Appendix J

STATUS OF AGREEMENT ON RRCA GROUND WATER MODEL

As of November 15, 2002

DOCUMENT CONTEXT

The purpose of this document is to summarize the status of the RRCA Ground Water Model. Agreement has been reached among the State of Colorado, State of Kansas, and State of Nebraska in consultation with the United States in the selection of model calibration targets and methods to estimate groundwater pumping and recharge. The RRCA Ground Water Model will be applied in a consistent manner with the RRCA Accounting and Reporting Procedures to ensure consumptive uses from surface water and ground water are properly accounted for. General agreement has also been reached on the process to calibrate the RRCA Ground Water Model. The States and United States agree that coordinated efforts will continue to refine data inputs and model calibration until completion, on or before July 1, 2003.

MODEL DESCRIPTION

The primary purpose of the RRCA Ground Water Model is to quantify within the Republican River Basin the amount, location, and timing of depletions to stream flow from ground water pumping and accretions to stream flows due to imported water supply from outside the basin. The major structural components of the model are:

? The model uses MODFLOW 2000 with the following modules: BAS1, RCH, WEL, STR, EVT, DRN, CHD, and LPF.

? The model domain extends beyond the Republican River watershed from the Platte River in the north and to the Ogallala aquifer outcrops on the southern, eastern, and western boundaries. The model domain coincides with that described in USGS Open File Report 02-175 except in the eastern portion of the Basin where it was extended eastward to the eastern edge of Kearney County, Nebraska and into Adams County, Nebraska to reflect increased water table elevations caused by imported water supplies from the Platte River. The model domain encompasses approximately 30,000 square miles.

? Constant head boundary conditions for the model were assigned along the Platte River, the eastern boundary of Kearney, Clay, Nuckolls, and Adams Counties, Nebraska; and in Cheyenne County, Colorado where the Republican River exits the domain. All other boundaries are no-flow boundaries. See attachment RRCA Ground Water Model Domain.

? The model represents the long term steady-state conditions up to 1940 and transient conditions from 1940 to 2000. Transient conditions are discretized into monthly stress periods. The model will be updated annually by the RRCA to reflect data from 1940 to the current accounting year.

? The model is discretized into one-square mile grid cells.

? The model is a single layer bounded on the bottom by the impermeable Pierre Shale.

? As an interim measure, Saturated Thickness is based upon an average saturated thickness for the period 1940-2000; values were obtained by kriging across the model domain between known data points. The minimum saturated thickness in a model cell is 10 feet.
? Stream Network was taken from USGS File Report 02-175.
? The interim aquifer base was taken from USGS File Report 02-175, and is subject to adjustment to reflect elevation variances near streams.
? Land surface elevations were obtained the National Elevation Dataset (NED) one arc second Digital Elevation Model (DEM).
? The aquifer is represented as confined in the present model structure, but will be changed to unconfined aquifer conditions prior to final model calibration.
? Initial hydraulic conductivity and specific yield estimates were taken from USGS File Report 02-175 and are subject to adjustment in model calibration.

CALIBRATION TARGETS

WATER LEVEL

Ground water levels have been measured throughout the Basin since the early 1900's, but the number of sites increased dramatically post-World War II. The source of ground water level information used in the RRCA Ground Water Model is the Ground Water Site Inventory (GWSI) maintained by the United States Geological Survey (USGS) in cooperation with all three States. The tenure of static ground water level data ranges from a single-year measurement at a discrete location to a continuum of annual measurements that began in the early 1950's and continues to date at the same well. Ground water levels are typically measured once each year, usually in the non-irrigation season when effects from irrigation pumping are minimized. The RRCA Ground Water Model is calibrated to a ground water level data set that contains a total of 350,233 water level records at 10,835 different sites. The GWSI dataset was converted from latitude/longitude to a X-Y coordinate system. The entire dataset, including one-measurement water levels, is available for model calibration except for wells that were determined by the representative State to be clearly erroneous. Water level data from continuous recorders are not presently being applied. A procedure to weight water level targets during the calibration process may be utilized. Additional water level targets may be included upon agreement by all States.

BASEFLOW

Hydrograph separation is a technique that partitions the amount of surface water and ground water that is measured as total streamflow at a river gaging station. Determining the component of total streamflow that is contributed by ground water (also called baseflow) requires professional expertise and judgment. The hydrograph separation analysis used in this application is referred to as the Pilot Point method. This procedure was adopted for application in this ground water model since it combines the increased accuracy of graphical baseflow analysis with the computational efficiency afforded by electronic spreadsheets. Daily streamflow information for one, or multiple years, is easily tabulated in a Microsoft Excel© electronic spreadsheet. Daily hydrographs are subsequently plotted using the graphics package. The analyst performing the baseflow separation uses the tools available in the electronic graphics package to select pilot or turning points that signify the baseflow component in the total amount of streamflow measured at a river gaging station. A significant contribution of the graphics and computational package afforded by Microsoft Excel© is the flexibility to easily change the assignment of each pilot or turning point upon comparative review with other nearby streamflow hydrographs or in collaboration with another analyst. The analyst may change one or multiple pilot points using the click-and-drag tool to another turning point and instantly recalculate the amount of baseflow for a defined period of time – from a month up to decades. Use of the electronic graphical/computational Pilot Point method also dampens the objectivity criticism of the traditional hand-graphics technique performed by an individual analyst.

For the RRCA Ground Water Model, fifty-seven (57) independent baseflow analyses were performed and adopted as calibration targets. A summary of the estimated monthly baseflows of each analysis is attached. Existing baseflow targets may be revised if found to be flawed, and additional baseflow targets may be adopted upon unanimous agreement by the RRCA Ground Water Modeling Committee. Adjustments for surface water diversions may also be considered and adopted by the RRCA Ground Water Modeling Committee, upon unanimous agreement.

As a supplement to the baseflow separation information developed for selected gaging stations and stream segments, Nebraska compiled miscellaneous streamflow measurements and synoptic baseflow survey data available from the USGS and State of Nebraska into a Microsoft Access© electronic database. The data were collected periodically since 1975, except for the data provided in the USGS Water Supply Paper 779, which were collected in the late 1920's and early 1930's. The synoptic baseflow data has not been included in model calibration to date, but is available for review and consideration in the final model calibration.

PUMPING

The pumping for municipal and industrial purposes was obtained from the USGS. Each State developed its own estimate of gross irrigation pumping. The following general methodologies for estimating ground water pumping have been agreed to by the States. The States commit to mutual verification of pumping datasets, primarily by comparison to meter records (where available) and to a lesser extent by power records, and independent CIR calculations. The RRCA Ground Water Modeling Committee will continue to refine pumping estimates on commingled irrigated lands in Nebraska.

<u>Colorado</u>

The State of Colorado employed a seven-step procedure to estimate ground water pumping:

1. Total acres irrigated by surface and ground water is estimated for each county based upon data from the respective County Assessor's Office for the area contained in the RRCA Ground Water Model boundaries.
2. The acreage irrigated by surface water is identified from the County Assessor's Records
3. The acreage irrigated by ground water is calculated as the difference between the total acreage and the acreage irrigated by surface water.
4. The maximum farm efficiency for center-pivot sprinkler irrigation and flood irrigation is estimated for each year.
5. The percent of acreage irrigated by center-pivot sprinkler is estimated for each county for each year.
6. The crop water requirement is estimated for each county using the Hargreaves empirical formula calibrated to the Penman-Montieth method for reference crop evapotranspiration. The crop mix for each county is determined from County Assessor records. The effective precipitation is estimated using the procedure outlined in Irrigation Water Requirements, Technical Release No. 21, United States Department of Agriculture, April 1967 (Revised September 1970). The crop irrigation requirement is calculated as the total or potential crop water requirement minus the effective precipitation.
7. Pumping for each county is estimated as Irrigated Ground water Acreage multiplied by Crop Irrigation Requirement multiplied by Fraction of Crop Irrigation Requirement satisfied. This total is then divided by the maximum farm efficiency. The maximum farm efficiency is a weighted average based on the amount of sprinkler and flood irrigation.

Kansas

The State of Kansas uses the following procedure to estimate irrigation pumping for the period of 1940 – 1988:

1. Determine the potential evapotranspiration (PET) for the irrigated area and crops determined for the study area.
   a. Compute reference ET with the Penman-Montieth method for years when detailed climate data are available.
   b. Develop calibration coefficients for the Hargreaves method to use prior to availability of detailed weather data.
   c. Compute crop PET for study period.
   d. Compute effective precipitation.
   e. Determine crop distribution from county level crop statistics.
   f. Compute crop demand for irrigation water (CIR) on a unit basis (inches per acre).

STATE OF NEBRASKA

DEPARTMENT OF NATURAL RESOURCES
Roger K. Patterson
Director

October 23, 2002

IN REPLY REFER TO:

Mike Johanns
Governor

To: Tom Riley

From: Steve Gaul Steve

Subject: Forwarding of Republican River Alluvial Mapping Material

Tom, enclosed are copies of a disk and a memo of work we did on a Republican River alluvial aquifer mapping project. We are mailing the associated map in a separate tube. Kevin Schwartman, our geologist headed up work on this effort. If you have any questions, Kevin's phone number is 471-3958 or mine is 471-3955.

sg
Enclosures

clrshare/planning

301 Centennial Mall South, 4th Floor • P.O. Box 94676 • Lincoln, Nebraska 68509-4676 • Phone (402) 471-2363 • Telefax (402) 471-2900

Draft 4/12/02

Confidential – Attorney Client Privilege Document

Potential Examination of Options for Water Right Purchase from Nebraska Bostwick in Order to Meet Obligations to Kansas

General Idea - Pay Nebraska Bostwick for rights to water in order to meet dry year obligations to Kansas. Suggest a lump sum payment for a multi-year period and then an additional payment for water that is actually used. Nebraska Bostwick can use the money for system improvements that increase the water use efficiency of their operation.

Assignment - Work up some ballpark numbers on:

1. How much water is needed
2. How much it might cost per acre foot
3. What type of revenue might be generated for the district
4. What system improvements needed for the District might cost

Notes on Conversation with Roger –

To Nebraska Bostwick:

- We will give you an upfront payment of X $.
- This payment entitles us to X acre feet in all years
- In years where it is called on we will pay X $ per acre foot more
- This should supply you with X $ for system improvement
- In times of shortage there may be a way to augment with groundwater???
- If in 10 years we call on water 4 times, that could be $2.4 million up front plus X $.
- 1.4 Million by 40,000 = $35 per acre foot
- Systems must increase efficiency by 8%

Bostwick Improvement Options Needing Study

Done
1. Improve Canal Efficiencies
   a) Bury Laterals
   b) Increase Capacity
   c) Line Canals
2. Add Wells in Reach Downstream of Guide Rock
3. Add Reservoirs on Tributaries
4. Add Irrigation Reuse Pits and Farm Ponds

Information Needed

1. Current O&M Costs for Water per Acre Foot
2. Delivery Costs
3. How many Miles of Lateral and Trunk do they have? Buried or open lateral?
4. 5972 acres irrigated are through Superior Canal. How many would need to be subject to call and what is the difference between dryland and irrigated net income?