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Requirements for Nebraska's Compliance with the Republican River Compact

Prepared by

Spronk Water Engineers, Inc

Dale E. Book, P.E.

DALE E. BOOK LICENSED 14313 11-18-11 KANSAS PROFESSIONAL ENGINEER

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1.0 Introduction

This report describes the analysis made to determine the reductions in Groundwater Computed Beneficial Consumptive Use (GW CBCU) necessary in Nebraska to achieve compliance with the Republican River Compact as implemented by the Final Settlement Stipulation (FSS). Nebraska's CBCU exceeded the allocation above Guide Rock for the two-year Water-Short Year test applied to 2005 and 2006. For the five-year period of 2003 through 2007, Nebraska's statewide CBCU also exceeded its statewide allocation. For the four years of 2003 through 2006, Nebraska's statewide CBCU has exceeded allocations by a total of 141,260 acre-feet using the Kansas methodology.

The analysis described in this report computes the level of GW CBCU that could occur within Nebraska's allocation to achieve compliance with the five-year test. Achieving compliance by pumping reductions assumes the surface water use by senior water rights in Nebraska continues into the future. The basic approach was to determine the level of pumping and associated GW CBCU that could be sustained and still achieve compliance with Nebraska's allocation.

Nebraska's GW CBCU has been increasing and is projected to continue to increase into the future, as the effects of past pumping, combined with continuing pumping reach the surface streams in the basin. Therefore, projections of future GW CBCU are necessary to consider the effects of past pumping. Given the overuse of allocation that occurred, pumping reductions going forward are necessary to balance CBCU and allocations over a dry period similar to the recent period of lower allocation. Nebraska's total CBCU is the combination of GW CBCU attributed to pumping and surface water CBCU, which consists of canal diversions, reservoir evaporation and pumps diverting from the streams. Much of the surface water use is by the Reclamation project reservoirs and canals.

The level of future GW CBCU, when combined with the surface water CBCU, that would maintain the total use within the allocations that occurred over the five-year period of 2002 – 2006 was determined. The RRCA Groundwater Model was used to determine reductions in pumping that would be necessary to achieve this level of CBCU. The limitation on pumping is expressed as a region of no irrigation pumping, which, if implemented at the present, would allow the CBCU to be within Nebraska's allocation in the future if water supply conditions and allocations similar to the five-year period are repeated. Compliance with the Water-Short Year standard would require that additional reduction of surface water CBCU or equivalent offset be supplied.

When the GW CBCU is reduced from historical amounts, the resulting additional streamflow in Nebraska would be subject to diversion and storage by the surface water facilities in Nebraska. It is necessary to consider the increase in Nebraska surface water use compared to historical use, when assessing the benefit of reduced GW CBCU to achieve compliance. The changes to surface water supply resulting from pumping reductions were evaluated to estimate changes in surface water use for the historical period under consideration. The amount of GW CBCU determined from this analysis is a reduction from the levels of GW CBCU that occurred for the five-year period 2002 – 2006, of approximately 200,000 acre-feet/year. The projected effects of these reductions on total CBCU in Nebraska and compliance with the FSS over this period were evaluated.

2.0 Criteria and Assumptions

The level of GW CBCU that would allow the total CBCU to be within Nebraska's allocation available over the five-year period of 2002 through 2006 was determined as follows: The approximate level of GW CBCU, in combination with the historical amount of surface water CBCU, that would provide a balance with the allocation was determined for this period. A Groundwater model projection was developed using historical precipitation and pumping conditions. Historical pumping was reduced to account for limitations adopted in current Integrated Management Plans (IMPs). The projection of baseline pumping impacts was compared to the estimated limit of GW CBCU. Reductions in pumping to achieve the limit were made within an area along the streams in Nebraska. The size of the reduction area was determined to achieve the necessary level of CBCU in the future. By establishing a reduction corridor along the streams, a more efficient benefit to streamflow occurs than if reductions were spread throughout the basin by priority or on a uniform basis.

The projections were made by repeating 15 year cycles of 1995 – 2009, extending beyond 2009. The results from the 3rd cycle were used for this analysis, which corresponds to a timeframe of 30 to 45 years in the future. With pumping continuing at expected levels, depletions continue to increase beyond that time. This analysis identifies pumping reductions necessary at the present to limit GW CBCU to levels that will provide compliance over this timeframe. It is recognized that the continuing upward trend in pumping depletions beyond that time would necessitate further reductions in pumping to maintain compliance beyond that time.

The increased streamflow, corresponding to the change in GW CBCU computed by the Groundwater model, was determined for the years 2002 – 2006. This was used to evaluate resulting changes in the amount of Nebraska surface water use expected to occur. The analysis of changes in surface water use over these years was made for a range of results from the GW model projection and a relationship between change in GW CBCU and expected change in surface water use developed. This relationship was used to determine the net effect of changing the GW CBCU. The net change in Nebraska GW and surface water CBCU was then compared to the Nebraska allocation for the period. The pumping reduction was derived to provide a balance between the allocation and total CBCU.

The analysis is based on the following criteria and assumptions:

- CBCU should not exceed the statewide allocation, over a five-year period.
- Reductions in CBCU necessary to achieve compliance are assumed to be accomplished from reductions in groundwater irrigation pumping, as represented in the groundwater model simulation.
- The level of GW CBCU to achieve compliance would be determined for depletions projected 30 to 45 years out.
- Surface water use in Nebraska would be increased due to the reduced GW CBCU and resulting increase in streamflow.
- The Imported Water Supply Credit was computed with the RRCA Groundwater Model for the adjusted pumping conditions.
- Compliance with the two-year standard for Water-Short conditions would require reduction in surface water use, in addition to the pumping reductions.
- The time required for GW CBCU, as quantified with the RRCA Groundwater model, to decline to the necessary level will be several years. Until CBCU is reduced to that level, other reductions may be needed to achieve compliance.

3.0 Description of Analysis

3.1 Compliance Status for 2002 - 2006

Using available compact data, the five-year average statewide allocation to Nebraska over the period of 2002 - 2006 was 211,000 acre-feet/year. The amount of overuse for the same period averaged 31,000 acre-feet/year. Table 1 shows the actual FSS accounting for this period. This is obtained from Table 3C of the RRCA accounting, which compares Nebraska's CBCU to its statewide allocation for each of the five years. GW CBCU averaged 201,000 acre-feet/year and surface water CBCU averaged 53,000 acre-feet/year. The surface water CBCU consists of the project canals, reservoir evaporation and use of small surface water pumps and ditches. The historical Imported Water Supply (IWS) Credit over this period averaged 12,000 acre-feet/year, as determined by the RRCA Accounting Procedures and the RRCA GW Model.

3.2 Groundwater CBCU

The RRCA Groundwater model was used to determine the GW CBCU for a projection period extending into the future. The historical period of 1995 – 2009 was used for projections. Four cycles were projected, extending out 60 years beyond the historical period. The projection is necessary to account for increasing stream depletions due to past and expected future pumping. The pumping for the projections was reduced from historical levels throughout the NRD areas to correspond to allocations imposed by the NRDs since 2007.

A series of model runs were made with reductions to pumping. Pumping reductions were made by eliminating pumping from selected areas along the stream corridors in Nebraska. The size of the corridor determined to be necessary was nominally five miles wide, centered on the streams. The pumping reduction was then set throughout this corridor at various levels, including 100%, 90%, 80%, etc. The amount of area for which pumping is eliminated to achieve compliance with the 2002 – 2006 allocation was determined for the corresponding GW CBCU. (The modeling analysis is described in more detail in Mr. Larson's report, *Reducing future Impacts of Pumping on Ground Water Consumptive Use*)

It is necessary to reduce the groundwater CBCU by more than the actual deficit, to account for increased surface water CBCU that would occur in Nebraska, as a result of the increased streamflow.

3.3 Surface Water CBCU

3.3.1 Description of Analysis

The amount of increased surface water use in Nebraska was computed, using an analysis of changes in surface supply upstream of the Project reservoirs and canals in Nebraska corresponding to reduction in GW CBCU. For the storage conditions that existed during these years, increased flows could have been diverted for irrigation in Nebraska, with some additional reservoir storage and evaporation also occurring. This section describes the assumptions and results of the analysis.

The purpose of the surface water analysis was to determine how the additional streamflow due to decreased pumping in Nebraska would have been distributed and used by the Nebraska surface water projects and consumed in Nebraska. The results are intended to develop a relationship between increased streamflow and change in Nebraska surface water CBCU over the specific period evaluated.

Data relied on for the analysis consisted of summaries of Bureau of Reclamation reservoir and canal data, supplied by the Kansas Division of Water Resources. The historical diversions, losses and reservoir data were used as the base for the analysis.

3.3.2 Assumptions

1. The RRCA groundwater model was used to quantify the changes to streamflow in Nebraska resulting from reductions in pumping. Results were obtained from model output on a monthly timestep at a number of locations in the stream system. Differences between historical and projected GW CBCU were calculated over the years 2002 – 2006.

2. The changes in streamflow, referred to as impacts, caused by pumping reductions would increase the supply available for surface water use in Nebraska, as well as increase the supply available to Kansas.

3. Surface water diversions and storage would be increased due to increased streamflow, resulting in additional surface water CBCU in Nebraska. Additional water would be regulated through the project reservoirs in Nebraska: Swanson, Enders, Hugh Butler, Harry Strunk and Harlan County.

4. Canals would divert additional water only during the irrigation season, defined as May through September. Additional diversions were considered to occur only for canals that actually diverted and up to historical demand levels. During the non-irrigation season additional water would be stored in project reservoirs, subject to available space.

3.3.3 Reservoir Operations

Impacts available in reaches above project reservoirs were considered to be storable and divertible, due to the large amount of available capacity and unmet crop demand that existed over the period. Releases to downstream canals would be made during the irrigation season based on historical demands. Reservoirs would release additional water during the irrigation season months and store during the other months. Additional water in Harlan County Reservoir is attributable to three sources: upstream impacts, return flows from upstream canal operations and upstream reservoir spills. The last category would have been minimal during the study period.

Monthly evaporation rates were calculated based on historical data for each reservoir. Additional evaporation was calculated by applying these rates to the change in reservoir area. The additional water in storage was then adjusted by the net change in evaporation.

The reservoirs deliver water to multiple service areas located within the projects and some canals divert storage water from multiple reservoirs. Harlan County Reservoir releases water for five canals. A relationship was developed between these releases and the distribution to downstream canals based on the historical release and diversion. A distribution percentage of diversion as a function of reservoir release was calculated for each canal and applied to the available water in Harlan County.

Additional storage in the reservoirs was allowed up to the top of the conservation pool capacity. Any additional inflow when storage was at the maximum capacity was routed through the reservoir as a spill.

3.3.4 Canal Operations

Canal operations in the analysis consisted of demands for additional diversion, canal loss and irrigation efficiency for delivered water.

3.3.4.1 Demands

A monthly canal demand schedule was generated from historical diversion data. The period 1960 – 2007 was used to generate demands for only the irrigation season. It was assumed that the canals would not divert any additional water during the non-irrigations months, October – April. The monthly demand was calculated as the maximum historical diversion for that particular month. A seasonal max demand was applied to the canals. The seasonal demand limit was the maximum season, May – September, total for the period.

3.3.4.2 Losses

Monthly data, for the May – September season, were used to develop relationships of losses to diversions. The historical data were used to determine these relationships. In deriving the relationships, data points were excluded if:

1. There were no diversions for the month.

2. There were diversions, but no farm deliveries.

3. Farm delivery amount exceeded the amount diverted.

The additional water supply computed to be available to the canals was added to the historical supply. The system efficiency for delivery of the additional water supply to the farms was based on the delivery efficiency corresponding to the total supply. This was determined by applying the derived canal loss functions to the historical diversions, with and without the additional supply, and taking the difference to determine the incremental canal loss. Appendix A shows the relationships for canal loss that were used in this analysis.

After deducting these losses, the remaining supply deliverable to farms was computed. Field loss factors by canal were obtained from the RRCA accounting spreadsheet and applied to the delivery amount.

Return flow results from canal and field losses. Consistent with the RRCA accounting procedures, 18% of these losses were assumed to be consumed and the balance becomes return flow to the stream. Recharge return flows were assumed to accrue to the stream at a steady state, over twelve months.

A minimum diversion threshold was applied to the sum of the historical and additional canal supply. If available flow or storage, when combined with the historical canal operations, was not enough to satisfy the minimum diversion then the canal would not divert any additional supply. Historical canal operations were not affected by the minimum allowable canal diversion. Minimums were applied to reflect historical operations and avoid excessive losses. A minimum was not applied to the Courtland Canal. It was allowed to divert additional return flows and impacts in the river at the time that they were available during the irrigation season. If a canal had not diverted during a month, additional diversion was not calculated for that month.

3.3.4.3 Superior and Courtland Canal

Additional supply for the Courtland and Superior Canals, which divert at Guide Rock, consisted of three sources of water: impacts from the reach Harlan County Reservoir to Guide Rock, return flows from upstream canals and water stored in Harlan County Reservoir. A monthly net impact was calculated by combining the impacts and return flows. The canals used the additional net impacts available before releases from Harlan County Reservoir were made. Gains that are not considered divertible due to timing or location accrue to the Hardy gage.

3.3.5 Results of Surface Water Analysis

The analysis was made over a range of changes in streamflow to evaluate how the amount of increased flow would affect the surface water use that occurred over the 2002 – 2006 period.

Change in Nebraska surface water CBCU was computed as the sum of the additional irrigation CBCU and the change in net reservoir evaporation resulting from the change in streamflow. The change in GW CBCU was plotted against the change in surface water CBCU for the different levels of reduction. Figure 1 shows the relationship obtained over a range of streamflow effects. At the level of reduced CBCU derived from this analysis, the average change in CBCU was 26% of the reduction in GW CBCU. Results of the surface water analysis are summarized in Appendix A.

3.4 Imported Water Supply Credit

The Imported Water Supply Credit was determined using the RRCA Groundwater Model, with the projected future level of pumping determined from this analysis. The computed credit averaged approximately 28,000 acre-feet/year over the five-year period. Actual credit into the future would of course depend on the amounts of continued importation of Platte River water into the basin.

4.0 Results of Analysis

1. The average annual historical allocation for Nebraska for 2002 - 2006 was 211,000 acre-feet/year. The actual use, including both surface and groundwater, averaged 254,000 acre-feet/year. After adjusting for the Imported Water Supply Credit, the CBCU exceeded the allocation by 31,000 acre-feet/year.

2. A 90% reduction in the nominal five mile corridor reduced Nebraska's GW CBCU to 178,000 acre-feet/year and corresponded to retiring 316,000 acres of irrigation. This level of reduction results in Nebraska CBCU less than the full statewide allocation for the five year period, as shown on Table 2. A pumping reduction of 80% reduced Nebraska's GW CBCU to 187,000 acre-feet/year and corresponded to retiring 281,000 acres of irrigation. Table 3 demonstrates that this level of reduction results in an overuse of 5,000 acre-ft/year.

3. When the groundwater CBCU is reduced to 181,000 acre-feet/year, average surface water CBCU would have increased from 53,000 to 58,000 acre-feet/year. Imported Water Supply Credits would be approximately 28,000 acre-feet/year. The reduction in area necessary to achieve this level is 302,000 acres.

4. The total CBCU that could occur within Nebraska's allocation is 239,000 acre-feet/year with the estimated Imported Water Supply Credit.

5. The GW CBCU must be reduced to 181,000 acre-feet/year to achieve a balance with the statewide allocation over the five year period.

5.0 Conclusions

The Nebraska beneficial consumptive use has exceeded the statewide allocation for each of the years 2002 - 2006. The five-year total for the period of 2003 - 2007 is expected to exceed the allocation over that period, given the status of the accounting through 2006. Based on the allocations for the years 2002 – 2006, it would be necessary to reduce the total CBCU to approximately 239,000 acre-feet/year for Nebraska to be in compliance with the FSS.

A reduction of GW CBCU in Nebraska from 201,000 to 181,000 acre-feet is necessary to maintain compliance with the five-year test of the FSS over a period of similar water supply conditions. This would result in a balance between CBCU and allocation. To limit CBCU to this level would require that pumping be eliminated now for an area of 302,000 acres located within a corridor approximately five miles wide along the streams in Nebraska.

To achieve compliance with the Water-Short Year periods, additional reductions to CBCU beyond those described above will be necessary. It would be necessary to limit surface water consumptive use or provide equivalent offsets from alternate sources.

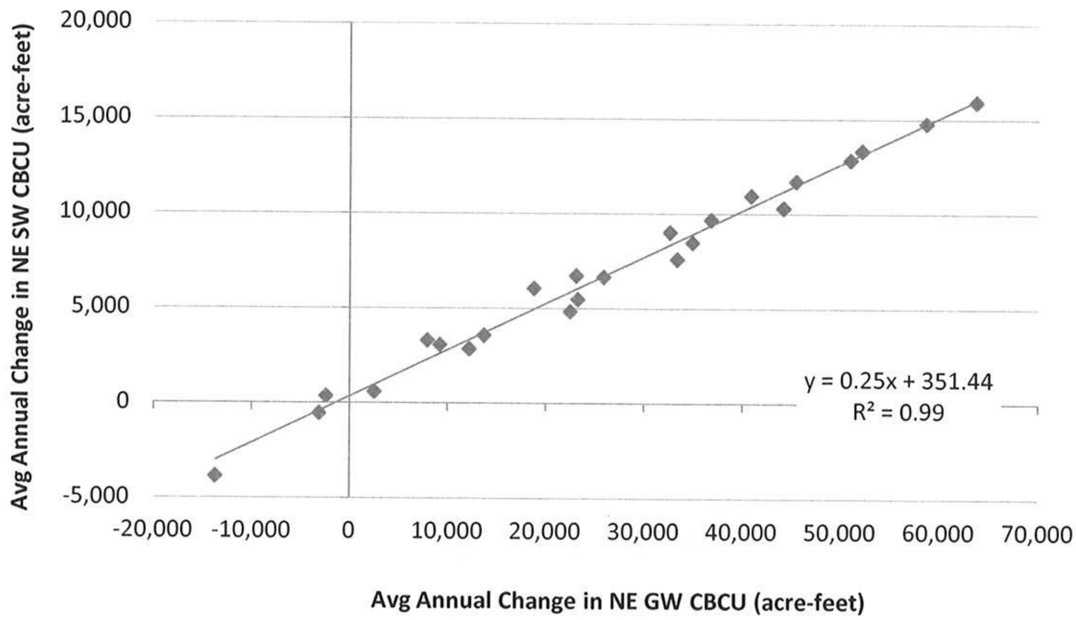
6.0 References

1. Perkins, S.P. and Larson, S.P., (2001), "Reducing Future Impacts of Pumping on Ground Water Consumptive Use"
2. RRCA Accounting spreadsheets
3. US Bureau of Reclamation spreadsheet data provided by KDWR (reservoir data)
4. US Bureau of Reclamation provided project data (diversions, farm deliveries)
5. US Bureau of Reclamation HYDROMET database (http://www.usbr.gov/gp/hydromet/)
6. URNRD, 2010, "INTEGRATED MANAGEMENT PLAN Jointly Developed by the DEPARTMENT OF NATURAL RESOURCES and the UPPER REPUBLICAN NATURAL RESOURCES DISTRICT".
7. MRNRD, 2010, "INTEGRATED MANAGEMENT PLAN Jointly Developed by the DEPARTMENT OF NATURAL RESOURCES and the MIDDLE REPUBLICAN NATURAL RESOURCES DISTRICT".
8. LRNRD, 2010, "INTEGRATED MANAGEMENT PLAN Jointly Developed by the DEPARTMENT OF NATURAL RESOURCES and the LOWER REPUBLICAN NATURAL RESOURCES DISTRICT".

FIGURE

Figure 1

Relationship Between Change in Nebraska GW CBCU and Change in Surface Water CBCU
Average Annual acre-feet



TABLES

Table 1

Nebraska's Historical Compact Compliance
2002 - 2006
acre-feet

Table 3C: Nebraska's Five-Year Average Allocation and CBCU

Year	Statewide Allocation	Ground Water CBCU	Surface Water CBCU	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2002	236,550	180,438	85,472	14,000	-15,360
2003	227,580	204,164	58,616	9,782	-25,420
2004	205,630	213,115	39,535	10,386	-36,630
2005	199,450	210,879	42,861	11,965	-42,330
2006	187,060	198,412	37,738	12,214	-36,880
Average	211,254	201,402	52,844	11,669	-31,320
Total	1,056,270	1,007,008	264,222	58,347	-156,610

Source: RRCA accounting spreadhseets

Table 2

Estimated Effect on Compliance from a Reduction in Nebraska's Pumping: 2002 - 2006

90% Reduction in the Nominal Five Mile Corridor

(1000 acre-ft)

Table 3C: Nebraska's Five-Year Average Allocation and CBCU

Year	Actual				
	Statewide Allocation	Ground Water CBCU	Surface Water CBCU	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
2002	237	180	85	14	-15
2003	228	204	59	10	-25
2004	206	213	40	10	-37
2005	199	211	43	12	-42
2006	187	198	38	12	-37
Average	211	201	53	12	-31

Year	Adjusted				
	Ground Water [1] CBCU	Effect on [2] Nebraska's Surface Water CBCU	Surface Water [3] CBCU	Imported Water [4] Supply Credit	Allocation - [5] (Adjusted CBCU - IWS Credit)
2002	164	4	89	24	7
2003	180	6	64	29	12
2004	185	7	46	31	5
2005	181	7	50	29	-3
2006	177	5	43	29	-3
Average	178	6	58	28	4

1 Nebraska's projected amount of Ground Water CBCU (90% reduction in nominal five mile corridor)

2 Estimated change in surface water CBCU based on relationship developed between the change in GW CBCU and change in SW CBCU

3 Adjusted Surface Water CBCU = the actual surface water CBCU plus the Effect on Nebraska's Surface Water CBCU

4 Nebraska's projected Imported Water Supply Credit

5 Adjusted compliance = Nebraska's allocation - (the adjusted Ground Water CBCU + the adjusted Surface Water CBCU - the adjusted imported water supply credit)

Table 3

Estimated Effect on Compliance from a Reduction in Nebraska's Pumping: 2002 - 2006

80% Reduction in the Nominal Five Mile Corridor

(1000 acre-feet)

Table 3C: Nebraska's Five-Year Average Allocation and CBCU

Year	Actual				
	Statewide Allocation	Ground Water CBCU	Surface Water CBCU	Imported Water Supply Credit	Allocation - (CBCU - IWS Credit)
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2004	206	213	40	10	-37
2005	199	211	43	12	-42
2006	187	198	38	12	-37
Average	211	201	53	12	-31

Year	Adjusted				
	Ground Water [1] CBCU	Effect on [2] Nebraska's Surface Water CBCU	Surface Water [3] CBCU	Imported Water [4] Supply Credit	Allocation - [5] (Adjusted CBCU - IWS Credit)
2002	173	1	87	22	-1
2003	190	3	62	27	3
2004	195	4	44	30	-3
2005	191	5	47	28	-11
2006	187	2	40	29	-11
Average	187	3	56	27	-5

1 Nebraska's projected amount of Ground Water CBCU (80% reduction in nominal five mile corridor)

2 Estimated change in surface water CBCU based on relationship developed between the change in GW CBCU and change in SW CBCU

3 Adjusted Surface Water CBCU = the actual surface water CBCU plus the Effect on Nebraska's Surface Water CBCU

4 Nebraska's projected Imported Water Supply Credit

5 Adjusted compliance = Nebraska's allocation - (the adjusted Ground Water CBCU + the adjusted Surface Water CBCU - the adjusted imported water supply credit)

APPENDIX A

Results of Surface Water Analysis and Supporting Data

Appendix A-1

Surface Water Analysis Results
Comparison of Change in GW CBCU and Surface Water CBCU in Nebraska
all values avgerage annual acre-feet

(1) GW Reduction Level	(2) Location of Reduction	(3) Cyle	Change in GW CBCU Statewide	Change in Surface Warer CBCU Irrigation	Net Evaporation	Total
60% Reduction	Corridor (3 mile)	4	-2,415	351	22	374
80% Reduction	Corridor (3 mile)	4	23,078	6,264	463	6,727
90% Reduction	Corridor (3 mile)	4	36,814	9,049	637	9,686
100% Reduction	Corridor (3 mile)	4	50,995	12,040	824	12,863
60% Reduction	Corridor (2 mile)	4	-13,691	-3,446	-412	-3,858
80% Reduction	Corridor (2 mile)	4	2,524	562	49	611
90% Reduction	Corridor (2 mile)	4	12,181	2,667	200	2,868
100% Reduction	Corridor (2 mile)	4	22,459	4,515	344	4,858
60% Reduction	Corridor (3 mile)	3	7,959	3,082	234	3,316
80% Reduction	Corridor (3 mile)	3	32,614	8,451	580	9,031
90% Reduction	Corridor (3 mile)	3	45,452	10,974	745	11,718
100% Reduction	Corridor (3 mile)	3	58,641	13,854	932	14,785
60% Reduction	Corridor (2 mile)	3	-3,130	-468	-63	-532
80% Reduction	Corridor (2 mile)	3	13,678	3,360	240	3,599
90% Reduction	Corridor (2 mile)	3	23,226	5,120	368	5,487
100% Reduction	Corridor (2 mile)	3	33,381	7,117	488	7,604
60% Reduction	Corridor (3 mile)	2	18,769	5,677	395	6,071
80% Reduction	Corridor (3 mile)	2	40,864	10,271	684	10,955
90% Reduction	Corridor (3 mile)	2	52,136	12,507	832	13,339
100% Reduction	Corridor (3 mile)	2	63,737	14,928	989	15,917
60% Reduction	Corridor (2 mile)	2	9,205	2,896	195	3,091
80% Reduction	Corridor (2 mile)	2	25,857	6,259	416	6,675
90% Reduction	Corridor (2 mile)	2	34,890	7,955	528	8,482
100% Reduction	Corridor (2 mile)	2	44,199	9,668	645	10,313

Notes:

(1) Level of GW CBCU reduction refers to the percent of pumping and acreage shut off in the RRCA Groundwater Model projection run.
(2) "2 mile" refers to the nominal five mile reduction in the corridor and "3 mile" refers to the nominal seven mile reduction in the corridor
(3) 15-year period within the projection run of the RRCA Groundwater Model.

Appendix A-2

Distribution of Change in GW Impacts
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
2002 - 2006
acre-feet

Year	Swanson	Enders	Hugh Butler	Harry Strunk	Harlan County	Downstream of Harlan	Total
2002	7,984	6,845	-2,055	-2,075	1,671	2,492	14,862
2003	13,677	6,427	-2,039	-1,566	2,411	4,640	23,550
2004	8,952	6,925	-1,953	-1,403	9,549	5,738	27,808
2005	6,339	6,706	-2,173	-2,027	14,699	5,649	29,193
2006	5,116	6,198	-2,086	-2,471	11,206	2,756	20,719
Total	42,068	33,101	-10,306	-9,542	39,536	21,275	116,132
Average	8,414	6,620	-2,061	-1,908	7,907	4,255	23,226

Appendix A-3

Additional Nebraska Diversions
Upstream of Harlan County
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	-	3,041	1,073	398	108	-	-	-	-	4,621
2003	-	-	-	-	5,309	10,165	1,011	82	-	-	-	-	16,567
2004	-	-	-	-	5,004	5,375	1,162	1,220	774	-	-	-	13,534
2005	-	-	-	-	5,041	2,382	782	1,080	-	-	-	-	9,285
2006	-	-	-	-	780	527	(1,004)	(202)	-	-	-	-	101
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	19,175	19,521	2,349	2,288	774	-	-	-	44,108
5-Year Avg	-	-	-	-	3,835	3,904	470	458	155	-	-	-	8,822

Additional Nebraska Diversions
Downstream of Harlan County
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	-	-	966	(228)	(393)	-	-	-	-	344
2003	-	-	-	-	-	620	258	91	-	-	-	-	969
2004	-	-	-	-	1,962	456	268	245	-	-	-	-	2,931
2005	-	-	-	-	-	2,633	185	225	-	-	-	-	3,043
2006	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	1,962	4,674	483	168	-	-	-	-	7,287
5-Year Avg	-	-	-	-	392	935	97	34	-	-	-	-	1,457

Note: Does not include additional NBID diversions.

Additional Diversions
Courtland Canal
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

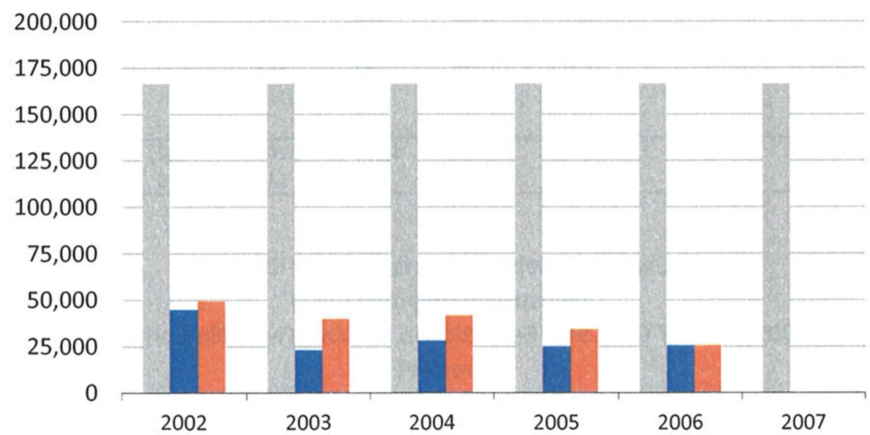
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	-	5,157	790	77	170	-	-	-	-	6,194
2003	-	-	-	-	3,168	1,940	558	534	636	-	-	-	6,835
2004	-	-	-	-	9,152	1,427	839	768	849	-	-	-	13,035
2005	-	-	-	-	10,936	8,243	579	704	443	-	-	-	20,905
2006	-	-	-	-	8,752	2,228	358	100	63	-	-	-	11,502
2007	-	-	-	-	1,874	445	105	24	6	-	-	-	2,454
Total	-	-	-	-	39,039	15,073	2,515	2,301	1,997	-	-	-	60,925
5-Year Avg	-	-	-	-	7,808	3,015	503	460	399	-	-	-	12,185

Note: Includes additional NBID diversions.

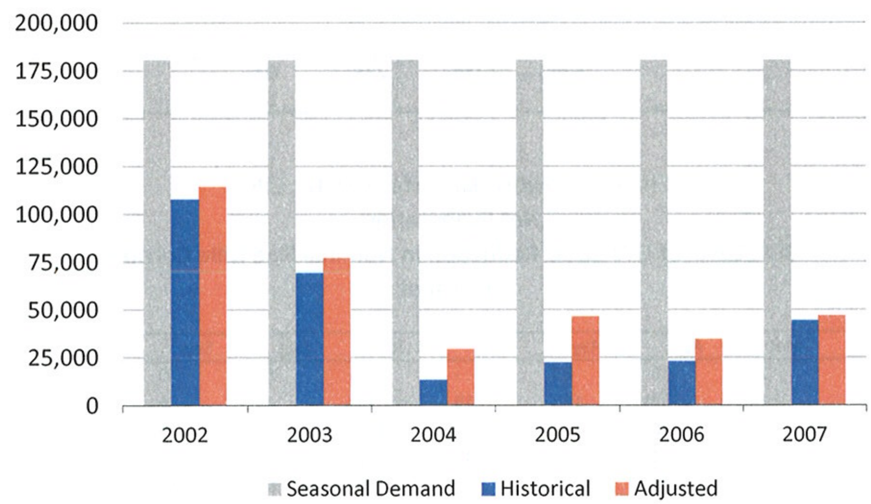
Appendix A-4

Seasonal Canal Demands and Diversions
May - September Total
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

Upstream of Harlan County



Downstream of Harlan County



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Appendix A-5

Change in Nebraska Surface Water CBCU
Upstream Irrigation CBCU
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	-	1,331	652	158	65	-	-	-	-	2,206
2003	-	-	-	-	2,328	5,715	533	50	-	-	-	-	8,626
2004	-	-	-	-	2,195	3,014	610	652	382	-	-	-	6,852
2005	-	-	-	-	2,211	1,216	387	564	-	-	-	-	4,378
2006	-	-	-	-	459	609	(630)	(125)	-	-	-	-	314
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	8,525	11,205	1,058	1,206	382	-	-	-	22,376
5-Year Avg	-	-	-	-	1,705	2,241	212	241	76	-	-	-	4,475

Change in Nebraska Surface Water CBCU
Downstream Irrigation CBCU
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

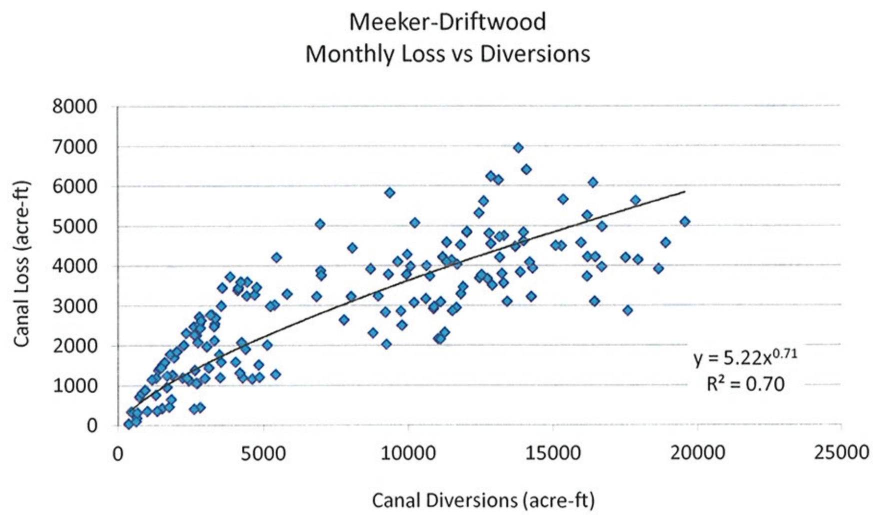
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	-	-	-	-	-	460	(113)	(179)	-	-	-	-	168
2003	-	-	-	-	-	243	137	52	-	-	-	-	432
2004	-	-	-	-	826	201	118	101	-	-	-	-	1,246
2005	-	-	-	-	-	1,210	81	87	-	-	-	-	1,378
2006	-	-	-	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	826	2,114	223	60	-	-	-	-	3,223
5-Year Avg	-	-	-	-	165	423	45	12	-	-	-	-	645

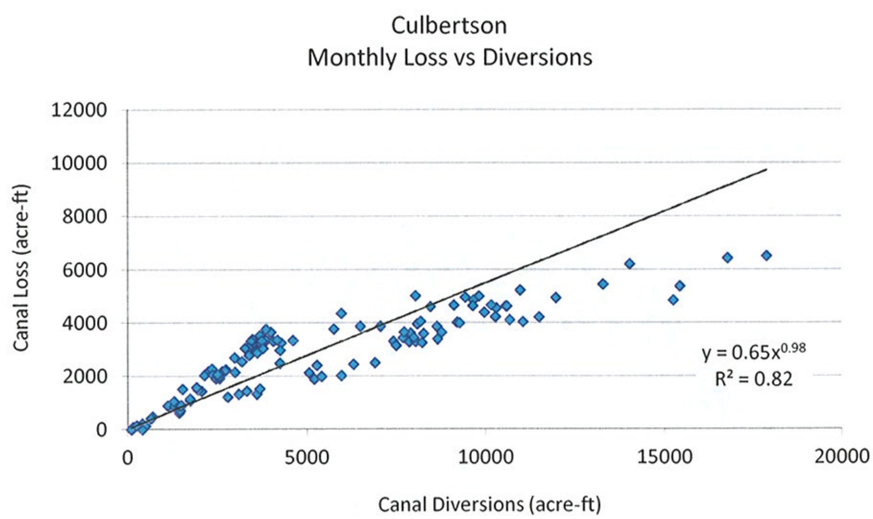
Change in Nebraska Surface Water CBCU
Net Evaporation
90% Level of GW CBCU Reduction in Nominal Five Mile Corridor
acre-feet

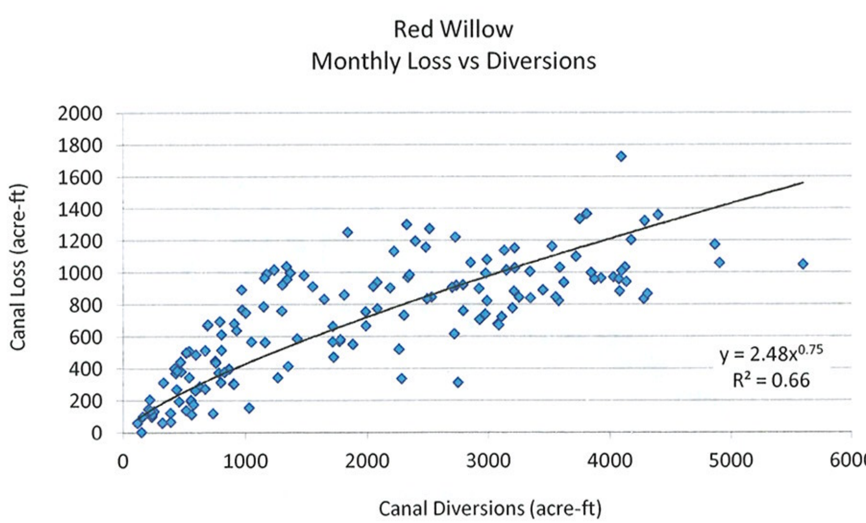
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2002	5	9	20	56	29	-	(6)	(3)	0	4	17	15	146
2003	22	15	10	(37)	113	15	19	8	5	21	16	20	227
2004	16	20	22	80	102	(39)	(82)	35	5	(2)	6	31	196
2005	14	29	(38)	61	29	47	22	7	78	(15)	22	20	277
2006	24	29	18	121	87	56	80	11	(25)	10	63	(37)	436
2007	6	14	36	1	30	1	103	72	114	124	55	-	557
Total	86	116	69	283	390	81	136	130	178	142	179	49	1,838
5-Year Avg	17	23	14	57	78	16	27	26	36	28	36	10	368

Appendix A-6

Surface Water Model Canal Loss Relationship Curves







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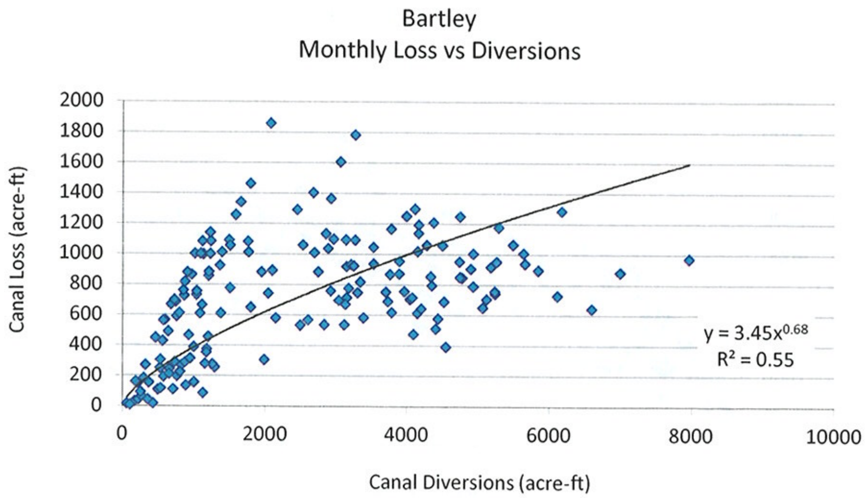
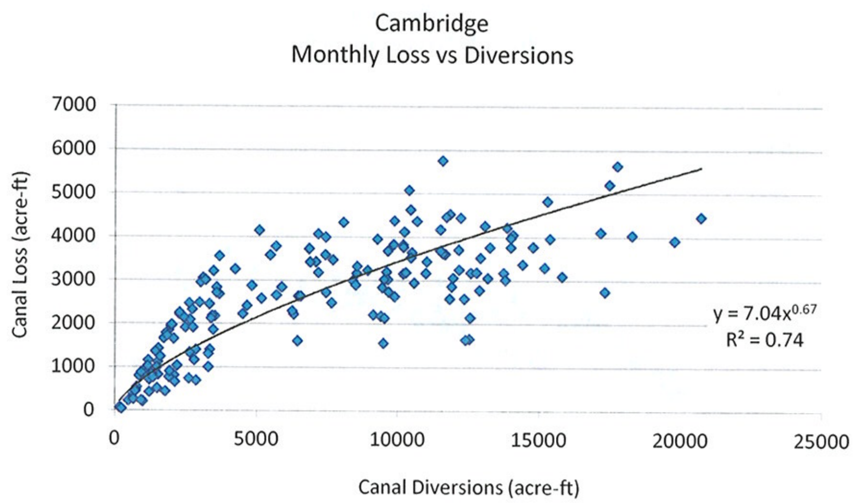
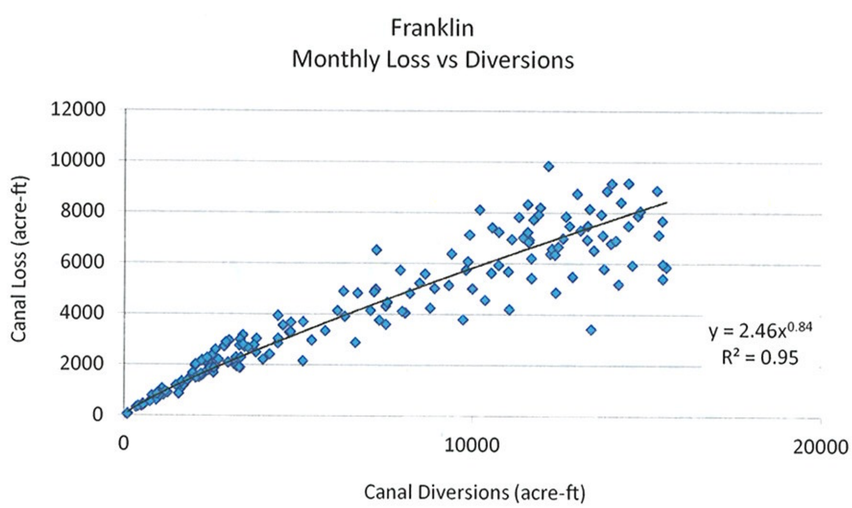
Appendix A-6

Surface Water Model Canal Loss Relationship Curves







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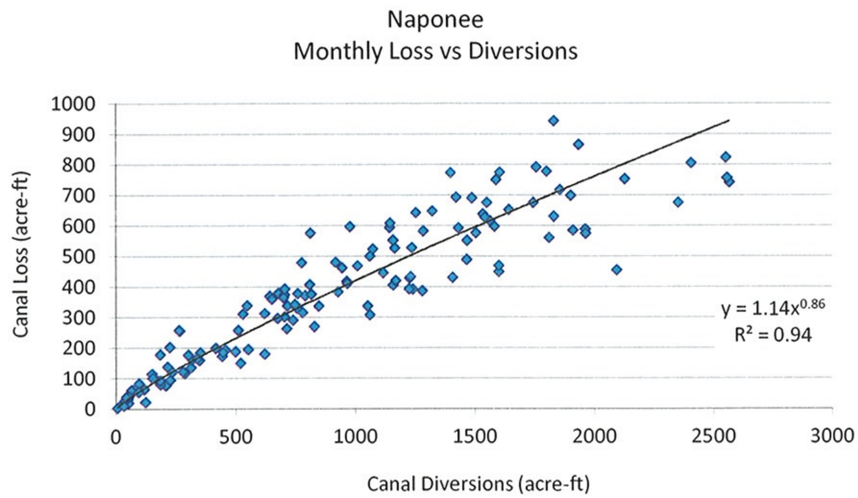
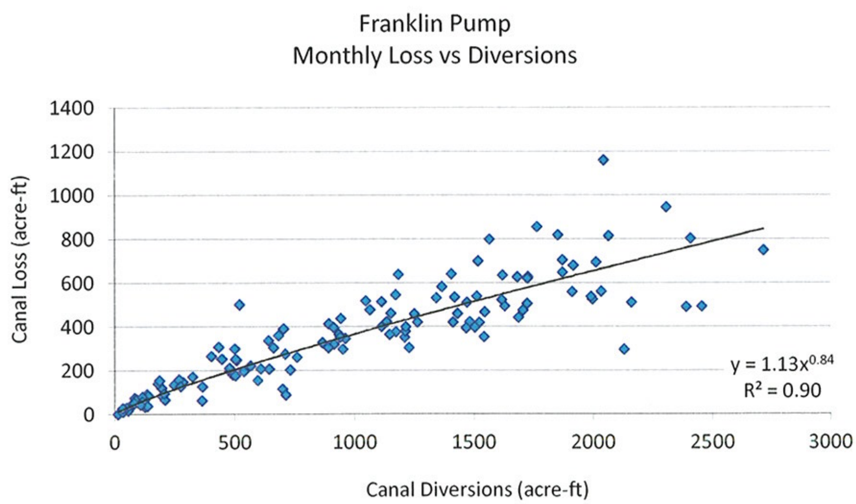
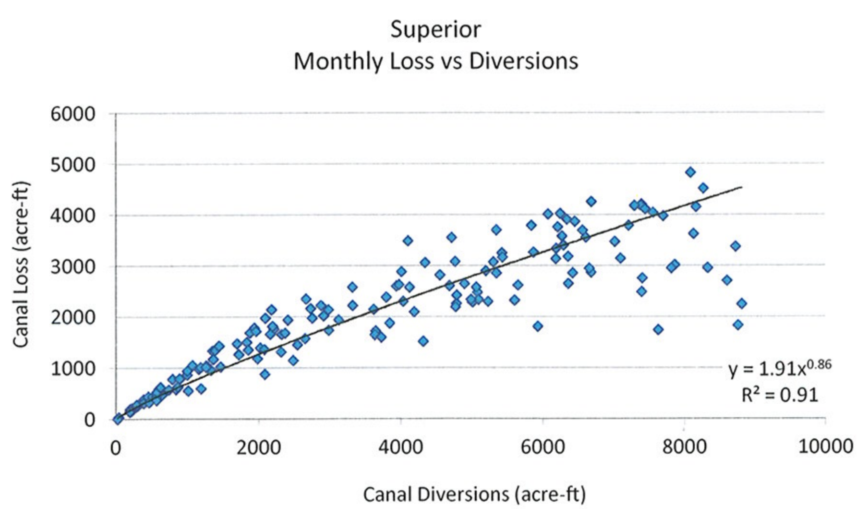
Appendix A-6

Surface Water Model Canal Loss Relationship Curves







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