frenchman Creek in Culbertson Stn. No. 06835500
- Driftwood Creek near McCook Gage Stn. No. 06836500
- Red Willow Creek near Red Willow Gage Stn. No. 06838000
- Medicine Creek below Harry Strunk Lake Gage Stn. No. 06842500
- Sappa Creek near Stamford Gage Stn. No. 06847500
- Prairie Dog Creek near Woodruff, Kansas Stn. No. 68-485000

+ CBCUc
+ CBCUn

+ 0.6 x Dk
+ % x Pk
+ 0.5 x M&Ik
+ EvNFRk
+ Harlan County Lake Ev charged to Kansas
+Amount of transportation loss of the Courtland Canal above the Stateline that does not return to the river, charged to Kansas

- 0.9 x Red Willow Canal CBCU
- 0.9 x Hugh Butler Ev
- Harry Strunk Ev

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+ 0.6 x Dn below Medicine Creek gage
+ % x Pn below Medicine Creek gage
+ 0.5 * M&In below Medicine Creek gage
+ EvNFRn below Medicine Creek gage

+ 0.6 x Dn below Beaver Creek gage
+ % x Pn below Beaver Creek gage
+ 0.5 * M&In below Beaver Creek gage
+ EvNFRn below Beaver Creek gage

+ 0.6 x Dn below Sappa Creek gage
+ % x Pn below Sappa Creek gage
+ 0.5 * M&In below Sappa Creek gage
+ EvNFRn below Sappa Creek gage

+ 0.6 x Dn below Prairie Dog Creek gage
+ % x Pn below Prairie Dog Creek gage
+ 0.5 * M&In below Prairie Dog Creek gage
+ EvNFRn below Prairie Dog Creek gage

+ Change in Storage Harlan County Lake
+ Change in Storage Swanson Lake

- Nebraska Haigler Canal RF
- 0.17 x Culbertson Canal RF
- Culbertson Canal Extension RF to Main Stem
+ 0.24 x Meeker Driftwood Canal RF which returns to Driftwood Creek
- 0.9 x Red Willow Canal RF

+ Courtland Canal at Kansas-Nebraska State Line Gage Stn No. 06852500
- Courtland Canal RF in Kansas above Lovewell Reservoir

-IWS

Notes:
None of the Nebraska Haigler Canal RF returns to the North Fork of the Republican River

83% of the Culbertson Diversion RF and none of the Culbertson Extension RF return to Frenchman Creek

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24 % of the Meeker Driftwood Canal RF returns to Driftwood Creek.

10% of the Red Willow Canal RF returns to Red Willow Creek

Courtland Canal RF in Kansas above Lovewell Reservoir = 0.015 x (Courtland Canal at Kansas-Nebraska State Line Gage Stn No. 06852500)

| | |
|---|---|
| CWS | = VWS - Change in Storage Harlan County Lake - Change in Storage Swanson Lake - FF |
| Allocation Kansas | = 0.511 x CWS |
| Allocation Nebraska | = 0.489 x CWS |

## V. Annual Data/ Information Requirements, Reporting, and Verification

The following information for the previous calendar year shall be provided to the members of the RRCA Engineering Committee by April 15th of each year, unless otherwise specified.

All information shall be provided in electronic format, if available.

Each State agrees to provide all information from their respective State that is needed for the RRCA Groundwater Model and RRCA Accounting Procedures and Reporting Requirements, including but not limited to the following:

### A. Annual Reporting

#### 1. Surface water diversions and irrigated acreage:

Each State will tabulate the canal, ditch, and other surface water diversions that are required by RRCA annual compact accounting and the RRCA Groundwater Model on a monthly format (or a procedure to distribute annual data to a monthly basis) and will forward the surface water diversions to the other States. This will include available diversion, wasteway, and farm delivery data for canals diverting from the Platte River that contribute to Imported Water Supply into the Basin. Each State will provide the water right number, type of use, system type, location, diversion amount, and acres irrigated.

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**2. Groundwater pumping and irrigated acreage:**

Each State will tabulate and provide all groundwater well pumping estimates that are required for the RRCA Groundwater Model to the other States.

**Colorado** – will provide an estimate of pumping based on a county format that is based upon system type, Crop Irrigation Requirement (CIR), irrigated acreage, crop distribution, and irrigation efficiencies. Colorado will require installation of a totalizing flow meter, installation of an hours meter with a measurement of the pumping rate, or determination of a power conversion coefficient for 10% of the active wells in the Basin by December 31, 2005. Colorado will also provide an annual tabulation for each groundwater well that measures groundwater pumping by a totalizing flow meter, hours meter or power conversion coefficient that includes: the groundwater well permit number, location, reported hours, use, and irrigated acreage.

**Kansas** - will provide an annual tabulation by each groundwater well that includes: water right number, groundwater pumping determined by a meter on each well (or group of wells in a manifold system) or by reported hours of use and rate; location; system type (gravity, sprinkler, LEPA, drip, etc.); and irrigated acreage. Crop distribution will be provided on a county basis.

**Nebraska** – will provide an annual tabulation through the representative Natural Resource District (NRD) in Nebraska that includes: the well registration number or other ID number; groundwater pumping determined by a meter on each well (or group of wells in a manifold system) or by reported hours of use and rate; wells will be identified by; location; system type (gravity, sprinkler, LEPA, drip, etc.); and irrigated acreage. Crop distribution will be provided on a county basis.

**3. Climate information:**

Each State will tabulate and provide precipitation, temperature, relative humidity or dew point, and solar radiation for the following climate stations:

| State | Identification | Name |
|---|---|---|
| Colorado | | |
| Colorado | C050109 | Akron 4 E |
| Colorado | C051121 | Burlington |
| Colorado | C054413 | Julesburg |
| Colorado | C059243 | Wray |
| Kansas | C140439 | Atwood 2 SW |
| Kansas | C141699 | Colby 1SW |
| Kansas | C143153 | Goodland |
| Kansas | C143837 | Hoxie |

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| | | |
|---|---|---|
| Kansas | C145856 | Norton 9 SSE |
| Kansas | C145906 | Oberlin1 E |
| Kansas | C147093 | Saint Francis |
| Kansas | C148495 | Wakeeny |
| Nebraska | C250640 | Beaver City |
| Nebraska | C250810 | Bertrand |
| Nebraska | C252065 | Culbertson |
| Nebraska | C252690 | Elwood 8 S |
| Nebraska | C253365 | Gothenburg |
| Nebraska | C253735 | Hebron |
| Nebraska | C253910 | Holdredge |
| Nebraska | C254110 | Imperial |
| Nebraska | C255090 | Madrid |
| Nebraska | C255310 | McCook |
| Nebraska | C255565 | Minden |
| Nebraska | C256480 | Palisade |
| Nebraska | C256585 | Paxton |
| Nebraska | C257070 | Red Cloud |
| Nebraska | C258255 | Stratton |
| Nebraska | C258320 | Superior |
| Nebraska | C258735 | Upland |
| Nebraska | C259020 | Wauneta 3 NW |

**4. Crop Irrigation Requirements:**

Each State will tabulate and provide estimates of crop irrigation requirement information on a county format. Each State will provide the percentage of the crop irrigation requirement met by pumping; the percentage of groundwater irrigated lands served by sprinkler or flood irrigation systems, the crop irrigation requirement; crop distribution; crop coefficients; gain in soil moisture from winter and spring precipitation, net crop irrigation requirement; and/or other information necessary to compute a soil/water balance.

**5. Streamflow Records from State-Maintained Gaging Records:**

Streamflow gaging records from the following State maintained gages will be provided:

| Station No. | Name |
|---|---|
| 00126700 | Republican River near Trenton |
| 06831500 | Frenchman Creek near Imperial |
| 06832500 | Frenchman Creek near Enders |

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| | |
|---|---|
| 06835000 | Stinking Water Creek near Palisade |
| 06837300 | Red Willow Creek above Hugh Butler Lake |
| 06837500 | Red Willow Creek near McCook |
| 06841000 | Medicine Creek above Harry Strunk Lake |
| 06842500 | Medicine Creek below Harry Strunk Lake |
| 06844000 | Muddy Creek at Arapahoe |
| 06844210 | Turkey Creek at Edison |
| 06847000 | Beaver Creek near Beaver City |
| | Republican River at Riverton |
| 06851500 | Thompson Creek at Riverton |
| 06852000 | Elm Creek at Amboy |
| | Republican River at the Superior-Courtland Diversion Dam |

**6. Platte River Reservoirs:**

The State of Nebraska will provide the end-of-month contents, inflow data, outflow data, area-capacity data, and monthly net evaporation, if available, from Johnson Lake; Elwood Reservoir; Sutherland Reservoir; Maloney Reservoir; and Jeffrey Lake.

**7. Water Administration Notification:**

The State of Nebraska will provide the following information that describes the protection of reservoir releases from Harlan County Lake and for the administration of water rights junior in priority to February 26, 1948:

Date of notification to Nebraska water right owners to curtail their diversions, the amount of curtailment, and length of time for curtailment.
The number of notices sent.
The number of diversions curtailed and amount of curtailment in the Harlan County Lake to Guide Rock reach of the Republican River.

**8. Moratorium:**

Each State will provide a description of all new Wells constructed in the Basin Upstream of Guide Rock including the owner, location (legal description), depth and diameter or dimension of the constructed water well, casing and screen information, static water level, yield of the water well in gallons per minute or gallons per hour, and intended use of the water well.

Designation whether the Well is a:

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a. Test hole;

b. Dewatering Well with an intended use of one year or less;

c. Well designed and constructed to pump fifty gallons per minute or less;

d. Replacement Water Well, including a description of the Well that is replaced providing the information described above for new Wells and a description of the historic use of the Well that is replaced;

e. Well necessary to alleviate an emergency situation involving provision of water for human consumption, including a brief description of the nature of the emergency situation and the amount of water intended to be pumped by and the length of time of operation of the new Well;

f. Transfer Well, including a description of the Well that is transferred providing the information described above for new Wells and a description of the Historic Consumptive Use of the Well that is transferred;

g. Well for municipal and/or industrial expansion of use;

Wells in the Basin in Northwest Kansas or Colorado. Kansas and Colorado will provide the information described above for new Wells along with copies of any other information that is required to be filed with either State of local agencies under the laws, statutes, rules and regulations in existence as of April 30, 2002, and;

Any changes in State law in the previous year relating to existing Moratorium.

**9. Non-Federal Reservoirs:**

Each State will conduct an inventory of Non Federal Reservoirs by December 31, 2004, for inclusion in the annual Compact Accounting. The inventory shall include the following information: the location, capacity (in Acre-feet) and area (in acres) at the principal spillway elevation of each Non-Federal Reservoir. The States will annually provide any updates to the initial inventory of Non-Federal Reservoirs, including enlargements that are constructed in the previous year.

Owners/operators of Non-Federal Reservoirs with 200 Acre-feet of storage capacity or greater at the principal spillway elevation will be required to provide an area-capacity survey from State-approved plans or prepared by a licensed professional engineer or land surveyor.

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**10. Augmentation Plan:**

Each State will provide a description of the wells, measuring devices, conveyance structure(s), and other infrastructure to describe the physical characteristics, water diversions, and consumptive use associated with each augmentation plan. The States will provide any updates to the plan on an annual basis.

## B. RRCA Groundwater Model Data Input Files

1. Monthly groundwater pumping, surface water recharge, groundwater recharge, and precipitation recharge provided by county and indexed to the one square mile cell size.

2. Potential Evapotranspiration rate is set as a uniform rate for all phreatophyte vegetative classes – the amount is X at Y climate stations and is interpolated spatially using kriging.

## C. Inputs to RRCA Accounting

### 1. Surface Water Information

a. Streamflow gaging station records: obtained as preliminary USGS or Nebraska streamflow records, with adjustments to reflect a calendar year, at the following locations:

Arikaree River at Haigler, Nebraska
North Fork Republican River at Colorado-Nebraska state line
Buffalo Creek near Haigler, Nebraska
Rock Creek at Parks, Nebraska
South Fork Republican River near Benkelman, Nebraska
Frenchman Creek at Culbertson, Nebraska
Red Willow Creek near Red Willow, Nebraska
Medicine Creek below Harry Strunk Lake, Nebraska*
Beaver Creek near Beaver City, Nebraska*
Sappa Creek near Stamford, Nebraska
Prairie Dog Creek near Woodruff, Kansas
Courtland Canal at Nebraska-Kansas state line
Republican River near Hardy, Nebraska
Republican River at Superior-Courtland Diversion Dam near Guide Rock,
Nebraska (new)*

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b. Federal reservoir information: obtained from the United States Bureau of Reclamation:

Daily free water surface evaporation, storage, precipitation, reservoir release information, and updated area-capacity tables.
Federal Reservoirs:
Bonny Reservoir
Swanson Lake
Harry Strunk Lake
Hugh Butler Lake
Enders Reservoir
Keith Sebelius Lake
Harlan County Lake
Lovewell Reservoir

c. Non-federal reservoirs obtained by each state: an updated inventory of reservoirs that includes the location, surface area (acres), and capacity (in Acre-feet), of each non-federal reservoir with storage capacity of fifteen (15) Acre-feet or greater at the principal spillway elevation. Supporting data to substantiate the average surface water areas that are different than the presumptive average annual surface area may be tendered by the offering State.

d. Diversions and related data from USBR

Irrigation diversions by canal, ditch, and pumping station that irrigate more than two (2) acres
Diversions for non-irrigation uses greater than 50 Acre-feet
Farm Deliveries
Wasteway measurements
Irrigated acres

e. Diversions and related data – from each respective State

Irrigation diversions by canal, ditch, and pumping station that irrigate more than two (2) acres
Diversions for non-irrigation uses greater than 50 Acre-feet
Wasteway measurements, if available

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### 2. Groundwater Information

(From the RRCA Groundwater model as output files as needed for the accounting procedures)

a. Imported water - mound credits in amount and time that occur in defined streamflow points/reaches of measurement or compliance – ex: gaging stations near confluence or state lines

b. Groundwater depletions to streamflow (above points of measurement or compliance – ex: gaging stations near confluence or state lines)

### 3. Summary

The aforementioned data will be aggregated by Sub-basin as needed for RRCA accounting.

## D. Verification

### 1. Documentation to be Available for Inspection Upon Request

a. Well permits/ registrations database
b. Copies of well permits/ registrations issued in calendar year
c. Copies of surface water right permits or decrees
d. Change in water right/ transfer historic use analyses
e. Canal, ditch, or other surface water diversion records
f. Canal, ditch, or other surface water measurements
g. Reservoir storage and release records
h. Irrigated acreage
i. Augmentation Plan well pumping and augmentation delivery records

### 2. Site Inspection

a. Accompanied – reasonable and mutually acceptable schedule among representative state and/or federal officials.

b. Unaccompanied – inspection parties shall comply with all laws and regulations of the State in which the site inspection occurs.

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Table 1: Annual Virgin and Computed Water Supply, Allocations and Computed Beneficial Consumptive Uses by State, Main Stem and Sub-basin

| Designated Drainage Basin | Col. 1: Virgin Water Supply | Col. 2: Computed Water Supply | Col. 3: Allocations | | | | Col. 4: Computed Beneficial Consumptive Use | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Colorado | Nebraska | Kansas | Unallocated | Colorado | Nebraska | Kansas |
| North Fork in Colorado | | | | | | | | | |
| Arikaree | | | | | | | | | |
| Buffalo | | | | | | | | | |
| Rock | | | | | | | | | |
| South Fork of Republican River | | | | | | | | | |
| Frenchman | | | | | | | | | |
| Driftwood | | | | | | | | | |
| Red Willow | | | | | | | | | |
| Medicine | | | | | | | | | |
| Beaver | | | | | | | | | |
| Sappa | | | | | | | | | |
| Prairie Dog | | | | | | | | | |
| North Fork of Republican River in Nebraska and Main Stem | | | | | | | | | |
| Total All Basins | | | | | | | | | |
| North Fork Of Republican River in Nebraska and Mainstem Including Unallocated Water | | | | | | | | | |
| Total | | | | | | | | | |

Table 2: Original Compact Virgin Water Supply and Allocations

| Designated Drainage Basin | Virgin Water Supply | Colorado Allocation | % of Total Drainage Basin Supply | Kansas Allocation | % of Total Drainage Basin Supply | Nebraska Allocation | % of Total Drainage Basin Supply | Unallo-cated | % of Total Drainage Basin Supply |
|---|---|---|---|---|---|---|---|---|---|
| North Fork - CO | 44,700 | 10,000 | 22.4 | | | 11,000 | 24.6 | 23,700 | 53.0 |
| Arikaree River | 19,610 | 15,400 | 78.5 | 1,000 | 5.1 | 3,300 | 16.8 | -90 | -0.4 |
| Buffalo Creek | 7,890 | | | | | 2,600 | 33.0 | 5,290 | 67.0 |
| Rock Creek | 11,000 | | | | | 4,400 | 40.0 | 6,600 | 60.0 |
| South Fork | 57,200 | 25,400 | 44.4 | 23,000 | 40.2 | 800 | 1.4 | 8,000 | 14.0 |
| Frenchman Creek | 98,500 | | | | | 52,800 | 53.6 | 45,700 | 46.4 |
| Driftwood Creek | 7,300 | | | 500 | 6.9 | 1,200 | 16.4 | 5,600 | 76.7 |
| Red Willow Creek | 21,900 | | | | | 4,200 | 19.2 | 17,700 | 80.8 |
| Medicine Creek | 50,800 | | | | | 4,600 | 9.1 | 46,200 | 90.9 |
| Beaver Creek | 16,500 | 3,300 | 20.0 | 6,400 | 38.8 | 6,700 | 40.6 | 100 | 0.6 |
| Sappa Creek | 21,400 | | | 8,800 | 41.1 | 8,800 | 41.1 | 3,800 | 17.8 |
| Prairie Dog Creek | 27,600 | | | 12,600 | 45.7 | 2,100 | 7.6 | 12,900 | 46.7 |
| Sub-total Tributaries | 384,400 | | | | | | | 175,500 | |
| Main Stem + Blackwood Creek | 94,500 | | | | | | | | |
| Main Stem + Unallocated | 270,000 | | | 138,000 | 51.1 | 132,000 | 48.9 | | |
| Total | 478,900 | 54,100 | | 190,300 | | 234,500 | | | |

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Table 3A: Table to Be Used to Calculate Colorado's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

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| Colorado | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit and/or Augmentation Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit and/or Augmentation Water Supply Credit Col 1 – (Col 2- Col 3) |
| Year t= -4 | | | | |
| Year t= -3 | | | | |
| Year t= -2 | | | | |
| Year t= -1 | | | | |
| Current Year t= 0 | | | | |
| Average | | | | |

Table 3B. Table to Be Used to Calculate Kansas's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

| Kansas | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Col 1 – (Col 2- Col 3) |
| Year t= -4 | | | | |
| Year t= -3 | | | | |
| Year t= -2 | | | | |
| Year t= -1 | | | | |
| Current Year t= 0 | | | | |

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| | | | | |
|---|---|---|---|---|
| Average | | | | |

Table 3C. Table to Be Used to Calculate Nebraska's Five-Year Running Average Allocation and Computed Beneficial Consumptive Use for Determining Compact Compliance

| Nebraska | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col. 4 |
| Year | Allocation | Computed Beneficial Consumptive | Imported Water Supply Credit | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Col 1 – (Col 2- Col 3) |
| Year T= -4 | | | | |
| Year T= -3 | | | | |
| Year T= -2 | | | | |
| Year T= -1 | | | | |
| Current Year T= 0 | | | | |
| Average | | | | |

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Table 4A: Colorado Compliance with the Sub-basin Non-impairment Requirement

| | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 |
|---|---|---|---|---|---|---|
| Sub-basin | Colorado Sub-basin Allocation (5-year running average) | Unallocated Supply (5-year running average) | Credits from Imported Water Supply and/or Augmentation Water Supply (5-year running average) | Total Supply Available = Col 1+ Col 2 + Col 3 (5-year running average) | Colorado Computed Beneficial Consumptive Use (5-year running average) | Difference Between Available Supply and Computed Beneficial Consumptive Use = Col 4 – Col 5 (5-year running average) |
| North Fork Republican River Colorado | | | | | | |
| Arikaree River | | | | | | |
| South Fork Republican River | | | | | | |
| Beaver Creek | | | | | | |

Table 4B: Kansas Compliance with the Sub-basin Non-impairment Requirement

| | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 |
|---|---|---|---|---|---|---|---|
| Sub-basin | Kansas Sub-basin Allocation (5-year running average) | Unallocated Supply (5-year running average) | Unused Allocation from Colorado (5-year running average) | Credits from Imported Water Supply (5-year running average) | Total Supply Available = Col 1+ Col 2+ Col 3 + Col 4 (5-year running average) | Kansas Computed Beneficial Consumptive Use (5-year running average) | Difference Between Available Supply and Computed Beneficial Consumptive Use = Col 5 – Col 6 (5-year running average) |
| Arikaree River | | | | | | | |
| South Fork Republican River | | | | | | | |
| Driftwood Creek | | | | | | | |
| Beaver Creek | | | | | | | |
| Sappa Creek | | | | | | | |
| Prairie Dog Creek | | | | | | | |

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Table 5A: Colorado Compliance During Water-Short Year Administration

| Colorado | | | | |
|---|---|---|---|---|
| | Col. 1 | Col. 2 | Col. 3 | Col 4 |
| Year | Allocation minus Allocation for Beaver Creek | Computed Beneficial Consumptive minus Computed Beneficial Consumptive Use for Beaver Creek | Imported Water Supply Credit and/or Augmentation Water Supply Credit excluding Beaver Creek | Difference between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit and/or Augmentation Water Supply Credit for All Basins Except Beaver Creek<br>Col 1 – (Col 2 – Col 3) |
| Year T= -4 | | | | |
| Year T= -3 | | | | |
| Year T= -2 | | | | |
| Year T= -1 | | | | |
| Current Year T= 0 | | | | |
| Average | | | | |

Table 5B: Kansas Compliance During Water-Short Year Administration

| Kansas | | | | | | |
|---|---|---|---|---|---|---|
| Year | Allocation | | | Computed Beneficial Consumptive Use` | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit |
| Column | 1 | 2 | 3 | 4 | 5 | 6 |
| | Sum Sub-basins | Kansas's Share of the Unallocated Supply | Total Col 1 + Col 2 | | | Col 3 – (Col 4 – Col 5) |
| Previous Year | | | | | | |
| Current Year | | | | | | |
| Average | | | | | | |

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Table 5C: Nebraska Compliance During Water-Short Year Administration

| Nebraska | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Allocation | | | Computed Beneficial Consumptive Use | | | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Above Guide Rock |
| Column | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 |
| | State Wide Allocation | Allocation below Guide Rock | State Wide Allocation above Guide Rock | State Wide CBCU | CBCU below Guide Rock | State Wide CBCU above Guide Rock | Credits above Guide Rock | Col 3 – (Col 6 – Col 7) |
| Previous Year | | | | | | | | |
| Current Year | | | | | | | | |
| Average | | | | | | | | |

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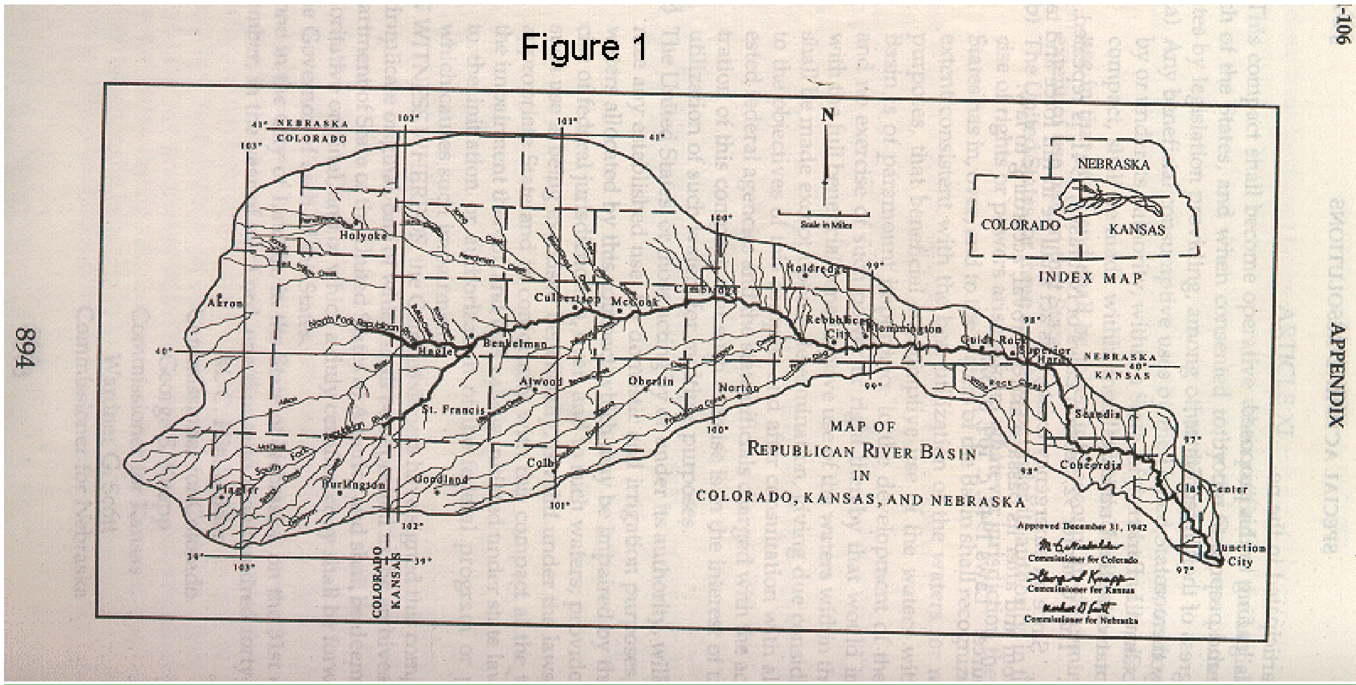
Table 5D: Nebraska Compliance Under a Alternative Water-Short Year Administration Plan

| Year | Allocation | | | Computed Beneficial Consumptive Use | | | Imported Water Supply Credit | Difference Between Allocation and the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit Above Guide Rock |
|---|---|---|---|---|---|---|---|---|
| Column | Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 |
| | State Wide Allocation | Allocation below Guide Rock | State Wide Allocation above Guide Rock | State Wide CBCU | CBCU below Guide Rock | State Wide CBCU above Guide Rock | Credits above Guide Rock | Col 3 – (Col 6- Col 7) |
| Year = -2 | | | | | | | | |
| Year = -1 | | | | | | | | |
| Current Year | | | | | | | | |
| Three-Year Average | | | | | | | | |
| Sum of Previous Two-year Difference | | | | | | | | |
| Expected Decrease in CBCU Under Plan | | | | | | | | |

Table 5E: Nebraska Tributary Compliance During Water-Short Year Administration

| Year | Sum of Nebraska Sub-basin Allocations | Sum of Nebraska's Share of Sub-basin Unallocated Supplies | Total Available Water Supply for Nebraska | Computed Beneficial Consumptive Use | Imported Water Supply Credit | Difference between Allocation And the Computed Beneficial Consumptive Use offset by Imported Water Supply Credit |
|---|---|---|---|---|---|---|
| | Col 1 | Col 2 | `Col 3 | Col 4 | Col 5 | Col 6 |
| Previous Year | | | | | | Col 3 -(Col 4-Col 5) |
| Current Year | | | | | | |
| Average | | | | | | |




Basin Map Attached to Compact that Shows the Streams and the Basin Boundaries

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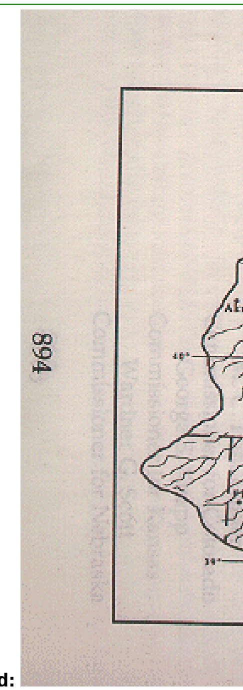

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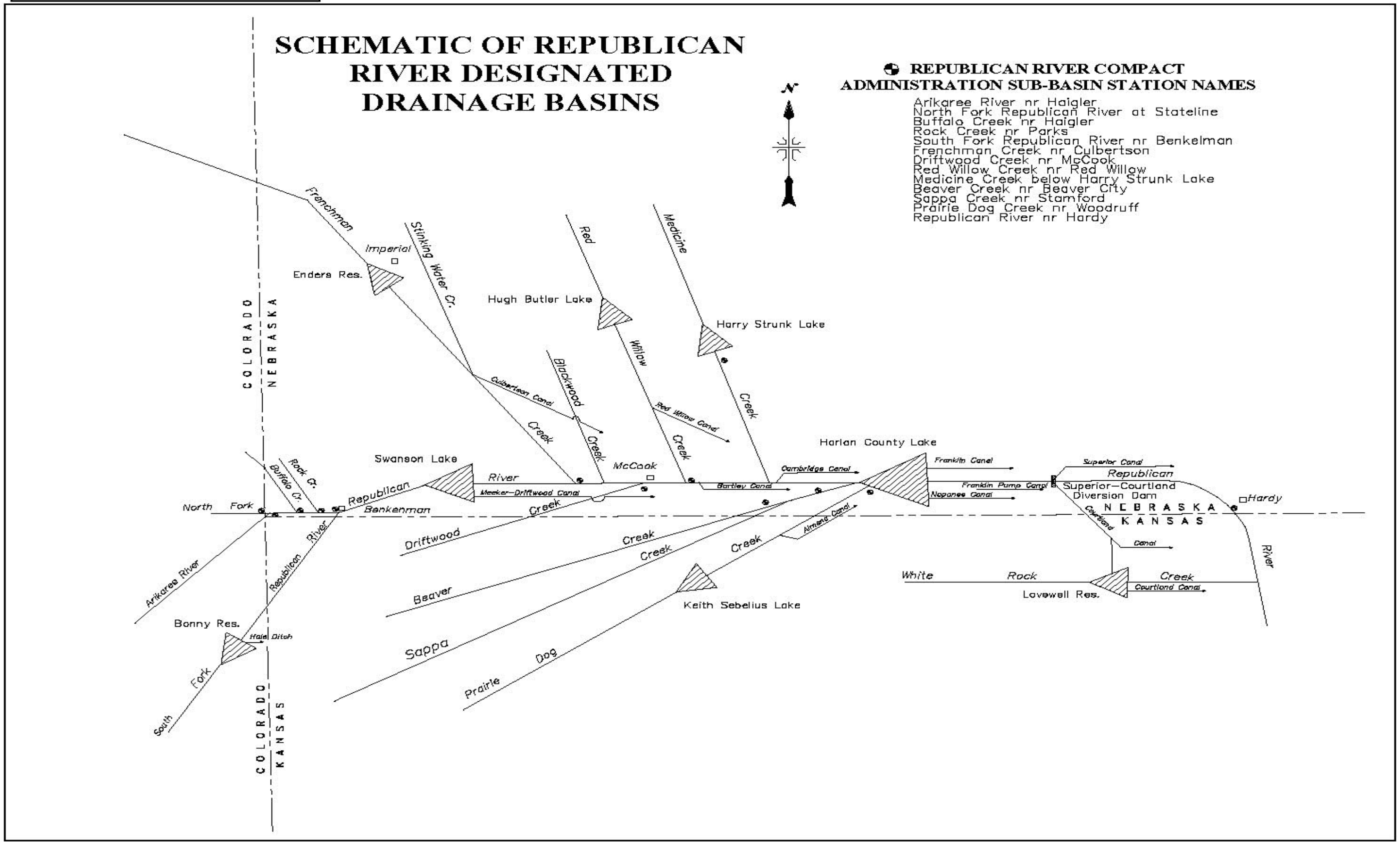
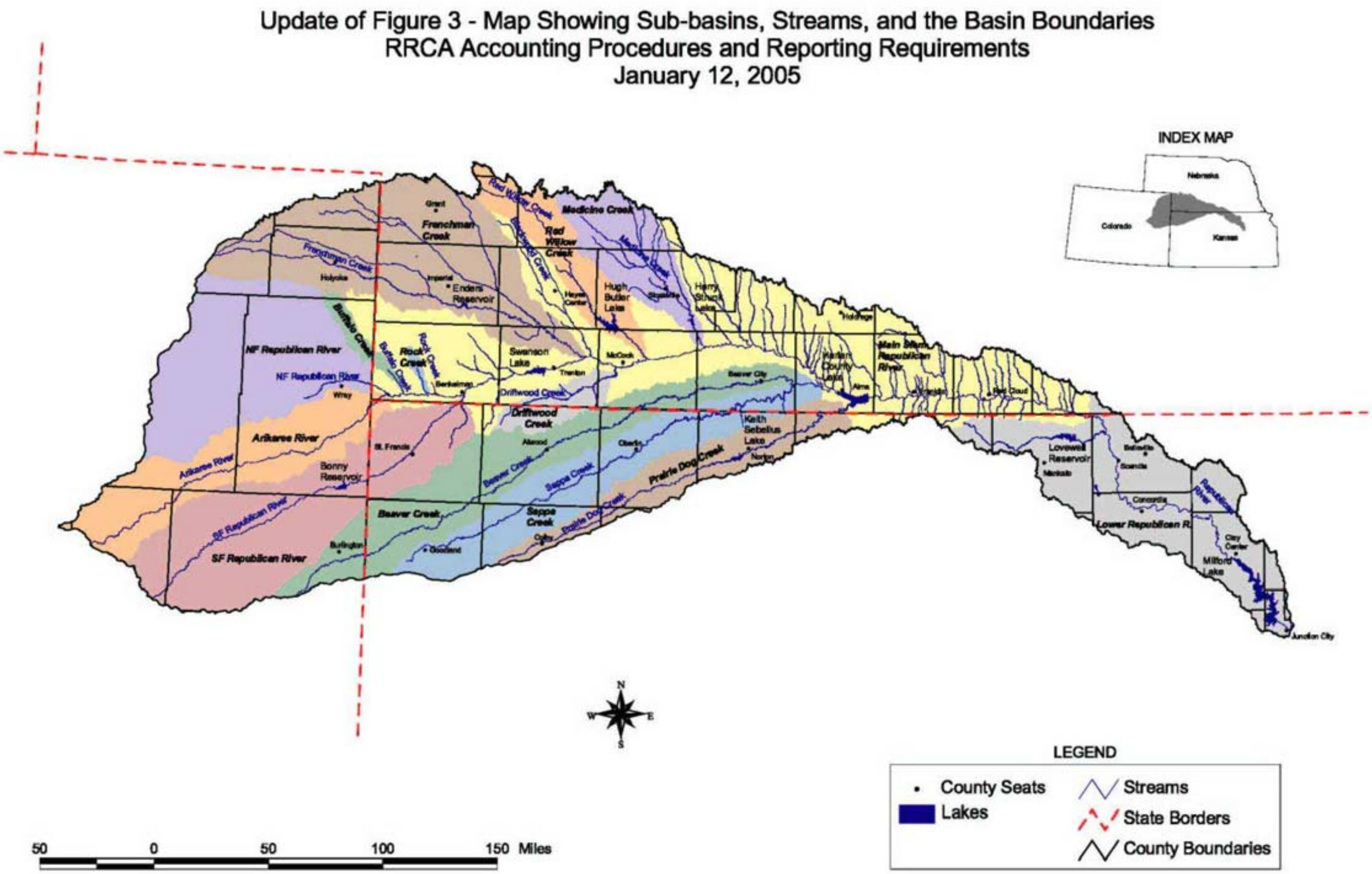
Figure 2




Line Diagram of Designated Drainage Basins Showing Federal Reservoirs and Sub-basin Gaging Stations




Map Showing Sub-basins, Streams, and the Basin Boundaries

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Attachment 1: Sub-basin Flood Flow Thresholds

| Sub-basin | Sub-basin Flood Flow Threshold Acre-feet per Year[3] |
|---|---|
| Arikaree River | 16,400 |
| North Fork of Republican River | 33,900 |
| Buffalo Creek | 4,800 |
| Rock Creek | 9,800 |
| South Fork of Republican River | 30,400 |
| Frenchman Creek | 51,900 |
| Driftwood Creek | 9,400 |
| Red Willow Creek | 15,100 |
| Medicine Creek | 55,100 |
| Beaver Creek | 13,900 |
| Sappa Creek | 26,900 |
| Prairie Dog | 15,700 |

[3] Flows considered to be Flood Flows are flows in excess of the 94% flow based on a flood frequency analysis for the years 1971-2000. The Gaged Flows are measured after depletions by Beneficial Consumptive Use and change in reservoir storage. For the purpose of compliance with III.B.1, the Gaged Flows shall not include Augmentation Water Supply Credits delivered in any calendar year.

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Attachment 2: Description of the Consensus Plan for Harlan County Lake

The Consensus Plan for operating Harlan County Lake was conceived after extended discussions and negotiations between Reclamation and the Corps. The agreement shaped at these meetings provides for sharing the decreasing water supply into Harlan County Lake. The agreement provides a consistent procedure for: updating the reservoir elevation/storage relationship, sharing the reduced inflow and summer evaporation, and providing a January forecast of irrigation water available for the following summer.

During the interagency discussions the two agencies found agreement in the following areas:

- The operating plan would be based on current sediment accumulation in the irrigation pool and other zones of the project.
- Evaporation from the lake affects all the various lake uses in proportion to the amount of water in storage for each use.
- During drought conditions, some water for irrigation could be withdrawn from the sediment pool.
- Water shortage would be shared between the different beneficial uses of the project, including fish, wildlife, recreation and irrigation.

To incorporate these areas of agreement into an operation plan for Harlan County Lake, a mutually acceptable procedure addressing each of these items was negotiated and accepted by both agencies.

1. Sediment Accumulation.

The most recent sedimentation survey for Harlan County project was conducted in 1988, 37 years after lake began operation. Surveys were also performed in 1962 and 1972; however, conclusions reached after the 1988 survey indicate that the previous calculations are unreliable. The 1988 survey indicates that, since closure of the dam in 1951, the accumulated sediment is distributed in each of the designated pools as follows:

| | |
|---|---|
| Flood Pool | 2,387 Acre-feet |
| Irrigation Pool | 4,853 Acre-feet |
| Sedimentation Pool | 33,527 Acre-feet |

To insure that the irrigation pool retained 150,000 Acre-feet of storage, the bottom of the irrigation pool was lowered to 1,932.4 feet, msl, after the 1988 survey.

To estimate sediment accumulation in the lake since 1988, we assumed similar conditions have occurred at the project during the past 11 years. Assuming a consistent rate of deposition since 1988, the irrigation pool has trapped an additional 1,430 Acre-feet.

A similar calculation of the flood control pool indicates that the flood control pool has captured an additional 704 Acre-feet for a total of 3,090 Acre-feet since construction.

The lake elevations separating the different pools must be adjusted to maintain a 150,000-acre-foot irrigation pool and a 500,000-acre-foot flood control pool. Adjusting these elevations results in the following new elevations for the respective pools (using the 1988 capacity tables).

| | |
|---|---|
| Top of Irrigation Pool | 1,945.70 feet, msl |
| Top of Sediment Pool | 1,931.75 feet, msl |

Due to the variability of sediment deposition, we have determined that the elevation capacity relationship should be updated to reflect current conditions. We will complete a new sedimentation survey of Harlan County Lake this summer, and new area capacity tables should be available by early next year. The new tables may alter the pool elevations achieved in the Consensus Plan for Harlan County Lake.

2. Summer Evaporation.

Evaporation from a lake is affected by many factors including vapor pressure, wind, solar radiation, and salinity of the water. Total water loss from the lake through evaporation is also affected by the size of the lake. When the lake is lower, the surface area is smaller and less water loss occurs. Evaporation at Harlan County Lake has been estimated since the lake's construction using a Weather Service Class A pan which is 4 feet in diameter and 10 inches deep. We and Reclamation have jointly reviewed this information and assumed future conditions to determine an equitable method of distributing the evaporation loss from the project between irrigation and the other purposes.

During those years when the irrigation purpose expected a summer water yield of 119,000 Acre-feet or more, it was determined that an adequate water supply existed and no sharing of evaporation was necessary. Therefore, evaporation evaluation focused on the lower pool elevations when water was scarce. Times of water shortage would also generally be times of higher evaporation rates from the lake.

Reclamation and we agreed that evaporation from the lake during the summer (June through September) would be distributed between the irrigation and sediment pools based on their relative percentage of the total storage at the time of evaporation. If the sediment pool held 75 percent of the total storage, it would be charged 75 percent of the evaporation. If the sediment pool held 50 percent of the total storage, it would be charged 50 percent of the evaporation. At the bottom of the irrigation pool (1,931.75 feet, msl) all of the evaporation would be charged to the sediment pool.

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Due to downstream water rights for summer inflow, neither the irrigation nor the sediment pool is credited with summer inflow to the lake. The summer inflows would be assumed passed through the lake to satisfy the water right holders. Therefore, Reclamation and we did not distribute the summer inflow between the project purposes.

As a result of numerous lake operation model computer runs by Reclamation, it became apparent that total evaporation from the project during the summer averaged about 25,000 Acre-feet during times of lower lake elevations. These same models showed that about 20 percent of the evaporation should be charged to the irrigation pool, based on percentage in storage during the summer months. About 20 percent of the total lake storage is in the irrigation pool when the lake is at elevation 1,935.0 feet, msl. As a result of the joint study, Reclamation and we agreed that the irrigation pool would be credited with 20,000 Acre-feet of water during times of drought to share the summer evaporation loss.

Reclamation and we further agreed that the sediment pool would be assumed full each year. In essence, if the actual pool elevation were below 1,931.75 feet, msl, in January, the irrigation pool would contain a negative storage for the purpose of calculating available water for irrigation, regardless of the prior year's summer evaporation from sediment storage.

3. Irrigation withdrawal from sediment storage.

During drought conditions, occasional withdrawal of water from the sediment pool for irrigation is necessary. Such action is contemplated in the Field Working Agreement and the Harlan County Lake Regulation Manual: "Until such time as sediment fully occupies the allocated reserve capacity, it will be used for irrigation and various conservation purposes, including public health, recreation, and fish and wildlife preservation."

To implement this concept into an operation plan for Harlan County Lake, Reclamation and we agreed to estimate the net spring inflow to Harlan County Lake. The estimated inflow would be used by the Reclamation to provide a firm projection of water available for irrigation during the next season.

Since the construction of Harlan County Lake, inflows to the lake have been depleted by upstream irrigation wells and farming practices. Reclamation has recently completed an in-depth study of these depleted flows as a part of their contract renewal process. The study concluded that if the current conditions had existed in the basin since 1931, the average spring inflow to the project would have been 57,600 Acre-feet of water. The study further concluded that the evaporation would have been 8,800 Acre-feet of water during the same period. Reclamation and we agreed to use these values to calculate the net inflow to the project under the current conditions.

In addition, both agencies also recognized that the inflow to the project could continue to decrease with further upstream well development and water conservation farming. Due to these

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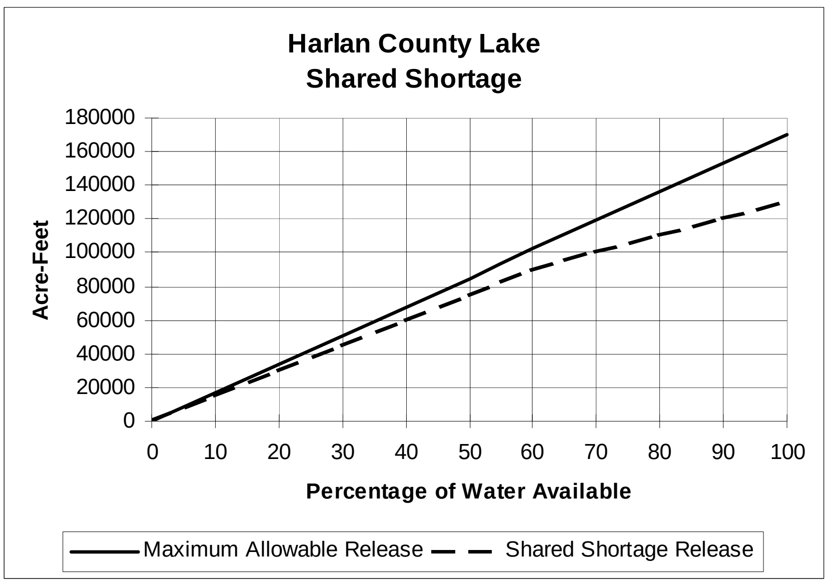
concerns, Reclamation and we determined that the previous 5-year inflow values would be averaged each year and compared to 57,600 Acre-feet. The inflow estimate for Harlan County Lake would be the smaller of these two values.

The estimated inflow amount would be used in January of each year to forecast the amount of water stored in the lake at the beginning of the irrigation season. Based on this forecast, the irrigation districts would be provided a firm estimate of the amount of water available for the next season. The actual storage in the lake on May 31 would be reviewed each year. When the actual water in storage is less than the January forecast, Reclamation may draw water from sediment storage to make up the difference.

4. Water Shortage Sharing.

A final component of the agreement involves a procedure for sharing the water available during times of shortage. Under the shared shortage procedure, the irrigation purpose of the project would remove less water then otherwise allowed and alleviate some of the adverse effects to the other purposes. The procedure would also extend the water supply during times of drought by "banking" some water for the next irrigation season. The following graph illustrates the shared shortage releases.




5. Calculation of Irrigation Water Available

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Each January, the Reclamation would provide the Bostwick irrigation districts a firm estimate of the quantity of water available for the following season. The firm estimate of water available for irrigation would be calculated by using the following equation and shared shortage adjustment:

Storage + Summer Sediment Pool Evaporation + Inflow – Spring Evaporation=Maximum Irrigation Water Available

The variables in the equation are defined as:

- Maximum Irrigation Water Available. Maximum irrigation supply from Harlan County Lake for that irrigation season.
- Storage. Actual storage in the irrigation pool at the end of December. The sediment pool is assumed full. If the pool elevation is below the top of the sediment pool, a negative irrigation storage value would be used.
- Inflow. The inflow would be the smaller of the past 5-year average inflow to the project from January through May, or 57,600 Acre-feet.
- Spring Evaporation. Evaporation from the project would be 8,800 Acre-feet which is the average January through May evaporation.
- Summer Sediment Pool Evaporation. Summer evaporation from the sediment pool during June through September would be 20,000 Acre-feet. This is an estimate based on lower pool elevations, which characterize the times when it would be critical to the computations.

6. Shared Shortage Adjustment

To ensure that an equitable distribution of the available water occurs during short-term drought conditions, and provide for a "banking" procedure to increase the water stored for subsequent years, a shared shortage plan would be implemented. The maximum water available for irrigation according to the above equation would be reduced according to the following table. Linear interpolation of values will occur between table values.

Shared Shortage Adjustment Table

| Irrigation Water Available (Acre-feet) | Irrigation Water Released (Acre-feet) |
|---|---|
| 0 | 0 |
| 17,000 | 15,000 |
| 34,000 | 30,000 |
| 51,000 | 45,000 |
| 68,000 | 60,000 |

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| | |
|---|---|
| 85,000 | 75,000 |
| 102,000 | 90,000 |
| 119,000 | 100,000 |
| 136,000 | 110,000 |
| 153,000 | 120,000 |
| 170,000 | 130,000 |

7. Annual Shutoff Elevation for Harlan County Lake

The annual shutoff elevation for Harlan County Lake would be estimated each January and finally established each June.

The annual shutoff elevation for irrigation releases will be estimated by Reclamation each January in the following manner:

1. Estimate the May 31 Irrigation Water Storage (IWS) (Maximum 150,000 Acre-feet) by taking the December 31 irrigation pool storage plus the January-May inflow estimate (57,600 Acre-feet or the average inflow for the last 5-year period, whichever is less) minus the January-May evaporation estimate (8,800 Acre-feet).
2. Calculate the estimated Irrigation Water Available, including all summer evaporation, by adding the Estimated Irrigation Water Storage (from item 1) to the estimated sediment pool summer evaporation (20,000 AF).
3. Use the above Shared Shortage Adjustment Table to determine the acceptable Irrigation Water Release from the Irrigation Water Available.
4. Subtract the Irrigation Water Release (from item 3) from the Estimated IWS (from item 1). The elevation of the lake corresponding to the resulting irrigation storage is the Estimated Shutoff Elevation. The shutoff elevation will not be below the bottom of the irrigation pool if over 119,000 AF of water is supplied to the districts, nor below 1,927.0 feet, msl. If the shutoff elevation is below the irrigation pool, the maximum irrigation release is 119,000 AF.

The annual shutoff elevation for irrigation releases would be finalized each June in accordance with the following procedure:

1. Compare the estimated May 31 IWS with the actual May 31 IWS.
2. If the actual end of May IWS is less than the estimated May IWS, lower the shutoff elevation to account for the reduced storage.
3. If the actual end of May IWS is equal to or greater than the estimated end of May IWS, the estimated shutoff elevation is the annual shutoff elevation.
4. The shutoff elevation will never be below elevation1,927.0 feet, msl, and will not be below the bottom of the irrigation pool if more than 119,000 Acre-feet of water is supplied to the districts.

Attachment 3: Inflows to Harlan County Lake 1993 Level of Development

BASELINE RUN - 1993 LEVEL INFLOW TO HARLAN COUNTY RESERVOIR

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1931 | 10.2 | 10.8 | 13.4 | 5.0 | 18.8 | 15.8 | 4.3 | 1.8 | 1.8 | 0.0 | 0.1 | 0.1 | 82.1 |
| 1932 | 6.8 | 16.6 | 18.5 | 4.6 | 3.8 | 47.6 | 3.8 | 2.8 | 4.8 | 0.0 | 0.0 | 0.4 | 109.7 |
| 1933 | 0.4 | 0.0 | 3.9 | 30.2 | 31.0 | 5.4 | 1.8 | 0.0 | 10.4 | 0.0 | 2.6 | 5.5 | 91.2 |
| 1934 | 2.1 | 0.0 | 3.2 | 1.8 | 0.7 | 7.3 | 0.8 | 0.0 | 1.3 | 0.0 | 2.2 | 0.0 | 19.4 |
| 1935 | 0.3 | 0.1 | 0.7 | 4.2 | 0.8 | 389.3 | 6.1 | 19.1 | 26.1 | 2.4 | 5.2 | 0.9 | 455.2 |
| 1936 | 0.3 | 0.0 | 11.9 | 0.0 | 35.9 | 4.7 | 0.4 | 0.0 | 1.8 | 0.0 | 1.6 | 3.8 | 60.4 |
| 1937 | 4.8 | 12.9 | 6.0 | 2.5 | 0.0 | 12.6 | 6.3 | 6.9 | 2.4 | 0.0 | 0.0 | 12.4 | 66.8 |
| 1938 | 9.9 | 7.8 | 8.7 | 10.4 | 18.7 | 8.6 | 7.3 | 7.8 | 4.9 | 0.2 | 0.0 | 4.7 | 89.0 |
| 1939 | 2.7 | 7.5 | 9.6 | 12.2 | 6.6 | 13.3 | 5.0 | 4.1 | 0.0 | 0.0 | 0.0 | 0.0 | 61.0 |
| 1940 | 0.0 | 0.0 | 12.2 | 5.2 | 4.6 | 23.7 | 2.8 | 3.2 | 0.0 | 3.6 | 0.0 | 1.4 | 56.7 |
| 1941 | 0.0 | 10.6 | 10.6 | 7.7 | 17.2 | 67.1 | 28.9 | 19.7 | 14.9 | 8.3 | 6.7 | 7.1 | 198.8 |
| 1942 | 3.3 | 10.6 | 0.5 | 34.1 | 30.8 | 83.9 | 11.7 | 10.9 | 36.5 | 3.1 | 8.7 | 0.3 | 234.4 |
| 1943 | 1.2 | 11.2 | 14.6 | 31.4 | 4.7 | 28.3 | 4.8 | 0.3 | 0.9 | 0.0 | 0.0 | 11.8 | 109.2 |
| 1944 | 0.1 | 4.3 | 9.0 | 43.1 | 31.9 | 63.9 | 26.6 | 15.4 | 0.5 | 0.3 | 3.0 | 4.5 | 202.6 |
| 1945 | 4.3 | 7.8 | 5.7 | 9.5 | 4.1 | 53.5 | 5.0 | 0.9 | 1.5 | 5.0 | 6.0 | 6.3 | 109.6 |
| 1946 | 5.9 | 11.2 | 9.3 | 4.9 | 7.0 | 3.1 | 1.6 | 11.4 | 28.1 | 129.9 | 25.0 | 12.1 | 249.5 |
| 1947 | 1.1 | 3.2 | 10.4 | 8.2 | 11.9 | 195.4 | 22.3 | 5.9 | 2.9 | 0.2 | 0.3 | 0.3 | 262.1 |
| 1948 | 6.2 | 9.8 | 24.1 | 5.4 | 0.2 | 39.8 | 13.5 | 6.8 | 4.2 | 0.0 | 0.1 | 0.1 | 110.2 |
| 1949 | 2.0 | 1.5 | 25.2 | 16.3 | 49.0 | 57.4 | 9.2 | 5.5 | 2.1 | 3.0 | 2.8 | 0.3 | 174.3 |
| 1950 | 0.3 | 5.7 | 10.8 | 10.9 | 28.9 | 10.1 | 12.7 | 9.3 | 7.8 | 7.2 | 3.8 | 3.1 | 110.6 |
| 1951 | 3.8 | 3.4 | 7.1 | 5.3 | 42.0 | 39.9 | 42.1 | 10.1 | 36.0 | 15.5 | 14.8 | 8.9 | 228.9 |
| 1952 | 16.4 | 21.4 | 26.3 | 23.8 | 34.6 | 4.0 | 9.3 | 3.1 | 1.5 | 11.7 | 4.3 | 0.1 | 156.5 |
| 1953 | 1.8 | 4.6 | 5.3 | 3.3 | 15.1 | 9.5 | 1.8 | 0.2 | 0.0 | 0.0 | 2.8 | 0.1 | 44.5 |
| 1954 | 1.0 | 6.8 | 1.9 | 3.2 | 7.1 | 2.4 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 23.6 |
| 1955 | 0.0 | 4.0 | 6.3 | 4.8 | 2.9 | 6.4 | 2.7 | 0.0 | 1.4 | 0.0 | 0.0 | 0.0 | 28.5 |
| 1956 | 1.6 | 3.4 | 2.9 | 2.4 | 1.3 | 1.5 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 13.7 |
| 1957 | 0.0 | 4.1 | 6.2 | 12.8 | 3.5 | 62.4 | 21.3 | 1.2 | 2.0 | 3.4 | 4.5 | 4.7 | 126.1 |
| 1958 | 0.8 | 3.0 | 14.2 | 14.0 | 18.7 | 1.3 | 3.4 | 2.2 | 0.0 | 0.4 | 0.0 | 0.6 | 58.6 |
| 1959 | 1.9 | 15.4 | 16.4 | 8.5 | 13.6 | 4.2 | 1.4 | 1.2 | 0.0 | 4.3 | 1.0 | 4.5 | 72.4 |
| 1960 | 1.4 | 12.3 | 71.4 | 23.9 | 21.7 | 53.7 | 14.1 | 3.2 | 0.0 | 0.0 | 0.2 | 2.8 | 204.7 |
| 1961 | 2.3 | 6.4 | 7.7 | 7.4 | 26.5 | 24.0 | 7.2 | 4.9 | 0.0 | 2.3 | 4.8 | 1.7 | 95.2 |

Attachment 3: Inflows to Harlan County Lake 1993 Level of Development

BASELINE RUN - 1993 LEVEL INFLOW TO HARLAN COUNTY RESERVOIR

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 4.5 | 9.1 | 16.2 | 9.9 | 14.4 | 42.6 | 41.6 | 21.1 | 2.3 | 8.7 | 8.3 | 5.7 | 184.4 |
| 1963 | 3.4 | 18.2 | 18.2 | 15.0 | 12.7 | 14.7 | 3.4 | 6.1 | 8.7 | 0.8 | 5.3 | 1.8 | 108.3 |
| 1964 | 5.4 | 7.6 | 8.3 | 8.4 | 9.9 | 11.9 | 7.2 | 6.5 | 2.4 | 1.9 | 1.4 | 2.3 | 73.2 |
| 1965 | 6.0 | 8.1 | 11.1 | 12.8 | 32.8 | 40.0 | 22.9 | 6.5 | 37.2 | 53.7 | 19.5 | 11.0 | 261.6 |
| 1966 | 8.9 | 21.4 | 15.7 | 11.4 | 12.0 | 34.7 | 12.4 | 2.5 | 3.5 | 5.4 | 6.8 | 5.7 | 140.4 |
| 1967 | 7.2 | 11.5 | 11.5 | 12.9 | 9.1 | 75.3 | 43.7 | 15.3 | 4.4 | 7.3 | 6.9 | 5.4 | 210.5 |
| 1968 | 3.9 | 10.2 | 8.5 | 11.6 | 10.8 | 12.5 | 3.1 | 2.7 | 1.6 | 2.0 | 4.3 | 3.4 | 74.6 |
| 1969 | 4.2 | 10.8 | 24.5 | 15.1 | 18.9 | 17.5 | 17.0 | 12.6 | 16.6 | 9.2 | 11.8 | 9.9 | 168.1 |
| 1970 | 3.5 | 8.7 | 8.5 | 10.5 | 11.1 | 7.7 | 4.6 | 3.2 | 0.5 | 3.3 | 4.7 | 4.5 | 70.8 |
| 1971 | 4.1 | 10.3 | 12.4 | 12.8 | 18.3 | 7.2 | 8.4 | 6.2 | 1.9 | 4.2 | 7.3 | 7.1 | 100.2 |
| 1972 | 5.5 | 8.1 | 9.2 | 8.3 | 14.8 | 8.5 | 6.5 | 4.4 | 0.1 | 2.9 | 7.6 | 4.1 | 80.0 |
| 1973 | 11.4 | 14.2 | 19.0 | 16.2 | 17.4 | 20.9 | 9.1 | 1.9 | 8.4 | 19.6 | 11.9 | 13.2 | 163.2 |
| 1974 | 13.2 | 13.4 | 12.0 | 14.3 | 15.4 | 17.2 | 5.5 | 0.0 | 0.0 | 0.0 | 4.9 | 5.5 | 101.4 |
| 1975 | 7.2 | 8.2 | 13.6 | 14.8 | 12.0 | 48.1 | 11.6 | 7.4 | 0.1 | 3.0 | 6.2 | 7.3 | 139.5 |
| 1976 | 7.0 | 10.2 | 10.1 | 16.0 | 12.1 | 3.5 | 2.2 | 1.8 | 0.9 | 1.0 | 3.2 | 3.1 | 71.1 |
| 1977 | 4.4 | 9.6 | 12.9 | 21.2 | 31.5 | 12.1 | 5.9 | 1.9 | 10.6 | 4.1 | 5.5 | 5.3 | 125.0 |
| 1978 | 5.0 | 6.5 | 20.6 | 12.9 | 11.8 | 3.8 | 0.0 | 1.0 | 0.0 | 0.0 | 0.3 | 1.6 | 63.5 |
| 1979 | 1.3 | 7.6 | 21.5 | 18.8 | 15.9 | 5.4 | 10.4 | 10.6 | 1.6 | 0.9 | 3.6 | 6.2 | 103.8 |
| 1980 | 5.7 | 9.3 | 11.6 | 15.2 | 10.4 | 2.1 | 2.5 | 0.0 | 0.0 | 0.0 | 2.5 | 2.2 | 61.5 |
| 1981 | 5.5 | 6.0 | 11.6 | 14.9 | 22.5 | 6.4 | 11.5 | 16.3 | 4.3 | 2.5 | 6.7 | 6.2 | 114.4 |
| 1982 | 5.3 | 12.5 | 17.9 | 14.3 | 26.8 | 27.1 | 8.9 | 2.7 | 0.0 | 6.5 | 6.3 | 15.5 | 143.8 |
| 1983 | 6.5 | 9.7 | 27.2 | 16.4 | 41.4 | 74.2 | 10.7 | 7.6 | 3.8 | 3.1 | 6.7 | 5.2 | 212.5 |
| 1984 | 6.8 | 14.6 | 17.2 | 32.9 | 40.6 | 15.5 | 8.1 | 4.5 | 0.0 | 5.5 | 4.8 | 6.2 | 156.7 |
| 1985 | 6.9 | 14.1 | 13.6 | 11.9 | 27.4 | 9.9 | 10.0 | 2.0 | 6.0 | 8.5 | 5.6 | 5.8 | 121.7 |
| 1986 | 9.1 | 9.4 | 12.2 | 11.7 | 34.3 | 13.0 | 13.5 | 4.6 | 3.3 | 5.9 | 5.4 | 7.1 | 129.5 |
| 1987 | 5.9 | 9.2 | 19.7 | 24.1 | 24.3 | 11.7 | 19.0 | 5.7 | 2.3 | 2.7 | 8.2 | 7.0 | 139.8 |
| 1988 | 6.2 | 13.7 | 11.6 | 15.2 | 15.2 | 7.0 | 17.9 | 10.4 | 0.6 | 2.0 | 5.9 | 5.4 | 111.1 |
| 1989 | 5.4 | 5.9 | 10.5 | 9.1 | 11.4 | 11.8 | 14.0 | 6.2 | 0.2 | 3.1 | 3.1 | 3.5 | 84.2 |
| 1990 | 6.6 | 7.7 | 13.2 | 9.7 | 15.5 | 1.4 | 4.3 | 10.7 | 0.6 | 3.2 | 2.0 | 2.7 | 77.6 |
| 1991 | 2.4 | 8.0 | 9.0 | 10.6 | 15.2 | 3.9 | 1.9 | 0.5 | 0.0 | 0.0 | 2.7 | 4.8 | 59.0 |
| 1992 | 8.0 | 8.8 | 12.7 | 8.5 | 4.5 | 6.1 | 6.5 | 9.4 | 2.4 | 6.9 | 6.7 | 5.2 | 85.7 |
| 1993 | 5.2 | 14.4 | 71.6 | 22.7 | 21.0 | 17.0 | 68.0 | 37.5 | 23.3 | 16.8 | 30.1 | 17.7 | 345.3 |

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avg | 4.5 | 8.8 | 14.1 | 13.0 | 17.2 | 30.6 | 11.0 | 6.2 | 5.4 | 6.3 | 5.0 | 4.7 | 126.8 |

Attachment 4: Evaporation Loss Harlan County Lake 1993 Level of Development

BASELINE - 1993 LEVEL FLOWS - HARLAN COUNTY EVAPORATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1931 | 0.7 | 0.9 | 1.6 | 2.9 | 4.2 | 7.4 | 6.9 | 5.2 | 2.7 | 2.1 | 1.2 | 0.4 | 36.2 |
| 1932 | 0.6 | 0.8 | 1.5 | 2.7 | 4.1 | 5.0 | 6.8 | 5.0 | 2.7 | 2.1 | 1.2 | 0.4 | 32.9 |
| 1933 | 0.6 | 0.8 | 1.4 | 2.5 | 3.8 | 7.8 | 6.1 | 4.2 | 2.7 | 2.1 | 1.2 | 0.4 | 33.6 |
| 1934 | 0.6 | 0.8 | 1.4 | 2.4 | 4.5 | 6.5 | 8.0 | 6.2 | 2.7 | 2.0 | 1.2 | 0.4 | 36.7 |
| 1935 | 0.6 | 0.8 | 1.3 | 2.3 | 2.2 | 3.6 | 9.7 | 6.2 | 3.1 | 2.5 | 1.4 | 0.5 | 34.2 |
| 1936 | 0.7 | 0.9 | 1.6 | 2.9 | 5.5 | 6.8 | 8.7 | 6.5 | 2.7 | 2.1 | 1.2 | 0.4 | 40.0 |
| 1937 | 0.6 | 0.8 | 1.4 | 2.5 | 3.6 | 4.0 | 6.2 | 6.5 | 2.7 | 2.1 | 1.2 | 0.4 | 32.0 |
| 1938 | 0.6 | 0.9 | 1.5 | 2.7 | 3.4 | 4.9 | 6.5 | 5.7 | 2.7 | 2.1 | 1.2 | 0.4 | 32.6 |
| 1939 | 0.6 | 0.8 | 1.4 | 2.6 | 4.3 | 4.9 | 6.8 | 4.6 | 2.7 | 2.1 | 1.2 | 0.4 | 32.4 |
| 1940 | 0.6 | 0.8 | 1.4 | 2.4 | 3.5 | 5.0 | 6.5 | 4.6 | 2.7 | 2.1 | 1.2 | 0.4 | 31.2 |
| 1941 | 0.6 | 0.8 | 1.4 | 2.5 | 3.9 | 4.2 | 6.7 | 5.3 | 2.8 | 2.1 | 1.3 | 0.5 | 32.1 |
| 1942 | 0.6 | 0.9 | 1.5 | 2.8 | 4.0 | 5.2 | 8.3 | 5.1 | 3.2 | 2.5 | 1.5 | 0.5 | 36.1 |
| 1943 | 0.7 | 1.0 | 1.8 | 3.2 | 4.3 | 5.7 | 7.9 | 6.3 | 2.7 | 2.1 | 1.2 | 0.4 | 37.3 |
| 1944 | 0.6 | 0.8 | 1.4 | 2.7 | 4.2 | 5.3 | 7.0 | 5.8 | 3.5 | 2.6 | 1.5 | 0.5 | 35.9 |
| 1945 | 0.7 | 1.0 | 1.8 | 3.1 | 3.8 | 3.0 | 6.7 | 5.7 | 2.9 | 2.2 | 1.3 | 0.5 | 32.7 |
| 1946 | 0.6 | 0.9 | 1.6 | 2.8 | 3.5 | 5.1 | 5.6 | 4.4 | 2.9 | 2.7 | 1.8 | 0.6 | 32.5 |
| 1947 | 1.0 | 1.5 | 2.9 | 3.2 | 3.4 | -1.2 | 5.8 | 5.3 | 3.7 | 1.7 | 0.5 | 0.1 | 27.9 |
| 1948 | 0.8 | 0.7 | 1.5 | 3.6 | 3.1 | 2.4 | 4.2 | 4.7 | 3.0 | 2.7 | 0.8 | 0.3 | 27.8 |
| 1949 | 0.1 | 0.9 | 0.7 | 1.8 | 1.1 | 0.7 | 6.5 | 4.1 | 3.1 | 1.7 | 1.5 | 0.4 | 22.6 |
| 1950 | 0.7 | 0.1 | 0.8 | 2.8 | 2.0 | 5.6 | 0.8 | 2.8 | 4.5 | 2.3 | 1.6 | 0.6 | 24.6 |
| 1951 | 0.5 | 0.2 | 2.1 | 0.7 | -0.1 | 1.9 | 3.5 | 4.1 | 0.4 | 3.1 | 2.2 | 0.9 | 19.5 |
| 1952 | 1.1 | 1.2 | 1.9 | 2.5 | 5.2 | 6.2 | 1.5 | 3.4 | 3.6 | 2.9 | 1.1 | -0.1 | 30.5 |
| 1953 | 0.5 | 1.0 | 1.5 | 2.9 | 4.7 | 4.5 | 4.6 | 6.6 | 5.3 | 3.3 | 0.1 | 0.0 | 35.0 |
| 1954 | 0.7 | 0.6 | 2.2 | 3.6 | 0.3 | 4.9 | 6.7 | 1.6 | 3.6 | 1.6 | 1.5 | 0.6 | 27.9 |
| 1955 | 0.5 | 1.0 | 2.1 | 4.6 | 3.4 | -0.5 | 7.3 | 6.9 | 2.7 | 2.6 | 1.4 | 0.4 | 32.4 |
| 1956 | 0.6 | 1.1 | 1.9 | 2.8 | 3.9 | 4.5 | 5.0 | 3.7 | 4.7 | 3.7 | 1.3 | 0.5 | 33.7 |
| 1957 | 0.7 | 1.0 | 1.3 | 0.5 | -0.6 | -1.1 | 6.1 | 3.7 | 2.3 | 1.7 | 1.2 | 0.4 | 17.2 |
| 1958 | 0.7 | 0.1 | 1.0 | 0.6 | 2.3 | 4.4 | 1.0 | 1.9 | 3.3 | 3.3 | 1.0 | 0.6 | 20.2 |
| 1959 | 0.4 | 1.0 | 1.1 | 2.1 | 1.0 | 3.5 | 5.0 | 4.8 | 2.3 | 0.7 | 1.5 | 0.6 | 24.0 |
| 1960 | 0.1 | 0.7 | 2.0 | 2.7 | 0.9 | 0.1 | 4.9 | 3.6 | 3.9 | 2.0 | 1.3 | 0.4 | 22.6 |
| 1961 | 0.9 | 1.0 | 1.4 | 2.7 | -1.1 | 0.6 | 5.1 | 2.9 | 1.2 | 2.4 | 0.7 | 0.1 | 17.9 |

Attachment 4: Evaporation Loss Harlan County Lake 1993 Level of Development

BASELINE - 1993 LEVEL FLOWS - HARLAN COUNTY EVAPORATION

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1962 | 0.6 | 0.6 | 0.9 | 3.7 | 3.4 | 1.5 | 0.3 | 1.6 | 2.0 | 2.0 | 1.7 | 0.3 | 18.6 |
| 1963 | 0.7 | 1.4 | 1.3 | 4.5 | 4.6 | 6.3 | 6.1 | 3.1 | -0.8 | 2.7 | 1.5 | 0.4 | 31.8 |
| 1964 | 0.8 | 0.8 | 1.7 | 3.2 | 5.6 | 1.2 | 6.9 | 3.0 | 3.0 | 3.3 | 1.2 | 0.6 | 31.3 |
| 1965 | 0.4 | 0.7 | 1.2 | 2.8 | 1.5 | -0.5 | 2.0 | 2.8 | -3.9 | 1.7 | 2.1 | 0.4 | 11.2 |
| 1966 | 0.9 | 0.8 | 2.9 | 2.7 | 7.5 | 2.8 | 5.8 | 3.7 | 2.7 | 2.8 | 1.5 | 0.4 | 34.5 |
| 1967 | 0.7 | 1.2 | 2.5 | 3.0 | 2.0 | -2.9 | 1.6 | 4.5 | 3.5 | 2.0 | 1.6 | 0.4 | 20.1 |
| 1968 | 0.9 | 1.2 | 2.8 | 2.6 | 3.2 | 4.9 | 4.7 | 1.8 | 2.3 | 0.7 | 1.2 | 0.2 | 26.5 |
| 1969 | 0.4 | 0.6 | 2.4 | 3.3 | 0.1 | 3.8 | -0.7 | 2.9 | 2.2 | -1.0 | 1.5 | 0.4 | 15.9 |
| 1970 | 0.7 | 1.4 | 2.3 | 2.8 | 4.7 | 4.4 | 6.5 | 5.9 | 0.9 | 1.0 | 1.5 | 0.7 | 32.8 |
| 1971 | 0.7 | 0.2 | 2.0 | 2.9 | 0.7 | 5.1 | 3.4 | 4.5 | 1.4 | 1.5 | 0.2 | 0.5 | 23.1 |
| 1972 | 0.8 | 1.3 | 2.0 | 1.7 | 1.1 | 0.0 | 3.3 | 1.8 | 2.1 | 1.7 | -0.4 | 0.1 | 15.5 |
| 1973 | 0.5 | 1.1 | -0.7 | 2.5 | 3.4 | 6.7 | -1.7 | 4.2 | -3.0 | 0.2 | 0.2 | 0.2 | 13.6 |
| 1974 | 0.7 | 1.5 | 2.6 | 1.5 | 3.7 | 2.5 | 9.1 | 2.6 | 3.4 | 1.4 | 1.1 | 0.3 | 30.4 |
| 1975 | 0.7 | 0.7 | 2.0 | 2.1 | 0.8 | 1.1 | 4.3 | 2.7 | 3.0 | 3.4 | 0.7 | 0.6 | 22.1 |
| 1976 | 0.8 | 1.2 | 1.7 | 0.7 | 1.5 | 5.0 | 5.9 | 5.7 | -0.2 | 1.4 | 1.4 | 0.7 | 25.8 |
| 1977 | 0.7 | 1.3 | 0.2 | 1.1 | 0.0 | 4.6 | 4.0 | 0.6 | 2.0 | 1.6 | 1.0 | 0.4 | 17.5 |
| 1978 | 0.5 | 0.7 | 1.2 | 3.4 | 3.9 | 6.2 | 7.1 | 4.5 | 4.5 | 3.0 | 1.1 | 0.5 | 36.6 |
| 1979 | 0.5 | 0.6 | 1.1 | 3.9 | 4.4 | 4.6 | 3.5 | 5.1 | 4.1 | 2.8 | 1.4 | 0.7 | 32.7 |
| 1980 | 0.5 | 0.6 | 1.2 | 3.4 | 3.7 | 4.7 | 6.8 | 6.0 | 3.9 | 2.7 | 1.3 | 0.6 | 35.4 |
| 1981 | 0.5 | 0.6 | 1.2 | 3.8 | 3.2 | 4.8 | 4.2 | 3.7 | 2.9 | 1.7 | 1.3 | 0.7 | 28.6 |
| 1982 | 0.5 | 0.7 | 1.2 | 3.9 | 3.8 | 3.9 | 5.1 | 3.8 | 2.9 | 2.2 | 1.4 | 0.8 | 30.2 |
| 1983 | 0.5 | 0.7 | 1.4 | 2.9 | 4.2 | 5.3 | 8.6 | 7.2 | 4.6 | 1.8 | 1.5 | 0.6 | 39.3 |
| 1984 | 0.6 | 0.8 | 1.4 | 2.9 | 4.2 | 5.8 | 7.2 | 5.7 | 4.7 | 1.4 | 1.4 | 0.7 | 36.8 |
| 1985 | 0.5 | 0.7 | 1.3 | 2.3 | 4.0 | 4.5 | 5.6 | 3.5 | 3.8 | 1.5 | 1.5 | 0.7 | 29.9 |
| 1986 | 0.6 | 0.7 | 1.3 | 2.8 | 4.4 | 5.8 | 6.7 | 4.0 | 2.7 | 1.3 | 1.4 | 0.7 | 32.4 |
| 1987 | 0.5 | 0.8 | 1.3 | 3.1 | 4.2 | 6.2 | 6.9 | 3.5 | 3.1 | 2.2 | 1.4 | 0.7 | 33.9 |
| 1988 | 0.5 | 0.7 | 1.3 | 3.5 | 4.9 | 6.6 | 4.6 | 4.8 | 3.5 | 2.2 | 1.4 | 0.7 | 34.7 |
| 1989 | 0.5 | 0.7 | 1.2 | 4.2 | 4.5 | 4.4 | 4.8 | 3.6 | 3.0 | 2.5 | 1.4 | 0.7 | 31.5 |
| 1990 | 0.5 | 0.7 | 1.2 | 3.0 | 3.5 | 5.6 | 6.4 | 4.0 | 5.0 | 3.4 | 1.4 | 0.6 | 35.3 |
| 1991 | 0.5 | 0.7 | 1.2 | 2.8 | 3.3 | 5.5 | 6.0 | 5.0 | 5.1 | 3.2 | 1.3 | 0.6 | 35.2 |
| 1992 | 0.6 | 0.7 | 1.2 | 1.8 | 3.2 | 2.2 | 4.1 | 3.5 | 4.2 | 2.9 | 1.9 | 1.0 | 27.3 |

Deleted: July

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1993 | 0.6 | 0.5 | 1.0 | 2.2 | 3.1 | 4.6 | 4.2 | 4.9 | 4.5 | 4.4 | 3.1 | 1.2 | 34.3 |
| Avg | 0.6 | 0.8 | 1.5 | 2.7 | 3.2 | 3.9 | 5.3 | 4.3 | 2.8 | 2.2 | 1.3 | 0.5 | 29.1 |

| **Trigger Calculations Based on Harlan County Lake Irrigation Supply** | Units-1000 Acre-feet | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Irrigation Trigger | 119.0 | | Assume that during irrigation release season | | | | | | | | | |
| | Total Irrigation Supply | 130.0 | | HCL Inflow = Evaporation Loss | | | | | | | | | |
| | Bottom Irrigation | 164.1 | | | | | | | | | | | |
| | Evaporation Adjust | 20.0 | | | | | | | | | | | |
| | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Total** |
| 1993 Level AVE inflow | 6.3 | 5 | 4.7 | 4.5 | 8.8 | 14.1 | 13.0 | 17.2 | 30.6 | 11.0 | 6.2 | 5.4 | 126.8 |
| 1993 Level AVE evap | 2.2 | 1.3 | 0.5 | 0.6 | 0.8 | 1.5 | 2.7 | 3.2 | 3.9 | 5.3 | 4.3 | 2.8 | 29.1 |
| (1931-93) | | | | | | | | | | | | | |
| | | | | | | | | | | | | | |
| Avg. Inflow Last 5 Years | 10.8 | 13.0 | 12.3 | 12.9 | 16.6 | 22.4 | 19.4 | 18.1 | 14.8 | 16.5 | 11.0 | 4.7 | 172.6 |

Attachment 5: Projected Water Supply Spread Sheet Calculations

| **Year 2001-2002 Oct - Jun Trigger and Irrigation Supply Calculation** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Calculation Month | **Oct** | **Nov** | **Dec** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** |
| Previous EOM Content | 236.5 | 235.9 | 238.6 | 242.9 | 248.1 | 255.1 | 263.8 | 269.6 | 276.2 |
| Inflow to May 31 | 73.6 | 67.3 | 62.3 | 57.6 | 53.1 | 44.3 | 30.2 | 17.2 | 0.0 |
| Last 5 Yrs Avg Inflow to May 31 | 125.6 | 114.8 | 101.7 | 89.5 | 76.6 | 59.9 | 37.5 | 18.1 | 0.0 |
| Evap to May 31 | 12.8 | 10.6 | 9.3 | 8.8 | 8.2 | 7.4 | 5.9 | 3.2 | 0.0 |
| Est. Cont May 31 | 297.3 | 292.6 | 291.6 | 291.7 | 293.0 | 292.0 | 288.1 | 283.6 | 276.2 |
| Est. Elevation May 31 | 1944.44 | 1944.08 | 1944.00 | 1944.01 | 1944.11 | 1944.03 | 1943.72 | 1943.37 | 1942.77 |
| Max. Irrigation Available | 153.2 | 148.5 | 147.5 | 147.6 | 148.9 | 147.9 | 144.0 | 139.5 | 132.1 |
| Irrigation Release Est. | 120.1 | 117.4 | 116.8 | 116.8 | 118.1 | 117.1 | 116.8 | 116.8 | 116.8 |
| Trigger - Yes/No | NO | YES | YES | YES | YES | YES | YES | YES | YES |
| 130 kAF Irrigation Supply - Yes/No | NO | NO | NO | NO | NO | NO | NO | NO | NO |

Deleted: July

Attachment 5: Projected Water Supply Spread Sheet Calculations

| **Year 2002<br>Jul - Sep<br>Final Trigger and<br>Total Irrigation Supply<br>Calculation** | | | | |
|---|---|---|---|---|
| | | | | |
| Calculation Month | | **Jul** | **Aug** | **Sep** |
| Previous EOM Irrigation Release Est. | | 116.8 | 116.0 | 109.7 |
| Previous Month Inflow | | 5.5 | 0.5 | 1.3 |
| Previous Month Evap | | 6.3 | 6.8 | 6.6 |
| Irrigation Release Estimate | | 116.0 | 109.7 | 104.4 |
| Final Trigger - Yes/No | | YES | | |
| 130 kAF Irrigation Supply - Yes/No | | NO | NO | NO |

Deleted: July 2005

Attachment 6: Computing Water Supplies and Consumptive Use Above Guide Rock

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Main Stem VWS | Hardy gage | Superior-Courtland Diversion Dam Gage | Courtland Canal Diversions | Superior Canal Diversions | Courtland Canal Returns | Superior Canal Returns | Total Bostwick Returns Below Guide Rock | NE CBCU Below Guide Rock | KS CBCU Below Guide Rock | Total CBCU Below Guide Rock | Gain Guide Rock to Hardy | VWS Guide Rock to Hardy | Main Stem Virgin Water Supply Above Guide Rock | Nebraska Main Stem Allocation Above Hardy | Kansas Main Stem Allocation Above Hardy | Nebraska Guide Rock to Hardy Allocation | Kansas Guide Rock to Hardy Allocation |
| | | | | | | | Col F+ Col G | | | Col I + Col J | + Col B - Col C+ Col K - Col H | + Col L + Col K | Col A - Col M | .489 x Col N | .511 x Col N | .489 x Col M | .511 x Col M |

Deleted: July 2005

Attachment 7: Calculations of Return Flows from Bureau of Reclamation Canals

| Col 1 | Col 2 | Col 3 | Col 4 | Col 5 | Col 6 | Col 7 | Col 8 | Col 9 | Col 10 | Col 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| Canal | Canal Diversion | Spill to Waste-way | Field Deliveries | Canal Loss | Average Field Loss Factor | Field Loss | Total Loss from District | Percent Field and Canal Loss That Returns to the Stream | Total Return to Stream from Canal and Field Loss | Return as Percent of Canal Diversion |
| Name Canal | Headgate Diversion | Sum of measured spills to river | Sum of deliveries to the field | +Col 2 - Col 4 | 1 -Weighted Average Efficiency of Application System for the District* | Col 4 x Col 6 | Col 5 + Col 7 | Estimated Percent Loss* | Columns 8 x Col 9 | Col 10/Col 2 |
| Example | 100 | 5 | 60 | 40 | 30% | 18 | 58 | 82% | 48 | 48% |
| Culbertson | | | | | 30% | | | | | |
| Culbertson Extension | | | | | 30% | | | | | |
| Meeker-Driftwood | | | | | 30% | | | | | |
| Red Willow | | | | | 30% | | | | | |
| Bartley | | | | | 30% | | | | | |
| Cambridge | | | | | 30% | | | | | |
| Naponne | | | | | 35% | | | | | |
| Franklin | | | | | 35% | | | | | |
| Franklin Pump | | | | | 35% | | | | | |
| Almena | | | | | 30% | | | | | |
| Superior | | | | | 31% | | | | | |
| Nebraska Courtland | | | | | 23% | | | | | |
| Courtland Canal Above Lovewell (KS) | | | | | 23% | | | | | |
| Courtland Canal Below Lovewell | | | | | 23% | | | | | |

*The average field efficiencies for each district and percent loss that returns to the stream may be reviewed and, if necessary, changed by the RRCA to improve the accuracy of the estimates.

# EXHIBIT 3 TO ATTACHMENT K

*Rights to Designated Groundwater*

Revised February 2009.

# Exhibit 3

## Rights to Designated Groundwater

| Field Number (1) | Permit #1 (2) | Permit #2 (3) | 1998-2007 Average Irrigated Acres (4) | 1998-2007 Average Annual Historical Consumptive Use (ac-ft/yr) (5) |
|---|---|---|---|---|
| 1-1 | 12967-FP | 16920-FP | 194 | 345 |
| 1-2 | 14403-FP | | 181 | 279 |
| 1-3 | 14019-FP | | 133 | 217 |
| 1-4 | 14018-FP | | 164 | 252 |
| 1-5 | 19372-FP | | 136 | 218 |
| 1-6 and 1-7 | 18780-FP | | 127 | 192 |
| **Subtotal** | | | **935** | **1,503** |
| 2-1 | 14396-FP | | 130 | 192 |
| 2-2 | 13858-FP | | 133 | 228 |
| 2-3 | 13859-FP | 16069-FP | 188 | 270 |
| 2-4 | 13857-FP | | 147 | 229 |
| 2-5 | 14398-FP | | 144 | 240 |
| 2-6 | 13856-FP | 16067-FP | 164 | 249 |
| **Subtotal** | | | **906** | **1,408** |
| 3-1 | 14397-FP | | 127 | 192 |
| 3-2 | 14027-FP | | 153 | 251 |
| 3-3 | 14022-FP | | 180 | 289 |
| 3-4 | 14023-FP | | 133 | 219 |
| 3-5 | 14600-FP | | 124 | 197 |
| 3-6 | 15285-FP | | 98 | 161 |
| 3-7 | 20896-FP | | 107 | 169 |
| **Subtotal** | | | **922** | **1,478** |
| 4-1 | 13513-FP | 16074-FP | 186 | 302 |
| 4-2 | 14028-FP | | 146 | 218 |
| 4-3 | 14753-FP | | 185 | 310 |
| 4-4 | 13522-FP | | 135 | 204 |
| 4-5 | 14024-FP | | 93 | 141 |
| 4-6 | 13509-FP | 16075-FP | 179 | 284 |
| 4-7 | 13511-FP | | 123 | 192 |
| 4-8 | 18781-FP | | 128 | 216 |
| 4-9 | 21476-FP | | 88 | 144 |
| 5-1 | 18783-FP | | 173 | 273 |
| **Subtotal** | | | **1,437** | **2,284** |
| 6-0 | 19004-FP | | 82 | 141 |
| 6-1 | 19005-FP | | 124 | 178 |
| 6-2 | 18966-FP | | 94 | 172 |
| 6-3 | 18018-FP | | 148 | 230 |
| 6-4,6-5 | 18017-FP | 19001-FP | 245 | 361 |
| 6-6, 6-7 | 23222-FP | | 148 | 230 |
| 6-8 | 18019-FP | | 107 | 173 |
| 6-9, 6-10 | 18014-FP | | 176 | 259 |
| 6-11,12,13,14 | 18013-FP | | 250 | 350 |
| 6-15, 6-16 | 18011-FP | | 244 | 431 |
| 6-17, 6-18, 6-19 | 18015-FP | | 329 | 549 |

# Exhibit 3

## Rights to Designated Groundwater

| Field Number (1) | Permit #1 (2) | Permit #2 (3) | 1998-2007 Average Irrigated Acres (4) | 1998-2007 Average Annual Historical Consumptive Use (ac-ft/yr) (5) |
|---|---|---|---|---|
| 6-20, 6-21 | 18012-FP | 19000-FP | 208 | 322 |
| **Subtotal** | | | **2,155** | **3,396** |
| 7-1 | 13813-FP | 16923-FP | 126 | 206 |
| 7-2, 7-2A | 13814-FP | | 219 | 334 |
| 7-3, 7-3a | 13815-FP | | 197 | 291 |
| 7-13, 7-14 | 14718-FP | | 358 | 526 |
| 7-15, 7-16 | 14121-FP | | 285 | 437 |
| 7-17, 7-18 | 14719-FP | | 263 | 455 |
| 7-19 [b)] | 14122-FP | | 131 | 215 |
| 7-21, 7-21A | 12589-FP | | 251 | 376 |
| 7-23 | 12567-FP | | 126 | 201 |
| **Subtotal** | | | **1,957** | **3,041** |
| Wiley | 4319-FP | 4922-FP | 65 | 75 |
| Wilder1 | 20198-FP | | 124 | 194 |
| Wilder2 | 20196-FP | | 163 | 249 |
| **Subtotal** | | | **352** | **518** |
| **Total** | | | **8,664** | **13,629** |

**Footnotes**

a) Change of use approved amounts on March 19, 2008.

b) Permit allows for irrigation of parcels 7-19 and 7-20. Only the portion of permit historically used to irrigate parcel 7-19 is included in this table.

**Explanation of Columns**

(1) Field Number.

(2) Final permit for the Northern High Plains Designated Ground Water Basin.

(3) Second permit associated with the permit shown in column 2. Typically, these are permits for additional acreage, but see permit for details.

(4) Average acreage reported in change of use form used to determine values in Column 5.

(5) Historical consumptive use determined from irrigated acreage, crop records and power records. Values as specified in March 19, 2008 and December 8, 2008 DWR Publication letters.

# EXHIBIT 4 TO ATTACHMENT K

Examples of Delivery Limitations

Revised August 5, 2009

# ATTACHMENT A

# AGENDA

**Hypothetical** **Calculations of the Projected Delivery and the Limit on Augmentation Water Sup** 8/5/2009

| A | B | C | D | E | F | G | H | I | J | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Colorado's Total Allocation | Computed Beneficial Consumptive Use | Deficit or Difference | Projected Delivery | Max Aug. Water Supply (AWS) Credit | Measured Pipeline Deliveries | Annual Calculation = Alloc - (CBCU - Deliveries) | Five-year running average | ***Limited??*** | Remarks |
| | | | | | | | | | | |
| 1993 | 42,214 | 35,274 | 6940 | | | 0 | 6,940 | | | |
| 1994 | 35,831 | 32,967 | 2864 | | | 0 | 2,864 | | | |
| 1995 | 40,714 | 35,125 | 5589 | | | 0 | 5,589 | | | |
| 1996 | 39,659 | 36,469 | 3190 | | | 0 | 3,190 | | | |
| 1997 | 32,641 | 35,442 | (2801) | 0 | 4,000 | 0 | -2,801 | **3156** | | No previous deficit; therefore, Max AWS Credit is 4000 af |
| 1998 | 33,294 | 36,148 | (2854) | 2,801 | 6,801 | 4,000 | 1,146 | **1998** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger Minimum 4000 af delivery |
| 1999 | 37,782 | 38,217 | (435) | 2,854 | 6,854 | 4,000 | 3,565 | **2138** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger Minimum 4000 af delivery |
| 2000 | 31,427 | 37,691 | (6264) | 2,854 | 6,854 | 4,000 | -2,264 | **567** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger Minimum 4000 af delivery |
| 2001 | 27,572 | 36,132 | (8560) | 6,264 | 10,264 | 4,000 | -4,560 | **(983)** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger Minimum 4000 af delivery |
| 2002 | 20,741 | 35,228 | (14487) | 8,560 | 12,560 | 4,000 | -10,487 | **(2520)** | | Max AWS Credit is Projected Delivery plus 4000 af because it is larger Minimum 4000 af delivery |
| 2003 | 21,420 | 33,470 | (12050) | 14,487 | 20,282 | 4,000 | -8,050 | **(4359)** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2004 | 22,540 | 33,670 | (11130) | 14,487 | 20,282 | 13,629 | 2,499 | **(4572)** | | Deliveries begin, but limited to Hist. CU b/c there has been no banking |
| 2005 | 25,040 | 35,460 | (10420) | 14,487 | 20,282 | 13,629 | 3,209 | **(3478)** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2006 | 21,090 | 30,760 | (9670) | 14,487 | 20,282 | 13,629 | 3,959 | **(1774)** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2007 | 24,520 | 32,850 | (8330) | 14,487 | 20,282 | 13,629 | 5,299 | **1383** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2008 | 27,000 | 32,000 | (5000) | 14,487 | 20,282 | 4,000 | -1,000 | **2793** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2009 | 27,000 | 33,000 | (6000) | 14,487 | 20,282 | 4,000 | -2,000 | **1893** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2010 | 27,000 | 33,000 | (6000) | 14,487 | 20,282 | 4,000 | -2,000 | **852** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2011 | 21,000 | 33,000 | (12000) | 14,487 | 20,282 | 20,500 | 8,282 | **1716** | ***Limited to Max*** | Deliveries > Hist. CU b/c of banking, but Max AWS Credit applies |
| 2012 | 27,000 | 32,000 | (5000) | 14,487 | 20,282 | 4,000 | -1,000 | **456** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2013 | 27,000 | 33,000 | (6000) | 12,050 | 16,870 | 4,000 | -2,000 | **256** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2014 | 32,641 | 35,442 | (2801) | 12,000 | 16,800 | 4,000 | 1,199 | **896** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2015 | 33,294 | 36,148 | (2854) | 12,000 | 16,800 | 4,000 | 1,146 | **1525** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2016 | 37,782 | 38,217 | (435) | 12,000 | 16,800 | 4,000 | 3,565 | **582** | | Max AWS Credit is 140% of Projected Delivery because it is larger Minimum 4000 af delivery |
| 2017 | 31,427 | 37,691 | (6264) | 12,000 | 16,800 | 6,500 | 236 | **829** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2018 | 27,572 | 36,132 | (8560) | 12,000 | 16,800 | 9,000 | 440 | **1317** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2019 | 20,741 | 35,228 | (14487) | 12,000 | 16,800 | 13,000 | -1,487 | **780** | | Max AWS Credit is 140% of Projected Delivery because it is larger |
| 2020 | 21,420 | 33,470 | (12050) | 14,487 | 20,282 | 13,000 | 950 | **741** | | Max AWS Credit is 140% of Projected Delivery because it is larger |

= formula amended to account for lack of data for 10 yrs

A Accounting Year
B From RRCA Accounting
C From RRCA Accounting
D Allocation (B) minus CBCU ©
E Largest Deficit in previous 10 years
F E + 4000 or E * 140% whichever is larger
G Augmentation Water Pumped during the accounting year
H Annual Calculation = Alloc - (CBCU - Deliveries) (B-(C-G))
I Running Average = ave of this year plus previous 4 years (Column H)
J Flag that notes if pumping (G) exceeds AWS limit (F)

# ATTACHMENT L

## RESOLUTION PROPOSED BY NEBRASKA
*Regarding the*
CREDITING ISSUE
AUGUST 12, 2009

## RESOLUTION OF THE REPUBLICAN RIVER COMPACT ADMINISTRATION

## NEBRASKA'S CREDITING ISSUE

**Whereas**, the States of Kansas, Nebraska and Colorado entered into a Final Settlement Stipulation (FSS) as of December 15, 2002, to resolve pending litigation in the United States Supreme Court regarding the Republican River Compact (Compact) in *Kansas v. Nebraska and Colorado*, No 126 Original;

**Whereas**, the FSS was approved by the United States Supreme Court on May 19, 2003;

**Whereas**, by letter dated June 15, 2009, the State of Nebraska identified a concern regarding the appropriate mechanism by which to recognize in the annual accounting a payment for damages based on a past failure to comply with the Compact;

**Whereas**, the States agree that Nebraska's proposed resolution of the "Crediting Issue" is acceptable and that the Republican River Compact Administration should adopt Nebraska's proposal; and

**Whereas**, the Crediting Issue has been properly presented and Submitted to the Republican River Compact Administration the Crediting Issue Pursuant to Section VII of the FSS.

**Now, therefore**, it is hereby resolved that the Republican River Compact Administration approves and adopts the proposal set forth in Nebraska's June 15, 2009 letter, a copy of which is attached hereto as Exhibit A and incorporated as if the same were set forth fully herein.

Approved by the Republican River Compact Administration this 12th day of August, 2009.

____________________________ ______________________

Brian Dunnigan, P.E. Date
Nebraska Member
Chairman

____________________________ ______________________

David Barfield, P.E. Date
Kansas Member

____________________________ ______________________

Dick Wolfe, P.E. Date
Colorado Member

2009 RRCA Annual Report

____________________________________
Brian Dunnigan, Chair, Nebraska Commissioner

____________________________________
David W. Barfield, Kansas Commissioner

____________________________________
Dick Wolfe, Colorado Commissioner