SSP-1414

Republican River

Colorado Compliance

Pipeline

July 2013

SPL Miscellaneous

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easy to apply, and consistent with the requirement of the FSS that augmentation credit be determined by using the Groundwater Model. *Id.* at 6.

In summary, Colorado's experts conclude that use of the Groundwater Model to determine augmentation credit is inappropriate and would result in a double accounting that would be unfair to Colorado and result in an added benefit to Kansas. Kansas' experts conclude that failure to use the Groundwater Model would result in a double benefit to Colorado as a result of giving 100% credit for pipeline discharges and providing increased offsets over time due to increases in negative pumping impacts.

Analysis and Recommendations

Regardless of whether there is a right or wrong answer on this highly disputed fact question, the legal question remains as to whether the FSS permits Colorado's proposed approach under any circumstances. The FSS appears to establish two separate requirements for use of the Model in connection with a proposed augmentation plan. First, Section III.B.1.K states the Model must be used to determine the net depletion from the wells used in an augmentation plan. Second, Section IV.H of the FSS requires that "augmentation credit, as further described in Subsection II.B.1.k, shall be calculated in accordance with the RRCA Accounting Procedures and by using the RRCA Groundwater Model." The CCP Proposal clearly does not use the Model for determining augmentation credit.

The issue of compliance with Section IV.H was raised squarely in the record by Kansas. However, Colorado did not directly respond in its rebuttal reports, expert testimony or in post-trial briefing. Neither Kansas nor Colorado submitted evidence into the record to explain the original intent of the provision in question or to shed light on how it should be interpreted in the present case. Colorado argues only that use of the Model is not appropriate for determining the amount of augmentation credit in connection with this particular proposal that relies on a direct and measurable discharge from the pipeline. Accordingly, the door is wide open for Kansas to deny its approval to the Colorado Proposal.

Absent the express requirement of the FSS, the States would be confronted with the underlying policy and factual determination as to whether the Model offers the most useful tool for computing augmentation credit for the pipeline concept. The answer to that question is probably not. The expert evidence provided by Colorado is convincing in demonstrating that discharge from the pipeline to the North Fork can and should be measured, rather than modeled. However, this determination alone does not fully address the issue of how much augmentation credit should be awarded for the measured delivery. That issue, in turn, triggers factual and policy concerns. The expert evidence provided by Kansas demonstrates use of the pipeline will result in an increase in negative pumping impacts, and thereby provide a long-term additional benefit to Colorado to the detriment of Kansas. Kansas raises a related issue regarding the treatment of transit losses between the point of discharge and Swanson Reservoir for purposes of determining augmentation credit. It is reasonable for Kansas to insist that such impacts be considered in calculating the amount of augmentation credit, whether by use of the Model, or through some other approach agreed to by the States and incorporated into the FSS through stipulated agreement.

For example, the States could agree to use measured discharge data for the purposes of determining the raw quantity of pipeline deliveries, but elect to apply additional factors in computing the amount of augmentation credit associated with the delivery. One such option may be to agree upon an automatic reduction of the raw quantity amount to offset the asserted negative pumping impacts and reflect a policy cost for implementing the pipeline as a method of mitigating the effects of other groundwater pumping by Colorado. A 10% reduction is recommended as a reasonable reflection of the potential impact based on seasonal deliveries, but an amount likely to be within the range of reasonable economic cost to Colorado.

Alternatively, Colorado could amend the CCP Proposal to include a method for utilizing the model to determine augmentation credit, and resubmit the proposal for approval by the RRCA.

In its present form, the CCP Proposal does not meet the requirement of Section IV.H. Therefore, it is not unreasonable for Kansas to withhold its consent to the Proposal.

2. **Whether the CCP Proposal would allow Colorado to replace South Fork overuse with augmentation flow delivered to the North Fork.**

Ultimate Findings and Conclusions

The CCP Proposal is not intended to allow Colorado to replace South Fork overuse with augmentation flow delivered to the North Fork for purposes of determining Compact compliance with sub-basin allocations; however, the intention should be more clearly reflected in the Proposal and related modifications to the RRCA Accounting Procedures. The CCP Proposal would allow for use of North Fork augmentation in computing Colorado's statewide compliance; however, Kansas raises a legitimate policy question as to whether an augmentation plan may be used to artificially create a surplus in one sub-basin in order to meet the statewide compliance test. Therefore, it was not unreasonable for Kansas to withhold its consent to the CCP Proposal on this basis.

Summary of Issue and Key Evidence

Kansas raises two objections with respect to the potential impacts of the CCP Proposal on South Fork compliance. First, Kansas asserts that the Proposal unreasonably allows Colorado to offset overuse on the South Fork with augmentation flow supplied only to the North Fork. C. Kan. Exh. 2 at 10 (Barfield Report); Tr. Vol.2, p. 471, ln. 25 – p. 472, ln. 7 (Barfield). Second, Kansas argues Colorado's pipeline plan, if approved, would allow it to achieve statewide compliance through crediting and not as a result of reducing its beneficial consumptive use. Kan. Post-Trial Brief at 19-20. Kansas explains that even if augmentation credit is limited to the North Fork basin for purposes of determining compliance with the sub-basin impairment test, the CCP Proposal will allow Colorado to offset overuse in the South Fork with excess water delivered into the North Fork sub-basin for purposes of demonstrating statewide compliance. This, in turn, would give Colorado access to un-allocated water in the South Fork sub-basin to which it would not otherwise be entitled in the absence of the augmentation effort. *Id.* at 21. According to Kansas, this approach offers too much flexibility to Colorado, allowing Colorado

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Non-Binding Arbitration initiated March 21, 2013

pursuant to

Decree of May 19, 2003, 538 U.S. 720
Kansas v. Nebraska & Colorado
No. 126 Orig., U.S. Supreme Court

Report on the

Colorado Bonny Reservoir Accounting Proposal

Republican River Compact

Response to proposal prepared by State of Colorado, dated April 5, 2103

Prepared by

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July 29, 2013

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Introduction

The purpose of this report is to present a response to the Colorado proposal for changing the accounting procedures to reflect future operations of Bonny Reservoir. The Colorado proposal is described in attachments to a letter dated April 5, 2013 from Dick Wolfe, Colorado Commissioner, RRCA to David Barfield and Brian Dunnigan, Kansas and Nebraska Commissioners, RRCA, respectively (Colorado DWR, 2013).

Background

Colorado has proposed changes to the RRCA accounting procedures to reflect new conditions associated with the operation of Bonny Reservoir. Under the proposal, accounting for the South Fork Subbasin would be done in three different ways depending on conditions in Bonny Reservoir. The three conditions are characterized as "Dry Bonny", "Small Bonny", and "Full Bonny". A so-called "Dry Bonny" condition is defined as a reservoir stage below an elevation of 3638.5 feet and presumably would not have any water in storage. A "Small Bonny" condition is defined as a reservoir elevation between 3638.5 feet and 3679.83 feet. The volume of stored water between these two extremes ranges from essentially zero at the low end to more than 54,500 acre-feet on the high end. A "Full Bonny" condition is defined as anything above the "Small Bonny" condition or more than 54,500 acre-feet of stored water.

Colorado proposes to adjust conditions used to represent Bonny Reservoir in the RRCA Groundwater Model based on which of the defined conditions fits the observed status of the reservoir under historical stream flow conditions. The status will be based on reservoir elevation data reported by the U. S. Bureau of Reclamation (USBR). The details of these adjustments are contained in the Colorado proposal and will not be repeated here.

As we understand Colorado's proposal, a "Dry Bonny" condition would assume no reservoir storage and no reservoir evaporation loss and would also assume that all inflows would pass through the reservoir structure without being re-regulated. This assumption would be made for both the historical or baseline run of the model with all State's pumping on and for the alternative model runs where one of the States pumping would be off. In other words, the presumption is that if inflows were passed downstream in the historical condition (not re-regulated), they would also pass downstream in the alternative condition in spite of higher inflows that might be occurring in the alternative model run.

The "Small Bonny" condition would assume that some water is being stored in the reservoir and that there would be some evaporation loss associated with the storage of water. The amount of evaporation loss will be computed based on the amount of water stored and the estimated surface area of the reservoir associated with that storage. Under the "Small Bonny" condition, the specification of conditions used to represent Bonny Reservoir in the RRCA Groundwater Model will vary depending upon data obtained from the USBR. Some of these conditions are described in the proposal (Colorado DWR, 2013). The proposal does not describe how inflows to and outflows from the reservoir will be specified in the RRCA Groundwater Model under the "Small Bonny" condition.

Colorado has provided examples of how their proposal would be applied in the RRCA Groundwater Model under a "Dry Bonny" condition and under a "Full Bonny" condition. No examples have been provided to show how their proposal would be applied under a "Small Bonny" condition. Based on the deposition of Dr. Willem Schreuder taken on July 23, 2013, Kansas believes that under the "Small Bonny" condition, Colorado intends to treat the reservoir in the same fashion that it does under the "Full Bonny" condition except that the size of the reservoir footprint would be adjusted based on the reservoir stage information obtained from the USBR. Further, based on Dr. Schreuder's testimony, Kansas believes that, under the "Small Bonny" condition, inflows to the reservoir will not be routed downstream and that the inflow into the reach below the reservoir will be specified as the amount of flow from a toe drain located at the base of the reservoir. It is also presumed that the amount of inflow into the reach below the reservoir would be the same for both the historical or baseline run of the model with all State's pumping on and for the alternative model runs where one of the States pumping would be off. If Kansas understanding is correct, the "Small Bonny" condition would have the exact same specifications as the "Full Bonny" condition except for the size and water elevation specified for the reservoir and the amount of toe drain flow specified as inflow below the reservoir.

<u>Calculation of Impacts with the Colorado Proposal</u>

Colorado has provided to Kansas examples of how their proposal would be applied under a "Dry Bonny" condition and under a "Full Bonny" condition. The "Dry Bonny" condition has been referred to as a "No Bonny" condition in the materials provided by Colorado. The essence of this condition is the assumption that all inflows to the stream reach associated with Bonny Reservoir will be translated downstream as if the stream system were in the same condition that existed prior to the construction of Bonny Reservoir. As mentioned previously, Colorado did not provide examples of how a "Small Bonny" condition would be applied under their proposal. In 2011, Colorado did provide some examples of a "Small Bonny" scenario as part of discussions with Kansas. However, this scenario did not include the variations in reservoir conditions that are part of the current Colorado proposal.

A comparison of impacts calculated under the Colorado proposal for a "Dry Bonny" or "No Bonny" condition with impacts under a "Full Bonny" condition were provided by Colorado. The calculated impacts from pumping in Colorado, Kansas, and Nebraska are shown on Tables 1 through 3, respectively. The impacts shown on these tables represent calculations over a 40-year study period from 2010 to 2049. Hydrologic conditions from the historical period from 2000 to 2009 were repeated four times to create the assumed conditions for the 40-year study period.

The impacts shown on the tables are the computed beneficial consumptive use for groundwater (CBCUg) associated with pumping in each State at each of the different accounting points. Results such as these are used to determine total CBCUg for each State and to determine the computed water supply that is part of the water allocated to each State under the compact and the FSS.

Tables 1 through 3 show three columns under each accounting point; the impacts with Bonny Reservoir or "Full Bonny" (designated as WB), the impacts without Bonny Reservoir or "Dry Bonny" (designated as NB), and the difference between the two impacts (designated Del). The far right hand set of columns provides the total impact for each year of the study period and the last line of each table shows the average impacts over the 40-year study period.

The results compiled on Tables 1 through 3 show that the difference between a "Full Bonny" condition (WB) and a "Dry Bonny" condition (NB) under the Colorado proposal is significant. For Colorado, the "Dry Bonny" condition would reduce CBCUg by an average of over 8,500 acre feet per year over the study period from what it would be under the "Full Bonny" condition (Table 1). Similarly, for Kansas, the "Dry Bonny" condition would reduce Kansas' CBCUg by an average of over 2,400 acre feet per year (Table 2). For Nebraska, the "Dry Bonny" condition would create a relatively small difference from the "Full Bonny" condition, a reduction of about 250 acre feet per year on average (Table 3). The nature of the significant differences under the "Dry Bonny" condition is discussed further below.

Impact of the Colorado Proposal on Calculations of CBCUg without Bonny Reservoir

As shown on Tables 1 through 3, almost all of the differences in CBCUg between the two conditions are under the South Fork accounting point column and the Bonny (Reservoir) column. The reduction in CBCUg under the "Dry Bonny" condition is related principally to two factors, the elimination of the reservoir conditions to represent Bonny Reservoir and the passing of inflows originating above the reservoir into downstream reaches.

The first factor (elimination of the reservoir) accounts for about 3,100 acre feet per year of the total average reduction in Colorado CBCUg. When Bonny Reservoir is included, the CBCUg for Colorado associated with the reservoir averages about 1,700 acre feet per year (Table 1). This CBCUg is associated with depletions from the reservoir water body associated with Colorado pumping.

When the reservoir is not included in the model, the stream reach that constitutes the reservoir is considered to be as it was prior the reservoir. Under this condition, model calculations show that more stream water is lost from this reach when there is no pumping in Colorado than when there is pumping in Colorado (the historical condition). This is due to the fact, that when Colorado pumping is on, inflows to the reservoir are totally depleted for many of the years in the study period. When there is no inflow, there is no loss of water in the reservoir stream reach. When

Colorado pumping is off, inflows to the reservoir are significant and relatively continuous and some of the flow is lost in the reservoir stream reach. The difference between the two results produces a negative impact in the CBCUg calculations as shown on Table 1. This negative impact averages about 1,400 acre feet per year over the study period. As a result, the total effect of removing the reservoir is to change from a positive impact of 1,700 acre feet per year on average to a negative impact of 1,400 acre feet per year for a total change of about 3,100 acre feet per year.

The remainder of the reduction in Colorado CBCUg (about 5,600 acre feet per year on average) is related to losses in other portions of the South Fork stream network associated with passing inflows originating above the reservoir into downstream reaches. Table 4 has been compiled to illustrate how losses in the different downstream reaches impact calculations of CBCUg.

Table 4 shows the calculated differences in stream base flow associated with pumping in Colorado at seven different points along the South Fork stream network. These calculations are the calculated CBCUg for Colorado pumping at the different points along the South Fork strem network. The columns in left to right order are: 1) South Fork above Bonny, 2) Landsman Creek tributary, 3) South Fork above Bonny Reservoir, 4) South Fork at Bonny Reservoir outlet, 5) South Fork below Bonny Reservoir, 6) South Fork at Colorado-Kansas State line, and 7) South Fork at the confluence with the Republican River. In subsequent columns, the differences in CBCUg across each of five reaches are tabulated. The first reach is from the combination of points 1 and 2 above to point 3. The next three reaches are; point 3 to point 4, point 4 to point 5, point 5 to point 6, and point 6 to point 7.

As shown on Table 4, the differences in CBCUg for the reaches below the combination of the South Fork above Bonny and Landsman Creek tributary are almost all negative. This means that the CBCUg for Colorado above Bonny Reservoir is progressively reduced as one moves down the stream network to the confluence with the Republican River. This reduction in CBCUg is a result of the same process that was discussed above for the Bonny Reservoir reach. Losses are greater when Colorado does not pump and more base flow is in the stream network than when Colorado is pumping and little or no base flow is in the stream network.

Some of the reduction in Colorado CBCUg occurs above the Colorado-Kansas State line (about 2,700 acre feet per year on average) and some occurs between the State line and the confluence (about 3,200 acre feet per year on average). At the State line, the Colorado CBCUg averages about 8,600 acre feet per year over the study period. At the confluence with the Republican River, the Colorado CBCUg averages about 5,400 acre feet per year.

Reductions in CBCUg and Unallocated Residuals

The reductions in CBCUg discussed above are largely related to calculations of dry stream conditions in the RRCA Groundwater Model. When dry stream conditions are calculated in the historical run of the model, no losses of base flow will occur. When one of the States' pumping is removed and the stream is calculated to have base flow, losses can occur that do not occur in the historical run of the model where pumping for all of States is included. These conditions can result in the calculation of a negative impact (negative CBCUg). As dry stream conditions become more extensive in the RRCA Groundwater Model, there is generally an increasing departure between the sum of the individual impacts (CBCUg) calculated for each State and the total impact that would be calculated if the pumping in all of the States were considered simultaneously. These departures represent a residual CBCUg that is not allocated under the calculation procedures outlined in the FSS. The departures are the result of non-linear behavior of the RRCA Groundwater Model which results in a situation where the sum of the individual impacts does not necessarily equal the whole.

In the case of the "Dry Bonny" condition under the Colorado proposal, the departures or unallocated depletions or CBCUg for the South Fork stream network described above are larger than when a "Full Bonny" condition is assumed. Under the "Dry Bonny" condition, the sum of the impacts for the South Fork stream network (including the Bonny reach) are about 3,800 acre feet per year less on average than the total impact over the 40-year study period used by Colorado. Under the "Full Bonny" condition, the comparable result for the South Fork stream network including Bonny Reservoir is about 700 acre feet per year less on average. These results demonstrate that under a "Dry Bonny" condition, unallocated depletions or residual CBCUg would be much more significant than under a "Full Bonny" condition.

Summary

The results described above provide some demonstration of how the Colorado proposal will impact calculations of CBCUg. Changing representation of Bonny Reservoir in the RRCA Groundwater Model from its current representation as a reservoir to its pre-reservoir condition as just another part of the South Fork stream network produces significant changes in the calculations of CBCUg. In particular, reductions in CBCUg caused by dry stream conditions along the South Fork stream network become significant both above and below the Colorado-Kansas State line when Bonny Reservoir is assumed to be in the "Dry Bonny" condition. Unallocated residual CBCUg for the South Fork stream network are also greater under the "Dry Bonny" condition.

Qualifications

This report was prepared by Steven P. Larson with assistance from Dr. Samuel P. Perkins and Dr. Alexandros Spiliotopoulos. I am a principal and the Executive Vice President of S.S. Papadopulos & Associates, Inc. (SSP&A), a firm that provides consulting services related to environmental and water-resource issues. My area of expertise is hydrology, with emphasis on groundwater hydrology.

I hold a Bachelor of Science in Civil Engineering from the University of Minnesota, conferred in 1969, and a Master of Science in Civil Engineering, also from the University of Minnesota, conferred in 1971. I am a member of the Association of Ground Water Scientists and Engineers (a division of the National Ground Water Association) and the American Institute of Hydrology. I am also certified as a Professional Hydrologist/Ground Water with the American Institute of Hydrology.

Prior to joining SSP&A in 1980, I was employed as a hydrologist with the Water Resources Division of the U.S. Geological Survey (USGS) for almost 9 years. During my tenure with the USGS, I conducted numerous hydrological studies on a variety of groundwater and surface water problems and conducted research into the development of mathematical models to simulate groundwater flow processes. This work included working on the project that ultimately led to the development of the program, MODFLOW, which was the program used to construct the RRCA Groundwater Model. I have spent the last 33 years with SSP&A conducting and managing projects related to a variety of environmental and water-resource issues. During my tenure at SSP&A, I have been involved in numerous projects covering a wide spectrum of technical, environmental, and legal issues including environmental impact evaluations, evaluations of water-resource development, water-rights permitting and adjudication, remedial investigations at CERCLA and other waste-disposal sites, feasibility studies, engineering evaluations/cost analyses, and remedial action plans.

I have also testified as an expert in numerous legal and administrative forums. These cases have included permit and licensing hearings, water-rights adjudications, arbitration hearings, interstate compact claims, toxic torts, liability claims, various legal actions under CERCLA, property damage claims, and insurance claims.

As part of my work for the State of Kansas on issues related to the Republican River, I served as an expert on modeling regarding development of the RRCA Groundwater Model. Further, I was a member of the Modeling Committee on behalf of the State of Kansas that was charged with development of the groundwater model. In that capacity, I actively participated in the technical efforts by the three states in development, calibration, and operation of the RRCA Groundwater Model. As a result of that work, I am very familiar with the groundwater Model, its structure, its capabilities, and the manner in which it is applied for use in the RRCA Accounting Procedures.

References

Colorado Depart of Water Resources (Colorado DWR). 2013. Resolution by the Republican River Compact Administration regarding modifications to the accounting procedures to reflect future operations of Bonny Dam and Reservoir. April 5, 2013.

Tables

Table 1. Colorado Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork			Above Swanson			Swanson - Harlan		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	1248	1248	0	0	0	0	386	386	0	0	0	0	1688	1688	0	16015	16016	1	-5268	-5284	-16	0	11	11
2011	1754	1754	0	0	0	0	318	318	0	0	0	0	120	120	0	16297	16297	0	-5631	-5632	-1	-13	-13	0
2012	580	580	0	0	0	0	192	192	0	0	0	0	100	100	0	16251	16251	0	-6747	-6737	10	0	0	0
2013	347	347	0	0	0	0	173	173	0	0	0	0	87	87	0	16673	16673	0	-1105	-1044	61	0	0	0
2014	414	414	0	0	0	0	200	200	0	0	0	0	84	85	1	16983	16983	0	-889	-821	68	0	0	0
2015	1022	1022	0	0	0	0	216	216	0	0	0	0	85	85	0	16996	16996	0	-2372	-2257	115	0	0	0
2016	1268	1268	0	0	0	0	228	228	0	0	0	0	87	87	0	16953	16953	0	-3890	-3795	95	0	0	0
2017	1300	1300	0	0	0	0	244	244	0	0	0	0	92	93	1	17380	17380	0	-2507	-2307	200	0	0	0
2018	1703	1703	0	0	0	0	281	281	0	0	0	0	96	96	0	17646	17646	0	-2888	-2687	201	0	0	0
2019	4450	4450	0	0	0	0	409	409	0	0	0	0	106	105	-1	18542	18542	0	-1764	-1739	25	0	0	0
2020	1552	1552	0	0	0	0	373	373	0	0	0	0	117	118	1	18593	18593	0	-7114	-6686	428	0	0	0
2021	1877	1877	0	0	0	0	265	265	0	0	0	0	115	115	0	18867	18867	0	-6355	-6248	107	0	0	0
2022	662	662	0	0	0	0	240	240	0	0	0	0	118	118	0	18751	18751	0	-7145	-7086	59	0	0	0
2023	417	417	0	0	0	0	226	226	0	0	0	0	126	126	0	19188	19188	0	-2669	-2557	112	0	0	0
2024	477	477	0	0	0	0	247	247	0	0	0	0	136	136	0	19502	19502	0	-796	-704	92	0	0	0
2025	1158	1158	0	0	0	0	279	279	0	0	0	0	143	143	0	19560	19560	0	-2578	-2460	118	0	0	0
2026	1363	1363	0	0	0	0	284	284	0	0	0	0	151	151	0	19423	19423	0	-4908	-4787	121	0	0	0
2027	1411	1411	0	0	0	0	314	314	0	0	0	0	162	161	-1	19907	19907	0	-2909	-2715	194	0	0	0
2028	1822	1822	0	0	0	0	360	360	0	0	0	0	171	170	-1	20181	20181	0	-3364	-3171	193	0	0	0
2029	4783	4783	0	0	0	0	385	385	0	0	0	0	180	180	0	21095	21095	0	-1865	-1825	40	0	0	0
2030	1962	1962	0	0	0	0	358	358	0	0	0	0	191	191	0	21057	21057	0	-9256	-8818	438	0	0	0
2031	1979	1979	0	0	0	0	322	322	0	0	0	0	196	196	0	21326	21326	0	-6806	-6660	146	0	0	0
2032	730	730	0	0	0	0	306	306	0	0	0	0	188	188	0	21158	21158	0	-7735	-7668	67	0	0	0
2033	480	480	0	0	0	0	321	321	0	0	0	0	145	145	0	21603	21603	0	-5314	-5238	76	0	0	0
2034	544	544	0	0	0	0	334	334	0	0	0	0	106	106	0	21938	21938	0	-1060	-949	111	0	0	0
2035	1273	1273	0	0	0	0	347	347	0	0	0	0	118	118	0	21996	21996	0	-2436	-2319	117	0	0	0
2036	1442	1442	0	0	0	0	353	353	0	0	0	0	114	114	0	21797	21797	0	6024	-5944	80	0	0	0
2037	1509	1509	0	0	0	0	371	371	0	0	0	0	131	131	0	22308	22308	0	-3049	-2857	192	0	0	0
2038	1930	1930	0	0	0	0	410	410	0	0	0	0	167	167	0	22591	22591	0	-3896	-3715	181	0	0	0
2039	5047	5047	0	0	0	0	461	461	0	0	0	0	387	387	0	23500	23500	0	-1847	-1808	39	0	0	0
2040	2462	2462	0	0	0	0	439	439	0	0	0	0	306	306	0	23399	23399	0	-11284	-10911	373	0	0	0
2041	2070	2070	0	0	0	0	404	404	0	0	0	0	203	203	0	23666	23666	0	-7302	-7112	190	0	0	0
2042	790	790	0	0	0	0	354	354	0	0	0	0	146	146	0	23457	23457	0	-8804	-8735	69	0	0	0
2043	537	537	0	0	0	0	317	317	0	0	0	0	155	155	0	23911	23911	0	-9294	-9194	100	0	0	0
2044	605	605	0	0	0	0	389	389	0	0	0	0	147	147	0	24249	24249	0	-2628	-2562	66	0	0	0
2045	1377	1377	0	0	0	0	473	473	0	0	0	0	157	157	0	24305	24305	0	-1887	-1730	157	0	0	0
2046	1513	1513	0	0	0	0	435	435	0	0	0	0	157	157	0	24061	24061	0	-7361	-7294	67	0	0	0
2047	1596	1596	0	0	0	0	488	488	0	0	0	0	171	171	0	24590	24590	0	-3000	-2823	177	0	0	0
2048	2027	2027	0	0	0	0	496	496	0	0	0	0	178	178	0	24879	24879	0	-4353	-4186	167	0	0	0
2049	5195	5195	0	0	0	0	522	522	0	0	0	0	188	189	1	25776	25776	0	-1545	-1513	32	0	0	0
2010 2049	1616	1616	0	0	0	0	338	338	0	0	0	0	187	187	0	20659	20659	0	-4441	-4314	127	0	0	0

Year	Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog			Red Willow			Rock			Sappa			South Fork			Hugh Butler		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	85	0	0	0	0	9567	4820	-4747	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	91	0	0	0	0	11076	4296	-6780	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	101	0	0	0	0	9211	4106	-5105	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	84	0	0	0	0	10693	3798	-6895	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	0	0	0	0	11337	4189	-7148	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	63	0	0	0	0	14308	7363	-6945	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	67	0	0	0	0	11051	7083	-3968	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	72	0	0	0	0	11878	7584	-4294	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	77	0	0	0	0	14036	9057	-4979	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	81	0	0	0	0	17665	15614	-2051	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	86	0	0	0	0	10456	9609	-847	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	93	0	0	0	0	11757	4668	-7089	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102	102	0	0	0	0	8956	3881	-5075	0	0	0
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	109	0	0	0	0	10661	3607	-7054	0	0	0
2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	106	106	0	0	0	0	11217	4018	-7199	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	109	0	0	0	0	14725	7098	-7627	0	0	0
2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	112	0	0	0	0	11456	6909	-4547	0	0	0
2027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119	119	0	0	0	0	12183	7356	-4827	0	0	0
2028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	125	0	0	0	0	14298	8836	-5462	0	0	0
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	132	0	0	0	0	20248	16510	-3738	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	140	0	0	0	0	11292	11501	209	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	147	147	0	0	0	0	11910	4497	-7413	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	153	153	0	0	0	0	8908	3727	-5181	0	0	0
2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	160	0	0	0	0	10836	3477	-7359	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157	157	0	0	0	0	11754	3945	-7309	0	0	0
2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156	156	0	0	0	0	14467	6884	-7583	0	0	0
2036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159	159	0	0	0	0	12107	6755	-5352	0	0	0
2037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167	167	0	0	0	0	12456	7177	-5279	0	0	0
2038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172	172	0	0	0	0	14557	8650	-5907	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	177	177	0	0	0	0	21569	16668	-4901	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	185	185	0	0	0	0	12219	11721	-498	0	0	0
2041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	197	197	0	0	0	0	12057	4345	-7712	0	0	0
2042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	204	0	0	0	0	9059	3583	-5476	0	0	0
2043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	190	0	0	0	0	10994	3362	-7632	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	170	0	0	0	0	11470	3911	-7559	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	180	0	0	0	0	14162	6724	-7438	0	0	0
2046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	160	0	0	0	0	12201	6611	-5590	0	0	0
2047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166	166	0	0	0	0	12874	7046	-5828	0	0	0
2048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181	181	0	0	0	0	14848	8480	-6368	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	235	235	0	0	0	0	21913	16393	-5518	0	0	0
2010 2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	133	0	0	0	0	12698	7146	-5552	0	0	0

Year	Bonny			Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	1305	-619	-1924	0	0	0	0	0	0	0	0	0	0	0	0	11	11	0	-5260	-5272	-12	25051	18368	-6683
2011	1365	-1082	-2447	0	0	0	0	0	0	0	0	0	0	0	0	12	12	0	-5644	-5645	-1	25394	16167	-9227
2012	1417	-1203	-2620	0	0	0	0	0	0	0	0	0	0	0	0	14	15	1	-6753	-6744	9	21120	13404	-7716
2013	1480	-1570	-3050	0	0	0	0	0	0	0	0	0	0	0	0	25	26	1	-1107	-1045	62	28463	18581	-9882
2014	1500	-1837	-3337	0	0	0	0	0	0	0	0	0	0	0	0	25	26	1	-890	-822	68	29723	19307	-10416
2015	1433	-1722	-3155	0	0	0	0	0	0	0	0	0	0	0	0	16	17	1	-2372	-2258	114	31777	21792	-9985
2016	1430	-1225	-2655	0	0	0	11	11	0	0	0	0	0	0	0	17	18	1	-3890	-3796	94	27222	20694	-6528
2017	1448	-1036	-2484	0	0	0	12	12	0	0	0	0	0	0	0	19	20	1	-2509	-2310	199	29935	23358	-6577
2018	1449	-2016	-3465	0	0	0	12	12	0	0	0	0	0	0	0	17	18	1	-2891	-2690	201	32426	24184	-8242
2019	1381	-927	-2308	0	0	0	13	13	0	0	0	0	0	0	0	14	16	2	-1770	-1745	25	40892	36559	-4333
2020	1466	-581	-2047	0	0	0	14	14	0	0	0	0	0	0	0	14	16	2	-7117	-6685	432	25555	23095	-2460
2021	1538	-1074	-2612	0	0	0	15	15	0	0	0	0	0	0	0	16	17	1	-6356	-6248	108	28188	18595	-9593
2022	1584	-1172	-2756	0	0	0	16	16	0	0	0	0	0	0	0	20	20	0	-7145	-7087	58	23304	15531	-7773
2023	1646	-1542	-3188	0	0	0	17	17	0	0	0	0	0	0	0	33	33	0	-2669	-2557	112	29753	19625	-10128
2024	1666	-1874	-3540	0	0	0	19	19	0	0	0	0	0	0	0	31	32	1	-797	-706	91	32603	21956	-10647
2025	1597	-1757	-3354	0	0	0	20	20	0	0	0	0	0	0	0	23	23	0	-2580	-2461	119	35034	24171	-10863
2026	1593	-1246	-2839	0	0	0	21	21	0	0	0	0	0	0	0	22	23	1	-4909	-4788	121	29516	22252	-7264
2027	1611	-1065	-2676	0	0	0	22	22	0	0	0	0	0	0	0	23	24	1	-2912	-2717	195	32840	25533	-7307
2028	1611	2076	-3687	0	0	0	24	24	0	0	0	0	0	0	0	21	23	2	-3366	-3173	193	35247	26293	-8954
2029	1566	-1626	-3192	0	0	0	25	25	0	0	0	0	0	0	0	18	20	2	-1868	-1828	40	46564	39675	-6889
2030	1625	-667	-2292	0	0	0	27	27	0	0	0	0	0	0	0	15	19	4	-9262	-8824	438	27405	25764	-1641
2031	1697	-1125	-2822	0	0	0	29	29	0	0	0	0	0	0	0	21	22	1	-6808	-6662	146	30818	20731	-10087
2032	1743	-1219	-2962	0	0	0	31	31	0	0	0	0	0	0	0	28	29	1	-7737	-7670	67	25509	17434	-8075
2033	1806	-1575	-3381	0	0	0	32	32	0	0	0	0	0	0	0	53	54	1	-5314	-5238	76	30122	19461	-10661
2034	1826	-1942	-3768	0	0	0	34	34	0	0	0	0	0	0	0	49	49	0	-1064	-953	111	35178	24213	-10965
2035	1756	-1859	-3615	0	0	0	37	37	0	0	0	0	0	0	0	34	35	1	-2438	-2322	116	37745	26665	-11080
2036	1749	-1286	-3035	0	0	0	39	39	0	0	0	0	0	0	0	31	32	1	-6027	-5947	80	31764	23457	-8307
2037	1767	-1121	-2888	0	0	0	42	42	0	0	0	0	0	0	0	31	32	1	-3055	-2863	192	35726	27754	-7972
2038	1767	-2154	-3921	0	0	0	45	45	0	0	0	0	0	0	0	27	29	2	-3900	-3720	180	37766	28119	-9647
2039	1727	-1702	-3429	0	0	0	48	48	0	0	0	0	0	0	0	24	26	2	-1852	-1813	39	51086	42800	-8286
2040	1781	-769	-2550	0	0	0	51	51	0	0	0	0	0	0	0	20	22	2	-11287	-10914	373	29574	26902	-2672
2041	1848	-1189	-3037	0	0	0	54	54	0	0	0	0	0	0	0	27	29	2	-7306	-7116	190	33221	22663	-10558
2042	1895	-1250	-3145	0	0	0	57	57	0	0	0	0	0	0	0	39	41	2	-8807	-8738	69	27193	18643	-8550
2043	1958	-1598	-3556	0	0	0	60	60	0	0	0	0	0	0	0	58	60	2	-9293	-9193	100	28887	17801	-11086
2044	1979	-1981	-3960	0	0	0	63	63	0	0	0	0	0	0	0	74	75	1	-2628	-2562	66	36520	25068	-11452
2045	1907	-1964	-3871	0	0	0	67	67	0	0	0	0	0	0	0	52	53	1	-1897	-1739	158	40782	29631	-11151
2046	1899	-1334	-3233	0	0	0	70	70	0	0	0	0	0	0	0	40	41	1	-7366	-7299	67	33168	24414	-8754
2047	1916	-1181	-3097	0	0	0	74	74	0	0	0	0	0	0	0	40	40	0	-3010	-2833	177	38904	30157	-8747
2048	1916	-2237	-4153	0	0	0	77	77	0	0	0	0	0	0	0	33	34	1	-4361	-4194	167	40274	29922	-10352
2049	1874	-1744	-3618	0	0	0	81	81	0	0	0	0	0	0	0	30	33	3	-1554	-1523	31	54259	45156	-9103
2010 2049	1663	-1428	-3091	0	0	0	31	31	0	0	0	0	0	0	0	27	29	2	-4444	-4317	127	32912	24397	-8515

Table 2. Kansas Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree WB	Arikaree NB	Arikaree Del	Beaver WB	Beaver NB	Beaver Del	Buffalo WB	Buffalo NB	Buffalo Del	Driftwood WB	Driftwood NB	Driftwood Del	Frenchman WB	Frenchman NB	Frenchman Del	North Fork WB	North Fork NB	North Fork Del	Above Swanson WB	Above Swanson NB	Above Swanson Del
2010	68	68	0	6893	6893	0	0	0	0	0	0	0	0	0	0	0	0	0	-199	18	217
2011	157	157	0	5972	5972	0	0	0	0	0	0	0	0	0	0	0	0	0	13	212	199
2012	100	100	0	2807	2807	0	0	0	0	0	0	0	0	0	0	0	0	0	421	137	-284
2013	92	92	0	897	897	0	0	0	0	0	0	0	0	0	0	0	0	0	-317	88	405
2014	105	105	0	784	784	0	0	0	0	0	0	0	0	0	0	0	0	0	388	241	-147
2015	107	107	0	2143	2143	0	0	0	0	0	0	0	0	0	0	0	0	0	110	198	88
2016	77	77	0	3453	3453	0	0	0	0	0	0	0	0	0	0	0	0	0	244	296	52
2017	91	91	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0	195	344	149
2018	86	86	0	7574	7574	0	0	0	0	0	0	0	0	0	0	0	0	0	146	313	167
2019	148	148	0	7925	7925	0	0	0	0	0	0	0	0	0	0	0	0	0	262	299	37
2020	63	63	0	7010	7010	0	0	0	0	0	0	0	0	0	0	0	0	0	-449	80	529
2021	153	153	0	6074	6074	0	0	0	0	0	0	0	0	0	0	0	0	0	299	335	36
2022	98	98	0	2849	2849	0	0	0	0	0	0	0	0	0	0	0	0	0	194	136	-58
2023	90	90	0	916	916	0	0	0	0	0	0	0	0	0	0	0	0	0	-448	62	510
2024	100	100	0	803	803	0	0	0	0	0	0	0	0	0	0	0	0	0	216	176	-40
2025	106	106	0	2155	2155	0	0	0	0	0	0	0	0	0	0	0	0	0	177	243	66
2026	75	75	0	3460	3460	0	0	0	0	0	0	0	0	0	0	0	0	0	157	321	164
2027	90	90	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0	223	348	125
2028	85	85	0	7537	7537	0	0	0	0	0	0	0	0	0	0	0	0	0	179	295	116
2029	148	148	0	8300	8300	0	0	0	0	0	0	0	0	0	0	0	0	0	186	254	68
2030	60	60	0	7206	7206	0	0	0	0	0	0	0	0	0	0	0	0	0	-447	205	652
2031	152	152	0	6134	6134	0	0	0	0	0	0	0	0	0	0	0	0	0	275	253	-22
2032	96	96	0	2834	2834	0	0	0	0	0	0	0	0	0	0	0	0	0	22	130	108
2033	86	86	0	907	907	0	0	0	0	0	0	0	0	0	0	0	0	0	-1633	-793	840
2034	96	96	0	789	789	0	0	0	0	0	0	0	0	0	0	0	0	0	213	392	179
2035	107	107	0	2138	2138	0	0	0	0	0	0	0	0	0	0	0	0	0	266	254	-12
2036	73	73	0	3440	3440	0	0	0	0	0	0	0	0	0	0	0	0	0	126	291	165
2037	90	90	0	5484	5484	0	0	0	0	0	0	0	0	0	0	0	0	0	463	429	-34
2038	85	85	0	7506	7506	0	0	0	0	0	0	0	0	0	0	0	0	0	77	258	181
2039	148	148	0	8579	8579	0	0	0	0	0	0	0	0	0	0	0	0	0	157	242	85
2040	56	56	0	7374	7374	0	0	0	0	0	0	0	0	0	0	0	0	0	-305	255	560
2041	154	154	0	6142	6142	0	0	0	0	0	0	0	0	0	0	0	0	0	232	195	-37
2042	93	93	0	2821	2821	0	0	0	0	0	0	0	0	0	0	0	0	0	-484	-113	371
2043	83	83	0	899	899	0	0	0	0	0	0	0	0	0	0	0	0	0	-3699	-827	2872
2044	93	93	0	776	776	0	0	0	0	0	0	0	0	0	0	0	0	0	-581	-533	48
2045	107	107	0	2123	2123	0	0	0	0	0	0	0	0	0	0	0	0	0	511	282	-229
2046	72	72	0	3429	3429	0	0	0	0	0	0	0	0	0	0	0	0	0	-124	257	381
2047	89	89	0	5473	5473	0	0	0	0	0	0	0	0	0	0	0	0	0	792	568	-224
2048	86	86	0	7479	7479	0	0	0	0	0	0	0	0	0	0	0	0	0	-20	216	236
2049	149	149	0	8816	8816	0	0	0	0	0	0	0	0	0	0	0	0	0	333	259	-74
2010 2049	100	100	0	4472	4472	0	0	0	0	0	0	0	0	0	0	0	0	0	-45	165	210

Year	Swanson - Harlan WB	Swanson - Harlan NB	Swanson - Harlan Del	Harlan - Guide Rock WB	Harlan - Guide Rock NB	Harlan - Guide Rock Del	Guide Rock - Hardy WB	Guide Rock - Hardy NB	Guide Rock - Hardy Del	Medicine WB	Medicine NB	Medicine Del	Prairie Dog WB	Prairie Dog NB	Prairie Dog Del
2010	-1173	-1173	0	0	0	0	245	245	0	0	0	0	3513	3513	0
2011	48	48	0	0	0	0	44	44	0	0	0	0	5026	5026	0
2012	344	344	0	0	0	0	54	54	0	0	0	0	3139	3139	0
2013	-235	-235	0	0	0	0	56	56	0	0	0	0	1690	1690	0
2014	0	0	0	0	0	0	69	69	0	0	0	0	1873	1873	0
2015	-34	-34	0	0	0	0	63	62	-1	0	0	0	5841	5841	0
2016	-394	-394	0	0	0	0	53	53	0	0	0	0	5564	5564	0
2017	382	382	0	0	0	0	68	68	0	0	0	0	5816	5816	0
2018	154	154	0	0	0	0	41	41	0	0	0	0	12547	12547	0
2019	82	82	0	0	0	0	54	54	0	0	0	0	10357	10357	0
2020	-1578	-1578	0	12	12	0	245	245	0	0	0	0	3776	3776	0
2021	63	62	-1	0	0	0	44	44	0	0	0	0	5432	5432	0
2022	542	542	0	0	0	0	54	54	0	0	0	0	3403	3403	0
2023	-276	-276	0	0	0	0	56	56	0	0	0	0	1914	1914	0
2024	0	0	0	0	0	0	69	69	0	0	0	0	2143	2143	0
2025	-557	-557	0	0	0	0	62	62	0	0	0	0	6159	6159	0
2026	-1066	-1066	0	0	0	0	53	53	0	0	0	0	5912	5912	0
2027	792	793	1	0	0	0	68	68	0	0	0	0	6190	6190	0
2028	191	191	0	0	0	0	41	41	0	0	0	0	12749	12749	0
2029	81	81	0	0	0	0	54	54	0	0	0	0	10481	10481	0
2030	-1700	-1700	0	13	13	0	245	245	0	0	0	0	3970	3970	0
2031	-71	-71	0	10	11	1	44	44	0	0	0	0	5723	5723	0
2032	623	623	0	0	0	0	53	53	0	0	0	0	3591	3591	0
2033	-274	-274	0	0	0	0	56	56	0	0	0	0	2091	2091	0
2034	0	0	0	0	0	0	69	69	0	0	0	0	2358	2358	0
2035	-622	-622	0	10	0	-10	62	62	0	0	0	0	6438	6438	0
2036	-2223	-2223	0	10	10	0	53	53	0	0	0	0	6164	6164	0
2037	1334	1333	-1	0	0	0	68	68	0	0	0	0	6501	6501	0
2038	253	253	0	0	0	0	40	40	0	0	0	0	12976	12976	0
2039	70	70	0	10	10	0	54	54	0	0	0	0	10646	10646	0
2040	-1769	-1769	0	14	14	0	245	245	0	0	0	0	4127	4127	0
2041	-199	-199	0	11	11	0	44	44	0	0	0	0	5964	5964	0
2042	651	651	0	0	0	0	54	54	0	0	0	0	3744	3744	0
2043	-273	-273	0	10	10	0	56	56	0	0	0	0	2246	2246	0
2044	0	0	0	0	0	0	69	69	0	0	0	0	2554	2554	0
2045	-668	-668	0	10	10	0	67	62	0	0	0	0	6670	6670	0
2046	-2442	-2443	-1	11	10	-1	53	53	0	0	0	0	6389	6389	0
2047	1411	1411	0	0	0	0	68	68	0	0	0	0	6768	6768	0
2048	369	369	0	0	0	0	40	40	0	0	0	0	13155	13155	0
2049	71	71	0	11	11	0	53	53	0	0	0	0	10846	10846	0
2010 2049	-202	-202	0	3	3	0	74	74	0	0	0	0	5911	5911	0

Year	Red Willow WB	Red Willow NB	Red Willow Del	Rock WB	Rock NB	Rock Del	Sappa WB	Sappa NB	Sappa Del	South Fork WB	South Fork NB	South Fork Del	Hugh Butler WB	Hugh Butler NB	Hugh Butler Del	Bonny WB	Bonny NB	Bonny Del	Keith Sebelius WB	Keith Sebelius NB	Keith Sebelius Del
2010	0	0	0	0	0	0	2482	2482	0	2343	1810	-533	0	0	0	10	0	-10	490	490	0
2011	0	0	0	0	0	0	1540	1540	0	7155	3213	-3942	0	0	0	11	0	-11	432	432	0
2012	0	0	0	0	0	0	266	266	0	4672	1578	-3094	0	0	0	12	0	-12	555	555	0
2013	0	0	0	0	0	0	-661	-661	0	4911	1189	-3722	0	0	0	13	0	-13	581	581	0
2014	0	0	0	0	0	0	-784	-784	0	5441	1858	-3583	0	0	0	14	0	-14	535	535	0
2015	0	0	0	0	0	0	-1700	-1700	0	7814	3951	-3863	0	0	0	14	0	-14	547	547	0
2016	0	0	0	0	0	0	-1038	-1038	0	4631	2911	-1720	0	0	0	15	0	-15	566	566	0
2017	0	0	0	0	0	0	820	820	0	5733	3505	-2228	0	0	0	16	0	-16	561	561	0
2018	0	0	0	0	0	0	3471	3471	0	6006	3932	-2074	0	0	0	18	0	-18	533	533	0
2019	0	0	0	0	0	0	4056	4056	0	8187	8004	-183	0	0	0	19	0	-19	476	476	0
2020	0	0	0	0	0	0	2529	2529	0	2320	3654	1334	0	0	0	20	0	-20	517	517	0
2021	0	0	0	0	0	0	1794	1794	0	6870	2999	-3871	0	0	0	21	0	-21	458	458	0
2022	0	0	0	0	0	0	399	399	0	4494	1406	-3088	0	0	0	22	0	-22	582	582	0
2023	0	0	0	0	0	0	-641	-641	0	4539	1007	-3532	0	0	0	23	0	-23	609	609	0
2024	0	0	0	0	0	0	-803	-803	0	5149	1642	-3507	0	0	0	24	0	-24	563	563	0
2025	0	0	0	0	0	0	-1598	-1598	0	8162	3738	-4424	0	0	0	26	0	-26	575	575	0
2026	0	0	0	0	0	0	-781	-781	0	4943	2775	-2168	0	0	0	27	0	-27	593	593	0
2027	0	0	0	0	0	0	1051	1051	0	5986	3337	-2649	0	0	0	28	0	-28	589	589	0
2028	0	0	0	0	0	0	3627	3627	0	6191	3757	-2434	0	0	0	29	0	-29	561	561	0
2029	0	0	0	0	0	0	3991	3991	0	8575	7636	-939	0	0	0	31	0	-31	503	503	0
2030	0	0	0	0	0	0	2589	2589	0	2340	4157	1817	0	0	0	32	0	-32	544	544	0
2031	0	0	0	0	0	0	1887	1887	0	6628	2824	-3804	0	0	0	33	0	-33	484	484	0
2032	0	0	0	0	0	0	478	478	0	4334	1277	-3057	0	0	0	35	0	-35	608	608	0
2033	0	0	0	0	0	0	-633	-633	0	4712	862	-3350	0	0	0	36	0	-36	634	634	0
2034	0	0	0	0	0	0	-789	-789	0	4895	1492	-3403	0	0	0	38	0	-38	589	589	0
2035	0	0	0	0	0	0	-1517	-1517	0	7919	3559	-4360	0	0	0	39	-11	-50	601	601	0
2036	0	0	0	0	0	0	-633	-633	0	5529	2653	-2876	0	0	0	40	0	-40	619	619	0
2037	0	0	0	0	0	0	1193	1193	0	6214	3205	-3009	0	0	0	42	0	-42	614	614	0
2038	0	0	0	0	0	0	3715	3715	0	6388	3619	-2769	0	0	0	43	-11	-54	586	586	0
2039	0	0	0	0	0	0	4004	4004	0	8956	7469	-1487	0	0	0	45	0	-45	528	528	0
2040	0	0	0	0	0	0	2672	2672	0	2352	3601	1249	0	0	0	46	0	-46	569	569	0
2041	0	0	0	0	0	0	1983	1983	0	6389	2604	-3785	0	0	0	48	0	-48	509	509	0
2042	0	0	0	0	0	0	542	542	0	4179	1164	-3015	0	0	0	49	0	-49	632	632	0
2043	0	0	0	0	0	0	-626	-626	0	3779	740	-3039	0	0	0	51	0	-51	658	658	0
2044	0	0	0	0	0	0	-776	-776	0	4660	1356	-3304	0	0	0	52	0	-52	613	613	0
2045	0	0	0	0	0	0	-1456	-1456	0	7691	3407	-4284	0	0	0	54	-21	-75	625	625	0
2046	0	0	0	0	0	0	-520	-520	0	5596	2555	-3041	0	0	0	56	0	-56	643	643	0
2047	0	0	0	0	0	0	1305	1305	0	6558	3086	-3472	0	0	0	57	-12	-69	638	638	0
2048	0	0	0	0	0	0	3780	3780	0	6626	3498	-3128	0	0	0	59	-16	-75	609	609	0
2049	0	0	0	0	0	0	4043	4043	0	9331	7317	-2014	0	0	0	61	-12	-73	552	552	0
2010 2049	0	0	0	0	0	0	981	981	0	5717	3108	-2609	0	0	0	32	-2	-34	567	567	0

Year	Enders WB	Enders NB	Enders Del	Harlan WB	Harlan NB	Harlan Del	Harry Strunk WB	Harry Strunk NB	Harry Strunk Del	Swanson WB	Swanson NB	Swanson Del	Mainstem WB	Mainstem NB	Mainstem Del	Total WB	Total NB	Total Del
2010	0	0	0	131	131	0	0	0	0	0	0	0	-1117	-900	217	14817	14492	-325
2011	0	0	0	102	102	0	0	0	0	0	0	0	113	313	200	20513	16759	-3754
2012	0	0	0	85	85	0	0	0	0	0	0	0	827	543	-284	12473	9077	-3396
2013	0	0	0	84	84	0	0	0	0	0	0	0	-489	-84	405	7127	3792	-3335
2014	0	0	0	81	81	0	0	0	0	0	0	0	465	318	-147	8523	4772	-3751
2015	0	0	0	78	78	0	0	0	0	0	0	0	148	234	86	14999	11203	-3796
2016	0	0	0	79	79	0	0	0	0	0	0	0	-89	-36	53	13266	11580	-1686
2017	0	0	0	79	79	0	0	0	0	0	0	0	653	802	149	19279	17180	-2099
2018	0	0	0	142	142	0	0	0	0	0	0	0	332	499	167	30714	28786	-1928
2019	0	0	0	165	165	0	0	0	0	0	0	0	406	443	37	31747	31584	-163
2020	0	0	0	137	137	0	0	0	0	0	0	0	-1770	-1241	529	14608	16453	1845
2021	0	0	0	107	107	0	0	0	0	0	0	0	416	451	35	21331	17472	-3859
2022	0	0	0	90	90	0	0	0	0	0	0	0	798	740	-58	12743	9568	-3175
2023	0	0	0	89	89	0	0	0	0	0	0	0	-659	-149	510	6893	3837	-3056
2024	0	0	0	89	89	0	0	0	0	0	0	0	294	254	-40	8374	4792	-3582
2025	0	0	0	89	89	0	0	0	0	0	0	0	-308	-243	65	15376	10982	-4394
2026	0	0	0	89	89	0	0	0	0	0	0	0	-847	-683	164	13480	11444	-2036
2027	0	0	0	88	88	0	0	0	0	0	0	0	1090	1216	126	20623	18065	-2558
2028	0	0	0	155	155	0	0	0	0	0	0	0	403	518	115	31347	28990	-2357
2029	0	0	0	168	168	0	0	0	0	0	0	0	330	399	69	32535	31630	-905
2030	0	0	0	139	139	0	0	0	0	0	0	0	-1888	-1236	652	14998	17439	2441
2031	0	0	0	109	109	0	0	0	0	0	0	0	258	236	-22	21418	17551	-3867
2032	0	0	0	92	92	0	0	0	0	0	0	0	707	815	108	12788	9794	-2994
2033	0	0	0	91	91	0	0	0	0	25	0	-25	-1841	-1002	839	5612	3041	-2571
2034	0	0	0	95	95	0	0	0	0	20	0	-20	291	471	180	8385	5109	-3276
2035	0	0	0	96	96	0	0	0	0	14	0	-14	-284	-296	-12	15556	11126	-4430
2036	0	0	0	95	95	0	0	0	0	11	0	-11	-2033	-1868	165	13310	10551	-2759
2037	0	0	0	92	92	0	0	0	0	10	0	-10	1872	1838	-34	22116	19018	-3098
2038	0	0	0	167	167	0	0	0	0	0	0	0	361	542	181	31841	29193	-2648
2039	0	0	0	169	169	0	0	0	0	0	0	0	291	376	85	33380	31925	-1455
2040	0	0	0	140	140	0	0	0	0	0	0	0	-1814	-1255	559	15532	17295	1763
2041	0	0	0	111	111	0	0	0	0	0	0	0	88	51	-37	21399	17517	-3882
2042	0	0	0	94	94	0	0	0	0	16	0	-16	230	601	371	12404	9701	-2703
2043	0	0	0	92	92	0	0	0	0	0	0	0	-3906	-1034	2872	3289	3069	-220
2044	0	0	0	99	99	0	0	0	0	32	17	-15	-502	-455	47	7606	4282	-3324
2045	0	0	0	102	102	0	0	0	0	23	13	-10	-85	-314	-229	15857	11259	-4598
2046	0	0	0	100	100	0	0	0	0	13	0	-13	-2503	-2123	380	13279	10549	-2730
2047	0	0	0	101	101	0	0	0	0	13	0	-13	2279	2055	-224	23286	19515	-3771
2048	0	0	0	177	177	0	0	0	0	0	0	0	379	616	237	32365	29396	-2969
2049	0	0	0	170	170	0	0	0	0	10	0	-10	468	394	-74	34450	32286	-2164
2010 2049	0	0	0	111	111	0	0	0	0	4	0	-4	-165	45	210	17740	15301	-2439

Table 3. Nebraska Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork			Above Swanson			Swanson - Harlan			Harlan - Guide Rock		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	126	126	0	5309	5309	0	3417	3417	0	1185	1185	0	77748	77748	0	978	978	0	9785	9784	-1	35347	35347	0	28926	28926	0
2011	320	320	0	5116	5116	0	3602	3602	0	1234	1234	0	80533	80533	0	1023	1023	0	11608	11608	0	42668	42669	1	28101	28101	0
2012	335	335	0	2946	2946	0	3602	3602	0	1278	1278	0	75800	75799	-1	1065	1065	0	10962	10946	-16	23476	23475	-1	29761	29761	0
2013	514	514	0	1465	1465	0	3650	3650	0	1397	1397	0	81465	81464	-1	1125	1125	0	18173	18151	-22	28954	28950	-4	31211	31211	0
2014	423	423	0	1816	1816	0	3675	3675	0	1479	1479	0	85962	85962	0	1177	1177	0	15323	15316	-7	35624	35622	-2	32675	32675	0
2015	242	242	0	3022	3022	0	3741	3741	0	1483	1483	0	80212	80212	0	1219	1219	0	11744	11728	-16	40778	40779	1	32616	32616	0
2016	122	122	0	3710	3710	0	3722	3722	0	1426	1426	0	74594	74594	0	1252	1252	0	9166	9130	-36	40093	40091	-2	30253	30253	0
2017	111	111	0	4964	4964	0	3743	3743	0	1362	1362	0	77253	77253	0	1293	1293	0	10352	10374	22	51227	51226	-1	29999	29999	0
2018	124	124	0	6485	6485	0	3783	3783	0	1299	1299	0	78165	78164	-1	1326	1326	0	9805	9832	27	51126	51123	-3	28903	28903	0
2019	154	154	0	6225	6225	0	3879	3879	0	1218	1218	0	81309	81309	0	1352	1352	0	10831	10875	44	59639	59639	0	28785	28785	0
2020	125	126	1	5277	5277	0	3924	3924	0	1201	1201	0	79293	79293	0	1379	1379	0	8361	8394	33	44028	44029	1	33138	33138	0
2021	318	318	0	5083	5083	0	3934	3934	0	1251	1251	0	81835	81837	2	1426	1426	0	11371	11439	68	45288	45292	4	32306	32307	1
2022	336	336	0	2938	2938	0	3887	3887	0	1295	1295	0	75961	75960	-1	1468	1468	0	10818	10843	25	26640	26637	-3	33812	33812	0
2023	510	510	0	1475	1475	0	3899	3899	0	1413	1413	0	81326	81325	-1	1532	1532	0	17760	17769	9	31013	31011	-2	35225	35225	0
2024	422	422	0	1727	1727	0	3942	3942	0	1495	1495	0	86106	86106	0	1587	1587	0	16045	16057	12	37434	37436	2	36700	36700	0
2025	246	246	0	2917	2917	0	4030	4030	0	1500	1500	0	80482	80482	0	1630	1630	0	12173	12166	-7	43194	43193	-1	36596	36595	-1
2026	124	124	0	3613	3613	0	4001	4001	0	1444	1444	0	74581	74580	-1	1661	1661	0	8864	8858	-6	43065	43064	-1	34188	34188	0
2027	113	113	0	4861	4861	0	4039	4039	0	1383	1383	0	78235	78234	-1	1706	1706	0	10617	10627	10	54383	54381	-2	34012	34012	0
2028	126	126	0	6355	6355	0	4114	4114	0	1325	1325	0	78904	78903	-1	1740	1740	0	10000	10015	15	54218	54215	-3	32904	32904	0
2029	157	157	0	6473	6473	0	4221	4221	0	1245	1245	0	83156	83156	0	1766	1766	0	11533	11587	54	61289	61289	0	32621	32621	0
2030	124	124	0	5370	5370	0	4226	4226	0	1228	1228	0	79835	79834	-1	1791	1791	0	6859	6869	10	46720	46719	-1	36931	36931	0
2031	316	316	0	5068	5068	0	4186	4186	0	1278	1278	0	82032	82033	1	1840	1840	0	11505	11603	98	48463	48467	4	36084	36084	0
2032	336	336	0	2930	2930	0	4114	4114	0	1320	1320	0	76035	76035	0	1878	1878	0	10568	10593	25	29570	29569	-1	37410	37409	-1
2033	502	502	0	1498	1498	0	4138	4138	0	1435	1435	0	80540	80541	1	1946	1946	0	16245	16211	-34	33682	33684	2	38806	38806	0
2034	422	422	0	1703	1703	0	4186	4186	0	1518	1518	0	86498	86498	0	2002	2002	0	16538	16558	20	38927	38927	0	40303	40303	0
2035	251	251	0	2882	2882	0	4262	4262	0	1523	1523	0	80649	80649	0	2045	2045	0	12960	12978	18	44859	44859	0	40132	40132	0
2036	126	126	0	3581	3581	0	4230	4230	0	1468	1468	0	74691	74692	1	2074	2074	0	8495	8456	-39	44838	44840	2	37678	37678	0
2037	116	116	0	4828	4828	0	4277	4277	0	1409	1409	0	79075	79074	-1	2123	2123	0	11145	11165	20	57549	57545	-4	37560	37560	0
2038	128	128	0	6315	6315	0	4347	4347	0	1354	1354	0	79299	79299	0	2158	2158	0	10149	10165	16	57339	57336	-3	36572	36573	1
2039	162	162	0	6718	6718	0	4478	4478	0	1279	1279	0	83798	83799	1	2183	2183	0	12351	12419	68	63841	63842	1	36132	36131	-1
2040	121	121	0	5495	5495	0	4468	4468	0	1263	1263	0	80469	80469	0	2205	2205	0	5509	5478	-81	48549	48550	1	40344	40344	0
2041	315	315	0	5066	5066	0	4404	4404	0	1311	1311	0	82248	82249	1	2255	2255	0	11640	11773	133	51094	51098	4	39527	39527	0
2042	336	336	0	2957	2957	0	4291	4291	0	1349	1349	0	76128	76127	-1	2290	2290	0	9928	9943	15	32073	32071	-2	40676	40676	0
2043	494	494	0	1532	1532	0	4275	4275	0	1463	1463	0	80010	80010	0	2360	2360	0	13307	13271	-36	36056	36058	2	41964	41964	0
2044	421	421	0	1700	1700	0	4379	4379	0	1546	1546	0	86665	86664	-1	2419	2419	0	15619	15583	-36	40518	40516	-2	43457	43457	0
2045	256	256	0	2857	2857	0	4526	4526	0	1551	1551	0	81164	81164	0	2461	2461	0	14131	14197	66	46105	46104	-1	43228	43228	0
2046	127	127	0	3562	3562	0	4445	4445	0	1496	1496	0	74875	74875	0	2488	2488	0	7821	7779	-42	46410	46411	1	40763	40763	0
2047	120	120	0	4807	4807	0	4529	4529	0	1438	1438	0	79716	79715	-1	2541	2541	0	11788	11803	15	60238	60235	-3	41005	41005	0
2048	129	129	0	6279	6279	0	4588	4588	0	1384	1384	0	79724	79723	-1	2577	2577	0	10312	10310	-2	60065	60060	-5	40075	40075	0
2049	167	167	0	6935	6935	0	4688	4688	0	1312	1312	0	84145	84145	0	2601	2601	0	13324	13388	64	66087	66085	-2	39451	39451	0
2010 2049	247	247	0	4096	4096	0	4096	4096	0	1370	1370	0	80012	80012	0	1798	1798	0	11637	11649	12	45061	45061	0	35770	35770	0

Year	Guide Rock - Hardy			Medicine			Prairie Dog			Red Willow			Rock			Sappa			South Fork			Hugh Butler		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	2503	2503	0	20127	20127	0	0	0	0	6969	6969	0	4362	4362	0	2751	2751	0	719	718	-1	2020	2020	0
2011	2695	2695	0	21311	21311	0	0	0	0	7422	7422	0	4400	4400	0	2304	2304	0	681	681	0	2016	2016	0
2012	2633	2633	0	22160	22160	0	0	0	0	6032	6032	0	4434	4434	0	1313	1313	0	821	731	-90	2169	2169	0
2013	3346	3346	0	23556	23556	0	0	0	0	6842	6842	0	4509	4509	0	867	867	0	1000	873	-127	2175	2175	0
2014	3224	3224	0	23879	23879	0	0	0	0	7180	7180	0	4624	4624	0	853	853	0	836	664	-172	2184	2184	0
2015	3728	3727	-1	23428	23428	0	0	0	0	7340	7340	0	4778	4778	0	949	949	0	1777	613	-1164	2113	2113	0
2016	3140	3140	0	22523	22523	0	0	0	0	6730	6730	0	4827	4827	0	1252	1252	0	1159	583	-576	2044	2044	0
2017	3054	3054	0	22848	22848	0	0	0	0	8433	8433	0	4934	4934	0	1975	1975	0	1107	586	-521	2054	2054	0
2018	2409	2409	0	22319	22319	0	63	63	0	8636	8636	0	5067	5067	0	3841	3841	0	1063	606	-457	2054	2054	0
2019	2314	2314	0	22165	22165	0	27	27	0	9235	9235	0	5267	5267	0	3881	3881	0	1360	1114	-246	2062	2062	0
2020	2590	2590	0	23251	23251	0	13	13	0	8280	8280	0	5291	5291	0	2682	2682	0	783	1424	641	2393	2393	0
2021	2805	2805	0	24322	24322	0	0	0	0	8226	8226	0	5209	5209	0	2471	2471	0	723	725	2	2382	2382	0
2022	2711	2711	0	24907	24907	0	0	0	0	6587	6587	0	5104	5104	0	1448	1448	0	755	756	1	2529	2529	0
2023	3420	3421	1	26279	26279	0	0	0	0	7347	7347	0	5113	5113	0	967	967	0	965	967	2	2529	2529	0
2024	3316	3316	0	26590	26590	0	0	0	0	7695	7695	0	5226	5226	0	950	950	0	713	713	0	2534	2534	0
2025	3807	3806	-1	26141	26141	0	0	0	0	7904	7904	0	5383	5383	0	1040	1040	0	1850	645	-1205	2457	2457	0
2026	3228	3228	0	25131	25131	0	0	0	0	7213	7213	0	5425	5425	0	1358	1358	0	1366	649	-717	2383	2383	0
2027	3174	3174	0	25652	25652	0	0	0	0	9047	9047	0	5537	5537	0	2120	2120	0	1185	616	-569	2388	2388	0
2028	2523	2523	0	25192	25192	0	45	45	0	9349	9349	0	5672	5672	0	3972	3972	0	1093	636	-457	2385	2385	0
2029	2377	2377	0	24960	24960	0	41	41	0	10001	10001	0	5871	5871	0	3785	3785	0	1426	888	-538	2387	2387	0
2030	2675	2675	0	25936	25936	0	16	16	0	8990	8990	0	5889	5889	0	2699	2699	0	829	1847	1018	2714	2714	0
2031	2905	2906	1	26949	26949	0	0	0	0	8846	8846	0	5797	5797	0	2537	2537	0	752	754	2	2698	2698	0
2032	2781	2781	0	27311	27311	0	0	0	0	7058	7058	0	5662	5662	0	1534	1534	0	801	804	3	2841	2841	0
2033	3491	3491	0	28713	28713	0	0	0	0	7811	7811	0	5695	5695	0	1027	1027	0	1036	1038	2	2837	2837	0
2034	3398	3398	0	29027	29027	0	0	0	0	8195	8195	0	5790	5790	0	1010	1010	0	812	818	6	2839	2839	0
2035	3876	3876	0	28537	28537	0	0	0	0	8411	8411	0	5907	5907	0	1099	1099	0	1208	680	-528	2756	2756	0
2036	3308	3308	0	27425	27425	0	0	0	0	7674	7674	0	5930	5930	0	1437	1437	0	1810	703	-1107	2679	2679	0
2037	3272	3272	0	28062	28062	0	0	0	0	9602	9602	0	6053	6053	0	2222	2222	0	1260	654	-606	2680	2680	0
2038	2610	2610	0	27552	27552	0	45	45	0	9918	9918	0	6180	6180	0	4053	4053	0	1139	666	-473	2673	2673	0
2039	2428	2427	-1	27263	27263	0	77	77	0	10604	10604	0	6373	6373	0	3780	3780	0	1489	783	-706	2671	2671	0
2040	2738	2738	0	28153	28153	0	27	27	0	9545	9545	0	6383	6383	0	2744	2744	0	860	2038	1178	2995	2995	0
2041	2982	2983	1	29133	29133	0	0	0	0	9346	9346	0	6284	6284	0	2612	2612	0	788	793	5	2975	2975	0
2042	2833	2833	0	29356	29356	0	0	0	0	7457	7457	0	6157	6157	0	1601	1601	0	856	859	3	3113	3113	0
2043	3548	3548	0	30796	30796	0	0	0	0	8250	8250	0	6184	6184	0	1071	1071	0	1095	1098	3	3106	3106	0
2044	3460	3460	0	31088	31088	0	0	0	0	8661	8661	0	6253	6253	0	1055	1055	0	920	925	5	3105	3105	0
2045	3931	3931	0	30561	30561	0	0	0	0	8857	8857	0	6370	6370	0	1146	1146	0	759	759	0	3018	3018	0
2046	3365	3365	0	29379	29379	0	0	0	0	8090	8090	0	6362	6362	0	1501	1501	0	1691	751	-940	2937	2937	0
2047	3338	3338	0	30063	30063	0	0	0	0	10095	10095	0	6478	6478	0	2307	2307	0	1492	729	-763	2935	2935	0
2048	2676	2676	0	29513	29513	0	62	62	0	10404	10404	0	6586	6586	0	4112	4112	0	1232	708	-524	2925	2925	0
2049	2459	2459	0	29180	29180	0	107	107	0	11116	11116	0	6790	6790	0	3805	3805	0	1555	774	-781	2919	2919	0
2010 2049	3026	3026	0	26268	26268	0	13	13	0	8384	8384	0	5603	5603	0	2103	2103	0	1094	834	-260	2566	2566	0

Year	Bonny			Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	0	0	0	0	0	0	4545	4545	0	1022	1022	0	312	312	0	254	254	0	76560	76560	0	208407	208406	-1
2011	0	0	0	0	0	0	4703	4703	0	878	878	0	322	322	0	273	273	0	85071	85072	1	221210	221211	1
2012	0	0	0	0	0	0	4843	4843	0	956	956	0	333	333	0	311	311	0	66831	66814	-17	195228	195120	-108
2013	0	0	0	0	0	0	5151	5151	0	959	959	0	470	470	0	510	510	0	81683	81657	-26	217337	217182	-155
2014	0	0	0	0	0	0	5236	5236	0	861	861	0	415	415	0	517	517	0	86846	86837	-9	227966	227784	-182
2015	0	0	0	0	0	0	5346	5346	0	950	950	0	371	371	0	450	450	0	88866	88850	-16	226287	225106	-1181
2016	0	0	0	0	0	0	5309	5309	0	911	911	0	346	346	0	403	402	-1	82652	82615	-37	212983	212370	-613
2017	0	0	0	0	0	0	5285	5285	0	888	888	0	341	341	0	358	358	0	94633	94653	20	231581	231081	-500
2018	0	0	0	0	0	0	5261	5261	0	883	883	0	336	336	0	338	339	1	92243	92268	25	233287	232855	-432
2019	0	0	0	0	0	0	5178	5178	0	860	860	0	332	332	0	267	268	1	101568	101612	44	246339	246138	-201
2020	0	0	0	0	0	0	5181	5181	0	1128	1128	0	337	337	0	276	277	1	88117	88151	34	228930	229606	676
2021	0	0	0	0	0	0	5326	5326	0	984	984	0	348	348	0	296	296	0	91771	91843	72	235904	235980	76
2022	0	0	0	0	0	0	5455	5455	0	1064	1064	0	359	359	0	334	334	0	73981	74002	21	208407	208430	23
2023	0	0	0	0	0	0	5752	5752	0	1069	1069	0	497	497	0	535	536	1	87418	87426	8	228626	228635	9
2024	0	0	0	0	0	0	5830	5830	0	977	977	0	443	443	0	544	544	0	93497	93508	11	240279	240291	12
2025	0	0	0	0	0	0	5929	5929	0	1070	1070	0	398	398	0	478	478	0	95770	95761	-9	239224	238010	-1214
2026	0	0	0	0	0	0	5882	5882	0	1030	1030	0	374	374	0	429	430	1	89345	89337	-8	225362	224636	-726
2027	0	0	0	0	0	0	5850	5850	0	1006	1006	0	369	369	0	385	385	0	102186	102194	8	246063	245501	-562
2028	0	0	0	0	0	0	5820	5820	0	999	999	0	365	365	0	364	365	1	99645	99657	12	247465	247020	-445
2029	0	0	0	0	0	0	5728	5728	0	977	977	0	361	361	0	291	292	1	107821	107874	53	260667	260182	-485
2030	0	0	0	0	0	0	5726	5726	0	1244	1244	0	366	366	0	298	300	2	93185	93195	10	240467	241495	1028
2031	0	0	0	0	0	0	5862	5862	0	1100	1100	0	377	377	0	318	319	1	98958	99060	102	248914	249021	107
2032	0	0	0	0	0	0	5985	5985	0	1179	1179	0	389	389	0	360	360	0	80328	80352	24	220061	220087	26
2033	0	0	0	0	0	0	6276	6276	0	1183	1183	0	527	527	0	575	575	0	92224	92193	-31	237964	237936	-28
2034	0	0	0	0	0	0	6349	6349	0	1094	1094	0	473	473	0	581	582	1	99166	99186	20	251667	251692	25
2035	0	0	0	0	0	0	6441	6441	0	1188	1188	0	429	429	0	508	507	-1	101828	101845	17	249925	249414	-511
2036	0	0	0	0	0	0	6390	6390	0	1148	1148	0	404	404	0	457	457	0	94319	94283	-36	235845	234701	-1144
2037	0	0	0	0	0	0	6354	6354	0	1121	1121	0	399	399	0	414	414	0	109526	109542	16	259523	258931	-592
2038	0	0	0	0	0	0	6321	6321	0	1115	1115	0	395	395	0	392	392	0	106671	106682	11	260056	259594	-462
2039	0	0	0	0	0	0	6225	6225	0	1093	1093	0	391	391	0	319	319	0	114751	114820	69	273654	273018	-636
2040	0	0	0	0	0	0	6720	6220	0	1359	1359	0	397	397	0	322	323	1	97140	97061	-79	250166	251266	1100
2041	0	0	0	0	0	0	6351	6351	0	1213	1213	0	408	408	0	345	346	1	105244	105381	137	260299	260444	145
2042	0	0	0	0	0	0	6470	6470	0	1292	1292	0	420	420	0	392	393	1	85510	85523	13	229973	229991	18
2043	0	0	0	0	0	0	6758	6758	0	1295	1295	0	558	558	0	601	602	1	94875	94841	-34	244723	244693	-30
2044	0	0	0	0	0	0	6829	6829	0	1207	1207	0	504	504	0	626	627	1	103054	103016	-38	260434	260400	-34
2045	0	0	0	0	0	0	6918	6918	0	1301	1301	0	460	460	0	545	545	0	107395	107459	64	260144	260208	64
2046	0	0	0	0	0	0	6864	6864	0	1259	1259	0	435	435	0	486	486	0	98359	98318	-41	244358	243378	-980
2047	0	0	0	0	0	0	6826	6826	0	1230	1230	0	430	430	0	442	442	0	116368	116381	13	271817	271065	-752
2048	0	0	0	0	0	0	6793	6793	0	1224	1224	0	426	426	0	419	419	0	113128	113120	-8	271507	270973	-534
2049	0	0	0	0	0	0	6693	6693	0	1208	1208	0	422	422	0	346	348	2	121321	121383	62	285311	284593	-718
2010 2049	0	0	0	0	0	0	5906	5906	0	1088	1088	0	400	400	0	408	409	1	95496	95508	12	240959	240711	-248

Table 4: Colorado CBCUg at various points on the South Fork stream network under the "No Bonny" condition.

Year	South Fork above Bonny Reservoir	Landsman Creek (above Bonny Reservoir)	South Fork inflow to Bonny Reservoir	South Fork at Bonny Reservoir Outlet	South Fork below Bonny Reservoir	South Fork at CO-KS State Line	South Fork at Confluence with RR	Difference Reach 1	Difference Reach 2	Difference Reach 3	Difference Reach 4	Difference Reach 5	Total Difference
2010	8,151	592	8,371	7,752	7,658	6,052	3,735	(372)	(619)	(94)	(1,606)	(2,317)	(5,008)
2011	10,395	261	10,787	9,705	9,659	9,189	3,299	132	(1,082)	(47)	(470)	(5,890)	(7,357)
2012	8,315	11	7,977	6,774	6,687	5,438	2,467	(349)	(1,203)	(87)	(1,249)	(2,971)	(5,859)
2013	9,886	-	9,606	8,036	7,916	6,437	1,828	(280)	(1,570)	(120)	(1,479)	(4,609)	(8,058)
2014	10,470	-	10,083	8,246	8,163	6,615	1,882	(387)	(1,837)	(83)	(1,548)	(4,734)	(8,589)
2015	12,131	19	11,806	10,084	10,006	8,954	5,219	(345)	(1,722)	(77)	(1,052)	(3,735)	(6,931)
2016	9,493	23	9,181	7,955	7,884	6,601	5,451	(335)	(1,225)	(72)	(1,282)	(1,151)	(4,065)
2017	10,218	37	10,036	9,000	8,944	8,239	6,273	(218)	(1,036)	(56)	(705)	(1,965)	(3,981)
2018	12,522	30	12,270	10,254	10,153	9,202	6,658	(282)	(2,016)	(101)	(951)	(2,543)	(5,894)
2019	14,928	571	16,156	15,230	15,230	16,528	15,345	658	(927)	0	1,298	(1,183)	(154)
2020	8,899	610	9,184	8,603	8,526	7,852	8,625	(326)	(581)	(77)	(674)	773	(885)
2021	11,016	287	11,009	9,935	9,883	9,275	3,249	(293)	(1,074)	(52)	(608)	(6,026)	(8,053)
2022	8,410	20	8,126	6,953	6,843	5,486	2,294	(304)	(1,172)	(110)	(1,357)	(3,192)	(6,136)
2023	9,988	-	9,758	8,216	8,082	6,486	1,701	(230)	(1,542)	(134)	(1,596)	(4,785)	(8,286)
2024	10,577	-	10,242	8,368	8,282	6,635	1,723	(335)	(1,874)	(86)	(1,647)	(4,912)	(8,854)
2025	12,239	31	11,981	10,223	10,143	8,988	4,970	(289)	(1,757)	(81)	(1,154)	(4,018)	(7,299)
2026	9,594	32	9,314	8,068	7,994	6,619	5,276	(312)	(1,246)	(74)	(1,375)	(1,342)	(4,350)
2027	10,324	50	10,193	9,128	9,058	8,271	6,041	(180)	(1,065)	(69)	(787)	(2,230)	(4,332)
2028	12,627	41	12,446	10,370	10,270	9,227	6,437	(222)	(2,076)	(100)	(1,043)	(2,789)	(6,231)
2029	17,280	604	18,023	16,396	16,382	16,658	15,008	139	(1,626)	(14)	276	(1,651)	(2,876)
2030	9,609	623	9,961	9,294	9,237	9,607	10,507	(270)	(667)	(57)	370	899	275
2031	11,116	302	11,157	10,032	9,979	9,295	3,058	(261)	(1,125)	(53)	(684)	(6,237)	(8,360)
2032	8,501	27	8,262	7,043	6,928	5,503	2,127	(267)	(1,219)	(115)	(1,426)	(3,376)	(6,401)
2033	10,086	0	9,887	8,312	8,182	6,502	1,573	(199)	(1,575)	(130)	(1,680)	(4,929)	(8,513)
2034	10,682	-	10,380	8,438	8,351	6,638	1,614	(302)	(1,942)	(86)	(1,713)	(5,024)	(9,068)
2035	12,341	38	12,166	10,307	10,225	9,000	4,731	(213)	(1,859)	(82)	(1,226)	(4,269)	(7,648)
2036	9,687	39	9,428	8,142	8,067	6,628	5,095	(298)	(1,286)	(75)	(1,439)	(1,532)	(4,631)
2037	10,423	58	10,337	9,216	9,137	8,292	5,834	(143)	(1,121)	(79)	(845)	(2,458)	(4,647)
2038	12,730	49	12,613	10,459	10,360	9,248	6,231	(166)	(2,154)	(99)	(1,112)	(3,017)	(6,549)
2039	18,374	624	18,790	17,089	17,012	16,708	14,683	(208)	(1,702)	(77)	(305)	(2,025)	(4,315)
2040	10,421	630	11,132	10,363	10,354	10,083	11,024	81	(769)	(9)	(270)	941	(27)
2041	11,210	311	11,295	10,106	10,052	9,358	2,876	(226)	(1,189)	(54)	(694)	(6,482)	(8,644)
2042	8,587	31	8,366	7,117	7,006	5,548	1,971	(251)	(1,250)	(111)	(1,458)	(3,576)	(6,646)
2043	10,177	1	9,986	8,388	8,260	6,539	1,443	(193)	(1,598)	(128)	(1,721)	(5,096)	(8,735)
2044	10,775	-	10,474	8,493	8,406	6,652	1,543	(301)	(1,981)	(87)	(1,755)	(5,109)	(9,232)
2045	12,435	42	12,341	10,377	10,294	9,021	4,541	(135)	(1,964)	(83)	(1,273)	(4,480)	(7,935)
2046	9,774	43	9,539	8,206	8,130	6,649	4,923	(278)	(1,334)	(76)	(1,481)	(1,725)	(4,895)
2047	10,515	63	10,473	9,291	9,204	8,318	5,672	(105)	(1,181)	(87)	(886)	(2,646)	(4,905)
2048	12,820	53	12,765	10,528	10,430	9,265	6,037	(108)	(2,237)	(98)	(1,165)	(3,228)	(6,836)
2049	18,499	635	18,931	17,187	17,104	16,754	14,364	(202)	(1,744)	(82)	(350)	(2,391)	(4,770)
Average 2010-2049	**11,156**	**170**	**11,121**	**9,692**	**9,612**	**8,609**	**5,433**	**(204)**	**(1,429)**	**(80)**	**(1,003)**	**(3,176)**	**(5,892)**

Non-Binding Arbitration initiated March 21, 2013

pursuant to

Decree of May 19, 2003, 538 U.S. 720
Kansas v. Nebraska & Colorado,
No. 126 Orig., U.S. Supreme Court
Report on the

Colorado's Compact Compliance Pipeline Proposal and
Bonny Reservoir Accounting Proposal

Republican River Compact

Response to application and proposal by State of Colorado, dated April 5, 2013

Prepared by

David W. Barfield, P.E.

Chief Engineer, Division of Water Resources

Kansas Department of Agriculture

July 29, 2013

I. Qualifications.

From late 1992 until becoming Chief Engineer in 2007, a principal part of my professional work was dedicated to the study and assessment of the hydrology and water infrastructure of the Republican River Basin ("Basin") and administration of the Republican River Compact ("Compact"). This work engaged the many technical challenges of administering the Compact before, during, and after the litigation that produced the Final Settlement Stipulation of 2003 ("FSS"). As part of these duties, I was involved in all of the technical discussions related to the negotiation of the FSS, its Accounting Procedures, the RRCA Groundwater Model ("Model"), and all joint sessions of the various negotiation teams. After the adoption of the FSS, my work focused on implementing that agreement.

Since 2007, I have served as the Chief Engineer of the Division of Water Resources, Kansas Department of Agriculture. In that capacity, I have two principal duties. My first duty is that of a professional engineer specializing in water resources. This duty includes the analysis of water supplies, water resources management, surface water and groundwater hydrology, groundwater modeling, and the assessment of water structures. My second duty is that of the Chief Engineer. As Chief Engineer, I have the duty to administer and enforce the laws relating to water supply for the State of Kansas. These consist principally of the Kansas Water Appropriation Act, the four interstate compacts to which Kansas is a party, and numerous other laws and implementing regulations related to special water districts in Kansas, dams and dams safety, floodplain activities, and more. It is my duty to ensure that my administration of these laws and regulations accords with the realities of the State of Kansas – most importantly, the realities of its water supplies and of its water needs. As the Kansas commissioner to the Republican River Compact Administration ("RRCA"), I am responsible for all Compact-related matters. As a technical expert for Kansas leading up to and during the 1998-2003 litigation and settlement, and now as Chief Engineer, I have served in the administration of the Compact for nearly twenty years.

II. Introduction.

This report summarizes my technical and administrative review of the Colorado's Compact Compliance Pipeline Proposal ("CCP Proposal") and Colorado's Bonny Reservoir Accounting Proposal ("Bonny Proposal") as was submitted to the RRCA in April 2013, and are now the subject of this arbitration. This report rests upon my three areas of expertise. First, it rests upon my role as Compact Commissioner for Kansas. Second, it rests upon my expertise in administering the Compact, the FSS, and its Accounting Procedures. I necessarily follow the rules, tests, and procedures set forth by these documents, and apply facts to them, using my own expertise. Finally, it rests upon my expertise in evaluating the hydrology and water resources of the Basin.

This report includes, for reference, my previous expert report on Colorado's previous CCP Proposal. Sections II through V of my previous report remain as important background for both the CCP issue and the Bonny issue, but will not be repeated here due to the Arbitrator's familiarity with this content from the 2010 arbitration.

Section III of this report includes an update to the procedural history on the CCP Proposal, with a focus on the current revised proposal. This section discusses the narrowing of the issues from the first arbitration by Colorado's revised proposal and through subsequent discussions between Colorado and Kansas since its submittal. Sections IV-VI discuss the remaining CCP issues, focusing on the remaining inadequacies of Colorado's proposal. Section VII provides background on Colorado's Bonny Proposal. Section VIII discusses the inadequacies of Colorado's Bonny proposal, focusing on its management implications.

My opinions are as follows:

1. The FSS requires RRCA approval of augmentation plans so that the States may fully review them to ensure that such plans are fully and appropriately integrated into the Accounting Procedures and the Model, and that such plans have sufficient terms and conditions to protect the interests of all the States consistent with the Compact and FSS. See section V of my previous report.

2. As set forth more fully in Section IV below, the CCP Proposal requires the following elements, which it presently lacks.

    a. The CCP Proposal requires determination of the augmentation credit through the appropriate use of the Model to account for losses. Colorado's current proposal is an inappropriate use of the Model for this purpose.

    b. The CCP Proposal continues to lack adequate operational limits which do not protect Kansas entitlements on the South Fork Republican River.

    c. The CCP Proposal continues to include a CCP delivery method that relies on a disputed interpretation of Colorado's water-short year requirements, and the calculation method must be resolved.

3. Colorado's Bonny Reservoir Accounting Proposal is inappropriate for the following reasons:

    a. It fails to accurately represent the effects of Colorado's pumping on the basin's water supply.

b. It fails to sufficiently address evaporation from Bonny Reservoir's area in its new operational mode.

c. Separate from the reduction in CBCUs caused by reductions to evaporation, the substantial reduction in Colorado's CBCUg affected by a simple change to the Groundwater Model is an inequitable departure from the agreement that was negotiated at the time the FSS was developed and adopted by the States and Court.

4. A revised Bonny Reservoir Accounting Proposal should be developed which:

a. Avoids a substantial increase in residuals (unallocated depletions) resulting from modeling of Bonny Reservoir; and

b. Includes methods to accurately assess the surface water losses from the Bonny Reservoir area.

III. Background on Colorado's revised CCP Proposal, its consideration by the RRCA, and subsequent discussions with Colorado.

In 2009, Colorado brought its CCP Proposal to the RRCA for approval. Kansas was not able to approval the Proposal and the issue was arbitrated. In my report for that arbitration, I listed seven issues of concern leading to Kansas rejection of the proposal as follows:

1. The Colorado Proposal does not follow the Model and the Accounting Procedures of the FSS.
2. North Fork accounting credits must be limited to protect Kansas' subbasin allocations on the South Fork.
3. The operational limitations of Colorado's Proposal are ineffective.
4. The Colorado Proposal lacks any temporal limits.
5. Colorado's proposed changes to the Accounting Procedures require full review by the States.
6. Colorado's "catch-up" provisions are inadequate.
7. Colorado must explain the reasons for its increase in augmentation water to 25,000 acre-feet per year.

The Arbitrator ruled that Kansas had legitimate concerns that were not adequately addressed in Colorado's proposal and that Kansas was justified in withholding its approval of the CCP.

Following this, Kansas and Colorado resumed settlement discussions. In late 2011, Colorado ordered the draining of Bonny Reservoir to address Colorado's South Fork Republican River overuse. This introduced a significant new issue; the appropriate way to deal with the accounting and modeling of Bonny Reservoir in light of its revised condition and anticipated operations.

Colorado presented a revised CCP Proposal to the RRCA on April 5, 2013. In submitting the matter to the RRCA, Colorado included a schedule that required RRCA action within 30 days and designated the issue as a "fast-track" issue, if the states did not adopt their proposal.

At the May 2, 2013 RRCA special meeting, Kansas voted not to adopt Colorado's proposal. At the meeting, I encouraged the State of Colorado to continue its dialogue with the State of Kansas to resolve our concerns, many of which appear to be close to resolution but are not yet fully resolved, in their revised proposal. Kansas devoted significant resources in working to resolve the issues between the States.

As of July 12, 2013, Colorado and Kansas reached an oral, conceptual agreement on the following issues:

Issue 4. Specific elements for regular, periodic review of the project.

Issue 5. Colorado would submit and Kansas would support additional clarifications to the accounting procedures that would include clear reporting requirements and attach the terms and conditions related to the project to the RRCA's accounting procedures

Issue 6. Kansas concerns related to "catch-up" provisions will be sufficiently addressed in Colorado's projection methodology for determining operations and Colorado's stated intent not to replace overuse prior to this existing account period.

Issue 7. The terms of the revised CCP are sufficient to address Colorado's desire to add up to 1500 acre-feet of additional capacity to the project in the future.

While our mutual agreement on these matters has not been finalized in written form, we are sufficiently confident in our agreement that Kansas has not addressed the foregoing Issues 4, 5, 6, and 7 in its reports and does not believe these issues need to be subjects of the arbitration trial. In the unlikely event that the states have misunderstood our mutual agreement, Kansas reserves its right to file supplemental report to address any unresolved issues.

In addition to issues 1-3 listed above which have not been resolved, Kansas has raised as a related issue to this proceeding the meaning of Colorado's Water-Short Year Administration compliance test.

IV. CCP Modeling and its accounting impacts

Kansas continues to hold that both augmentation pumping and augmentation flows must be properly treated in the Compact's accounting procedures. The States agree on the representation of pumping from augmentation wells in the model.

The States do not agree on the proper way to treat augmentation water that is placed into the river system. In demanding 100% credit for CCP deliveries, Colorado effectively refuses to account for and be held responsible for any losses that will befall the augmentation water. To fail to account for the losses that occur in the physical world would be to not only inflate the credit available to the augmenting state but would also result in errors in the RRCA's accounting.

In the previous arbitration, Kansas noted Colorado's failure to propose a method for determining augmentation credit that included using the Model to evaluate the impacts of Colorado's augmentation outflows. Kansas continues to hold that the Model must be used in this way to be consistent with the FSS and with the practical requirement to consider downstream losses.

In its commentary on its revised proposal, Colorado states the following:

> "*Based on further discussion with Kansas, Colorado proposes that Colorado be given 100% credit for CCP deliveries as an offset to stream depletions to the North Fork of the Republican River, provided the deliveries are in compliance with the other terms and conditions of the resolution, and that the CCP deliveries be included in all runs of the RRCA Groundwater Model (including the "Colorado Pumping" and the "No Colorado Pumping" runs used to determine stream depletions), as shown in the proposed revisions to the RRCA Accounting Procedures.*"

For reasons cited in Mr. Larson's report, Kansas does not believe Colorado's proposal for use of the Model is appropriate as it does not use the model to determine the "augmentation credit" as required by the FSS. Instead it increases each state's groundwater CBCU in the Swanson reach based on the additional flows. This also increases CBCU to Nebraska and Kansas.

The Colorado method of including augmentation outflows in the "No Colorado Pumping" run of the Model creates an artificial condition, one that has never occurred, and one that appears to contradict itself, since the outflows cannot occur without the pumping that produces them.

The Colorado method underestimates the downstream losses of augmentation flows. Augmentation water that is pumped from groundwater and offsets groundwater depletions is a direct substitute for baseflow, and so whatever the fate of such baseflow, the same fate should attach to the augmentation water.

Colorado's explanation of its modeling proposal indicates it is responsive to Kansas' suggestions in our settlement discussion. Kansas did not advocate or suggest the modeling approach proposed by Colorado.

The use of the model to determine the augmentation credit as explained in Mr. Larson's expert report instead adjusts the augmentation credit to reflect the losses estimated by the Model. That is a more appropriate treatment of the basin's water supplies and allocations. As is shown in

Mr. Larson's expert report, the calculation of Colorado's augmentation credit estimated using Kansas' modeling method and Colorado's projected hydrologic future would result in a credit of approximately 88.5% on average of Colorado's deliveries, rather than the 100% credit that Colorado proposes.

V. Operational Limits and Protecting Kansas South Fork allocation

Kansas continues to hold that defined, transparent, and enforceable operational limits are necessary to ensure that Colorado's augmentation operations are reasonably tied to its compliance requirements and that North Fork augmentation does not replace Colorado's overuse of the South Fork. As is discussed in Mr. Book's report, Colorado's revised proposal continues to have insufficient operational limits.

VI. Colorado's Water-short year test

Under the FSS (Section V.B and its related accounting procedures), during periods when the basin is in a water-short condition, each state must keep its use to a more restrictive limit than that set by the normal 5-year average compliance test. Each state's test is specific to that state, and was crafted as a product of the FSS negotiations. These state-specific tests were intended to provide each State as much flexibility as possible in the use of its allocation, while remaining consistent with the needs and rights of the other States. Both Kansas and Nebraska have two-year compliance tests in water-short years. Nebraska must keep its use above Guide Rock within its allocation above Guide Rock over the two years; importantly, the accounting treats the year that is determined to be water-short as the second year, or Year 2, of the two-year average. Kansas must restrict its northwest Kansas use for the same two years. Colorado negotiated a five-year average test under water-short years rather than a two-year test. However, Colorado cannot include its share of the Beaver Creek allocation in this five-year test. See Attachment 1.

Kansas believes that the FSS and the accounting procedures require Colorado to exclude its share of the Beaver Creek allocation from all five years of this water-short year test. On the contrary, Colorado believes that only the water-short years are adjusted in the water-short test.

This issue has important ramifications for the CCP Proposal, because how it is resolved will significantly affect the amounts of projected deliveries estimated under that proposal. The difference between the States' positions is most pronounced in the first year of a water-short period. In Kansas' approach, all five years of Beaver Creek allocation would not be used in the accounting; in Colorado's approach, only that first year would not be used. See Attachment 2.

VII. Background on Colorado's Bonny Proposal

To address its overuse of the South Fork Republican River, Colorado drained Bonny Reservoir in late 2011. Colorado seeks to leverage the draining of Bonny Reservoir to reduce its CBCU on the South Fork in two ways. First, Colorado will be charged less evaporation from the drained reservoir. Second, Colorado proposes a change to the Model which will effectively move the point in the river system at which Colorado's groundwater pumping impacts are evaluated from Bonny Reservoir to 40 miles downstream at Benkelman, Nebraska. Though there are no anticipated reductions to Colorado's groundwater pumping in the South Fork basin, this proposed Model change would have the effect of significantly reducing Colorado's groundwater CBCU. Attachment 3 displays the estimates of the groundwater pumping by the states of Colorado and Kansas from the work of the RRCA Groundwater Modeling Committee through the year 2000 and as reported to the RRCA by the states since the year 2000. Attachment 4 displays the determinations of the groundwater computed beneficial consumptive use (CBCU) from the RRCA Groundwater Model from the work of the RRCA Groundwater Modeling Committee through the year 2000 and based on data submitted to the RRCA since the year 2000.

As a result of the very significant impacts to the RRCA accounting in Colorado's modeling proposal, Kansas was not able to approve the proposed modeling change. Once again, Kansas invited additional negotiations with the State of Colorado to seek resolution of the issue. We have been unable to reach agreement on this issue.

This issue has not been arbitrated before.

VIII. Water Management Implications of Colorado's Bonny Proposal and the need for revisions to the Colorado Proposal

Mr. Larson's expert report discusses Colorado's proposal for modeling Bonny Reservoir and summarizes its dramatic reduction to Colorado's groundwater CBCU and increase in residuals (unallocated impacts). Thus, Colorado's Proposal appears to be an inaccurate representation of the impacts of Colorado's groundwater pumping.

In addition, Colorado's Proposal, if adopted, would affect the future management of this part of the Basin. Specifically:

- By producing a "paper water" reduction of Colorado's pumping impacts on the South Fork, the proposal allow Colorado to avoid making necessary reductions in South Fork consumption.
- By reducing Kansas' South Fork allocation, the proposals make Kansas' future compliance on the South Fork test more difficult.
- By reducing Kansas' allocation on the South Fork, the proposals also make Kansas' compliance on the Northwest Kansas test more difficult during water-short years. Kansas has relied upon its unused South Fork allocation to help meet its Water-Short Year Administration compliance test.

Mr. Book's report provides the specifics on these accounting impacts.

Regarding the accounting for Bonny Reservoir under Colorado's current operations, Kansas believes the following:

Bonny Modeling – Kansas believes that it is necessary to deal with these residuals when considering a change to Bonny Modeling.

Surface water evaporation – Colorado's Proposal would assess reservoir evaporation from Bonny Reservoir in the same way as other federal reservoirs. Kansas believes this assumption will need to be closely examined. The reservoir area is undergoing significant changes, with the growth of substantial growth of certain phreatophytes, which are likely resulting in significant water use. This evolution will likely to continue over time. Kansas suggests the states assess the use of alternative methods to represent the evaporative losses from areas that are not water surface but are beyond the normal band of riparian vegetation of a stream corridor. This evaporation should be charged to Colorado.

List of attachments:

1. Attachment 1, "RRCA Accounting Procedures, Table 5a."
2. Attachment 2, Colorado Beaver Creek Accounting Values
3. Attachment 3, *Annual Groundwater Pumping by Colorado and Kansas in South Fork Basin 1940-2012*
4. Attachment 4, South Fork Groundwater CBCU by Colorado and Kansas 1940-2011

References:

- Colorado's Compact Compliance Pipeline Proposal, April 5, 2013
- Bonny Reservoir Accounting Proposal, April 5, 2013
- Dale E. Book, Report on Colorado Compliance Pipeline, July 29, 2013
- Steven P. Larson and Samuel P. Perkins PhD., Report on the Colorado Compact Compliance Pipeline Proposal, July 29, 2013
- Steven P. Larson and Samuel P. Perkins PhD., Report on the Colorado Bonny Reservoir Accounting Proposal, July 29, 2013
- David W. Barfield, Report on the Colorado Compliance Pipeline, June 22, 2010
- Dale E. Book, Report on the Colorado Compliance Pipeline, June 22, 2010
- Steven P. Larson, Kansas Expert Response to Colorado's Expert Report, June 22, 2010.
- Republican River Compact
- Final Settlement Stipulation
- RRCA accounting procedures, August 12, 2010
- *Kansas v. Nebraska & Colorado,* No. 126 Orig., FIRST REPORT OF THE SPECIAL MASTER (SUBJECT: NEBRASKA MOTION TO DISMISS); 530 U.S. 1272 (2000)
- *Kansas v. Nebraska & Colorado,* No. 126 Orig., SECOND REPORT OF THE SPECIAL MASTER, April 15, 2003
- *Kansas v. Nebraska & Colorado,* No. 126 Orig., FINAL REPORT OF THE SPECIAL MASTER WITH CERTIFICATE OF ADOPTION OF RRCA GROUNDWATER MODEL, September 17, 2003.
- Steve's expert report in KS v CO on the inadequacies of the 5-Run

Attachment 1

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	Credits from Imported Water Supply excluding Beaver Creek	Difference between Allocation and Computed Beneficial Consumptive Use Minus Imported Water Supply for All Basins Except Beaver Creek Col 1 – (Col 2 – Col 3)
Year T= -4				
Year T= -3				
Year T= -2				
Year T= -1				
Current Year T= 0				
Average				

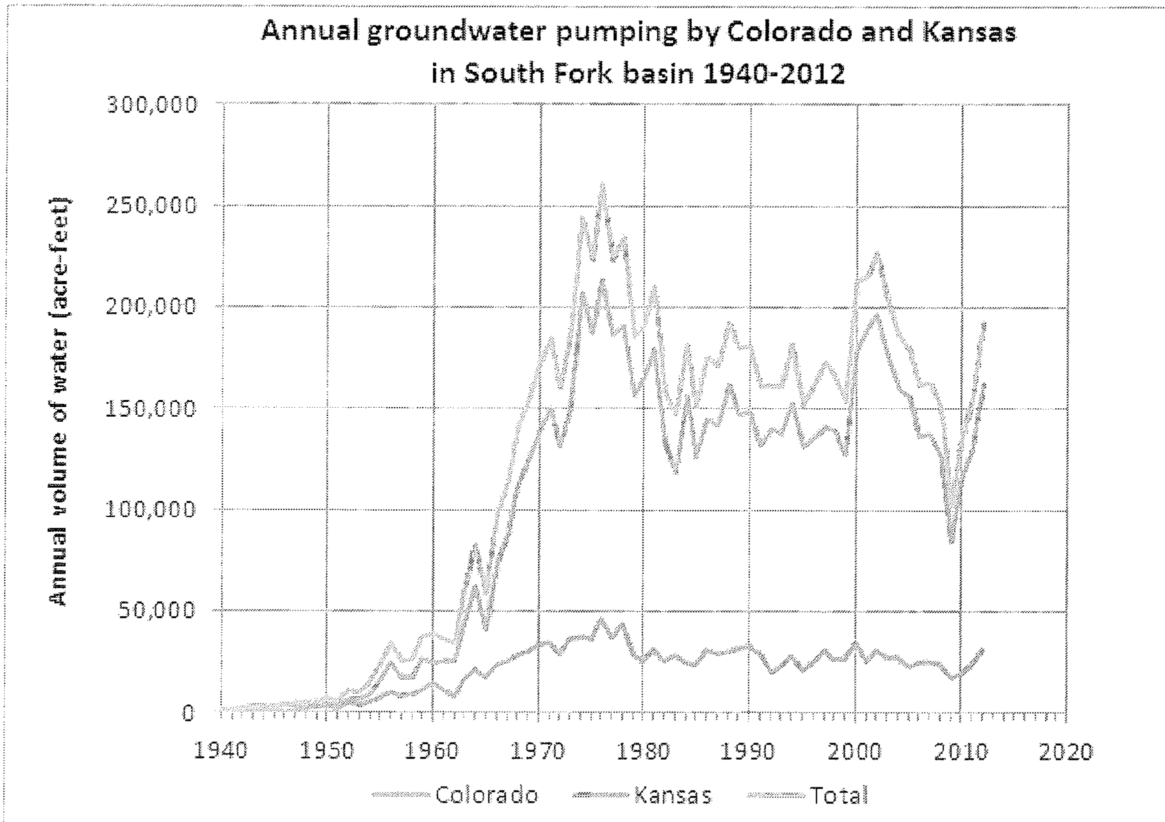
Attachment 2

Colorado's Beaver Creek Allocations

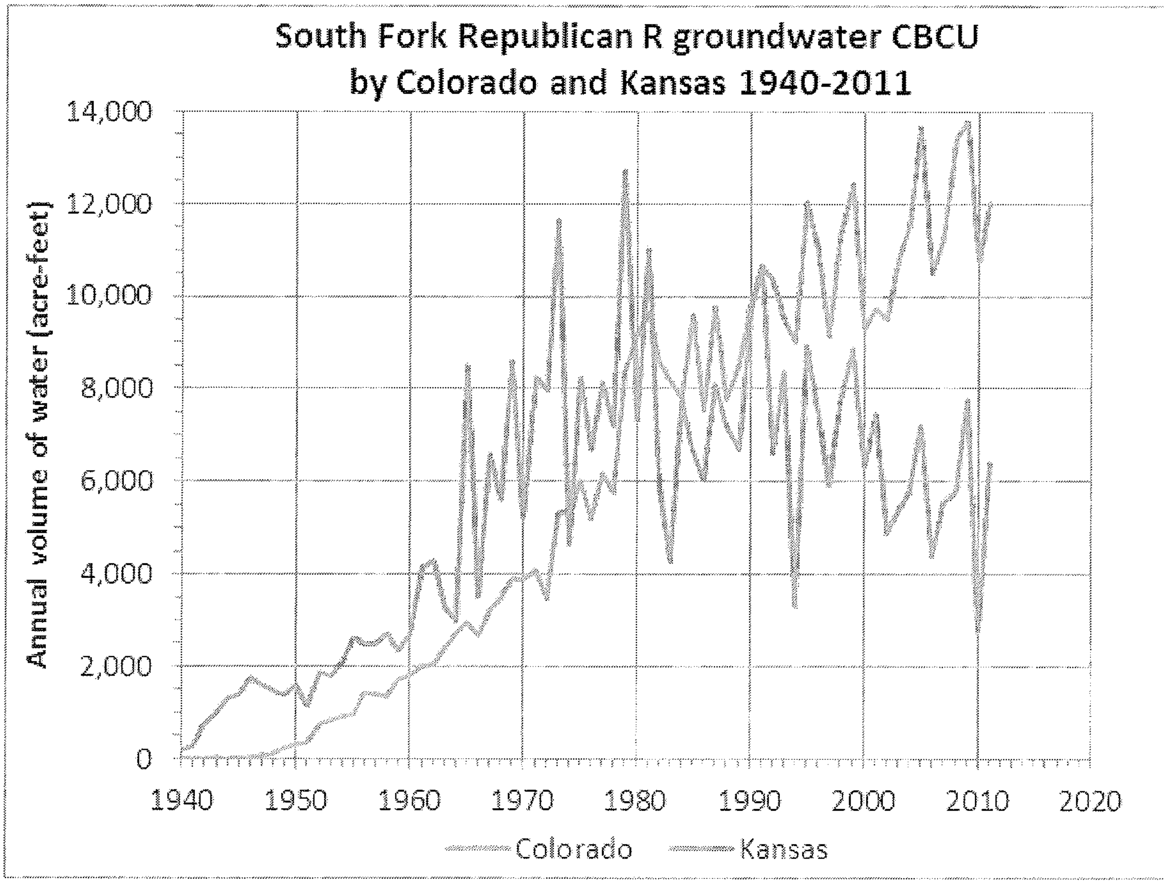
	Colorado Computed Water Supply	Colorado Beaver Creek allocation	Colorado Beaver Creek CBCU	Colorado Beaver Creek Compliance	5-year Sum of Colorado Beaver Creek Allocation	Sum of Colorado Beaver Creek Allocations in Water-Short Years	Criteria met for Water-Short Year Declaration
1995	15,410	3,080	0	3,080			No
1996	27,430	5,490	0	5,490			No
1997	19,880	3,980	0	3,980			No
1998	12,880	2,580	0	2,580			No
1999	13,080	2,620	0	2,620	17,750		No
2000	9,690	1,940	0	1,940	16,610		No
2001	7,480	1,500	0	1,500	12,620		No
2002	3,870	**770**	0	770	**9,410**	**770**	Yes
2003	1,290	**260**	0	260	**7,090**	**1,030**	Yes
2004	1,820	**360**	0	360	**4,830**	**1,390**	Yes
2005	4,560	**910**	0	910	**3,800**	**2,300**	Yes
2006	7,110	**1,420**	0	1,420	**3,720**	**3,720**	Yes
2007	11,600	**2,320**	0	2,320	**5,270**	**5,270**	Yes
2008	15,480	3,100	0	3,100	8,110		No
2009	14,780	2,960	0	2,960	10,710		No
2010	13,630	2,730	0	2,730	12,530		No
2011	12,810	2,560	0	2,560	13,670		No
2012	9,310	1,860	0	1,860	13,210		No
2013*		800	0	800	**10,910**	10,910	Yes

* 2013 values are estimated for illustration purposes only

Attachment 3



Attachment 4



Non-Binding Arbitration initiated May 2, 2013

Pursuant to

Decree of May 19, 2003, 538 U.S. 720

Kansas v. Nebraska & Colorado

No. 126 Orig., U.S. Supreme Court

Report on the
Colorado Compliance Pipeline

Republican River Compact

Response to Application Submitted by Colorado, dated April 5, 2013

Prepared by

Dale E. Book

Spronk Water Engineers, Inc.

July 29, 2013

Table of Contents

Table

1.0 Introduction

Colorado has resubmitted a proposal for the Compact Compliance Pipeline (CCP) Augmentation Plan. This Plan was previously considered during the arbitration proceeding of 2010. The physical components of the Project are essentially the same as for the prior submittal. A description of the project and some of the issues raised by the State of Kansas is included in my previous report, dated June 22, 2010. (2010 SWE report)

Colorado submitted an application, with a report (Exhibit 1), draft resolution for adoption by the RRCA (Exhibit A) and a mark-up of revised Accounting Procedures (Exhibit 2), on April 5, 2013. It is my understanding that no modifications were made to the proposal as a result of the RRCA Work Session of April 22, 2013 or the special administration Meeting of May 2. The Colorado submittal report includes discussion of the previous arbitrator's decision and responses to the recommendations from that report.

Since the time of the previous proceeding, compact accounting has been compiled on a preliminary basis, but has not been agreed to by the RRCA. The status of Colorado's compact compliance was documented in the 2010 SWE report through the year 2008 and has not been updated for this report.

2.0 Operational Limits - Whether Additional Operational Limits are Needed

The proposed operation of the CCP project is described in Exhibit A, the draft resolution (¶8. A. – G.) and at section 2.3 of the report (pg. 8 and 9). These provisions are similar to the operational details testified to by Mr. Slattery at the hearing in 2010. Several modifications from the original Colorado proposal in 2009 have been incorporated.

The "Projected Delivery" will form the basis for the delivery of augmentation credit each year. An initial estimate is to be developed by April 1 each year. The initial Projected Delivery is now proposed to be based on the maximum stream depletion for the North Fork sub-basin over the previous five years, without pipeline deliveries. (¶8A). This is different than the "Projected Delivery" proposed in 2009, which was the largest annual compliance deficit in the preceeding ten years, statewide.

The Projected Delivery is then updated sometime prior to September 1. The basis for the update is stated in ¶8.F of Exhibit A and in the report (pg. 9, ¶4). The projected compact compliance status will be used to establish the pumping for the remainder of the year.

Table 1 provides the annual North Fork depletions and the comparison of CBCU to allocation for the South Fork and the North Fork for the years 2003 - 2007. The North Fork depletions averaged 14,364 acre-feet/yr. over this period. The statewide overuse is listed and averaged 11,574 acre-feet/yr. The amount that the CBCU exceeded the sub-basin allocations in the North Fork and South Fork is also shown. These comparisons averaged 7,814 and 5,818 acre-feet/yr.

respectively. Finally, the amount of the Statewide overuse, after subtracting out the South Fork overuse, averaged 5,756 acre-feet/yr.

The following comments are provided regarding the current proposal.

The term Projected Delivery is not explicitly defined. The resolution does not limit the allowable credit to the Projected Delivery. The proposal generally states that it is to be initially based on the largest stream depletions to the North Fork sub-basin during the previous five years without Pipeline deliveries (CO Resolution, ¶8.A.). Taken literally, this would be about 15,000 acre-feet at current levels of depletions.

Later in Colorado's resolution, they describe an update to the Projected Delivery required for the remainder of the subject accounting year, which will include any deficit owed from the previous four years (Exhibit A, ¶8.E.). It is unclear whether Colorado intends to include their Statewide deficit or if it will be limited to the North Fork deficit. Additionally, the Arbitrator recommended that the amount of credit approved for the North Fork, and used to determine Statewide compliance, should be reasonably tied to the amount of estimated overuse, not stream depletions, on the North Fork.

The resolution is silent on what amount, if any, of flexibility is to be included in the calculation of Projected Delivery in the update. The current language does not provide enough detail about the specifics of the calculation to identify how the projected delivery would be related to the projected compliance status. I previously recommended some flexibility in the application of projection calculations to determine the amount of augmentation pumping each year to account for uncertainty in the calculations.

3.0 South Fork Overuse

The current proposal does not identify a limit on the amount of augmentation credit for North Fork overuse to be applied to the determination of statewide overuse that is reasonably tied to North Fork overuse.

The proposal does not exclude any overuse in the South Fork sub-basin from the determination of projected delivery. Colorado's response on this matter is to note that augmentation credit will only be applied to the North Fork compliance in the sub-basin test (Table 4A). However, this limitation was also part of the 2009 proposal. This limitation is not sufficient to prevent the application of the credit in the statewide compliance test (Table 3A). Therefore it remains necessary to adjust the Projected Delivery to remove the South Fork overuse from the calculated need for compact compliance.

To address this issue, it is necessary to include in the procedure to update the Projected Delivery (¶8.E.) the following:

A forecast method is envisioned by the current proposal. To limit the credit for CCP deliveries to exclude South Fork overuse, it should be deducted from the Statewide forecasted overuse. Elements needed for the forecast would be CBCU, surface water hydrology, and Compact compliance status for the four previous years. A mechanism for estimating the current accounting year's hydrology and use would also be necessary. Consideration of Colorado's previous four year deficit, excluding the South Fork, needs to be factored into determination of the allowable CCP credit. The minimum delivery for any one year continues to be 4,000 acre-feet, as in the previous proposal.

Colorado's response on the matter of South Fork compliance with the sub-basin non-impairment test is that Bonny Reservoir has been ordered drained, and a proposal for revisions to the accounting has been submitted. Irrespective of how this separate request is resolved, the CCP Augmentation Plan should address the issue identified in the first arbitration proceeding to limit the use of North Fork augmentation credit reasonably to the North Fork overuse, to avoid the use of excess credit to satisfy the test for statewide compliance.

4.0 Use of the Groundwater Model

This issue was addressed in my 2010 report (pg. 11 – 12). I continue to hold the opinion that the augmentation water should be included in the model run with pumping on (i.e. actual conditions), when calculating the Colorado depletions due to Groundwater pumping.

Colorado's current proposal is different than this recommendation and includes the augmentation water in both the pumping and no-pumping model runs. This variation on representing augmentation water discharges with the model would include the augmentation well discharge in a condition with all pumping off in Colorado. This would result in a quantity of baseflow that is too high for such a condition.

5.0 References

1. Colorado Compact Compliance Pipeline Proposal; Submittal to RRCA; April 5, 2013
2. Pagel, Martha O., October 7, 2010, Arbitrator's Final Decision, In Re: Non-Binding Arbitration Pursuant to the Final Settlement Stipulation, *Kansas v. Nebraska and Colorado*, No. 126, Orig., U.S. Supreme Court
3. Book, Dale E., June 22, 2010, Report on the Colorado Compliance Pipeline Republican River Compact Response to reports prepared on behalf of Colorado, dated May 24, 2010, Expert Report prepared for Kansas in non-binding Arbitration initiated May 2, 2013 pursuant to Decree of May 19,2003, 538 U.S. 720 in Kansas v. Nebraska & Colorado No. 126, Orig., U.S. Supreme Court

4. Larson, Steven P. and Perkins, Samuel P, July 29, 2013, Report on the Compact Compliance Proposal, Expert Report prepared for Kansas in non-binding Arbitration initiated May 2, 2013 pursuant to Decree of May 19,2003, 538 U.S. 720 in Kansas v. Nebraska & Colorado No. 126, Orig., U.S. Supreme Court

5. RRCA Accounting Spreadsheet; 2003 - 2008

TABLE

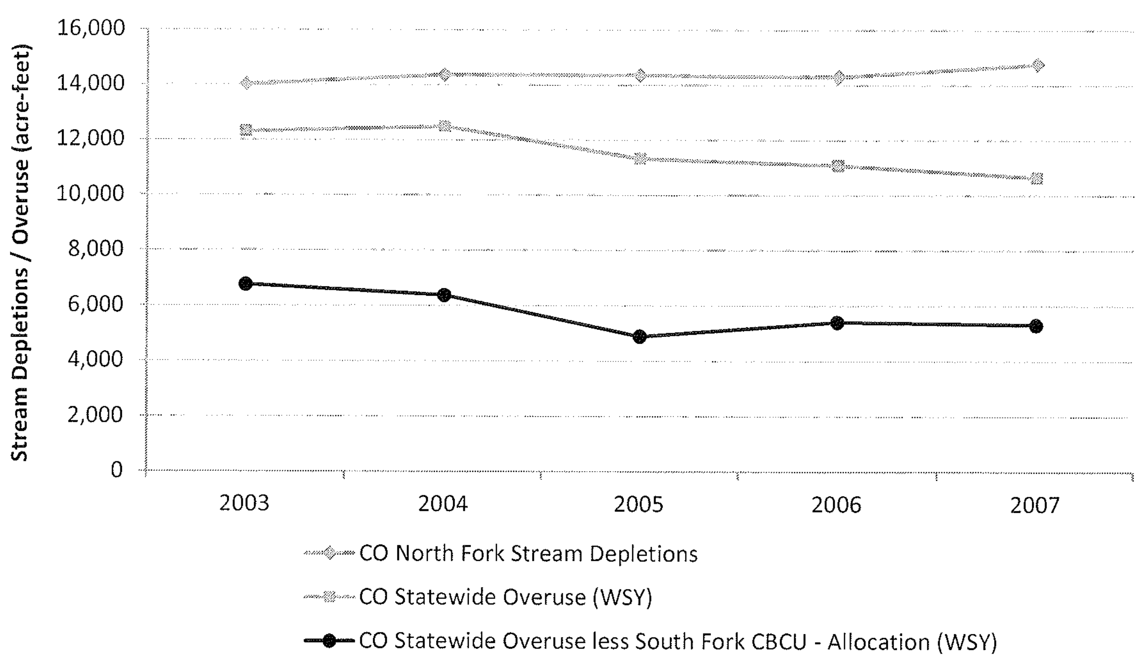
Table 1

Comparison of Colorado North Fork Stream Depletions and Colorado Overuse
2003 - 2007
(acre-feet)

Year	(1) CO North Fork Stream Depletions	(2) CO Statewide Overuse (WSY)	(3) CO North Fork (CBCU - Allocation)	(4) CO South Fork (CBCU - Allocation)	(5) CO Statewide Overuse less South Fork CBCU - Allocation (WSY)
2003	14,023	12,310	7,520	5,550	6,760
2004	14,373	12,490	7,910	6,110	6,380
2005	14,359	11,330	7,490	6,430	4,900
2006	14,301	11,090	8,290	5,670	5,420
2007	14,762	10,650	7,860	5,330	5,320
Avg	14,364	11,574	7,814	5,818	5,756

Notes:

(1) Colorado ground water CBCU in the North Fork sub-basin. Results generated using the RRCA Ground Water Model.
(2) Colorado annual Statewide overuse under water-short year administration (WSY).
(3) Colorado North Fork CBCU minus their allocation on the North Fork.
(4) Colorado South Fork CBCU minus their allocation on the Sorth Fork.
(5) equals (2) - (4)



Non-Binding Arbitration initiated May 2, 2013

Pursuant to

Decree of May 19, 2003, 538 U.S. 720

Kansas v. Nebraska & Colorado

No. 126 Orig., U.S. Supreme Court

Report on the Colorado Bonny Reservoir Accounting Proposal

Republican River Compact

Response to Application Submitted by Colorado, dated April 5, 2013

Prepared by

Dale E. Book

Spronk Water Engineers, Inc.

July 29, 2013

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1.0. Introduction

Colorado has submitted a proposal for modifying the representation of Bonny Reservoir with the RRCA Groundwater Model. (GW Model) The purpose of the modification is to represent the reservoir under changed operations, with the reservoir being managed as a "run of the river" structure. Colorado's stated intention is to regulate Bonny Reservoir such that streamflow will be passed through the reservoir as possible, subject to the capacity of the outlet works at the dam. The proposed change to the modeling is to set up a test based on reservoir content, whereby inflows are passed through to the downstream reach if water is not being stored, but is intercepted and not passed if water is being stored in the reservoir. The effect of the change is a significant reduction to the Colorado groundwater pumping depletions computed by the model. In addition, Colorado anticipates that the reservoir evaporation would be effectively eliminated.

The change was submitted by Colorado to the RRCA for consideration on April 5, 2013 and subsequently voted upon by the administration on May 2. Arbitration was invoked on May 2 for the proposal submitted to the Administration in April.

I have reviewed the request submitted by Colorado and the changes to the modeling results created by the change. I have consulted with David Barfield and Steve Larson in the review of the proposal. This report provides my conclusions and opinions regarding this proposal.

2.0. Description

The request by Colorado has been caused by the administrative action taken by the State of Colorado to assist with compact compliance in the Republican River Basin, by eliminating storage in Bonny Reservoir to the extent possible with the existing outlet works. This produces a reduction in consumptive use by reducing or eliminating reservoir evaporation. The reservoir also contributes to GW pumping depletions in Colorado and is modeled at the stage corresponding to the water level surface. Removing the reservoir storage therefore results in some reduction of pumping depletions in the vicinity of the reservoir.

Bonny Reservoir was constructed as a federal reservoir project in approximately 1950 and has been managed by the State of Colorado as a recreational facility. Since approximately 1996, storage has been declining due to lack of stream inflow and in 2011, Colorado began to release water remaining in storage. The reservoir storage has since been evacuated.

Bonny Reservoir is located on the South Fork of the Republican River in Colorado, approximately 10 miles west of the Colorado – Kansas Stateline. From the Reservoir it is approximately 54 stream miles to the Republican River at Benkelman, Nebraska. (See Figure 1). This is one of seven reservoirs included in the RRCA Groundwater Model.

The proposal requests a change to the representation of the reservoir in the GW Model. Essentially the change would be to remove the reservoir from the stream system in the model under most, if not all, conditions. There are two important elements involved for modeling the reservoirs; the water level and interception of baseflow. The water level stage is specified in the model for each stress period. Model base inflows are intercepted and not passed downstream. The change proposed is to pass the base inflows at the reservoir site downstream.

The details of the change are described in more detail in the report prepared by Larson and Perkins.

The change has been determined to cause a large reduction on the calculated depletions for Colorado Groundwater pumping. The reasons for this are described in more detail below and in the Larson and Perkins report. Effects have been determined for the historical years of 2003 – 2008 and for a projected period of 40 years, using historical hydrology and pumping.

The total pumping depletions for Colorado would be reduced by 60%, from approximately 14,000 ac-ft/yr to 5,700 ac-ft/yr. A smaller reduction to the Kansas pumping depletion would also result, from 5,700 to 3,100 acre-feet/yr., or 45%. Kansas GW depletions are less than the Kansas allocation in the South Fork sub-basin. Historical ('03 – '08) average indicates Kansas CBCU 5,900 acre-feet/yr. with an allocation of 9,500 acre-feet/yr, or 3,600 acre-feet/yr. of unused allocation.

3.0 Modeling Results

The changes to the representation of the Bonny Reservoir with the Model have the effect of passing the base inflow through the reservoir to the downstream reach. This results in a significant change in the computed pumping depletions for Colorado. It also has some effect on the pumping depletions computed for the states of Kansas and Nebraska.

Table 1 is a compilation of the allocation, CBCU and balance from the sub-basin non-impairment test for Colorado for the years 2003 – 2008. The historical and projected results for the No-Bonny condition are included. The CBCU for Bonny Reservoir evaporation has been set to zero in the No-Bonny condition. The GW CBCU using the Colorado proposal changes from 12,850 acre-feet/yr. to 5,240 acre-feet/yr. This table includes revised allocations for the No-Bonny condition. This calculation required an assumption about the impact that eliminating the reservoir evaporation would have on the historical Benkelman streamflow. For purposes of this calculation, it was assumed that 50% of the evaporation removed from Table A would translate to the Benkelman gage. The resulting allocation with the revised GW CBCU and reservoir evaporation would be calculated as 5,080 acre-feet/yr.

Table 1 shows the Colorado balance with the sub-basin non-impairment test changes from a shortfall of -2,300 acre-feet/yr. to positive 1,120 acre-feet/yr. for this period.

Table 2 shows the Kansas allocation, CBCU and balance with the sub-basin non-impairment test for the years 2003 – 2008. The amount of allocation in excess of CBCU with the current modeling procedure was 3,640 acre-feet/yr. This is unused allocation for Kansas on the South

Fork. With the changed computation of CBCU, the unused allocation is reduced to 1,300 acre-feet/yr., or approximately 35% of the amount of unused allocation with Bonny Reservoir as currently modeled.

The effects of the change in CBCU and allocation for the South Fork for Colorado and Kansas accounting are shown on Figure 2.

Table 3 is a summary of the accounting for the Kansas Water Short Year Test. This test (Table 5B of the Accounting Procedures) is a two-year test for Northwest Kansas. The accounting is summarized for the years 2003 – 2007, which were water short years for compact accounting purposes. The Test shows that the NW Kansas balance (Total allocation – CBCU) ranged from 6,010 acre-feet to 7,500 acre-feet. With the changes proposed by Colorado the Kansas water-short year test balance is reduced to 2,330 to 4,660 acre-feet.

The proposed change to pass the inflows at the reservoir to the downstream reach results in baseflow passing downstream in the No-Colorado pumping condition, but not in any significant amount in the historical pumping condition, since the baseflow has been largely eliminated upstream of Bonny Reservoir. Therefore, the no-pumping baseflow is subject to significant reduction between Bonny Reservoir and Benkelman, resulting in a reduction in computed GW CBCU. This effect is the same as that which occurs downstream of Colorado on the mainstem of the Republican River above Swanson Reservoir, where negative depletions are compiled and netted out against Colorado's pumping depletions.

As noted in the Larson and Perkins report, the pumping impacts on the South Fork, when calculated separately for each of the three states with the Colorado proposal, results in a total pumping effect that is less than the pumping impacts determined when all pumping is considered simultaneously. This is described as the residual CBCU not allocated and represents a deviation from the no-pumping condition at Benkelman.

4.0 Summary and Conclusions

The change proposed by Colorado would reduce Colorado GW CBCU on the South Fork from 14,300 to 5,700 acre-feet/yr. for a projected future condition. This is allocated as 3,100 acre-feet/yr at the reservoir due to the changed water level conditions, 3,200 ac-ft/yr downstream in Kansas and the balance downstream of the reservoir in Colorado.

The Colorado balance between the CBCU and allocation on the South Fork would be improved from -5,620 to -480 acre-feet/yr. for the 2003 – 2008 period. When adding the unallocated supply for the sub-basin non-impairment test, CBCU would be less than the available supply.

Kansas unused allocation on the South Fork (allocation – CBCU) would be reduced by 65% or 2,340 acre-feet/yr as a result of the change proposed by Colorado to represent Bonny Reservoir for computing Groundwater pumping depletions in Colorado.

A portion of the change in the Colorado Groundwater pumping depletion computed with the proposed change, 38%, occurs downstream of the Stateline. Changes to pumping depletions computed downstream of Bonny Reservoir are attributed to changing the assumption being made for passing the baseflow past the reservoir in the no-pumping condition.

The change in computing pumping impacts for the Colorado proposal has significantly increased the amount of unallocated pumping depletion for the South Fork, to 3,800 acre-feet/yr. for the projected pumping and precipitation condition.

TABLES

Table 1

Colorado South Fork Sub-Basin

Allocation, Computed Beneficial Consumptive Use (CBCU), and Compliance Status

2003 - 2008

(acre-feet)

A. Historical

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Year	Allocation	Ground Water	CBCU Bonny Evaporation	Total	Allocation - CBCU	Unallocated Supply	Total Available Supply	Available Supply - CBCU
2003	10,540	12,115	3,375	16,090	(5,550)	3,320	13,860	(2,230)
2004	10,690	12,874	3,158	16,800	(6,110)	3,370	14,060	(2,740)
2005	12,230	14,952	3,430	18,660	(6,430)	3,860	16,090	(2,570)
2006	9,120	11,756	3,031	14,790	(5,670)	2,880	12,000	(2,790)
2007	10,160	12,511	2,716	15,490	(5,330)	3,200	13,360	(2,130)
2008	10,320	12,892	1,980	14,920	(4,600)	3,250	13,570	(1,350)
Average	10,510	12,850	2,950	16,130	(5,620)	3,310	13,820	(2,300)

B. No Bonny [9]

Year	Allocation	Ground Water	CBCU Bonny Evaporation	Total	Allocation - CBCU	Unallocated Supply	Total Available Supply	Available Supply - CBCU
2003	3,560	2,636	0	3,230	330	1,120	4,680	1,450
2004	3,620	2,783	0	3,550	70	1,140	4,760	1,210
2005	5,870	6,177	0	6,450	(580)	1,850	7,720	1,270
2006	5,070	5,980	0	5,980	(910)	1,600	6,670	690
2007	5,940	6,687	0	6,950	(1,010)	1,870	7,810	860
2008	6,430	7,182	0	7,230	(800)	2,030	8,460	1,230
Average	5,080	5,240	0	5,570	(480)	1,600	6,680	1,120

(1) Colorado's allocation on the South Fork, equal to 44.4% of the Computed Water Supply.

(2) Colorado's ground water cbcu computed using the RRCA Ground Water Model.

(3) Bonny Reservoir evaporation.

(4) Total CBCU equals the ground water CBCU plus surface water CBCU, rounded to the nearest ten acre-feet. Colorado had 327 acre-feet/year of surface water CBCU in addition to Bonny evaporation.

(5) equals (1) - (4)

(6) Unallocated supply equals 14% of the Computed Water Supply.

(7) equals (1) + (6)

(8) equals (7) - (4)

(9) No Bonny condition incorporates results from the RRCA Ground Water without Bonny, assumes zero Bonny evaporation with 50% effect at Benkelman gage, and zero change in storage without modification to the gage.

Table 2

Kansas South Fork Sub-Basin

Allocation, Computed Beneficial Consumptive Use (CBCU), and Compliance Status

2003 - 2008

(acre-feet)

A. Historical

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		CBCU						
Year	Allocation	Ground Water	Surface Water	Total	Allocation - CBCU	Unallocated Supply	Total Available Supply	Available Supply - CBCU
2003	9,540	5,351	29	5,380	4,160	3,320	12,860	7,480
2004	9,680	5,781	303	6,080	3,600	3,370	13,050	6,970
2005	11,080	7,227	294	7,520	3,560	3,860	14,940	7,420
2006	8,260	4,398	325	4,720	3,540	2,880	11,140	6,420
2007	9,200	5,527	144	5,670	3,530	3,200	12,400	6,730
2008	9,340	5,748	121	5,870	3,470	3,250	12,590	6,720
Average	9,520	5,670	200	5,870	3,640	3,310	12,830	6,960

B. No Bonny (9)

		CBCU						
Year	Allocation	Ground Water	Surface Water	Total	Allocation - CBCU	Unallocated Supply	Total Available Supply	Available Supply - CBCU
2003	3,220	1,395	29	1,420	1,800	1,120	4,340	2,920
2004	3,280	2,095	303	2,400	880	1,140	4,420	2,020
2005	5,310	4,184	294	4,480	830	1,850	7,160	2,680
2006	4,590	3,080	325	3,400	1,190	1,600	6,190	2,790
2007	5,370	3,690	144	3,830	1,540	1,870	7,240	3,410
2008	5,820	4,137	121	4,260	1,560	2,030	7,850	3,590
Average	4,600	3,100	200	3,300	1,300	1,600	6,200	2,900

(1) Kansas' allocation on the South Fork, equal to 40.2% of the Computed Water Supply.
(2) Kansas' ground water cbcu computed using the RRCA Ground Water Model.
(3) Total of small pumps and non-Federal reservoir evaporation CBCU.
(4) equals (2) plus (3), rounded to the nearest ten acre-feet.
(5) equals (1) - (4)
(6) Unallocated supply equals 14% of the Computed Water Supply.
(7) equals (1) + (6)
(8) equals (7) - (4)
(9) No Bonny condition incorporates results from the RRCA Ground Water without Bonny, assumes zero Bonny evaporation with 50% effect at Benkelman gage, and zero change in storage without modification to the gage.

Table 3

Table 5B of the Accounting Procedures
Kansas Water Short Year Test
Historical and Without Bonny Reservoir
2003 - 2007
(acre-feet)

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

Year	Allocation			Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS)	**Two-Year Avg. [2] WSY Test**
	Sub-Basin Total	Kansas's Share [1] of Unallocated Supply	Total				
2003	13,900	4,527	18,427	12,130	NA	6,297	
2004	13,060	3,976	17,036	11,320	NA	5,716	**6,010**
2005	18,380	6,060	24,440	16,370	NA	8,070	**6,890**
2006	14,750	4,589	19,339	14,630	NA	4,709	**6,390**
2007	23,060	7,849	30,909	20,610	NA	10,299	**7,500**

Table 5B: Kansas Compliance During Water-Short Year Administration - No Bonny [3]

Year	Allocation			Computed Beneficial Consumptive Use	Imported Water Supply Credit	Allocation - (CBCU - IWS)	**Two-Year Avg. [2] WSY Test**
	Sub-Basin Total	Kansas's Share [1] of Unallocated Supply	Total				
2003	7,580	3,403	10,983	8,170	NA	2,813	
2004	6,660	2,836	9,496	7,640	NA	1,856	**2,330**
2005	12,610	5,038	17,648	13,330	NA	4,318	**3,090**
2006	11,080	3,935	15,015	13,310	NA	1,705	**3,010**
2007	19,230	7,164	26,394	18,770	NA	7,624	**4,660**

Notes:

(1) Kansas receives 51.1% of the unallocated supply.

(2) Table 5B is a two-year test. This was added by Kansas to show the two-year running average for the five years in the table.

(3) No Bonny condition incorporates results from the RRCA Ground Water without Bonny, assumes zero Bonny evaporation with 50% effect at Benkelman gage, and zero change in storage without modification to the gage.

FIGURES

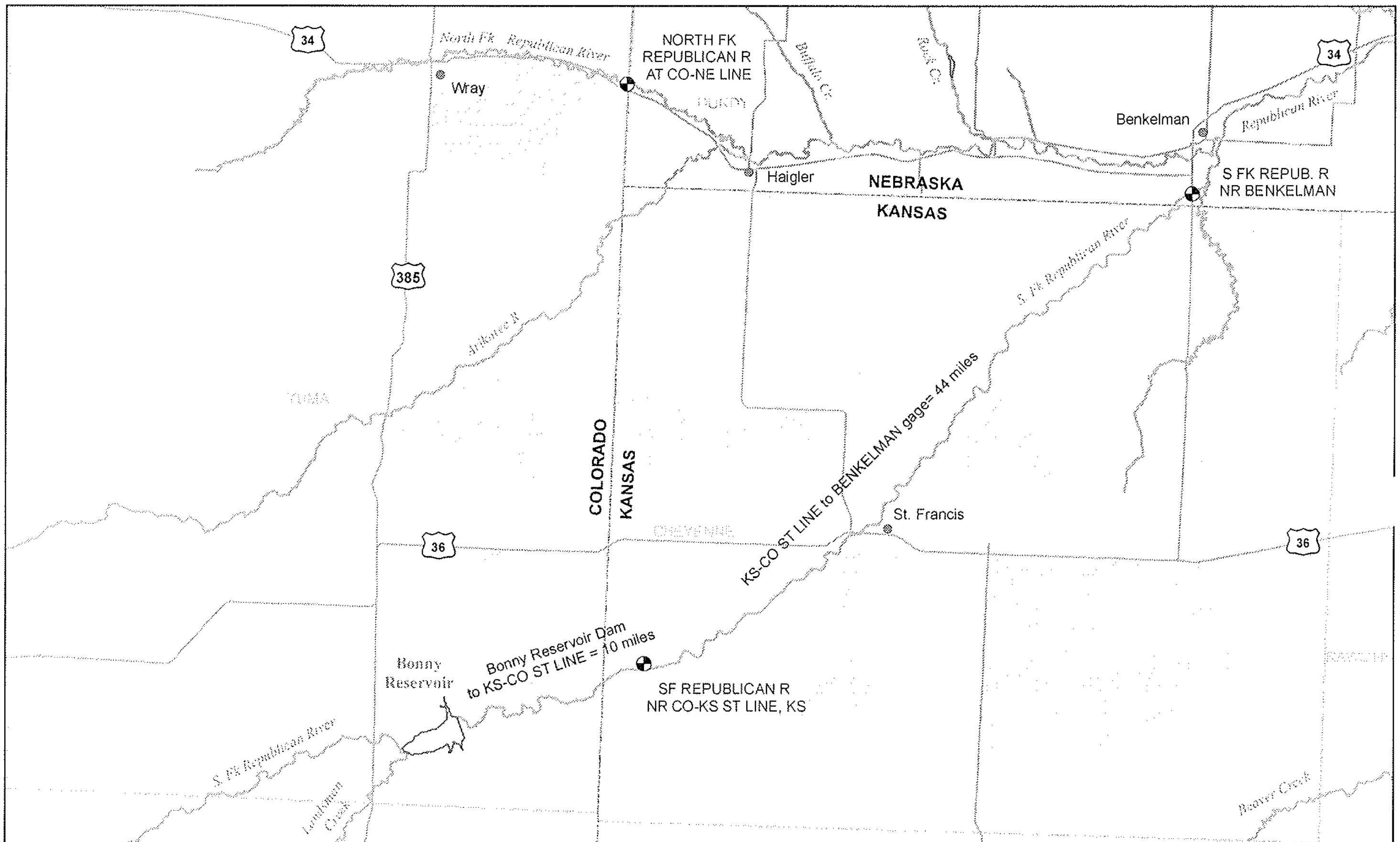
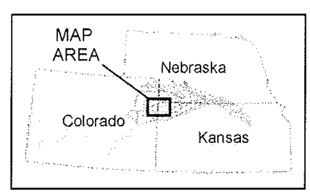


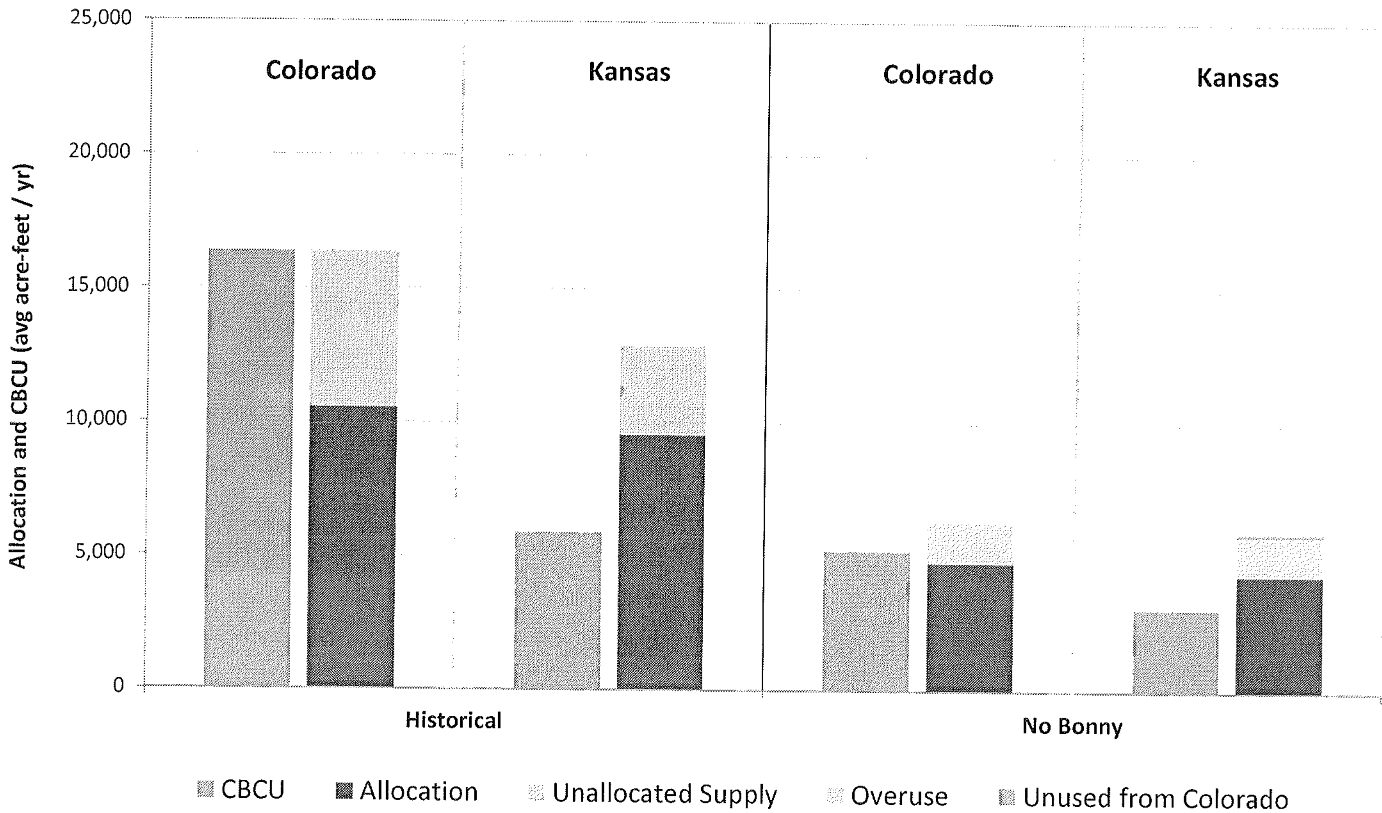
FIGURE 1
General Location Map
South Fork of the Republican River

5 2.5 0 5 10 Miles
Approximate Scale = 1:400,000



Spronk Water Engineers, Inc.
1000 Logan Street Denver, CO 80203

Figure 2
South Fork of the Republican River
Comparison of CBCU and Available Supply for Colorado and Kansas
2003 - 2007
average acre-feet / yr



Notes:

(1) Unallocated supply equals 14% of the Computed Water Supply. Colorado has access to the unallocated if they are in compliance with their Statewide test.

(2) Overuse equals the maxiumum of the Available Supply minus CBCU or zero.

(3) Kansas is allowed access to the unused portion of Colorado's allocation. It is equal to the maximum of Colorado's allocation less CBCU or zero.

(4) No Bonny condition incorporates results from the RRCA Ground Water without Bonny, assumes zero Bonny evaporation with 50% effect at Benkelman gage, and zero change in storage without modification to the gage.

2

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

John W. Hickenlooper
Governor

Mike King
Executive Director

Dick Wolfe, P.E.
Director/State Engineer

April 5, 2013

David Barfield
Kansas Commissioner, RRCA
Kansas Division of Water Resources
109 SW 9th Street, 2nd Floor
Topeka, KS 66612-1283

Brian Dunnigan
Nebraska Commissioner, RRCA
Nebraska Department of Natural Resources
301 Centennial Mall South
P.O. Box 94676
Lincoln, NE 68509-4676

Re: Colorado Compact Compliance Pipeline Proposal; Submittal to RRCA

Dear Commissioners Barfield and Dunnigan,

The State of Colorado hereby submits its Bonny Reservoir Accounting Proposal ("Bonny Proposal") to the RRCA pursuant to section VII.A of the Final Settlement Stipulation. A copy of the Bonny Proposal is attached hereto as Exhibit A.

Further pursuant to section VII.A.3, Colorado designates the Bonny Proposal as a "Fast Track" issue for action by the RRCA within the next 30 days. A schedule for resolution before the RRCA, and for non-binding arbitration, is attached hereto as Exhibit B. Colorado requests the Chairman schedule a special meeting of the RRCA on or before May 5, 2013.

Best Regards,

Dick Wolfe

Dick Wolfe, P.E.
Colorado Commissioner, RRCA
State Engineer
Colorado Division of Water Resources

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RESOLUTION BY THE REPUBLICAN RIVER COMPACT ADMINISTRATION REGARDING MODIFICATIONS TO THE ACCOUNTING PROCEDURES TO REFLECT FUTURE OPERATIONS OF BONNY DAM AND RESERVOIR

May 5, 2013

Whereas, the active storage pool in Bonny Reservoir is empty and the outflow gates in Bonny Dam have been left open so as to pass all inflow reaching the gates;

Whereas, Bonny Reservoir has no dead pool and no water in storage;

Whereas, due to changing hydrologic conditions and other factors, Bonny Reservoir is planned to be operated as a "run of the river" dam without active storage and is unlikely to store significant water in the future;

Whereas, operating Bonny Dam as a run of the river dam will allow all baseflows and non-flood surface flows to pass through the former reservoir area and such water will continue to flow down the South Fork of the Republican River;

Whereas, Bonny Dam will continue to provide valuable flood control benefits and any temporarily stored flood flows will be released at the maximum rate and time that will avoid damage to the dam and downstream property;

Whereas, the area now comprising Bonny Dam and Reservoir was simulated in the RRCA Ground Water Model for the years 1918 to 1950 as a stream segment;

Whereas, The RRCA Ground Water Model simulates Bonny Dam and Reservoir as an active storage reservoir, rather than a run of the river dam. Specifically, the baseflow from the upstream portions of the South Fork and Landsman Creek are removed from the Model. This reservoir segment is essentially a specified head in the Model. The baseflow into the reservoir is not routed through the remainder of the stream network of the Model. Below the reservoir, outflow from the toe drain is simulated by setting the flow rate into that stream segment to a constant 10 cfs, regardless of reservoir stage;

Whereas, because Bonny Reservoir is not storing water, the current representation of Bonny Dam and Reservoir in the RRCA Groundwater Model no longer represents the physical and hydrogeological characteristics of the South Fork of the Republican River to a reasonable degree;

Now, therefore, it is hereby resolved that in order for the RRCA Groundwater Model to accurately represent the physical and hydrogeological characteristics of the South Fork of the Republican River to a reasonable degree the following conditions, which are described in detail in Exhibit 1, shall apply:

1. When this monthly average reservoir stage is less than 3638.5 feet, the reservoir will be modeled using the "Dry Bonny" condition. For any stage between 3638.5 and 3679.82 feet, the reservoir will be modeled using the "Small Bonny" condition. Once the stage reaches 3679.83 feet, the "Full Bonny" condition will be used.

   ~41 ft
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2. The stage of the reservoir will be determined each month as the arithmetic average of the daily Reservoir Forebay Elevation reported by the United States Bureau of Reclamation (USBR).

3. The State of Colorado shall report to the RRCA when the stage is above 3638.5 feet, and shall further report when the outflow gates in Bonny Dam have been closed so as to store inflow reaching the gates;

4. During Small Bonny and Full Bonny conditions, calculation of evaporation from active storage or from temporary storage of flood flows, if any, shall be made in a manner similar to the other Federal Reservoirs, and;

5. The "mkstr" program used to prepare the stream package and the "mkres" program used to calculate the reservoir stage will be modified to reflect the different conditions for Bonny Reservoir.

6. The "acct" program used to summarize the groundwater model results for use in the Accounting Procedures will be updated to represent the fact that the simulated baseflow into the Bonny Reservoir reach and into the reach between Bonny Reservoir and the confluence of the South Fork and main stem of the Republican River will no longer be a constant. The $CBCU_G$ for these two reaches will be calculated as the change in baseflow out of the reach minus the change in baseflow into the reach.

Approved by the RRCA this ___ day of ______, 2013.

______________________________ ______________________________
David Barfield, P.E. Date
Kansas Member
Chairman, RRCA

______________________________ ______________________________
Brian Dunnigan, P.E. Date
Nebraska Member

______________________________ ______________________________
Dick Wolfe, P.E. Date
Colorado Member

Exhibit 1

Modeling of Bonny Reservoir in the RRCA Groundwater Model

Current Modeling of Bonny Reservoir

The RRCA Groundwater Model (the "Model") was constructed in 2002 and 2003. Segment 150 of the Model represents the reach of the South Fork of the Republican River from about the Idalia gage to Bonny Dam. That is also the area that was inundated by Bonny Reservoir between 1950 and April 2012. The Model models two different time periods for Segment 150: (1) pre-1950 before construction of Bonny Dam; and (2) post-1950 after construction of Bonny Dam.

1. Pre-1950

The Model represents Segment 150 prior to 1950 as a stream. It uses six model cells to represent the stream course prior to construction of the Reservoir. Two additional model cells were assigned zero conductance values and were added to the original six cells in order to permit the HYDMOD package to be used to extract stream flows. The Model routes inflow into Segment 150 prior to July 1950 from Segments 140 and 141, representing the South Fork of the Republican River above Bonny Reservoir and Landsman Creek, respectively. Outflow from Segment 150 was routed to Segment 156 representing the South Fork below Bonny Reservoir.

2. Post-1950

The Model represents Segment 150 after July 1950 as a Reservoir. It uses eight model cells to represent the area of the reservoir. Those models cells correspond to about 60,000 acre-feet or more of storage. Also inflow from Segments 140 and 141 are no longer routed to Segment 150. Instead, inflow is represented as a constant 1,000,000 cfs, and the reservoir stage be set to the observed reservoir stage. Below Bonny Reservoir, the South Fork of the Republican River is modeled starting with 10 cfs below Bonny Dam to represent the outflow of the toe drain below Bonny Dam. The 10 cfs value was based on the observed outflow from that toe drain around the time the model was constructed.

Future Modeling of Bonny Reservoir

The Resolution by the Republican River Compact Administration Regarding Modification to the Accounting Procedures to Reflect Future Operations of Bonny Dam and Reservoir allow Bonny Reservoir to be modeled under three different conditions: (1) Dry Bonny; (2) Full Bonny; and (3) Small Bonny.

1. Dry Bonny

Bonny was drained in 2012. Bonny Dam still exists to provide flood protection for St Francis and other downstream communities, but the headgate at Bonny Reservoir is open and all inflow into the reservoir is flowing down a channel naturally cut by the Republican River to the outlet works. This will be referred to as the "Dry Bonny" condition.

During Dry Bonny conditions, the reservoir will be modeled as it was prior to July 1950. In other words, the model cells in Segment 150 will use the same settings as they do it the Pre-1950 condition described above. Outflow from Segments 140 and 141 will be routed to Segment 150, and the outflow from Segment 150 routed to Segment 156.

2. Full Bonny

In the event the Colorado State Engineer lifts the order to drain Bonny and Bonny stores water above 3679.83 feet, then the Model will represent the reservoir as described above in the Post-1950 condition. This will be referred to as the "Full Bonny" condition. Under these conditions, the eight cells in Segment 150 would revert to the values used from July 1950 until April 2012. The routing would be changed to remove the flow from Segments 140 and 141 from the model, and the inflow into Segment 150 would again be set to 1,000,000 cfs and the reservoir stage be set to the observed reservoir stage. Outflow from the toe drain will be set to the outflow from the toe drain observed at that time.

3. Small Bonny

It is also anticipated that there may be times in the future when a large thunderstorm or similar event would cause a large inflow into Bonny Reservoir that will exceed the ability of the outlet works, or may require controlling the rate of release of such inflow for flood protection of the downstream reach. Under such conditions, Bonny Reservoir may store water for a limited period of time. For ease of reference, we will refer to this as the "Small Bonny" condition. Under these conditions the number of active cells in Segment 150 will be set based on the volume of water in storage as determined by the observed stage.

Figure 1 shows the area-capacity curve for Bonny Reservoir based on the 2011 area-capacity survey. The horizontal axis represent the stage starting at an elevation of 3638 feet. The reservoir capacity is shown as a red line and is read on the left vertical axis. The reservoir area is represented using a blue line and is read on the right vertical axis. For modeling purposes, the area curve will be approximated using the black line. The black line is a piecewise linear approximation of the area curve to integer multiples of 640 acres, which correspond to the area of model cells. Figure 1 shows that this closely approximates the blue area curve from the survey. Green vertical lines mark the stage at which the area reaches integer multiples of 640 acres, and are labeled with the corresponding reservoir storage. Note that 640 acres correspond to 3189 acre-feet of storage, 1280 acres with 14,598 acre-feet of storage, and so on.

The stage of the reservoir will first be determined each month as the arithmetic average of the daily Reservoir Forebay Elevation reported by the United States Bureau of Reclamation (USBR). When this monthly average reservoir stage is less than 3638.5 feet, the reservoir will be modeled using the "Dry Bonny" condition. For any stage between 3638.5 and 3679.82 feet, the reservoir will be modeled using the "Small Bonny" condition. Once the stage reaches 3679.83 feet, the "Full Bonny" condition will be used.

Under Small Bonny conditions, the model will adjust the conductance values for up to four model cells depending on the stage of the reservoir. Figure 2 shows the area around Bonny Reservoir. The four model cells used to represent Bonny Reservoir during Small Bonny conditions are labeled 1-4. The four model cells shown labeled "*" are the four additional cells used to represent the Full Bonny condition. When the reservoir stage is between 3638.5 and 3679.83, Bonny Reservoir will be represented using those four model cells in sequence. For a stage from 3638.00 feet (0 acre-feet storage) to 3647.51 feet (3189 acre-feet storage), the conductance of cell 1 (106,91) will linearly increase from 0 ft^2/sec to 32.267 ft^2/sec. For a stage from 3647.51 feet (3189 acre-feet storage) to 3659.00 feet (14,598 acre-feet storage), the conductance of cell 1 (106,91) will be 32.267 ft^2/sec while the conductance of cell 2 (107,91) will linearly increase from 0 ft^2/sec to 32.267 ft^2/sec. For a stage from 3659.00 feet (14,598 acre-feet storage) to 3670.17 feet (32,881 acre-feet of storage), the conductance of cells 1 and 2 will be 32.267 ft^2/sec, and the conductance of cell 3 (107,90) will linearly increase from 0 ft^2/sec to 32.267 ft^2/sec. Finally, for a stage from 3670.17 feet (32,881 acre-feet of storage) to 3679.83 feet (54,526 acre-feet storage), the conductance of cells 1-3 will be 32.267 ft^2/sec, and the conductance of cell 4 (107,89) will linearly increase from 0 ft^2/sec to 32.267 ft^2/sec. For any higher stage, the "Full Bonny" representation will be used.

In order to represent the three conditions of Bonny Reservoir, the "mkstr" program, which generates the stream package file for the Model, will be enhanced to be able to model any reservoir using the "Dry", "Small" or "Full" condition. The new "mkstr" program will be called "mkstr2". The behavior of the "mkstr2" program is controlled by the reservoir.dbf file. When the reservoir.dbf file contains a positive stage, the reservoir is modeled as storing using the "Full" condition, while a stage of 0 the reservoir is modeled as "Dry" and the baseflow is passed through the reservoir. This behavior is unaltered from how the stream network was generated during the V12p7 calibration run which simulated the reservoirs being built over time. However, when the reservoir stage is specified as a negative value, the reservoir will be modeled using the "Small" condition with a stage equal to the absolute value of the specified stage and the cell conductances will be set as described above.

The "mkstr2" has the relationship between the stage, cells, area and conductances defined for Bonny Reservoir in a data structure that is part of the "mkstr2" program. If the Bonny area-capacity curve were to change in the future, this data structure in "mkstr2" program would have to be changed to reflect the new area-capacity curve.

The "mkstr2" program also allows the user to set the outflow from the toe drain. When the reservoir is operated as storing water, the toe drain outflow will be used to set the inflow into the lower reach. How much that flow would be is difficult to anticipate. Therefor the observed monthly average outflow from the toe drain will be recorded and input to the "mkstr2" program using the flow.dbf file.

The "mkres" program is used to download the reservoir information from the USBR web site. The "mkres" program will be updated to automate the process of calculating the reservoir stage. Currently the "mkres" program simply extracts the end of month value for the reservoir stage. The program will be updated to also calculate the daily average reservoir stage for Bonny Reservoir and set the stage to 0 if the stage is below 3638.5 feet, the negative of the monthly average stage if it is between 3638.5 and 3679.83 feet, and the end of month stage if it is above 3679.83 feet.

Groundwater Model Accounting for Bonny Reservoir.

The groundwater model results are summarized using the "acct" program for inclusion into the accounting spreadsheets. On the South Fork of the Republican River, the "acct" program reports two values labeled "South Fork" and "Bonny". Both values represent the change in baseflow along the South Fork of the Republican River as a result of well pumping or Imported Water Supply. This quantity is called $CBCU_G$ in the RRCA Accounting Procedures.

The "acct" program operates on the simulated baseflow at appropriate locations in the stream network. The MODFLOW HYDMOD package is used to save these baseflows to a file for each simulation. The "acct" program then calculates the baseflow reach gain for the appropriate reaches by subtracting the inflow to the reach from the outflow of the reach. The "acct" program then calculates the $CBCU_G$ by calculating the change in the baseflow reach gain between, for example, simulations with pumping for each state off and on.

The reaches in the "acct" program are defined by a parameter file. In the current 12s2 stream network, the "South Fork" and "Bonny" terms are defined as

```
" South Fork" +SI185007acctSFRepublican +SI0970326825000 +SI141004LandsmanabvB
" Bonny"       +SO150008Bonny
```

The +SI0970326825000 term represents the South Fork of the Republican River above the Idalia gage which is at the inflow to Bonny Reservoir, and the +SI141004LandsmanabvB term represents Landsman Creek which flows into Bonny Reservoir. The +SI185007acctSFRepublican represents the South Fork between Bonny Reservoir and the confluence of the South Fork of the Republican River with the main stem of the Republican River, and the +SO150008Bonny term represents Bonny Reservoir itself.

The parameter file contains some arithmetic simplifications. The "acct" program must calculate the outflow from the reach minus the inflow from the reach. However, for many reaches, the inflow into the reach is a constant for all simulations. For example, the inflow into the reach representing the South Fork of the Republican River above the Idalia gage is always zero because it is the beginning of the river as modeled. Similarly, in version 12s2 of the model, the inflow into the reach representing the South Fork between Bonny Reservoir and the confluence of the South Fork of the Republican River with the main stem of the Republican River is always 10 cfs. When the flow at the top of a reach is the same between simulations, the terms cancel in the $CBCU_G$ calculation.

For reaches where the inflow into the reach varies between simulations, the inflow into the reach must be subtracted. For example, on Sappa Creek the inflow from Beaver Creek is subtracted as

```
" Sappa" +SI201006acctSappa -SI195030acctBeaver
```

Similarly, the inflow into each reach is subtracted for the four main stem reaches.

When Bonny Reservoir may at different times of the simulation be operated as "Dry", "Small" or "Full", the "acct" program cannot assume that the inflow into the reaches representing Bonny Reservoir and the South Fork below Bonny reservoir will be a constant. Therefore the "acct" parameter file must explicitly subtract the inflow into that reach as follows:

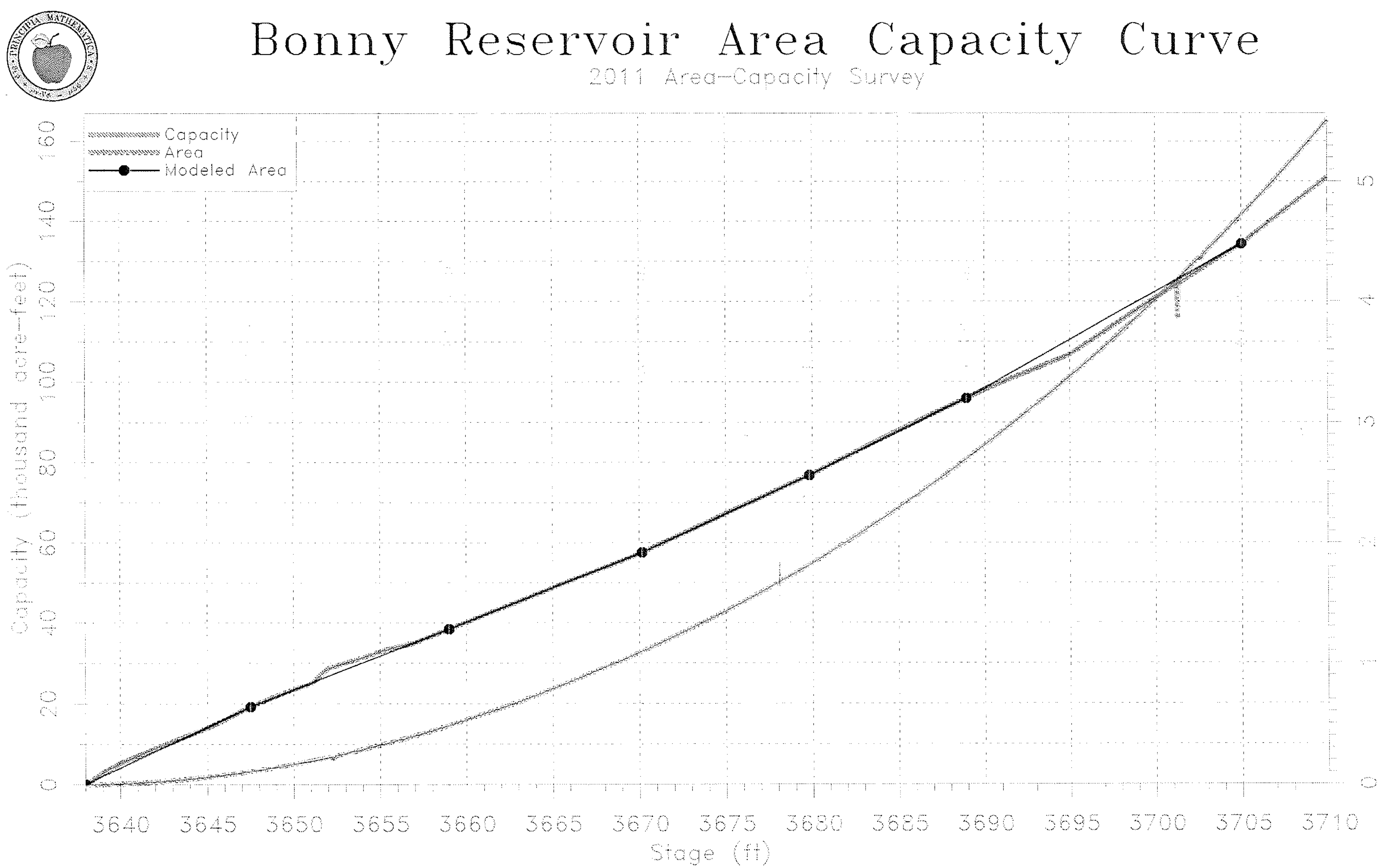
```
" South Fork" +SI185007acctSFRepublican -SI176001SFbloBonny
              +SI0970326825000 +SI141004LandsmanabvB
" Bonny"      +SO150008Bonny -SI150001Bonny
```

Here the -SI150001Bonny term explicitly subtracts the inflow into Segment 150 from the outflow from Segment 150. Whether this value is a constant 1,000,000 or the outflow from Segments 140 and 141 that would vary over time and vary between simulations does not matter because the "acct" program will no longer assume that it is constant.

Similarly, the -SI176001SFbloBonny term explicitly subtracts the inflow into Segment 176 which represent the start the South Fork of the Republican River below Bonny Reservoir. Once again, it does not matter whether this value is a constant 10 cfs or the outflow from Segment 156 above it that will vary between simulations or over time. The "acct" program would not make any assumptions regarding that flow and explicitly account for that inflow.

This change to the parameter file will allow the "acct" program to correctly calculate the baseflow gain for the three South Fork reaches. The South Fork above the Idalia gage reach, the Landsman Creek Reach and the South Fork between Bonny and the confluence with the main stem reaches will continue to be reported as the "South Fork" term, as it is currently. The reach across Bonny Reservoir will be also still reported as the "Bonny". In the accounting spreadsheet, these two terms are summed and used as the $CBCU_G$ term for the South Fork. Therefore, the "acct" program will calculate the total $CBCU_G$ for the South Fork regardless of whether Bonny is storing water or not.

No changes are required to the accounting spreadsheets to represent whether Bonny Reservoir is storing water or not. The evaporation from Bonny Reservoir will be calculated as it was done previously, but using the updated stage-area relationship. When the reservoir is dry, the evaporation will simply be zero based on an area of zero.



Bonny Reservoir Area Capacity Curve
2011 Area-Capacity Survey
Capacity
Area
Modeled Area
Capacity (thousand acre-feet)
0
20
40
60
80
100
120
140
160
Area (thousand acres)
0
1
2
3
4
5
Stage (ft)
3640
3645
3650
3655
3660
3665
3670
3675
3680
3685
3690
3695
3700
3705
3710

Figure 1.

Bonny Reservoir Modeled Cells

Republican River Compact Administration Groundwater Model

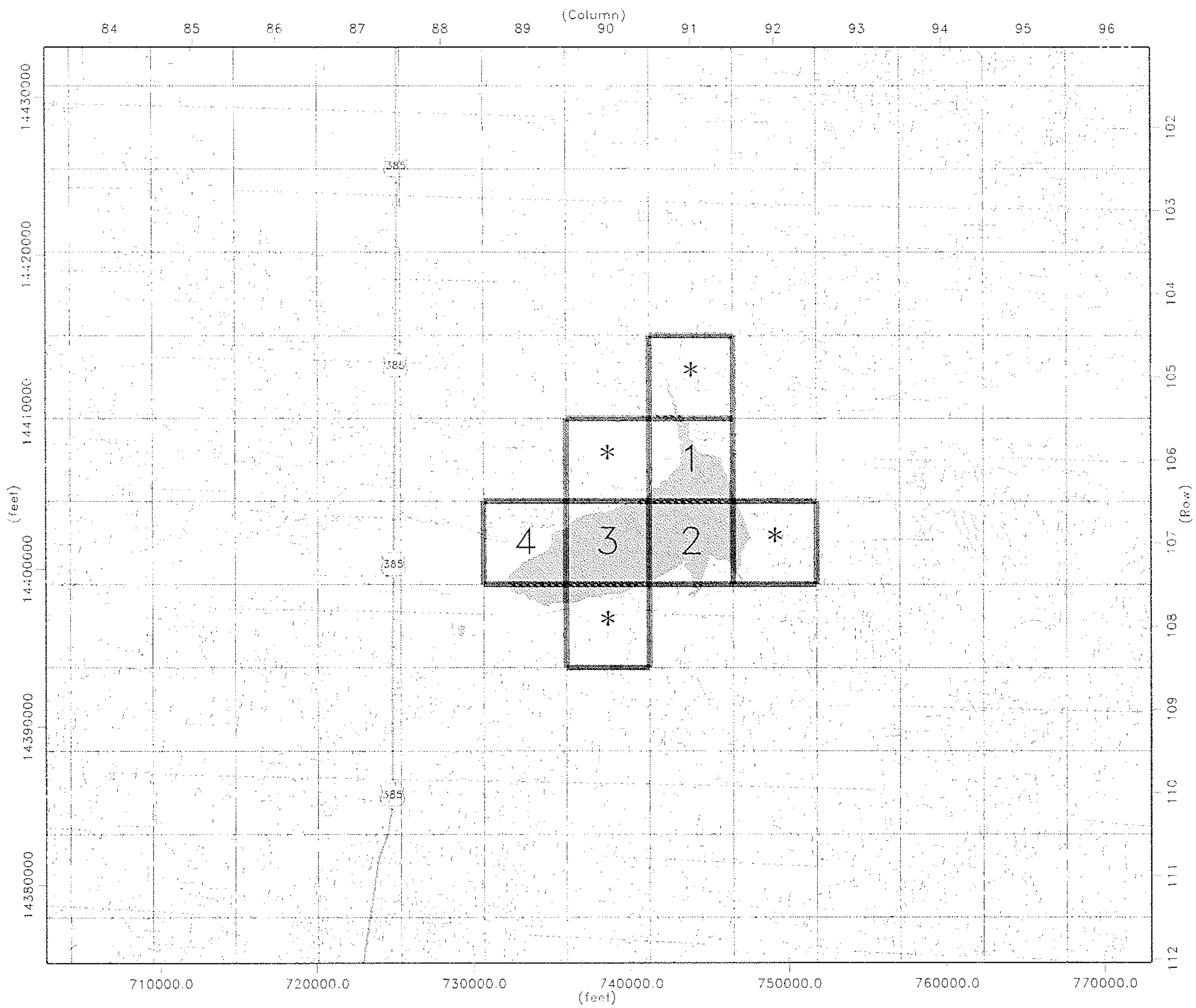


Figure 2.

Exhibit B

Arbitration Time Frame Designation

Colorado v. Kansas & Nebraska

Bonny Reservoir Accounting

Colorado Formally Submits Resolution to RRCA	4/5/2013
RRCA Special Meeting and Vote on Resolution	5/5/2013
If Necessary…	
Colorado Formally Submits the Issue to Arbitration	5/5/2013
Nebraska and Kansas May Amend the Scope of the Dispute	5/15/2013
States Submit Lists of Proposed Arbitrators	5/15/2013
States Meet and Confer Regarding Arbitrator Selection	5/25/2013
CDR Selects Arbitrator (*if necessary)*	5/25/2013
Initial Conference with Mediator; Set Schedule for Arbitration	6/1/2013
Final Day of Arbitration Hearings	9/29/2013
Arbitrator Issues Written Decision	11/28/2013

Steve Larson

From:	Dale Book <debook@spronkwater.com>
Sent:	Monday, July 08, 2013 4:05 PM
To:	Larson, Steve
Subject:	FW: Bonny Simulation
Attachments:	BonnyCO.htm; BonnyKS.htm; BonnyMD.htm; BonnyNE.htm

These appear to be the results with the latest proposal.

Dale

-----Original Message-----
From: Perkins, Sam [mailto:Sam.Perkins@KDA.KS.GOV]
Sent: Tuesday, April 23, 2013 11:23 AM
To: Beightel, Chris; Barfield, David; Ross, Scott; Erickson, Chelsea; Dale Book; 'Burke Griggs'; 'Grunewald, Chris'
Cc: Steve Larson (slarson@sspa.com); Alex Spiliotopoulos
Subject: FW: Bonny Simulation

Fyi--

This just in from Willem.

Sam

-----Original Message-----
From: Willem Schreuder [mailto:willem@prinmath.com]
Sent: Tuesday, April 23, 2013 12:20 PM
To: Wolfe, Dick; Sullivan, Mike; Franco, Ivan; Barfield, David; Perkins, Sam; Dunnigan, Brian; Schneider, Jim; Koester, Paul
Cc: Scott Steinbrecher
Subject: Bonny Simulation

Howdy!

On yesterday's call Kansas asked if we can provide an updated projection on the effect of drying up Bonny Reservoir.

I ran the model repeating 2000-2009 verbatim for pumping, precipitation and evapotranspiration, except that in one simulation the historical Bonny stage for 2000-2009 was repeated, while in the second simulation Bonny was modeled as empty. The simulation repeats 2000-2009 four times to provide a 40 year projection. I used the mkstr2 program to create the stream package, so the difference between the simulations is entirely in the reservoir.dbf file which sets the reservoir stage.

These simulations are essentially the same as the simulations provided before, except that these runs use the current processing programs to generate the model inputs and summaries.

If you are interested in the gory details, the model files are at
http://www.republicanrivercompact.org/restricted/misc/bonny13.zip
However, the attached tables summarizes the differences in the impacts.
The columns labeled WB and NB shows the CBCU_G calculated in the simulation with or without Bonny, and the column Del (highlighted with a yellow background) is the change resulting from the reservoir not storing water.

For Colorado, there are small changes to the Above Swanson reach (127 af on average) due to the change in flow between Benkleman and Swanson.
However, the changes are primarily to the South Fork and Bonny reaches.
The change for the South Fork reach averages -5552 af/yr and is largely due to increased losses in the Bonny-Benkleman reach. For the Bonny reach, the change is -3091 af/yr on average. Overall a dry Bonny reduces Colorado's CBCU_G by 8515 af/yr on average.

For Kansas, the Benkleman-Swanson reach shows an increase in CBCU of 210 af/yr on average due to flow from the South Fork reaching the main stem more often if the baseflow is not stored in Bonny. On the South Fork, Kansas' CBCU_G is reduced by about half, changing by -2609 af/yr on average.

For Nebraska, the CBCU_G on the South Fork is reduced by 260 af/yr, while on other reaches changes are on the order of 10 af/yr. The mound calculation is uneffected by Bonny.

As can be seen in the attached results, exactly what the change in CBCU_G will be in the future is a strong function of unknowable factors such as future precipitation. For example, Colorado's South Fork CBCU_G decreases on average by 5552 af/yr, but for individual years the change varies from
+209 af to -7712 af. However, when Bonny is dry, the overall CBCU_G for
Colorado, Kansas and Nebraska should decrease by around 1/4 to 1/2 of the amount of South Fork CBCU_G with Bonny storing water.

Let me know if you have any questions.

Regards
-Willem

==
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INTRODUCTION

These simulations evaluate a future scenario where the 2000-2009 conditions are repeated four times (40 years). This represents two 20 year cycles per the proposed pipeline approval.

The current set of simulations is essentially the same as the simulations provided earlier, but with the following modifications:

1) The pipeline deliveries are estimated based on the projected amount Colorado will exceed its allocation in the absence of the pipeline;

2) The 2003 pumping in Nebrsaka was redistributed based on the irrigated acreage by Sam Perkins.

3) The analysis is done with Bonny modeled in two ways. The first represents the reservoir as completely drained ("No Bonny"), while the second represents the reservoir as 178 acres and 2cfs seepage ("Small Bonny").

In all there are 20 simulations. Each of the 5 simulations needed to calculate CBCU for each state were done four ways. The four ways combine two analysis: the first considers including the pipeline water in the model or not including the pipeline water in the model. The second considers whether Bonny Reservoir is completely drained, or storing a small amount of water in Bonny Reservoir.

As will be demonstrated below, these two issues, that is running the water through the model or using the cap on the North Fork; and how Bonny is represented are basically orthogonal. The large number of simulations is basically intended to demonstrate this orthogonality.

RUNNING THE MODELS

The steps to complete the simulation is shown the "run" script.

Runs are named NNNNbbq. NNNN for runs where the pipeline water is not included in the model are called 200X, while runs where the pipeline water is included in the model are called 200K. bb for the runs where Bonny is drained and water is bypassed (No Bonny) is nb, while for runs where Bonny is 178 acres and seeping 2cfs (Small Bonny) is sb. The Extension q is blank for the reference run, while letters a, b, c and d are used per the RRCA convention to represent no Colorado, Kansas or Nebraska pumping, and the mound imports.

First the "mkccp" script is run. It copies the 2000 to 2009 state files in the co, ks and ne directories to corresponding co, ks and ne directories. Where the files are unchanged, the copy is achieved by setting a soft link. For the .pmp, .rcg and .agw files for Colorado, the agricultural wells transferred to the pipeline is removed by setting the cells corresponding to these well to zero in the .pmp, .rcg and .agw files.

For 2003, the Nebraska groundwater usage (pumping, recharge and acres) was replaced by a data set provided by Sam Perkins. This data sets redistributes the volume of pumping based on irrigated acres

Next the RRPP program is run to generate a 10 year data set for the five standard scenarios. The "mkdup" script is then used to duplicate that 10 year period four times by adding three additional 10 year cycles.

The mkshead is used to generate starting heads from the 2009 ending heads.

The mkstr and mket programs are used to produce the 2000-2009 data sets repeated four times. The mkstr program is run twice, once for the No Bonny and once for the Small Bonny configuration. The No Bonny configuration represents segment 150 (Bonny Reservoir) as it existed prior to the construction of the dam. Flows are routed from the upstream segments (140 and 141) through section 150 and downstream to segment 156. The Small Bonny configuration reduces the size of the reservoir to one cell (106,91) and reduces the conductance by 178/640 to represent the smaller size of the reservoir. The reservoir elevation is set to 3640 ft. The stream routing is unchanged from the current 12s2 stream package. However, the leakage from the dam is reduced from 10 cfs to 2 cfs to represent the reduction in leakage from the toe drains.

Finally the "mkpif" program is used to generate the pipeline flows. For this simulation, pumping occurs from October to March every year. The pumping is based on estimated pipeline releases from the projected amount Colorado exceeds its allocation.

The "mkpif" program creates three files. The first is a well pumping file representing monthly pumping for the pipeline. The pipeline well pumping is represented in the oct-mar.wel file. In order to facilitate processing, the RGDSS MODFLOW program was used which allows multiple well packages to be used. Therefore the well pumping produced by RRPP is mapped to the first well package (WEL1) and the pipeline pumping is mapped to the second well package (WEL2). Internal to MODLFOW the pumping is simply added, but it is reported as separate volumes in the water budget.

The pipeline pumping is included in both historical simulations, but not in the Colorado Impact run.

The second and third files created by mkpif are stream package files for the No Bonny and Small Bonny versions, respectively. The mkpif program adds the pipeline outflow to the appropriate stream package at segment 153, which is the North Fork reach from the State Line to the Arikaree. In order to satisfy the MODFLOW stream package requirement that the segments must appear in upstream to downstream order, segments 122 and 125 (Muddy Creek Nebraska) were combined into a single segment 125, which frees up segment 122 to be used as a stub inflow (stream segment with no aquifer conductance) which is made tributary to segment 153.

The North Fork State Line accounting point was moved from the confluence of the Arikaree and the North Fork to the North Fork at the State Line by the RRCA in 2009. This made the North Fork accounting point the inflow to segment 130 Reach 28. Adding the pipeline above this reach would require renumbering all subsequent segments of the stream package. Therefore, in order to capture the pipeline inflow at segment 153, the accounting point was moved to segment

153 reach 1 which is one cell downstream from the previous location.

Joining segments 122 and 125 and moving the North Fork accounting point one cell downstream allows the pipeline water to be added to the model without requiring the wholesale renumbering of segments and assignment of accounting points in the model.

MODFLOW is then run for the five runs needed to evaluate CBCU for each state and the mound imports. When pipeline water is included in the model, all runs except the run without Colorado pumping includes the pipeline water. These runs are called 200Kbbq, When the pipeline water is not included in the model, the runs are called 200Xbbq, and contains only the pumping associated with the pipeline, except in the run without Colorado pumping. Similarly the model is run using the No Bonny (nb) and Small Bonny (sb) scenarios.

In the No Bonny Scenario, the Kansas proposal historical simulation (200Knb.nam) includes the pipeline deliveries in the stream package as well as pumping from the pipeline wells. The Colorado proposal simulation (200Xnb.nam) differs from the Kansas historical simulation only in that the stream package does not contain the pipeline flows.

The stream package without the pipeline flows (200Xnb.str) is used in the the Colorado Impact run (200Xnba) and the Colorado proposal Historical run (200Xnb), while the stream package with the pipeline flows (oct-mar-nb.str) is used in the Kansas proposal Historical run (200Knb).

A similar set of runs are run for the Small Bonny (sb) scenario.

MODFLOW is run for the using the standard RRCA packages, except that the RGDSS MODFLOW program must be used to accommodate the two well packages.

RESULTS

Finally, the accounting program from V12P7 was adapted to extract the differences in baseflows calculated by the model.

The impact runs are name for the run used to difference with the reference case. So, for example, the Colorado Pumping Impacts - No Bonny - Pipeline not in the Model is the difference between 200Xnb and 200Xnba, and is in the file 200Xnba.htm.

The South Fork and North Fork analysis are essentially independent. Comparing the South Fork depletions with or without the pipeline water in the model results in a difference on the South Fork of less than 200 acre-feet on average for both the No Bonny (200Xnba.htm & 200Knba.htm) and the Small Bonny (200Xsba.htm & 200Ksba.htm) simulations.

Similarly, for the No Bonny vs. Small Bonny comparison, the differences on the North Fork are zero on the North Fork and less than 200 acre-feet for the Above Swanson reach for the pipeline water in the model (200Knba.htm & 200Ksba.htm) as well as the pipeline water not in the model (200Xnba.htm * 200Xsba.htm).

The small changes that are observed occur in the area near Benkleman where changes in the north and south forks interact.

We therefore submit that instead of reviewing all the possible combinations of runs, the conclusions remain the same when evaluated individually.

For the No Bonny scenario, the Colorado Pumping Impacts using the historical run which includes the pipeline deliveries is contained in the file 200Knba.htm, while the Colorado Well Pumping Impacts without including Pipeline Deliveries but including pipeline well pumping is shown in 200Xnba.htm.

The 200Knba and 200Xnba runs are actually the same, as are the 200Ksba and 200Xsba runs, because all these simulations omit Colorado pumping and pipeline flows. Since the Colorado Pumping Impact with the pipeline deliveries in the stream package is
  CIp = 200Knb - 200Knba
while the Colorado Pumping Impact with the pipeline deliveries NOT in the stream package is
  CIo = 200Xnb - 200Xnba
The pipeline credit can therefore be isolated as
  Pipeline Credit = CIp - CIo = 200Knb - 200Xnb
because 200Knba = 200Xnba. This was calculated directly using the acct program and is shown in 200Xnb.htm. The same calculation can be done for the Small Bonny simulation with virtually identical results.i (See 200Xsb.htm).

NORTH FORK ANALYSIS

Figure 1 shows the pipeline releases as a purple line and the pipeline credit as a red line. The fraction of the release credited is shown as a blue line. The thin blue line represent the annual values. Note that the credit can be as much as 105% of the amount released and as low as 58% for any individual year. The five year running average is shown as a thick blue line, which varies from 96% to 75%. The long term average is shown as a thick dashed line and averages 89%.

The reason for the variability is shown in Figure 2. Figure 2 shows the North Fork depletions when the pipeline water is included in the model as a red line, and the when the pipeline water is not included in the model as an orange line. Note that the pipeline releases generally match the slope of the North Fork depletions without the pipeline, so that when the pipeline deliveries are included, the North Fork depletions averages about 12,000 af/yr.

The Above Swanson values are shown as a light blue line in the absence of the pipeline, and a dark blue line when the pipeline is included. The Above Swanson values are actually negative, but are shown here as positive values for ease of comparison. Note that in the absence of the pipeline water, the Above Swanson values grow to more than 11,000 af in one year.

Also shown in Figure 2 is the pipeline credit represented by a green line. What is particularly striking is how the pipeline credits goes down when the Above Swanson goes up when the water is not in the model. This is because large Above Swanson values are caused by the stream going dry. Conversely, when the stream goes dry, the pipeline water does not reach Swanson Reservoir and reduces the pipeline credit.

What Colorado is proposing is to NOT model adding the pipeline water to the .nodel, but to achieve the same result by capping the Above Swanson values.

Figure 3 shows the difference between the pipeline deliveries and the pipeline credit when the pipeline water is included in the model as a red line. The thin red line are the annual values, and the thick red line is the five year running average. The thick red line therefore represent pipeline deliveries for which Colorado will not receive a credit in the Compact accounting.

The Above Swanson values computed when the pipeline water is not in the model is shown as a dark blue line. The thin dark blue line represents the annual values and the thick dark blue line represents the five year running average.

The light blue line represents Colorado's proposal. This line represents the Above Swanson values calculated by the mode, but the values are capped at 5000 af/yr. Therefore the light blue values match the dark blue when the flows are less than 5000 af/yr, but differ when they are greater.

What Colorado gives up as a result of the cap on the Above Swanson values is the difference between the dark blue and light blue lines. This is shown as a green line, with again the thin green line representing the annual values, and the thick line representing the five year running average.

The key thing to note is that the thick green line tracks the thick red line almost perfectly.

This is the essence of the Colorado proposal. Putting the pipeline deliveries in the model causes the pipeline credit to be less than the pipeline deliveries. The red line represents that difference. This difference captures the net effect of putting the pipeline water in the model.

The green line represents the amount of Above Swanson credits that Colorado is giving up by agreeing to a cap of 5000 af/yr on the Above Swanson values. On an annual basis, the amount given up by Colorado tracks the difference between the pipeline deliveries and pipeline credits fairly well, but on the five year running average the correspondence is very good. Also note that on average the amount of Above Swanson credit given up is greater than the difference between the pipeline deliveries and pipeline credits.

Figure 4 shows the results from a CBCU point of view for the North Fork, that is the Norrth Fork and Above Swanson terms added together. The blue line represents the projected North Fork plus Above Swanson CBCU without considering the pipeline. The thin blue line are the annual values, while the thick blue line is the 5 year running average.

The green line represents the result of running the water through the pipeline, with the thin and thick lines representing the annual and 5 year running averages, respectively. The red line represents the Colorado proposal, which caps the Above Swanson credits and then subtracts the pipeline deliveries. While not identical, the red and green lines represent the same effective result.

Figure 5 shows the same analysis, but for Colorado's basin wide CBCU. Again the red and green lines track very closely.

So the bottom line here is that by agreeing to a cap on the Above Swanson values, we achieve the exact same effect as running the pipeline water through the model.

The advantage to Colorado is that the variability in the pipeline credits are reduced because the Colorado will receive 100% credit for what is delivered in exchange for limiting the Above Swanson values.

The advantage to Kansas and Nebraska is that by capping the Above Swanson values, Colorado will be required to deliver more water to be in compliance with the Compact and at the same time satisfy the desire expressed by Kansas that the deliveries should be more steady from year to year.

It is my understanding that this is the modeling question Dick Wolfe and David Barfield asked us to address: Does a cap on the Above Swanson cap achieve the same result as running the pipeline water through the model? I submit that Figures 3 to 5 demonstrates exactly that.

NORTH FORK ANALYSIS ? Bonny / No Bonny

A comparison of the No Bonny vs. the Small Bonny results for Kansas Pumping Impacts (200Xnbb.htm & 200Xsbb.htm), Nebraska Pumping (200Xnbc.htm & 200Xsbc) and Nebraska Mound (200Xnbd.htm & 200Xsbd.htm) differ by less than 10 acre-feet. So for purposes of this discussion, we will ignore these results. Note that this is also that for the 200K series simulations.

The difference appears in the Colorado impact runs. In the run with No Bonny, the South Fork plus Bonny impacts are on average 4945 acre-feet, while in the Small Bonny simulation the South Fork plus Bonny impacts average 11737 acre-feet, a difference of 6792 acre-feet.

The reason for these differences are readily understood. Figure 6 shows the baseflow into Bonny. The flow for the base (historical) case is shown in light blue for the Small Bonny and dark blue for the No Bonny simulations. The light blue line is not visible in Figure 6 because it is perfectly overlain by the dark blue line. Similary, the baseflow into Bonny with Colorado pumping off is shown as an orange line for the Small Bonny run and in red for the No Bonny run. Once again the red alone is visible because it overlies the orange. So the baseflow into Bonny remains unchanged as a result of the representation of Bonny, as is to be expected.

Figure 7 shows the baseflow on the South Fork at the confluence with the North Fork near Benkleman, which in the groundwater model is the accounting point for the South Fork.

In Figure 7, the light and dark blue lines do differ at times, indicating that if the baseflow into Bonny is passed under historical (base) conditions then there will at times be a change in flow near Benkleman. However, for most of the period, the flow remains essentially the same.

Comparing the red and orange lines, however, shows that in the absence of Colorado Pumping, a significant difference in the flows occur between the No Bonny and Small Bonny simulations. This is because in the No Bonny simulation, baseflow into Bonny reservoir is passed into the lower reach, and some fraction of that flow will reach Benkleman. However, in the Small Bonny simulation only two cfs is released into the lower reach.

In the absence of transit losses between Bonny and Benkleman due to evapotranspiraton and pumping in Kansas and Nebraska, the Colorado Pumping impact at Bonny shown in Figure 6 would match the Colorado Pumping impact at Benkleman shown in Figure 7. This, however, is not the case.

When Bonny stores water, the Colorado CBCU is calculated as the change in baseflow into Bonny reservoir. The baseflow in the reach below Bonny is then set to the seepage below the dam and additional Colorado CBCU is calculated as the change in baseflow near Benkleman.

However with the baseflow into Bonny is passed through because the reservoir is no longer storing water, Figure 7 shows that some of the water is lost in transit due to evapotransipration and pumping, and so the flow that reaches Benkleman is only a fraction of what had reached Bonny.

As a result, the CBCU calculated at end of the basin is several thousand acre-feet smaller then the CBCU calculated at the peak of the baseflow near Bonny in the middle of the basin.

Pumping w/ NB
No Pumping w B

3

DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATER RESOURCES

John W. Hickenlooper
Governor

Mike King
Executive Director

Dick Wolfe, P.E.
Director/State Engineer

April 5, 2013

David Barfield
Kansas Commissioner, RRCA
Kansas Division of Water Resources
109 SW 9th Street, 2nd Floor
Topeka, KS 66612-1283

Brian Dunnigan
Nebraska Commissioner, RRCA
Nebraska Department of Natural Resources
301 Centennial Mall South
P.O. Box 94676
Lincoln, NE 68509-4676

Re: Colorado Compact Compliance Pipeline Proposal; Submittal to RRCA

Dear Commissioners Barfield and Dunnigan,

The State of Colorado hereby submits its Compact Compliance Pipeline Proposal ("CCP Proposal") to the RRCA pursuant to section VII.A of the Final Settlement Stipulation. A copy of the CCP Proposal is attached hereto as Exhibit A.

Further pursuant to section VII.A.3, Colorado designates the CCP Proposal as a "Fast Track" issue for action by the RRCA within the next 30 days. A schedule for resolution before the RRCA, and for non-binding arbitration, is attached hereto as Exhibit B. Colorado requests the Chairman schedule a special meeting of the RRCA on or before May 5, 2013.

Best Regards,

Dick Wolfe

Dick Wolfe, P.E.
Colorado Commissioner, RRCA
State Engineer
Colorado Division of Water Resources

Exhibit A

RESOLUTION BY THE REPUBLICAN RIVER COMPACT ADMINISTRATION APPROVING AN AUGMENTATION PLAN AND RELATED ACCOUNTING PROCEDURES FOR THE COLORADO COMPACT COMPLIANCE PIPELINE

May 5, 2013

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 2012, 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 acquired fifteen wells ("Compact Compliance Wells") in the Republican River Basin in Colorado and has constructed collector pipelines, a storage tank, a main transmission pipeline, and an outlet structure capable of delivering groundwater to the North Fork of the Republican River 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 purchased groundwater rights in the Republican River Basin within Colorado and proposes to pump the historical consumptive use of some or all of these groundwater rights from the Compact Compliance Wells into the pipeline it has constructed 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 (the "Colorado Compact Compliance Pipeline" or the "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 a revised application for approval of an augmentation plan and related accounting procedures for the Pipeline 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 an augmentation plan and the related accounting procedures for the Colorado Compact Compliance Pipeline subject to the terms and conditions set forth herein. The Colorado Compact Compliance Pipeline project is described in the revised application submitted by the State of Colorado and the RRWCD WAE, which is attached hereto as Exhibit 1. The augmentation plan for the Pipeline and the terms and conditions for the operation of the augmentation plan are described below. 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 for the Pipeline is 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 the amounts determined by the Colorado Ground Water Commission pursuant to its rules and regulations, as shown on Exhibit 3.

2. Diversions from any individual Compact Compliance Well shall not exceed 2,500 acre-feet per year.

3. Diversions during any calendar year under the groundwater rights listed on Exhibit 3 and any additional groundwater rights approved for diversion through the Compact Compliance Wells pursuant to paragraph 11 shall not exceed the total average annual historical consumptive use of the rights, except that banking of groundwater shall be permitted in accordance with the rules and regulations of the Colorado Ground Water Commission, subject to the terms and conditions of this resolution.

4. Diversions from the Compact Compliance Wells shall be measured by totalizing flow meters in compliance with the Colorado State Engineer's rules and regulations for the measurement of groundwater diversions in the Republican River basin, 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. 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 (See Exhibit 2; also Exhibit 4).

5. Deliveries from the Colorado Compact Compliance Pipeline to the North Fork of the Republican River shall be measured by a Parshall flume or other measuring device located at the outlet structure. Authorized representatives of Kansas and Nebraska shall have the right to inspect the Parshall flume and other measurement devices for the Pipeline at any reasonable time upon notice to the RRWCD WAE.

6. Each year, the measured deliveries from the Colorado Compact Compliance Pipeline, to the extent they are in compliance with this resolution, shall offset stream depletions to the North Fork of the Republican River sub-basin on an acre-foot for acre-foot basis in accordance with the revised RRCA Accounting Procedures.

7. Each year, the measured deliveries from the Colorado Compact Compliance Pipeline shall be added to the RRCA Groundwater Model in all model runs in accordance with the revised RRCA Accounting Procedures (See Exhibit 2; also Exhibit 4).

8. Colorado shall 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 that will be delivered from the Pipeline during the subject accounting year as provided below, and the RRWCD WAE shall make deliveries from the Pipeline as provided below:

   A. Colorado will initially estimate the Projected Delivery required for the current year based on the largest stream depletions to the North Fork of the Republican River sub-basin during the previous five years without Pipeline deliveries. The RRWCD WAE will begin deliveries from the Colorado Compact Compliance Pipeline during the subject accounting year based on the Projected Delivery and shall make a minimum delivery of 4,000 acre-feet per year as provided below.

   B. Accounting for deliveries will start January 1 of each year.

   C. The RRWCD WAE will begin deliveries from the Pipeline on January 1 and will make the minimum annual delivery of 4,000 acre-feet during the months of January, February, and March, unless such deliveries cannot be made due to operational conditions beyond the control of the RRWCD WAE. If the minimum annual delivery of 4,000 acre-feet cannot be made during the months of January, February and March due to such operational conditions, Colorado will consult with Nebraska and Kansas to schedule such deliveries later in the year.

D. Colorado will calculate and provide notice to the Kansas and Nebraska RRCA Members by April 1, of the Projected Delivery as provided in the Colorado resolution. Unless Colorado determines by April 1 that it will not be able to deliver additional required augmentation water in October through December, Colorado shall stop deliveries at the end of March. If Colorado anticipates that deliveries in the months of November and December will not be sufficient for Compact compliance, Colorado will maximize deliveries first in January, then sequentially in the months of February, March, and April. Deliveries will be made in May only if there is reason to believe that additional deliveries in the months of October through December will not be sufficient for Compact compliance.

E. Because the final accounting for determining Compact compliance is not done until after the compact year is completed and because Colorado's allocations and computed beneficial consumptive use are dependent upon such factors as runoff, the amount of pumping, precipitation and crop evapotranspiration, Colorado cannot know the precise amount of augmentation water that will be needed in any given year. However, because Compact accounting is done on a five-year running average, Colorado will know the accounting for the previous four years and will know whether there is a deficit from the prior four years that will need to be made up in the subject accounting year in addition to the delivery required for the coming year. After the initial minimum delivery of 4,000 acre-feet, Colorado will collect preliminary data for Compact accounting for the subject accounting year and, no later than September 1 of the subject accounting year, will update the Projected Delivery required for the remainder of the subject accounting year, including any deficit owed from the previous 4 years, less the initial minimum delivery of the 4,000 acre-feet that has already been delivered; provided that during the first four years of full operation of the Pipeline under this augmentation plan, the RRWCD WAE may limit deliveries to the updated Projected Delivery for the subject accounting year or the updated Projected Delivery for the subject accounting year plus a percentage of the deficit owed from the previous 4 years to prevent large over deliveries in subsequent years.

F. After updating the Projected Delivery, as described above, if additional deliveries in excess of the initial delivery of 4,000 acre-feet are necessary, Colorado and the RRWCD WAE will maximize such additional deliveries first in the month of December, then November and October of the subject accounting year. If the total necessary additional deliveries cannot be made within those three months, Colorado will attempt to schedule those deliveries in April and May of the subject accounting year, or at such time so as to avoid, to the extent practicable, deliveries during the subject accounting year's irrigation season.

G. Colorado's shortage and Projected Delivery will be calculated in accordance with the FSS.

9. The as-built design for the Colorado Compact Compliance Pipeline, including the location of the Compact Compliance Wells and the river outlet structure, is described in the revised application attached hereto as Exhibit 1. No future changes to the Pipeline that would materially change the location of the Compact Compliance Wells or the river outlet structure shall be made without prior approval of the RRCA.

10. Augmentation credit for deliveries from the Pipeline to the North Fork of the Republican River shall be limited to offsetting stream depletions to the North Fork of the Republican River Colorado sub-basin for the purpose of determining Colorado's compliance with the sub-basin non-impairment requirement (Table 4A) and for calculating Colorado's five-year running average allocation and computed beneficial use for determining Compact compliance (Table 3A).

11. The RRWCD WAE may acquire additional groundwater rights to be diverted through the Compact Compliance Wells upon the terms and conditions of this resolution, provided that such groundwater rights in total do not to exceed an average annual historical consumptive use of 1,500 acre-feet, as determined by the Colorado Ground Water Commission in accordance with its rules and regulations. 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. Any increase in the groundwater rights to be diverted through the Compact Compliance Wells, other than as provided in this paragraph, shall require approval of the RRCA.

12. The approval of this augmentation plan and the related accounting procedures for the Pipeline shall not govern the approval of any future proposed augmentation plan and

related accounting procedures submitted by the State of Colorado or any other State under Subsection III.B.1.k of the FSS.

13. The approval of this augmentation plan and the related accounting procedures for the Pipeline 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.

14. 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.

15. The approval of this augmentation plan and the related accounting procedures for the Pipeline shall be subject to review every twenty years after the date of the approval of this resolution to determine whether aquifer conditions are capable of sustaining the augmentation plan based on the Pipeline; provided that the Pipeline may continue in operation in accordance with this resolution unless there is a substantial change in aquifer conditions demonstrating the augmentation plan for the Pipeline is not sustainable. The State suggesting that there has been a change in aquifer conditions demonstrating that the augmentation plan is not sustainable shall have the burden of proof on that issue. If it is determined that there has been a change in aquifer conditions demonstrating that the augmentation plan for the Pipeline is not sustainable, Colorado shall propose a plan to comply with the State of Colorado's Compact Allocations.

Approved by the RRCA this ____ day of ____, 2013.

______________________________	______________________________
Brian Dunnigan, P.E. Nebraska Member	date
______________________________	______________________________
David Barfield, P.E. Kansas Member Chairman, RRCA	date
______________________________	______________________________
Dick Wolfe, P.E. Colorado Member	date

Exhibit 1

REVISED 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

For

The Colorado Compact Compliance Pipeline

Submitted by

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

April 5, 2013

compliance under the projection made for this scenario with the combination of actions shown in Figure 8. However, as shown in Figure 7, Colorado cannot achieve Compact compliance in the next 25 years without the CCP, absent a dramatic change in the hydrology of the basin in Colorado.

The State of Colorado exceeded its compact allocation by approximately 11,000 ac-ft/yr for period of 2003-2007. In order to comply with Colorado's Compact Allocations, the RRWCD WAE has purchased ground water rights that were historically used for irrigation in the Republican River Basin in Colorado and has constructed the Colorado CCP to deliver ground water pumped under these rights to the North Fork of the Republican River through an outlet structure located a short distance upstream from the Colorado-Kansas State line. This is the stream gage location where the Virgin Water Supply of the North Fork and Colorado stream depletions on the North Fork are calculated under the RRCA Accounting Procedures.

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, which has the highest recharge rates of any location in the Republican River Basin in Colorado. The location of the Compact Compliance Wells was selected to ensure a long-term water supply as water levels decline.

4.0 CLARIFICATIONS AND REVISIONS TO ADDRESS THE ARBITRATOR'S 2010 FINAL DECISION

During the 2010 arbitration, Kansas raised eight deficiencies in the Colorado CCP proposal ("Colorado's Proposal"), which were addressed by the Arbitrator in the Final Decision. The objections were: (1) the augmentation water to be delivered to the North Fork of the Republican River was not included in the RRCA ("Republican River Compact Administration") Groundwater Model; (2) the Colorado Proposal did not address Colorado's failure to meet the sub-basin non-impairment requirement in the South Fork sub-basin; (3) the limitations set forth in the Colorado Resolution were insufficient to require augmentation deliveries on a reliable basis and left those deliveries to Colorado's discretion; (4) the Colorado Proposal lacked "temporal limits"; (5) the States had not conducted a detailed review of Colorado's proposed changes to the RRCA Accounting Procedures; (6) Colorado's "catch-up" provisions were inadequate; (7) Colorado had not explained the reasons for adding language to the Resolution that would allow future augmentation deliveries to increase to 25,000 acre-feet per year; and (8) Colorado and Nebraska had refused to disclose the terms of their stipulated agreement.

The following sections respond to the Arbitrator's rulings.

5.0 Responses to Kansas' Objections Noted in Arbitrator's Final Decision

5.1. Kansas' Objection Number 1: The Colorado Proposal Did Not Include the Augmentation Water in the RRCA Groundwater Model

Kansas' first objection to Colorado's Proposal was that the augmentation water to be delivered to the North Fork of the Republican River was not included in the RRCA Groundwater Model.

The States were in agreement that pumping from the Compact Compliance Wells would be included in the RRCA Groundwater Model to determine the net depletions from these wells, but disagreed on whether the RRCA Groundwater Model should be informed of the water delivered from the CCP. The Arbitrator reviewed Kansas' and Colorado's positions and noted that the expert evidence provided by Kansas had demonstrated that use of the CCP would result in an increase in negative pumping impacts and had raised a related issue regarding the treatment of transit losses between the point of discharge and Swanson Reservoir. The Arbitrator concluded that it was reasonable for Kansas to insist that such impacts be considered in calculating the amount of augmentation credit, whether by use of the RRCA Groundwater Model or through some other approach.

Based on further discussion with Kansas, Colorado proposes that Colorado be given 100% credit for CCP deliveries as an offset to stream depletions to the North Fork of the Republican River, provided the deliveries are in compliance with the other terms and conditions of the resolution, and that the CCP deliveries be included in all runs of the RRCA Groundwater Model (including the "Colorado Pumping" and the "No Colorado Pumping" runs used to determine stream depletions), as shown in the proposed revisions to the RRCA Accounting Procedures.

5.2. Kansas' Objection Number 2: The North Fork Credits Should be Limited to Protect Kansas' Allocation in the South Fork Sub-basin

Kansas' second objection to Colorado's Proposal was that it would allow Colorado to replace its South Fork overuse on the North Fork for purposes of determining Compact compliance with sub-basin allocations.

Steve Larson

From:	Perkins, Sam <Sam.Perkins@KDA.KS.GOV>
Sent:	Friday, July 19, 2013 5:35 PM
To:	Steve Larson (slarson@sspa.com); Alex Spiliotopoulos; Barfield, David
Subject:	FW: Follow-up on CCP Modeling
Attachments:	BonnyCO.htm; BonnyKS.htm; BonnyMD.htm; BonnyNE.htm; CCPCO.htm; CCPKS.htm; CCPMD.htm; CCPNE.htm

-----Original Message-----
From: Willem Schreuder [mailto:willem@prinmath.com]
Sent: Monday, May 13, 2013 10:40 AM
To: Wolfe, Dick; Sullivan, Mike; Franco, Ivan; Barfield, David; Perkins, Sam; Dunnigan, Brian; Schneider, Jim; Koester, Paul
Subject: Follow-up on CCP Modeling

Howdy!

Chuck Spalding pointed out that in the CCP runs I sent out on Apr 24, I had used the wrong recharge files in the CCP simulation. As a result, the simulation considered retiring the pumping from the transferred wells, but retained the return flows associated with those lands. The benefit of retiring those lands were therefore overstated by about 20%.

I have corrected this mistake and posted the corrected runs at
http://www.republicanrivercompact.org/restricted/misc/BonnyCCP13-ks.zip
The attached tables summarize the results.

The biggest change as a result of the correction is that on the North Fork, Colorado's decrease in CBCU resulting from the pipeline averages 67 af/yr over the simulation instead of 114 af/yr as previously predicted.
The decrease in the above Swanson credit for Colorado changes from 528 af/yr to 519 af/yr on average. Transferring the consumptive use from the retired wells to the CCP remains a net reduction in consumptive use because the CCP production on average is less than the historical consumptive use.

Other values for Colorado, Kansas and Nebraska all change by a few acre-feet, but in essence the results remain the same, and the conclusions are unchanged.

Nebraska also requested that we analyze the CCP and Bonny simulations using the 5 Run Proposal instead of the current procedure. I have posted that run at
http://www.republicanrivercompact.org/restricted/misc/BonnyCCP13-ne.zip
The results for those runs differ from the analysys presented by only a few acre-feet for all the analyses. This is what we would expect since the North Fork and South Fork is far enough from the mound that the influence of imported water on these reaches is negligible.

I provided these runs to Sam and Paul last week, so hopefully they can fill you in on the gory details of the simulations.

Let me know if you have any questions or concerns.

Regards
-Willem

==

Dr. Willem A. Schreuder, President, Principia Mathematica
Address: 445 Union Blvd, Suite 230, Lakewood, CO 80228, USA
Tel: (303) 716-3573 Fax: (303) 716-3575
WWW: www.prinmath.com Email: Willem.Schreuder@prinmath.com

Exhibit 4

Modeling the Colorado Compliance Pipeline in the RRCA Groundwater Model

Modeling the Colorado Compliance Pipeline (the "CCP") in the RRCA Groundwater Model (the "Model") consists of two parts. The first involves fifteen wells that will be pumped via a collector system and storage tank into the pipeline (the "CCP Wells"). The water rights for these wells were changed from existing irrigation wells that will be retired. The historic consumptive use from those wells has been transferred to the CCP Wells. The second part involves the surface water outflow from the pipeline.

Modeling of Well Pumping

The irrigation wells that were acquired as part of the CCP will be removed from the irrigation well data set used to represent irrigation wells in the Republican River Basin in Colorado. Because the irrigation wells will no longer be pumped, they will not be included when calculating pumping and return flows from agricultural wells.

Instead, production for each CCP Well will be recorded and supplied as monthly input values by well based on actual production of each well. The pumping of each well will be considered to be fully consumptive and the appropriate volume added to the Republican River Pre-Processor ("rrpp") pumping input files (".pmp" files) for each month. Since there are no irrigation return flows associated with these wells, nothing will be added to the ".rcg" files.

Those pumping values for the CCP Wells will be ON in all of the model simulations except the simulation with pumping in Colorado turned OFF. Therefore, the impacts of the CCP Wells on baseflow will be evaluated as part of the evaluation of other Colorado pumping. No changes are required to "rrpp" to simulate the CCP Wells.

Only the consumptive use of the retired irrigation wells is transferred to the CCP Wells. It was previously demonstrated that due to the distance between the wells and the North Fork of the Republican River, the changes in the timing of the pumping results in no net increase in depletions of baseflow in the Republican River.

Modeling of Pipeline Outflow

The outflow of the CCP will be added to the stream network for all the Model simulations.

The MODFLOW stream package requires that the stream network be specified in such a way that the flows in the stream network can be solved from the top to the bottom of the system. The outflow from the CCP must be added to the stream network as a tributary to Segment 153. In order to do so, a new segment must be created in the stream network with a segment number less than 153. To avoid renumbering all of the segments in the stream network and the corresponding change required to the accounting that would occur as a result of renumbering all the segments, a change will be made to the stream network that avoids renumbering.

Muddy Creek in Nebraska is represented as Segments 122 and 125. The model cells representing Segment 122 will be added to Segment 125, and the routing updated so that the flow from Segments 33 and 66 that previously went to Segment 122 will go to Segment 125 instead.

Segment 122 will then be re-purposed to represent the outflow from the CCP. The new Segment 122 will have a single cell with a stream conductance of zero. The monthly CCP outflow volume will be set as the inflow to Segment 122. The stream routing will be updated so that the outflow from Segments 122 and 130 will go to Segment 153. The result will be that the inflow into Segment 153 will be the sum of the simulated baseflow in the North Fork of the Republican River at the Colorado-Nebraska State Line and the CCP outflow.

Exhibit 4

The monthly CCP outflow volume will be added to all simulations. The outflow will therefore cancel out in all the $CBCU_G$ terms it would potentially be included. Therefore no changes are required to the acct program used to summarize the groundwater model results for the accounting spreadsheets.

A change to the "mkstr" program will be required in order to add the CCP outflow to the stream package file for every month. The existing Model version 12s.str stream template file will be updated to reflect the change to Segments 122 and 125 and changes to the routing of segments 63, 66, 122 and 130. A new version of the "mkstr" program called "mkstr2" will be used to read monthly CPP volumes from the file "flow.dbf" and add it to Segment 122.

Changes to Procedures

The CCP Wells and CCP outflow will be processed along with the annual updates to the Model and the CCP data supplied along with the backup information for other components of the Colorado data.

The Model will be updated to Version 12s3 to reflect changes in the stream network required to add the outflow from the CCP to the stream network. Version 12s3 will use the updated "mkstr2" program that will require an additional "flow.dbf" input file to specify the monthly CCP outflow volume. No changes are required to the other programs used to run the Model.

The CCP will require no changes to the "acct" program that summarizes the Model results for incorporation into the accounting spreadsheets. Changes to the accounting spreadsheets to account for the Augmentation Water Supply resulting from the CCP are described elsewhere.

Table 1. Colorado Pumping Impacts - NB=No Bonny, CCP=No Bonny, CCP added (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork			Above Swanson		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	1248	1246	-2	0	0	0	386	385	-1	0	0	0	1688	1688	0	16016	16015	-1	-5284	-5115	169
2011	1754	1752	-2	0	0	0	318	317	-1	0	0	0	120	120	0	16297	16297	0	-5632	-5518	114
2012	580	578	-2	0	0	0	192	191	-1	0	0	0	100	100	0	16251	16251	0	-6737	-6704	33
2013	347	344	-3	0	0	0	173	173	0	0	0	0	87	87	0	16673	16673	0	-1044	-612	432
2014	414	411	-3	0	0	0	200	199	-1	0	0	0	85	85	0	16983	16982	-1	-821	-665	156
2015	1022	1018	-4	0	0	0	216	215	-1	0	0	0	85	85	0	16996	16994	-2	-2257	-2203	54
2016	1268	1265	-3	0	0	0	228	227	-1	0	0	0	87	87	0	16953	16948	-5	-3795	-3493	302
2017	1300	1295	-5	0	0	0	244	243	-1	0	0	0	93	92	-1	17380	17373	-7	-2307	-2161	146
2018	1703	1699	-4	0	0	0	281	279	-2	0	0	0	96	96	0	17646	17635	-11	-2687	-2596	91
2019	4450	4447	-3	0	0	0	409	408	-1	0	0	0	105	105	0	18542	18528	-14	-1739	-1703	36
2020	1552	1549	-3	0	0	0	373	371	-2	0	0	0	118	118	0	18593	18575	-18	-6686	-6436	250
2021	1877	1874	-3	0	0	0	265	263	-2	0	0	0	115	115	0	18867	18843	-24	-6248	-6125	123
2022	662	659	-3	0	0	0	240	238	-2	0	0	0	118	118	0	18751	18722	-29	-7086	-6821	265
2023	417	413	-4	0	0	0	226	223	-3	0	0	0	126	126	0	19188	19154	-34	-2557	-1717	840
2024	477	473	-4	0	0	0	247	244	-3	0	0	0	136	136	0	19502	19463	-39	-704	-273	431
2025	1158	1151	-7	0	0	0	279	275	-4	0	0	0	143	143	0	19560	19515	-45	-2460	-2459	1
2026	1363	1357	-6	0	0	0	284	279	-5	0	0	0	151	151	0	19423	19372	-51	-4787	-4285	502
2027	1411	1404	-7	0	0	0	314	309	-5	0	0	0	161	161	0	19907	19850	-57	-2715	-2543	172
2028	1822	1815	-7	0	0	0	360	354	-6	0	0	0	170	170	0	20181	20118	-63	-3171	-3010	161
2029	4783	4776	-7	0	0	0	385	377	-8	0	0	0	180	180	0	21095	21025	-70	-1825	-1866	-41
2030	1962	1956	-6	0	0	0	358	351	-7	0	0	0	191	191	0	21057	20982	-75	-8818	-8324	494
2031	1979	1974	-5	0	0	0	322	315	-7	0	0	0	196	196	0	21326	21245	-81	-6660	-6436	224
2032	730	726	-4	0	0	0	306	298	-8	0	0	0	188	188	0	21158	21072	-86	-7668	-7084	584
2033	480	475	-5	0	0	0	321	313	-8	0	0	0	145	145	0	21603	21512	-91	-5238	-1918	3320
2034	544	538	-6	0	0	0	334	324	-10	0	0	0	106	106	0	21938	21842	-96	-949	-398	551
2035	1273	1262	-11	0	0	0	347	337	-10	0	0	0	118	118	0	21996	21895	-101	-2319	-2918	-599
2036	1442	1433	-9	0	0	0	353	342	-11	0	0	0	114	114	0	21797	21692	-105	-5944	-4858	1086
2037	1509	1498	-11	0	0	0	371	359	-12	0	0	0	131	131	0	22308	22199	-109	-2857	-2958	-101
2038	1930	1920	-10	0	0	0	410	397	-13	0	0	0	167	167	0	22591	22478	-113	-3715	-3885	-170
2039	5047	5037	-10	0	0	0	461	448	-13	0	0	0	387	387	0	23500	23384	-116	-1808	-1744	64
2040	2462	2453	-9	0	0	0	439	426	-13	0	0	0	306	306	0	23399	23281	-118	-10911	-8102	2809
2041	2070	2062	-8	0	0	0	404	390	-14	0	0	0	203	203	0	23666	23546	-120	-7112	-7746	-634
2042	790	787	-3	0	0	0	354	346	-8	0	0	0	146	146	0	23457	23336	-121	-8735	-8095	640
2043	537	532	-5	0	0	0	317	311	-6	0	0	0	155	155	0	23911	23789	-122	-9194	-2027	7167
2044	605	598	-7	0	0	0	389	389	0	0	0	0	147	147	0	24249	24125	-124	-2562	-889	1673
2045	1377	1364	-13	0	0	0	473	452	-21	0	0	0	157	156	-1	24305	24181	-124	-1730	-3112	-1382
2046	1513	1503	-10	0	0	0	435	424	-11	0	0	0	157	157	0	24061	23938	-123	-7294	-5335	1959
2047	1596	1585	-11	0	0	0	488	469	-19	0	0	0	171	172	1	24590	24467	-123	-2823	-3312	-489
2048	2027	2014	-13	0	0	0	496	478	-18	0	0	0	178	177	-1	24879	24756	-123	-4186	-4363	-177
2049	5195	5180	-15	0	0	0	522	504	-18	0	0	0	189	188	-1	25776	25655	-121	-1513	-2029	-516
2010 2049	1616	1610	-6	0	0	0	338	331	-7	0	0	0	187	187	0	20659	20592	-67	-4314	-3795	519

Year	Swanson - Harlan			Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog			Red Willow			Rock			Sappa		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	85	0	0	0	0
2011	-13	-13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	91	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	100	-1	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	83	-1	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	59	-1	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	63	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	67	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	72	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	76	-1	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	81	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	86	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	92	-1	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102	101	-1	0	0	0
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	108	-1	0	0	0
2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	106	105	-1	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	108	-1	0	0	0
2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	111	-1	0	0	0
2027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119	118	-1	0	0	0
2028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	124	-1	0	0	0
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	130	-2	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	138	-2	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	147	145	-2	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	153	151	-2	0	0	0
2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	158	-2	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157	154	-3	0	0	0
2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156	154	-2	0	0	0
2036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159	156	-3	0	0	0
2037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167	164	-3	0	0	0
2038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172	169	-3	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	177	174	-3	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	185	181	-4	0	0	0
2041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	197	193	-4	0	0	0
2042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	199	-5	0	0	0
2043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	186	-4	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	167	-3	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	177	-3	0	0	0
2046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	156	-4	0	0	0
2047	0	-11	-11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166	162	-4	0	0	0
2048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181	177	-4	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	235	232	-3	0	0	0
2010 2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	131	-2	0	0	0

Year	South Fork			Hugh Butler			Bonny			Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	4820	4811	-9	0	0	0	-619	-619	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11	0	-5272	-5104	168	18368	18525	157
2011	4296	4288	-8	0	0	0	-1082	-1082	0	0	0	0	0	0	0	0	0	0	0	0	0	12	12	0	-5645	-5532	113	16167	16268	101
2012	4106	4100	-6	0	0	0	-1203	-1203	0	0	0	0	0	0	0	0	0	0	0	0	0	15	12	-3	-6744	-6711	33	13404	13425	21
2013	3798	3785	-13	0	0	0	-1570	-1570	0	0	0	0	0	0	0	0	0	0	0	0	0	26	20	-6	-1045	-613	432	18581	18991	410
2014	4189	4179	-10	0	0	0	-1837	-1837	0	0	0	0	0	0	0	0	0	0	0	0	0	26	21	-5	-822	-666	156	19307	19442	135
2015	7363	7352	-11	0	0	0	-1722	-1722	0	0	0	0	0	0	0	0	0	0	0	0	0	17	16	-1	-2258	-2204	54	21792	21826	34
2016	7083	7070	-13	0	0	0	-1225	-1225	0	0	0	0	11	11	0	0	0	0	0	0	0	18	18	0	-3796	-3494	302	20694	20973	279
2017	7584	7574	-10	0	0	0	-1036	-1036	0	0	0	0	12	12	0	0	0	0	0	0	0	20	19	-1	-2310	-2164	146	23358	23480	122
2018	9057	9047	-10	0	0	0	-2016	-2016	0	0	0	0	12	12	0	0	0	0	0	0	0	18	18	0	-2690	-2599	91	24184	24249	65
2019	15614	15605	-9	0	0	0	-927	-927	0	0	0	0	13	13	0	0	0	0	0	0	0	16	15	-1	-1745	-1709	36	36559	36565	6
2020	9609	9592	-17	0	0	0	-581	-581	0	0	0	0	14	14	0	0	0	0	0	0	0	16	15	-1	-6685	-6436	249	23095	23303	208
2021	4668	4660	-8	0	0	0	-1074	-1074	0	0	0	0	15	15	0	0	0	0	0	0	0	17	17	0	-6248	-6126	122	18595	18679	84
2022	3881	3872	-9	0	0	0	-1172	-1172	0	0	0	0	16	16	0	0	0	0	0	0	0	20	17	-3	-7087	-6821	266	15531	15750	219
2023	3607	3599	-8	0	0	0	-1542	-1542	0	0	0	0	17	17	0	0	0	0	0	0	0	33	24	-9	-2557	-1717	840	19625	20405	780
2024	4018	4000	-18	0	0	0	-1874	-1874	0	0	0	0	19	19	0	0	0	0	0	0	0	32	26	-6	-706	-275	431	21956	22315	359
2025	7098	7078	-20	0	0	0	-1757	-1757	0	0	0	0	20	20	0	0	0	0	0	0	0	23	19	-4	-2461	-2460	1	24171	24091	-80
2026	6909	6883	-26	0	0	0	-1246	-1246	0	0	0	0	21	21	0	0	0	0	0	0	0	23	20	-3	-4788	-4286	502	22252	22664	412
2027	7356	7337	-19	0	0	0	-1065	-1065	0	0	0	0	22	22	0	0	0	0	0	0	0	24	22	-2	-2717	-2545	172	25533	25613	80
2028	8836	8817	-19	0	0	0	-2076	-2076	0	0	0	0	24	24	0	0	0	0	0	0	0	23	22	-1	-3173	-3012	161	26293	26356	63
2029	16510	16487	-23	0	0	0	-1626	-1626	0	0	0	0	25	25	0	0	0	0	0	0	0	20	18	-2	-1828	-1868	-40	39675	39525	-150
2030	11501	11472	-29	0	0	0	-667	-667	0	0	0	0	27	27	0	0	0	0	0	0	0	19	17	-2	-8824	-8330	494	25764	26138	374
2031	4497	4482	-15	0	0	0	-1125	-1125	0	0	0	0	29	29	0	0	0	0	0	0	0	22	20	-2	-6662	-6438	224	20731	20842	111
2032	3727	3727	0	0	0	0	-1219	-1219	0	0	0	0	31	31	0	0	0	0	0	0	0	29	21	-8	-7670	-7086	584	17434	17911	477
2033	3477	3448	-29	0	0	0	-1575	-1575	0	0	0	0	32	32	0	0	0	0	0	0	0	54	29	-25	-5238	-1917	3321	19461	22619	3158
2034	3945	3888	-57	0	0	0	-1942	-1942	0	0	0	0	34	34	0	0	0	0	0	0	0	49	26	-23	-953	-402	551	24213	24570	357
2035	6884	6847	-37	0	0	0	-1859	-1859	0	0	0	0	37	37	0	0	0	0	0	0	0	35	21	-14	-2322	-2921	-599	26665	25890	-775
2036	6755	6725	-30	0	0	0	-1286	-1286	0	0	0	0	39	39	0	0	0	0	0	0	0	32	21	-11	-5947	-4861	1086	23457	24375	918
2037	7177	7139	-38	0	0	0	-1121	-1121	0	0	0	0	42	42	0	0	0	0	0	0	0	32	22	-10	-2863	-2964	-101	27754	27469	-285
2038	8650	8617	-33	0	0	0	-2154	-2154	0	0	0	0	45	45	0	0	0	0	0	0	0	29	23	-6	-3720	-3890	-170	28119	27772	-347
2039	16668	16638	-30	0	0	0	-1702	-1702	0	0	0	0	48	48	0	0	0	0	0	0	0	26	21	-5	-1813	-1749	64	42800	42686	-114
2040	11721	11718	-3	0	0	0	-769	-769	0	0	0	0	51	51	0	0	0	0	0	0	0	22	19	-3	-10914	-8105	2809	26902	29562	2660
2041	4345	4313	-32	0	0	0	-1189	-1189	0	0	0	0	54	54	0	0	0	0	0	0	0	29	19	-10	-7116	-7749	-633	22663	21841	-822
2042	3583	3596	13	0	0	0	-1250	-1250	0	0	0	0	57	57	0	0	0	0	0	0	0	41	23	-18	-8738	-8098	640	18643	19141	498
2043	3362	3295	-67	0	0	0	-1598	-1598	0	0	0	0	60	60	0	0	0	0	0	0	0	60	33	-27	-9193	-2027	7166	17801	24737	6936
2044	3911	3809	-102	0	0	0	-1981	-1981	0	0	0	0	63	63	0	0	0	0	0	0	0	75	30	-45	-2562	-889	1673	25068	26459	1391
2045	6724	6660	-64	0	0	0	-1964	-1964	0	0	0	0	67	67	0	0	0	0	0	0	0	53	24	-29	-1739	-3121	-1382	29631	27995	-1636
2046	6611	6574	-37	0	0	0	-1334	-1334	0	0	0	0	70	70	0	0	0	0	0	0	0	41	22	-19	-7299	-5340	1959	24414	26170	1756
2047	7046	6989	-57	0	0	0	-1181	-1181	0	0	0	0	74	73	-1	0	0	0	0	0	0	40	24	-16	-2833	-3323	-490	30157	29437	-720
2048	8480	8426	-54	0	0	0	-2237	-2237	0	0	0	0	77	77	0	0	0	0	0	0	0	34	23	-11	-4194	-4371	-177	29922	29520	-402
2049	16393	16345	-48	0	0	0	-1744	-1744	0	0	0	0	81	81	0	0	0	0	0	0	0	33	21	-12	-1523	-2038	-515	45156	44424	-732
2010 2049	7146	7121	-25	0	0	0	-1428	-1428	0	0	0	0	31	31	0	0	0	0	0	0	0	29	20	-9	-4317	-3799	518	24397	24800	403

Table 2. Kansas Pumping Impacts - NB=No Bonny, CCP=No Bonny, CCP added (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	68	68	0	6893	6893	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	157	158	1	5972	5972	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	100	100	0	2807	2807	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	92	92	0	897	897	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	105	106	1	784	784	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	107	107	0	2143	2143	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	77	76	-1	3453	3453	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	91	91	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	86	86	0	7574	7574	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	148	148	0	7925	7925	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	63	63	0	7010	7010	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	153	154	1	6074	6074	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	98	98	0	2849	2849	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	90	90	0	916	916	0	0	0	0	0	0	0	0	0	0	0	0	0
2024	100	101	1	803	803	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	106	106	0	2155	2155	0	0	0	0	0	0	0	0	0	0	0	0	0
2026	75	75	0	3460	3460	0	0	0	0	0	0	0	0	0	0	0	0	0
2027	90	90	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0
2028	85	85	0	7537	7537	0	0	0	0	0	0	0	0	0	0	0	0	0
2029	148	148	0	8300	8300	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	60	60	0	7206	7206	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	152	154	2	6134	6134	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	96	98	2	2834	2834	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	86	88	2	907	907	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	96	98	2	789	789	0	0	0	0	0	0	0	0	0	0	0	0	0
2035	107	107	0	2138	2138	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	73	73	0	3440	3440	0	0	0	0	0	0	0	0	0	0	0	0	0
2037	90	90	0	5484	5484	0	0	0	0	0	0	0	0	0	0	0	0	0
2038	85	85	0	7506	7506	0	0	0	0	0	0	0	0	0	0	0	0	0
2039	148	148	0	8579	8579	0	0	0	0	0	0	0	0	0	0	0	0	0
2040	56	56	0	7374	7374	0	0	0	0	0	0	0	0	0	0	0	0	0
2041	154	154	0	6142	6142	0	0	0	0	0	0	0	0	0	0	0	0	0
2042	93	95	2	2821	2821	0	0	0	0	0	0	0	0	0	0	0	0	0
2043	83	85	2	899	899	0	0	0	0	0	0	0	0	0	0	0	0	0
2044	93	93	0	776	776	0	0	0	0	0	0	0	0	0	0	0	0	0
2045	107	108	1	2123	2123	0	0	0	0	0	0	0	0	0	0	0	0	0
2046	72	72	0	3429	3429	0	0	0	0	0	0	0	0	0	0	0	0	0
2047	89	90	1	5473	5473	0	0	0	0	0	0	0	0	0	0	0	0	0
2048	86	86	0	7479	7479	0	0	0	0	0	0	0	0	0	0	0	0	0
2049	149	149	0	8816	8816	0	0	0	0	0	0	0	0	0	0	0	0	0
2010 2049	100	100	0	4472	4472	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Above Swanson			Swanson - Harlan			Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	18	21	3	-1173	-1173	0	0	0	0	245	245	0	0	0	0	3513	3513	0
2011	212	220	8	48	48	0	0	0	0	44	44	0	0	0	0	5026	5026	0
2012	137	156	19	344	344	0	0	0	0	54	54	0	0	0	0	3139	3139	0
2013	88	120	32	-235	-235	0	0	0	0	56	57	1	0	0	0	1690	1690	0
2014	241	273	32	0	0	0	0	0	0	69	69	0	0	0	0	1873	1873	0
2015	198	182	-16	-34	-34	0	0	0	0	62	62	0	0	0	0	5841	5841	0
2016	296	361	65	-394	-394	0	0	0	0	53	53	0	0	0	0	5564	5564	0
2017	344	333	-11	382	382	0	0	0	0	68	68	0	0	0	0	5816	5816	0
2018	313	300	-13	154	154	0	0	0	0	41	41	0	0	0	0	12547	12547	0
2019	299	313	14	82	82	0	0	0	0	54	54	0	0	0	0	10357	10357	0
2020	80	83	3	-1578	-1578	0	12	12	0	245	245	0	0	0	0	3776	3776	0
2021	335	392	57	62	63	1	0	0	0	44	44	0	0	0	0	5432	5432	0
2022	136	195	59	542	542	0	0	0	0	54	54	0	0	0	0	3403	3403	0
2023	62	152	90	-276	-276	0	0	0	0	56	56	0	0	0	0	1914	1914	0
2024	176	292	116	0	0	0	0	0	0	69	69	0	0	0	0	2143	2143	0
2025	243	220	-23	-557	-557	0	0	0	0	62	62	0	0	0	0	6159	6159	0
2026	321	329	8	-1066	-1066	0	0	0	0	53	53	0	0	0	0	5912	5911	-1
2027	348	331	-17	793	793	0	0	0	0	68	68	0	0	0	0	6190	6190	0
2028	295	352	57	191	191	0	0	0	0	41	41	0	0	0	0	12749	12749	0
2029	254	263	9	81	81	0	0	0	0	54	54	0	0	0	0	10481	10481	0
2030	205	218	13	-1700	-1700	0	13	13	0	245	245	0	0	0	0	3970	3970	0
2031	253	280	27	-71	-71	0	11	11	0	44	44	0	0	0	0	5723	5723	0
2032	130	153	23	623	623	0	0	0	0	53	53	0	0	0	0	3591	3591	0
2033	-793	135	928	-274	-274	0	0	0	0	56	56	0	0	0	0	2091	2091	0
2034	392	293	-99	0	0	0	0	0	0	69	69	0	0	0	0	2358	2358	0
2035	254	230	-24	-622	-622	0	0	10	10	62	63	1	0	0	0	6438	6438	0
2036	291	323	32	-2223	-2223	0	10	10	0	53	53	0	0	0	0	6164	6164	0
2037	429	393	-36	1333	1333	0	0	0	0	68	68	0	0	0	0	6501	6501	0
2038	258	290	32	253	253	0	0	0	0	40	40	0	0	0	0	12976	12976	0
2039	242	234	-8	70	70	0	10	10	0	54	54	0	0	0	0	10646	10646	0
2040	255	320	65	-1769	-1769	0	14	14	0	245	245	0	0	0	0	4127	4127	0
2041	195	230	35	-199	-199	0	11	11	0	44	44	0	0	0	0	5964	5964	0
2042	-113	164	277	651	651	0	0	0	0	54	53	-1	0	0	0	3744	3744	0
2043	-827	134	961	-273	-273	0	10	10	0	56	56	0	0	0	0	2246	2246	0
2044	-533	300	833	0	0	0	0	0	0	69	69	0	0	0	0	2554	2554	0
2045	282	197	-85	-668	-668	0	10	10	0	62	62	0	0	0	0	6670	6670	0
2046	257	333	76	-2443	-2443	0	10	11	1	53	53	0	0	0	0	6389	6389	0
2047	568	365	-203	1411	1411	0	0	0	0	68	67	-1	0	0	0	6768	6768	0
2048	216	273	57	369	369	0	0	0	0	40	40	0	0	0	0	13155	13155	0
2049	259	220	-39	71	71	0	11	11	0	53	54	1	0	0	0	10846	10846	0
2010 2049	165	249	84	-202	-202	0	3	3	0	74	74	0	0	0	0	5911	5911	0

Year	Red Willow			Rock			Sappa			South Fork			Hugh Butler			Bonny		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	0	0	0	0	0	0	2482	2482	0	1810	1812	2	0	0	0	0	0	0
2011	0	0	0	0	0	0	1540	1540	0	3213	3215	2	0	0	0	0	0	0
2012	0	0	0	0	0	0	266	266	0	1578	1578	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	-661	-661	0	1189	1191	2	0	0	0	0	0	0
2014	0	0	0	0	0	0	-784	-784	0	1858	1861	3	0	0	0	0	0	0
2015	0	0	0	0	0	0	-1700	-1700	0	3951	3953	2	0	0	0	0	0	0
2016	0	0	0	0	0	0	-1038	-1038	0	2911	2916	5	0	0	0	0	0	0
2017	0	0	0	0	0	0	820	820	0	3505	3507	2	0	0	0	0	0	0
2018	0	0	0	0	0	0	3471	3471	0	3932	3936	4	0	0	0	0	0	0
2019	0	0	0	0	0	0	4056	4056	0	8004	8006	2	0	0	0	0	0	0
2020	0	0	0	0	0	0	2529	2529	0	3654	3648	-6	0	0	0	0	0	0
2021	0	0	0	0	0	0	1794	1794	0	2999	3001	2	0	0	0	0	0	0
2022	0	0	0	0	0	0	399	399	0	1406	1409	3	0	0	0	0	0	0
2023	0	0	0	0	0	0	-641	-641	0	1007	1015	8	0	0	0	0	0	0
2024	0	0	0	0	0	0	-803	-803	0	1642	1647	5	0	0	0	0	0	0
2025	0	0	0	0	0	0	-1598	-1598	0	3738	3743	5	0	0	0	0	0	0
2026	0	0	0	0	0	0	-781	-781	0	2775	2779	4	0	0	0	0	0	0
2027	0	0	0	0	0	0	1051	1051	0	3337	3341	4	0	0	0	0	0	0
2028	0	0	0	0	0	0	3627	3627	0	3757	3761	4	0	0	0	0	0	0
2029	0	0	0	0	0	0	3991	3991	0	7636	7641	5	0	0	0	0	0	0
2030	0	0	0	0	0	0	2589	2589	0	4157	4147	-10	0	0	0	0	0	0
2031	0	0	0	0	0	0	1887	1887	0	2824	2828	4	0	0	0	0	0	0
2032	0	0	0	0	0	0	478	478	0	1277	1283	6	0	0	0	0	0	0
2033	0	0	0	0	0	0	-633	-633	0	862	874	12	0	0	0	0	0	0
2034	0	0	0	0	0	0	-789	-789	0	1492	1495	3	0	0	0	0	0	0
2035	0	0	0	0	0	0	-1517	-1517	0	3559	3567	8	0	0	0	-11	-11	0
2036	0	0	0	0	0	0	-633	-633	0	2653	2667	14	0	0	0	0	0	0
2037	0	0	0	0	0	0	1193	1193	0	3205	3208	3	0	0	0	0	0	0
2038	0	0	0	0	0	0	3715	3715	0	3619	3625	6	0	0	0	-11	-11	0
2039	0	0	0	0	0	0	4004	4004	0	7469	7477	8	0	0	0	0	0	0
2040	0	0	0	0	0	0	2672	2672	0	3601	3610	9	0	0	0	0	0	0
2041	0	0	0	0	0	0	1983	1983	0	2604	2606	2	0	0	0	0	0	0
2042	0	0	0	0	0	0	542	542	0	1164	1172	8	0	0	0	0	0	0
2043	0	0	0	0	0	0	-626	-626	0	740	770	30	0	0	0	0	0	0
2044	0	0	0	0	0	0	-776	-776	0	1356	1365	9	0	0	0	0	0	0
2045	0	0	0	0	0	0	-1456	-1456	0	3407	3426	19	0	0	0	-21	-21	0
2046	0	0	0	0	0	0	-520	-520	0	2555	2572	17	0	0	0	0	0	0
2047	0	0	0	0	0	0	1305	1305	0	3086	3099	13	0	0	0	-12	-12	0
2048	0	0	0	0	0	0	3780	3780	0	3498	3503	5	0	0	0	-16	-16	0
2049	0	0	0	0	0	0	4043	4043	0	7317	7327	10	0	0	0	-12	-12	0
2010 2049	0	0	0	0	0	0	981	981	0	3108	3114	6	0	0	0	-2	-2	0

Year	Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	490	490	0	0	0	0	131	131	0	0	0	0	0	0	0	-900	-898	2	14492	14496	4
2011	432	432	0	0	0	0	102	102	0	0	0	0	0	0	0	313	321	8	16759	16769	10
2012	555	555	0	0	0	0	85	85	0	0	0	0	0	0	0	543	562	19	9077	9096	19
2013	581	581	0	0	0	0	84	84	0	0	0	0	0	0	0	-84	-51	33	3792	3826	34
2014	535	535	0	0	0	0	81	81	0	0	0	0	0	0	0	318	349	31	4772	4807	35
2015	547	547	0	0	0	0	78	78	0	0	0	0	0	0	0	234	218	-16	11203	11189	-14
2016	566	566	0	0	0	0	79	79	0	0	0	0	0	0	0	-36	29	65	11580	11650	70
2017	561	561	0	0	0	0	79	79	0	0	0	0	0	0	0	802	791	-11	17180	17171	-9
2018	533	533	0	0	0	0	142	142	0	0	0	0	0	0	0	499	486	-13	28786	28777	-9
2019	476	476	0	0	0	0	165	165	0	0	0	0	0	0	0	443	458	15	31584	31600	16
2020	517	517	0	0	0	0	137	137	0	0	0	0	0	0	0	-1241	-1238	3	16453	16450	-3
2021	458	458	0	0	0	0	107	107	0	0	0	0	0	0	0	451	509	58	17472	17533	61
2022	582	582	0	0	0	0	90	90	0	0	0	0	0	0	0	740	799	59	9568	9631	63
2023	609	609	0	0	0	0	89	89	0	0	0	0	0	0	0	-149	-60	89	3837	3933	96
2024	563	563	0	0	0	0	89	89	0	0	0	0	0	0	0	254	370	116	4792	4914	122
2025	575	575	0	0	0	0	89	89	0	0	0	0	0	0	0	-243	-266	-23	10982	10963	-19
2026	593	593	0	0	0	0	89	89	0	0	0	0	0	0	0	-683	-675	8	11444	11455	11
2027	589	589	0	0	0	0	88	88	0	0	0	0	0	0	0	1216	1199	-17	18065	18050	-15
2028	561	561	0	0	0	0	155	155	0	0	0	0	0	0	0	518	575	57	28990	29050	60
2029	503	503	0	0	0	0	168	168	0	0	0	0	0	0	0	399	407	8	31630	31643	13
2030	544	544	0	0	0	0	139	139	0	0	0	0	0	0	0	-1236	-1223	13	17439	17441	2
2031	484	484	0	0	0	0	109	109	0	0	0	0	0	0	0	236	263	27	17551	17585	34
2032	608	608	0	0	0	0	92	92	0	0	0	0	0	0	0	815	839	24	9794	9821	27
2033	634	634	0	0	0	0	91	91	0	0	0	0	0	0	0	-1002	-73	929	3041	3981	940
2034	589	589	0	0	0	0	95	95	0	0	0	0	0	0	0	471	371	-100	5109	5009	-100
2035	601	601	0	0	0	0	96	96	0	0	0	0	0	0	0	-296	-319	-23	11126	11107	-19
2036	619	619	0	0	0	0	95	95	0	0	0	0	0	0	0	-1868	-1837	31	10551	10592	41
2037	614	614	0	0	0	0	92	92	0	0	0	0	0	0	0	1838	1803	-35	19018	18983	-35
2038	586	586	0	0	0	0	167	167	0	0	0	0	0	0	0	542	575	33	29193	29231	38
2039	528	528	0	0	0	0	169	169	0	0	0	0	0	0	0	376	368	-8	31925	31923	-2
2040	569	569	0	0	0	0	140	140	0	0	0	0	0	0	0	-1255	-1189	66	17295	17370	75
2041	509	509	0	0	0	0	111	111	0	0	0	0	0	0	0	51	86	35	17517	17552	35
2042	632	632	0	0	0	0	94	94	0	0	0	0	0	0	0	601	877	276	9701	9981	280
2043	658	658	0	0	0	0	92	92	0	0	0	0	0	0	0	-1034	-73	961	3069	4057	988
2044	613	613	0	0	0	0	99	99	0	0	0	0	17	0	-17	-455	379	834	4282	5109	827
2045	625	625	0	0	0	0	102	102	0	0	0	0	13	0	-13	-314	-398	-84	11259	11185	-74
2046	643	643	0	0	0	0	100	100	0	0	0	0	0	0	0	-2123	-2047	76	10549	10637	88
2047	638	638	0	0	0	0	101	101	0	0	0	0	0	0	0	2055	1852	-203	19515	19321	-194
2048	609	609	0	0	0	0	177	177	0	0	0	0	0	0	0	616	673	57	29396	29453	57
2049	552	552	0	0	0	0	170	170	0	0	0	0	0	0	0	394	355	-39	32286	32252	-34
2010 2049	567	567	0	0	0	0	111	111	0	0	0	0	0	0	0	45	129	84	15301	15389	88

Table 3. Nebraska Pumping Impacts - NB=No Bonny, CCP=No Bonny, CCP added (acre-feet

Year	Arikaree NB	Arikaree CCP	Arikaree Del	Beaver NB	Beaver CCP	Beaver Del	Buffalo NB	Buffalo CCP	Buffalo Del	Driftwood NB	Driftwood CCP	Driftwood Del	Frenchman NB	Frenchman CCP	Frenchman Del	North Fork NB	North Fork CCP	North Fork Del
2010	126	126	0	5309	5309	0	3417	3417	0	1185	1185	0	77748	77748	0	978	978	0
2011	320	320	0	5116	5116	0	3602	3602	0	1234	1234	0	80533	80533	0	1023	1023	0
2012	335	335	0	2946	2946	0	3602	3602	0	1278	1278	0	75799	75799	0	1065	1065	0
2013	514	515	1	1465	1465	0	3650	3650	0	1397	1397	0	81464	81464	0	1125	1125	0
2014	423	424	1	1816	1816	0	3675	3675	0	1479	1479	0	85962	85962	0	1177	1177	0
2015	242	241	-1	3022	3022	0	3741	3741	0	1483	1483	0	80212	80212	0	1219	1219	0
2016	122	122	0	3710	3710	0	3722	3723	1	1426	1426	0	74594	74594	0	1252	1252	0
2017	111	110	-1	4964	4964	0	3743	3744	1	1362	1362	0	77253	77253	0	1293	1293	0
2018	124	124	0	6485	6485	0	3783	3786	3	1299	1299	0	78164	78164	0	1326	1326	0
2019	154	153	-1	6225	6225	0	3879	3883	4	1218	1218	0	81309	81309	0	1352	1352	0
2020	126	125	-1	5277	5277	0	3924	3930	6	1201	1201	0	79293	79294	1	1379	1379	0
2021	318	318	0	5083	5083	0	3934	3941	7	1251	1251	0	81837	81838	1	1426	1426	0
2022	336	336	0	2938	2938	0	3887	3895	8	1295	1295	0	75960	75962	2	1468	1468	0
2023	510	511	1	1475	1475	0	3899	3909	10	1413	1413	0	81325	81327	2	1532	1532	0
2024	422	423	1	1727	1727	0	3942	3953	11	1495	1495	0	86106	86109	3	1587	1587	0
2025	246	245	-1	2917	2917	0	4030	4043	13	1500	1500	0	80482	80485	3	1630	1630	0
2026	124	123	-1	3613	3613	0	4001	4016	15	1444	1444	0	74580	74585	5	1661	1661	0
2027	113	112	-1	4861	4861	0	4039	4055	16	1383	1383	0	78234	78239	5	1706	1706	0
2028	126	126	0	6355	6355	0	4114	4131	17	1325	1325	0	78903	78909	6	1740	1740	0
2029	157	156	-1	6473	6473	0	4221	4238	17	1245	1245	0	83156	83164	8	1766	1766	0
2030	124	123	-1	5370	5370	0	4226	4246	20	1228	1228	0	79834	79843	9	1791	1791	0
2031	316	317	1	5068	5068	0	4186	4209	23	1278	1278	0	82033	82043	10	1840	1840	0
2032	336	337	1	2930	2930	0	4114	4138	24	1320	1320	0	76035	76047	12	1878	1878	0
2033	502	504	2	1498	1498	0	4138	4155	17	1435	1435	0	80541	80553	12	1946	1946	0
2034	422	424	2	1703	1703	0	4186	4202	16	1518	1518	0	86498	86512	14	2002	2002	0
2035	251	248	-3	2882	2882	0	4262	4288	26	1523	1523	0	80649	80664	15	2045	2045	0
2036	126	124	-2	3581	3581	0	4230	4255	25	1468	1468	0	74692	74705	13	2074	2074	0
2037	116	114	-2	4828	4828	0	4277	4300	23	1409	1409	0	79074	79089	15	2123	2123	0
2038	128	127	-1	6315	6315	0	4347	4375	28	1354	1354	0	79299	79315	16	2158	2158	0
2039	162	161	-1	6718	6718	0	4478	4510	32	1279	1279	0	83799	83821	22	2183	2183	0
2040	121	120	-1	5495	5495	0	4468	4499	31	1263	1263	0	80469	80490	21	2205	2205	0
2041	315	315	0	5066	5066	0	4404	4434	30	1311	1311	0	82249	82267	18	2255	2255	0
2042	336	341	5	2957	2957	0	4291	4315	24	1349	1349	0	76127	76146	19	2290	2289	-1
2043	494	501	7	1532	1532	0	4275	4303	28	1463	1463	0	80010	80030	20	2360	2360	0
2044	421	427	6	1700	1700	0	4379	4414	35	1546	1546	0	86664	86685	21	2419	2419	0
2045	256	255	-1	2857	2857	0	4526	4541	15	1551	1551	0	81164	81184	20	2461	2461	0
2046	127	130	3	3562	3562	0	4445	4470	25	1496	1496	0	74875	74896	21	2488	2487	-1
2047	120	121	1	4807	4807	0	4529	4545	16	1438	1438	0	79715	79736	21	2541	2540	-1
2048	129	127	-2	6279	6279	0	4588	4605	17	1384	1384	0	79723	79743	20	2577	2576	-1
2049	167	164	-3	6935	6935	0	4688	4712	24	1312	1312	0	84145	84164	19	2601	2601	0
2010 2049	247	248	1	4096	4096	0	4096	4111	15	1370	1370	0	80012	80022	10	1798	1798	0

Year	Above Swanson NB	Above Swanson CCP	Above Swanson Del	Swanson - Harlan NB	Swanson - Harlan CCP	Swanson - Harlan Del	Harlan - Guide Rock NB	Harlan - Guide Rock CCP	Harlan - Guide Rock Del	Guide Rock - Hardy NB	Guide Rock - Hardy CCP	Guide Rock - Hardy Del	Medicine NB	Medicine CCP	Medicine Del	Prairie Dog NB	Prairie Dog CCP	Prairie Dog Del
2010	9784	9958	174	35347	35347	0	28926	28926	0	2503	2503	0	20127	20127	0	0	0	0
2011	11608	11728	120	42669	42669	0	28101	28101	0	2695	2695	0	21311	21311	0	0	0	0
2012	10946	11086	140	23475	23475	0	29761	29761	0	2633	2633	0	22160	22160	0	0	0	0
2013	18151	18508	357	28950	28950	0	31211	31211	0	3346	3346	0	23556	23556	0	0	0	0
2014	15316	15485	169	35622	35622	0	32675	32675	0	3224	3224	0	23879	23879	0	0	0	0
2015	11728	11760	32	40779	40779	0	32616	32616	0	3727	3727	0	23428	23428	0	0	0	0
2016	9130	9394	264	40091	40091	0	30253	30253	0	3140	3140	0	22523	22523	0	0	0	0
2017	10374	10510	136	51226	51226	0	29999	29999	0	3054	3054	0	22848	22848	0	0	0	0
2018	9832	9909	77	51123	51123	0	28903	28903	0	2409	2409	0	22319	22319	0	63	63	0
2019	10875	10866	-9	59639	59639	0	28785	28785	0	2314	2314	0	22165	22165	0	27	27	0
2020	8394	8652	258	44029	44029	0	33138	33138	0	2590	2590	0	23251	23251	0	13	13	0
2021	11439	11584	145	45292	45292	0	32307	32307	0	2805	2805	0	24322	24322	0	0	0	0
2022	10843	11229	386	26637	26636	-1	33812	33812	0	2711	2711	0	24907	24907	0	0	0	0
2023	17769	18477	708	31011	31010	-1	35225	35225	0	3421	3420	-1	26279	26279	0	0	0	0
2024	16057	16452	395	37436	37436	0	36700	36700	0	3316	3316	0	26590	26590	0	0	0	0
2025	12166	12155	-11	43193	43193	0	36595	36595	0	3806	3806	0	26141	26141	0	0	0	0
2026	8858	9257	399	43064	43064	0	34188	34188	0	3228	3228	0	25131	25131	0	0	0	0
2027	10627	10774	147	54381	54381	0	34012	34012	0	3174	3174	0	25652	25652	0	0	0	0
2028	10015	10137	122	54215	54215	0	32904	32904	0	2523	2523	0	25192	25192	0	45	45	0
2029	11587	11523	-64	61289	61288	-1	32621	32621	0	2377	2377	0	24960	24960	0	41	41	0
2030	6869	7320	451	46719	46718	-1	36931	36931	0	2675	2675	0	25936	25936	0	16	16	0
2031	11603	11872	269	48467	48467	0	36084	36084	0	2906	2906	0	26949	26949	0	0	0	0
2032	10593	12101	1508	29569	29569	0	37409	37410	1	2781	2781	0	27311	27311	0	0	0	0
2033	16211	18552	2341	33684	33684	0	38806	38806	0	3491	3491	0	28713	28713	0	0	0	0
2034	16558	17029	471	38927	38927	0	40303	40303	0	3398	3398	0	29027	29027	0	0	0	0
2035	12978	12338	-640	44859	44859	0	40132	40132	0	3876	3876	0	28537	28537	0	0	0	0
2036	8456	9439	983	44840	44840	0	37678	37678	0	3308	3308	0	27425	27425	0	0	0	0
2037	11165	11009	-156	57545	57545	0	37560	37560	0	3272	3272	0	28062	28062	0	0	0	0
2038	10165	9989	-176	57336	57335	-1	36573	36573	0	2610	2610	0	27552	27552	0	45	45	0
2039	12419	12349	-70	63842	63842	0	36131	36131	0	2427	2427	0	27263	27263	0	77	77	0
2040	5428	8296	2868	48550	48550	0	40344	40344	0	2738	2738	0	28153	28153	0	27	27	0
2041	11773	11080	-693	51098	51098	0	39527	39527	0	2983	2983	0	29133	29133	0	0	0	0
2042	9943	12473	2530	32071	32071	0	40676	40676	0	2833	2833	0	29356	29356	0	0	0	0
2043	13271	18788	5517	36058	36058	0	41964	41964	0	3548	3547	-1	30796	30796	0	0	0	0
2044	15583	17073	1490	40516	40516	0	43457	43457	0	3460	3460	0	31088	31088	0	0	0	0
2045	14197	12738	-1459	46104	46104	0	43228	43228	0	3931	3931	0	30561	30561	0	0	0	0
2046	7779	9652	1873	46411	46411	0	40763	40763	0	3365	3365	0	29379	29379	0	0	0	0
2047	11803	11199	-604	60235	60235	0	41005	41005	0	3338	3338	0	30063	30063	0	0	0	0
2048	10310	10089	-221	60060	60060	0	40075	40075	0	2676	2676	0	29513	29513	0	62	62	0
2049	13388	12682	-706	66085	66086	1	39451	39451	0	2459	2459	0	29180	29180	0	107	107	0
2010 2049	11649	12137	488	45061	45061	0	35770	35770	0	3026	3026	0	26268	26268	0	13	13	0

Year	Red Willow NB	Red Willow CCP	Red Willow Del	Rock NB	Rock CCP	Rock Del	Sappa NB	Sappa CCP	Sappa Del	South Fork NB	South Fork CCP	South Fork Del	Hugh Butler NB	Hugh Butler CCP	Hugh Butler Del	Bonny NB	Bonny CCP	Bonny Del	Keith Sebelius NB	Keith Sebelius CCP	Keith Sebelius Del
2010	6969	6969	0	4362	4362	0	2751	2751	0	718	714	-4	2020	2020	0	0	0	0	0	0	0
2011	7422	7422	0	4400	4400	0	2304	2304	0	681	676	-5	2016	2016	0	0	0	0	0	0	0
2012	6032	6032	0	4434	4434	0	1313	1313	0	731	725	-6	2169	2169	0	0	0	0	0	0	0
2013	6842	6842	0	4509	4508	-1	867	867	0	873	861	-12	2175	2175	0	0	0	0	0	0	0
2014	7180	7180	0	4624	4624	0	853	853	0	664	660	-4	2184	2184	0	0	0	0	0	0	0
2015	7340	7340	0	4778	4778	0	949	949	0	613	606	-7	2113	2113	0	0	0	0	0	0	0
2016	6730	6730	0	4827	4827	0	1252	1252	0	583	574	-9	2044	2044	0	0	0	0	0	0	0
2017	8433	8433	0	4934	4934	0	1975	1975	0	586	582	-4	2054	2054	0	0	0	0	0	0	0
2018	8636	8636	0	5067	5067	0	3841	3841	0	606	602	-4	2054	2054	0	0	0	0	0	0	0
2019	9235	9235	0	5267	5267	0	3881	3881	0	1114	1109	-5	2062	2062	0	0	0	0	0	0	0
2020	8280	8280	0	5291	5291	0	2682	2682	0	1424	1412	-12	2393	2393	0	0	0	0	0	0	0
2021	8226	8226	0	5209	5209	0	2471	2471	0	725	720	-5	2382	2382	0	0	0	0	0	0	0
2022	6587	6587	0	5104	5104	0	1448	1448	0	756	749	-7	2529	2529	0	0	0	0	0	0	0
2023	7347	7347	0	5113	5113	0	967	967	0	967	961	-6	2529	2529	0	0	0	0	0	0	0
2024	7695	7695	0	5226	5226	0	950	950	0	713	704	-9	2534	2534	0	0	0	0	0	0	0
2025	7904	7904	0	5383	5383	0	1040	1040	0	645	633	-12	2457	2457	0	0	0	0	0	0	0
2026	7213	7213	0	5425	5425	0	1358	1358	0	649	630	-19	2383	2383	0	0	0	0	0	0	0
2027	9047	9047	0	5537	5538	1	2120	2120	0	616	607	-9	2388	2388	0	0	0	0	0	0	0
2028	9349	9349	0	5672	5672	0	3972	3972	0	636	626	-10	2385	2385	0	0	0	0	0	0	0
2029	10001	10001	0	5871	5872	1	3785	3785	0	888	874	-14	2387	2387	0	0	0	0	0	0	0
2030	8990	8990	0	5889	5890	1	2699	2699	0	1847	1830	-17	2714	2714	0	0	0	0	0	0	0
2031	8846	8846	0	5797	5798	1	2537	2537	0	754	746	-8	2698	2698	0	0	0	0	0	0	0
2032	7058	7058	0	5662	5662	0	1534	1534	0	804	807	3	2841	2841	0	0	0	0	0	0	0
2033	7811	7811	0	5695	5695	0	1027	1027	0	1038	1013	-25	2837	2837	0	0	0	0	0	0	0
2034	8195	8195	0	5790	5790	0	1010	1010	0	818	775	-43	2839	2839	0	0	0	0	0	0	0
2035	8411	8411	0	5907	5909	2	1099	1099	0	680	658	-22	2756	2756	0	0	0	0	0	0	0
2036	7674	7674	0	5930	5932	2	1437	1437	0	703	684	-19	2679	2679	0	0	0	0	0	0	0
2037	9602	9602	0	6053	6056	3	2222	2222	0	654	630	-24	2680	2680	0	0	0	0	0	0	0
2038	9918	9918	0	6180	6184	4	4053	4053	0	666	648	-18	2673	2673	0	0	0	0	0	0	0
2039	10604	10604	0	6373	6377	4	3780	3780	0	783	764	-19	2671	2671	0	0	0	0	0	0	0
2040	9545	9545	0	6383	6387	4	2744	2744	0	2038	2049	11	2995	2995	0	0	0	0	0	0	0
2041	9346	9346	0	6284	6289	5	2612	2612	0	793	769	-24	2975	2975	0	0	0	0	0	0	0
2042	7457	7457	0	6157	6158	1	1601	1601	0	859	891	32	3113	3113	0	0	0	0	0	0	0
2043	8250	8250	0	6184	6185	1	1071	1071	0	1098	1037	-61	3106	3106	0	0	0	0	0	0	0
2044	8661	8661	0	6253	6256	3	1055	1055	0	925	839	-86	3105	3105	0	0	0	0	0	0	0
2045	8857	8857	0	6370	6374	4	1146	1146	0	759	710	-49	3018	3018	0	0	0	0	0	0	0
2046	8090	8090	0	6362	6365	3	1501	1501	0	751	728	-23	2937	2937	0	0	0	0	0	0	0
2047	10095	10095	0	6478	6482	4	2307	2307	0	729	690	-39	2935	2935	0	0	0	0	0	0	0
2048	10404	10404	0	6586	6590	4	4112	4112	0	708	670	-38	2925	2925	0	0	0	0	0	0	0
2049	11116	11116	0	6790	6798	8	3805	3805	0	774	738	-36	2919	2919	0	0	0	0	0	0	0
2010 2049	8384	8384	0	5603	5605	2	2103	2103	0	834	817	-17	2566	2566	0	0	0	0	0	0	0

Year	Enders NB	Enders CCP	Enders Del	Harlan NB	Harlan CCP	Harlan Del	Harry Strunk NB	Harry Strunk CCP	Harry Strunk Del	Swanson NB	Swanson CCP	Swanson Del	Mainstem NB	Mainstem CCP	Mainstem Del	Total NB	Total CCP	Total Del
2010	4545	4545	0	1022	1022	0	312	312	0	254	254	0	76560	76734	174	208406	208576	170
2011	4703	4703	0	878	878	0	322	322	0	273	272	-1	85072	85192	120	221211	221326	115
2012	4843	4843	0	956	956	0	333	333	0	311	309	-2	66814	66954	140	195120	195251	131
2013	5151	5151	0	959	959	0	470	470	0	510	504	-6	81657	82015	358	217182	217523	341
2014	5236	5236	0	861	861	0	415	415	0	517	511	-6	86837	87007	170	227784	227944	160
2015	5346	5346	0	950	950	0	371	371	0	450	448	-2	88850	88882	32	225106	225130	24
2016	5309	5309	0	911	911	0	346	346	0	402	401	-1	82615	82878	263	212370	212623	253
2017	5285	5285	0	888	888	0	341	341	0	358	357	-1	94653	94789	136	231081	231213	132
2018	5261	5261	0	883	883	0	336	336	0	339	338	-1	92268	92344	76	232855	232930	75
2019	5178	5178	0	860	860	0	332	332	0	268	267	-1	101612	101603	-9	246138	246127	-11
2020	5181	5181	0	1128	1128	0	337	337	0	277	276	-1	88151	88409	258	229606	229857	251
2021	5326	5326	0	984	984	0	348	348	0	296	296	0	91843	91988	145	235980	236129	149
2022	5455	5455	0	1064	1064	0	359	359	0	334	332	-2	74002	74387	385	208430	208814	384
2023	5752	5752	0	1069	1069	0	497	497	0	536	527	-9	87426	88133	707	228635	229339	704
2024	5830	5830	0	977	977	0	443	443	0	544	537	-7	93508	93903	395	240291	240685	394
2025	5929	5929	0	1070	1070	0	398	398	0	478	474	-4	95761	95749	-12	238010	237997	-13
2026	5882	5882	0	1030	1030	0	374	374	0	430	426	-4	89337	89737	400	224636	225032	396
2027	5850	5850	0	1006	1006	0	369	369	0	385	382	-3	102194	102341	147	245501	245656	155
2028	5820	5820	0	999	999	0	365	365	0	365	362	-3	99657	99778	121	247020	247153	133
2029	5728	5728	0	977	977	0	361	361	0	292	290	-2	107874	107809	-65	260182	260127	-55
2030	5726	5726	0	1244	1244	0	366	366	0	300	298	-2	93195	93645	450	241495	241955	460
2031	5862	5862	0	1100	1100	0	377	377	0	319	317	-2	99060	99329	269	249021	249314	293
2032	5985	5985	0	1179	1179	0	389	389	0	360	354	-6	80352	81860	1508	220087	221628	1541
2033	6276	6276	0	1183	1183	0	527	527	0	575	550	-25	92193	94534	2341	237936	240256	2320
2034	6349	6349	0	1094	1094	0	473	473	0	582	559	-23	99186	99657	471	251692	252131	439
2035	6441	6441	0	1188	1188	0	429	429	0	507	495	-12	101845	101205	-640	249414	248780	-634
2036	6390	6390	0	1148	1148	0	404	404	0	457	448	-9	94283	95266	983	234701	235695	994
2037	6354	6354	0	1121	1121	0	399	399	0	414	404	-10	109542	109385	-157	258931	258778	-153
2038	6321	6321	0	1115	1115	0	395	395	0	392	385	-7	106682	106507	-175	259594	259441	-153
2039	6225	6225	0	1093	1093	0	391	391	0	319	314	-5	114820	114749	-71	273018	272979	-39
2040	6220	6220	0	1359	1359	0	397	397	0	323	320	-3	97061	99929	2868	251266	254197	2931
2041	6351	6351	0	1213	1213	0	408	408	0	346	336	-10	105381	104688	-693	260444	259769	-675
2042	6470	6470	0	1292	1292	0	420	420	0	393	374	-19	85523	88053	2530	229991	232581	2590
2043	6758	6758	0	1295	1295	0	558	558	0	602	569	-33	94841	100357	5516	244693	250172	5479
2044	6829	6829	0	1207	1207	0	504	504	0	627	579	-48	103016	104505	1489	260400	261819	1419
2045	6918	6918	0	1301	1301	0	460	460	0	545	514	-31	107459	105999	-1460	260208	258707	-1501
2046	6864	6864	0	1259	1259	0	435	435	0	486	468	-18	98318	100191	1873	243378	245261	1883
2047	6826	6826	0	1230	1230	0	430	430	0	442	425	-17	116381	115777	-604	271065	270447	-618
2048	6793	6793	0	1224	1224	0	426	426	0	419	407	-12	113120	112900	-220	270973	270741	-232
2049	6693	6693	0	1208	1208	0	422	422	0	348	336	-12	121383	120677	-706	284593	283886	-707
2010 2049	5906	5906	0	1088	1088	0	400	400	0	409	400	-9	95508	95996	488	240711	241199	488

Table 4. Nebraska Mound Impacts - NB=No Bonny, CCP=No Bonny, CCP added (acre-feet

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork			Above Swanson		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	11	11	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	17	17	0	0	0	0	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2048	0	0	0	0	0	0	0	0	0	0	0	0	14	14	0	0	0	0	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0	14	14	0	0	0	0	0	0	0
2010 2049	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Year	Swanson - Harlan			Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	7491	7491	0	341	341	0	-10	-10	0	10134	10134	0	0	0	0
2011	7833	7833	0	335	335	0	0	0	0	10286	10286	0	0	0	0
2012	4419	4419	0	331	331	0	-11	-11	0	9101	9101	0	0	0	0
2013	0	0	0	342	342	0	-12	-12	0	10112	10112	0	0	0	0
2014	0	0	0	362	362	0	0	0	0	10126	10126	0	0	0	0
2015	702	702	0	393	393	0	-12	-12	0	10230	10230	0	0	0	0
2016	936	936	0	418	418	0	0	0	0	9873	9873	0	0	0	0
2017	8998	8998	0	457	457	0	0	0	0	11263	11263	0	0	0	0
2018	14409	14409	0	483	483	0	0	0	0	11257	11257	0	0	0	0
2019	11295	11295	0	486	486	0	-16	-16	0	11247	11247	0	0	0	0
2020	7262	7262	0	514	514	0	-15	-15	0	10690	10690	0	0	0	0
2021	5826	5826	0	537	537	0	0	0	0	10779	10779	0	0	0	0
2022	3129	3129	0	513	513	0	-18	-18	0	9384	9384	0	0	0	0
2023	0	0	0	532	532	0	-19	-19	0	10314	10314	0	0	0	0
2024	0	0	0	567	567	0	-13	-13	0	10302	10302	0	0	0	0
2025	0	0	0	604	604	0	-22	-22	0	10419	10419	0	0	0	0
2026	0	0	0	636	636	0	-10	-11	-1	10001	10001	0	0	0	0
2027	6879	6879	0	687	687	0	0	0	0	11490	11490	0	0	0	0
2028	13081	13081	0	717	717	0	0	0	0	11715	11715	0	0	0	0
2029	10557	10557	0	707	707	0	-23	-23	0	11802	11802	0	0	0	0
2030	6788	6788	0	719	719	0	-20	-20	0	11005	11005	0	0	0	0
2031	4419	4419	0	770	770	0	-13	-12	1	11053	11053	0	0	0	0
2032	2086	2086	0	721	721	0	-26	-26	0	9460	9460	0	0	0	0
2033	0	0	0	727	727	0	-24	-24	0	10395	10395	0	0	0	0
2034	0	0	0	790	790	0	-19	-19	0	10378	10378	0	0	0	0
2035	0	0	0	812	812	0	-24	-24	0	10502	10502	0	0	0	0
2036	0	0	0	869	869	0	-16	-16	0	10050	10050	0	0	0	0
2037	4823	4824	1	954	953	-1	-10	-10	0	11604	11604	0	0	0	0
2038	11897	11897	0	983	983	0	-13	-13	0	11866	11866	0	0	0	0
2039	9724	9724	0	958	958	0	-31	-31	0	12150	12150	0	0	0	0
2040	6473	6473	0	953	953	0	-26	-26	0	11247	11247	0	0	0	0
2041	3409	3409	0	1010	1010	0	-16	-16	0	11176	11176	0	0	0	0
2042	1276	1276	0	927	927	0	-30	-30	0	9462	9462	0	0	0	0
2043	0	0	0	939	939	0	-30	-30	0	10452	10452	0	0	0	0
2044	0	0	0	983	983	0	-23	-23	0	10429	10429	0	0	0	0
2045	0	0	0	1014	1014	0	-31	-31	0	10558	10558	0	0	0	0
2046	0	0	0	1063	1063	0	-18	-18	0	10080	10080	0	0	0	0
2047	3281	3282	1	1228	1228	0	-16	-16	0	11704	11704	0	0	0	0
2048	10694	10694	0	1271	1271	0	-17	-17	0	11956	11956	0	0	0	0
2049	9051	9051	0	1207	1207	0	-39	-39	0	12258	12258	0	0	0	0
2010 2049	**4418**	**4418**	**0**	**721**	**721**	**0**	**-15**	**-15**	**0**	**10707**	**10707**	**0**	**0**	**0**	**0**

Year	Red Willow			Rock			Sappa			South Fork			Hugh Butler			Bonny		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	47	47	0	0	0	0	37	37	0	0	0	0	0	0	0	0	0	0
2011	42	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	33	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	27	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	29	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	39	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	46	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	67	67	0	0	0	0	22	22	0	0	0	0	0	0	0	0	0	0
2019	79	79	0	0	0	0	116	116	0	0	0	0	0	0	0	0	0	0
2020	49	49	0	0	0	0	51	51	0	0	0	0	0	0	0	0	0	0
2021	61	61	0	0	0	0	13	13	0	0	0	0	0	0	0	0	0	0
2022	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	37	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2024	43	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	41	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2026	40	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2027	49	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2028	73	73	0	0	0	0	41	41	0	0	0	0	0	0	0	0	0	0
2029	85	85	0	0	0	0	133	133	0	0	0	0	0	0	0	0	0	0
2030	75	75	0	0	0	0	59	59	0	0	0	0	0	0	0	0	0	0
2031	71	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	39	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	49	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	56	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2035	52	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	51	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2037	65	65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2038	64	64	0	0	0	0	75	75	0	0	0	0	0	0	0	0	0	0
2039	67	67	0	0	0	0	142	142	0	0	0	0	0	0	0	0	0	0
2040	100	100	0	0	0	0	63	63	0	0	0	0	0	0	0	0	0	0
2041	59	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2042	47	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2043	63	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2044	70	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2045	64	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2046	61	61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2047	83	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2048	81	81	0	0	0	0	101	101	0	0	0	0	0	0	0	0	0	0
2049	84	84	0	0	0	0	142	142	0	0	0	0	0	0	0	0	0	0
2010 2049	**56**	**56**	**0**	**0**	**0**	**0**	**24**	**24**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Year	Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del	NB	CCP	Del
2010	0	0	0	0	0	0	20	20	0	0	0	0	0	0	0	7821	7821	0	18069	18069	0
2011	0	0	0	0	0	0	22	22	0	0	0	0	0	0	0	8163	8163	0	18522	18523	1
2012	0	0	0	0	0	0	23	23	0	0	0	0	0	0	0	4739	4739	0	13905	13905	0
2013	0	0	0	0	0	0	25	25	0	0	0	0	0	0	0	329	329	0	10501	10501	0
2014	0	0	0	0	0	0	27	27	0	0	0	0	0	0	0	353	353	0	10542	10542	0
2015	0	0	0	0	0	0	30	30	0	0	0	0	0	0	0	1083	1083	0	11390	11390	0
2016	0	0	0	0	0	0	32	32	0	0	0	0	0	0	0	1346	1346	0	11290	11290	0
2017	0	0	0	0	0	0	33	33	0	0	0	0	0	0	0	9450	9450	0	20805	20805	0
2018	0	0	0	0	0	0	34	34	0	0	0	0	0	0	0	14885	14885	0	26279	26279	0
2019	0	0	0	0	0	0	35	35	0	0	0	0	0	0	0	11765	11765	0	23260	23260	0
2020	0	0	0	0	0	0	36	36	0	0	0	0	0	0	0	7761	7761	0	18599	18599	0
2021	0	0	0	0	0	0	38	38	0	0	0	0	0	0	0	6355	6355	0	17257	17256	-1
2022	0	0	0	0	0	0	40	40	0	0	0	0	0	0	0	3624	3624	0	13087	13087	0
2023	0	0	0	0	0	0	42	42	0	0	0	0	0	0	0	512	512	0	10915	10915	0
2024	0	0	0	0	0	0	44	44	0	0	0	0	0	0	0	553	553	0	10952	10952	0
2025	0	0	0	0	0	0	47	47	0	0	0	0	0	0	0	581	580	-1	11098	11097	-1
2026	0	0	0	0	0	0	50	50	0	0	0	0	0	0	0	624	624	0	10726	10725	-1
2027	0	0	0	0	0	0	52	52	0	0	0	0	0	0	0	7559	7559	0	19164	19164	0
2028	0	0	0	0	0	0	53	53	0	0	0	0	0	0	0	13788	13788	0	25683	25683	0
2029	0	0	0	0	0	0	54	54	0	0	0	0	0	0	0	11241	11241	0	23335	23335	0
2030	0	0	0	0	0	0	56	56	0	0	0	0	0	0	0	7487	7487	0	18709	18709	0
2031	0	0	0	0	0	0	58	58	0	0	0	0	0	0	0	5176	5176	0	16374	16375	1
2032	0	0	0	0	0	0	60	60	0	0	0	0	0	0	0	2781	2780	-1	12351	12350	-1
2033	0	0	0	0	0	0	62	62	0	0	0	0	0	0	0	703	704	1	11220	11220	0
2034	0	0	0	0	0	0	65	65	0	0	0	0	0	0	0	768	768	0	11281	11281	0
2035	0	0	0	0	0	0	68	68	0	0	0	0	0	0	0	786	785	-1	11421	11421	0
2036	0	0	0	0	0	0	70	70	0	0	0	0	0	0	0	851	851	0	11035	11035	0
2037	0	0	0	0	0	0	73	73	0	0	0	0	0	0	0	5767	5767	0	17527	17526	-1
2038	0	0	0	0	0	0	75	75	0	0	0	0	0	0	0	12868	12868	0	24967	24967	0
2039	0	0	0	0	0	0	76	76	0	0	0	0	0	0	0	10651	10651	0	23106	23106	0
2040	0	0	0	0	0	0	78	78	0	0	0	0	0	0	0	7400	7400	0	18905	18905	0
2041	0	0	0	0	0	0	80	80	0	0	0	0	0	0	0	4404	4403	-1	15735	15734	-1
2042	0	0	0	0	0	0	82	82	0	11	11	0	0	0	0	2172	2173	1	11779	11780	1
2043	0	0	0	0	0	0	85	85	0	11	11	0	0	0	0	909	909	0	11522	11522	0
2044	0	0	0	0	0	0	88	88	0	10	10	0	0	0	0	960	960	0	11560	11560	0
2045	0	0	0	0	0	0	91	91	0	10	10	0	0	0	0	976	975	-1	11710	11709	-1
2046	0	0	0	0	0	0	94	94	0	10	10	0	0	0	0	1041	1040	-1	11294	11292	-2
2047	0	0	0	0	0	0	97	97	0	11	11	0	0	0	0	4494	4494	0	16399	16398	-1
2048	0	0	0	0	0	0	99	99	0	11	11	0	0	0	0	11949	11948	-1	24215	24215	0
2049	0	0	0	0	0	0	100	100	0	11	11	0	0	0	0	10219	10219	0	22831	22832	1
2010 2049	**0**	**0**	**0**	**0**	**0**	**0**	**57**	**57**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**5122**	**5122**	**0**	**15983**	**15982**	**-1**

INTRODUCTION

These simulations evaluate a future scenario where the 2000-2009 conditions are repeated four times (40 years). This represents two 20 year cycles per the proposed pipeline approval.

The current set of simulations is essentially the same as the simulations provided earlier, but with the following modifications:

1) The pipeline deliveries are estimated based on the projected amount Colorado will exceed its allocation in the absence of the pipeline;

2) The 2003 pumping in Nebrsaka was redistributed based on the irrigated acreage by Sam Perkins.

3) The analysis is done with Bonny modeled in two ways. The first represents the reservoir as completely drained ("No Bonny"), while the second represents the reservoir as 178 acres and 2cfs seepage ("Small Bonny").

In all there are 20 simulations. Each of the 5 simulations needed to calculate CBCU for each state were done four ways. The four ways combine two analysis: the first considers including the pipeline water in the model or not including the pipeline water in the model. The second considers whether Bonny Reservoir is completely drained, or storing a small amount of water in Bonny Reservoir.

As will be demonstrated below, these two issues, that is running the water through the model or using the cap on the North Fork; and how Bonny is represented are basically orthogonal. The large number of simulations is basically intended to demonstrate this orthogonality.

RUNNING THE MODELS

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The steps to complete the simulation is shown the "run" script.

Runs are named NNNNbbq. NNNN for runs where the pipeline water is not included in the model are called 200X, while runs where the pipeline water is included in the model are called 200K. bb for the runs where Bonny is drained and water is bypassed (No Bonny) is nb, while for runs where Bonny is 178 acres and seeping 2cfs (Small Bonny) is sb. The Extension q is blank for the reference run, while letters a, b, c and d are used per the RRCA convention to represent no Colorado, Kansas or Nebraska pumping, and the mound imports.

First the "mkccp" script is run. It copies the 2000 to 2009 state files in the co, ks and ne directories to corresponding co, ks and ne directories.

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Where the files are unchanged, the copy is achieved by setting a soft link. For the .pmp, .rcg and .agw files for Colorado, the agricultural wells transferred to the pipeline is removed by setting the cells corresponding to these well to zero in the .pmp, .rcg and .agw files.

For 2003, the Nebraska groundwater usage (pumping, recharge and acres) was replaced by a data set provided by Sam Perkins. This data sets redistributes the volume of pumping based on irrigated acres

Next the RRPP program is run to generate a 10 year data set for the five standard scenarios. The "mkdup" script is then used to duplicate that 10 year period four times by adding three additional 10 year cycles.

The mkshead is used to generate starting heads from the 2009 ending heads.

The mkstr and mket programs are used to produce the 2000-2009 data sets repeated four times. The mkstr program is run twice, once for the No Bonny and once for the Small Bonny configuration. The No Bonny configuration represents segment 150 (Bonny Reservoir) as it existed prior to the construction of the dam. Flows are routed from the upstream segments (140 and 141) through section 150 and downstream to segment 156. The Small Bonny configuration reduces the size of the reservoir to one cell (106,91) and reduces the conductance by 178/640 to represent the smaller size of the reservoir. The reservoir elevation is set to 3640 ft. The stream routing is unchanged from the current 12s2 stream package. However, the leakage from the dam is reduced from 10 cfs to 2 cfs to represent the reduction in leakage from the toe drains.

Finally the "mkpif" program is used to generate the pipeline flows. For this simulation, pumping occurs from October to March every year. The pumping is based on estimated pipeline releases from the projected amount Colorado exceeds its allocation.

The "mkpif" program creates three files. The first is a well pumping file representing monthly pumping for the pipeline. The pipeline well pumping is represented in the oct-mar.wel file. In order to facilitate processing, the RGDSS MODFLOW program was used which allows multiple well packages to be used. Therefore the well pumping produced by RRPP is mapped to the first well package (WEL1) and the pipeline pumping is mapped to the second well package (WEL2). Internal to MODLFOW the pumping is simply added, but it is reported as separate volumes in the water budget.

The pipeline pumping is included in both historical simulations, but not in the Colorado Impact run.

The second and third files created by mkpif are stream package files for the

No Bonny and Small Bonny versions, respectively. The mkpif program adds the pipeline outflow to the appropriate stream package at segment 153, which is the North Fork reach from the State Line to the Arikaree. In order to satisfy the MODFLOW stream package requirement that the segments must appear in upstream to downstream order, segments 122 and 125 (Muddy Creek Nebraska) were combined into a single segment 125, which frees up segment 122 to be used as a stub inflow (stream segment with no aquifer conductance) which is made tributary to segment 153.

The North Fork State Line accounting point was moved from the confluence of the Arikaree and the North Fork to the North Fork at the State Line by the RRCA in 2009. This made the North Fork accounting point the inflow to segment 130 Reach 28. Adding the pipeline above this reach would require renumbering all subsequent segments of the stream package. Therefore, in order to capture the pipeline inflow at segment 153, the accounting point was moved to segment 153 reach 1 which is one cell downstream from the previous location.

Joining segments 122 and 125 and moving the North Fork accounting point one cell downstream allows the pipeline water to be added to the model without requiring the wholesale renumbering of segments and assignment of accounting points in the model.

MODFLOW is then run for the five runs needed to evaluate CBCU for each state and the mound imports. When pipeline water is included in the model, all runs except the run without Colorado pumping includes the pipeline water. These runs are called 200Kbbq, When the pipeline water is not included in the model, the runs are called 200Xbbq, and contains only the pumping associated with the pipeline, except in the run without Colorado pumping. Similarly the model is run using the No Bonny (nb) and Small Bonny (sb) scenarios.

In the No Bonny Scenario, the Kansas proposal historical simulation (200Knb.nam) includes the pipeline deliveries in the stream package as well as pumping from the pipeline wells. The Colorado proposal simulation (200Xnb.nam) differs from the Kansas historical simulation only in that the stream package does not contain the pipeline flows.

The stream package without the pipeline flows (200Xnb.str) is used in the the Colorado Impact run (200Xnba) and the Colorado proposal Historical run (200Xnb), while the stream package with the pipeline flows (oct-mar-nb.str) is used in the Kansas proposal Historical run (200Knb).

A similar set of runs are run for the Small Bonny (sb) scenario.

MODFLOW is run for the using the standard RRCA packages, except that the RGDSS MODFLOW program must be used to accommodate the two well packages.

RESULTS

Finally, the accounting program from V12P7 was adapted to extract the differences in baseflows calculated by the model.

The impact runs are name for the run used to difference with the reference case. So, for example, the Colorado Pumping Impacts - No Bonny - Pipeline not in the Model is the difference between 200Xnb and 200Xnba, and is in the file 200Xnba.htm.

The South Fork and North Fork analysis are essentially independent. Comparing the South Fork depletions with or without the pipeline water in the model results in a difference on the South Fork of less than 200 acre-feet on average for both the No Bonny (200Xnba.htm & 200Knba.htm) and the Small Bonny (200Xsba.htm & 200Ksba.htm) simulations.

Similarly, for the No Bonny vs. Small Bonny comparison, the differences on the North Fork are zero on the North Fork and less than 200 acre-feet for the Above Swanson reach for the pipeline water in the model (200Knba.htm & 200Ksba.htm) as well as the pipeline water not in the model (200Xnba.htm * 200Xsba.htm).

The small changes that are observed occur in the area near Benkleman where changes in the north and south forks interact.

We therefore submit that instead of reviewing all the possible combinations of runs, the conclusions remain the same when evaluated individually.

For the No Bonny scenario, the Colorado Pumping Impacts using the historical run which includes the pipeline deliveries is contained in the file 200Knba.htm, while the Colorado Well Pumping Impacts without including Pipeline Deliveries but including pipeline well pumping is shown in 200Xnba.htm.

? The 200Knba and 200Xnba runs are actually the same, as are the 200Ksba and 200Xsba runs, because all these simulations omit Colorado pumping and pipeline flows. Since the Colorado Pumping Impact with the pipeline deliveries in the stream package is

CIp = 200Knb - 200Knba

while the Colorado Pumping Impact with the pipeline deliveries NOT in the stream package is

CIo = 200Xnb - 200Xnba

The pipeline credit can therefore be isolated as

? Pipeline Credit = CIp - CIo = 200Knb - 200Xnb ✓

because 200Knba = 200Xnba. This was calculated directly using the acct program and is shown in 200Xnb.htm. The same calculation can be done for the Small

Bonny simulation with virtually identical results.i (See 200Xsb.htm).

NORTH FORK ANALYSIS

Figure 1 shows the pipeline releases as a purple line and the pipeline credit as a red line. The fraction of the release credited is shown as a blue line. The thin blue line represent the annual values. Note that the credit can be as much as 105% of the amount released and as low as 58% for any individual year. The five year running average is shown as a thick blue line, which varies from 96% to 75%. The long term average is shown as a thick dashed line and averages 89%.

The reason for the variability is shown in Figure 2. Figure 2 shows the North Fork depletions when the pipeline water is included in the model as a red line, and the when the pipeline water is not included in the model as an orange line. Note that the pipeline releases generally match the slope of the North Fork depletions without the pipeline, so that when the pipeline deliveries are included, the North Fork depletions averages about 12,000 af/yr.

The Above Swanson values are shown as a light blue line in the absence of the pipeline, and a dark blue line when the pipeline is included. The Above Swanson values are actually negative, but are shown here as positive values for ease of comparison. Note that in the absence of the pipeline water, the Above Swanson values grow to more than 11,000 af in one year.

Also shown in Figure 2 is the pipeline credit represented by a green line. What is particularly striking is how the pipeline credits goes down when the Above Swanson goes up when the water is not in the model. This is because large Above Swanson values are caused by the stream going dry. Conversely, when the stream goes dry, the pipeline water does not reach Swanson Reservoir and reduces the pipeline credit.

What Colorado is proposing is to NOT model adding the pipeline water to the model, but to achieve the same result by capping the Above Swanson values.

Figure 3 shows the difference between the pipeline deliveries and the pipeline credit when the pipeline water is included in the model as a red line. The thin red line are the annual values, and the thick red line is the five year running average. The thick red line therefore represent pipeline deliveries for which Colorado will not receive a credit in the Compact accounting.

The Above Swanson values computed when the pipeline water is not in the model is shown as a dark blue line. The thin dark blue line represents the annual values and the thick dark blue line represents the five year running average.

The light blue line represents Colorado's proposal. This line represents the Above Swanson values calculated by the mode, but the values are capped at 5000 af/yr. Therefore the light blue values match the dark blue when the flows are less than 5000 af/yr, but differ when they are greater.

What Colorado gives up as a result of the cap on the Above Swanson values is the difference between the dark blue and light blue lines. This is shown as a green line, with again the thin green line representing the annual values, and the thick line representing the five year running average.

The key thing to note is that the thick green line tracks the thick red line almost perfectly.

This is the essence of the Colorado proposal. Putting the pipeline deliveries in the model causes the pipeline credit to be less than the pipeline deliveries. The red line represents that difference. This difference captures the net effect of putting the pipeline water in the model.

The green line represents the amount of Above Swanson credits that Colorado is giving up by agreeing to a cap of 5000 af/yr on the Above Swanson values. On an annual basis, the amount given up by Colorado tracks the difference between the pipeline deliveries and pipeline credits fairly well, but on the five year running average the correspondence is very good. Also note that on average the amount of Above Swanson credit given up is greater than the difference between the pipeline deliveries and pipeline credits.

Figure 4 shows the results from a CBCU point of view for the North Fork, that is the Norrth Fork and Above Swanson terms added together. The blue line represents the projected North Fork plus Above Swanson CBCU without considering the pipeline. The thin blue line are the annual values, while the thick blue line is the 5 year running average.

The green line represents the result of running the water through the pipeline, with the thin and thick lines representing the annual and 5 year running averages, respectively. The red line represents the Colorado proposal, which caps the Above Swanson credits and then subtracts the pipeline deliveries. While not identical, the red and green lines represent the same effective result.

Figure 5 shows the same analysis, but for Colorado's basin wide CBCU. Again the red and green lines track very closely.

So the bottom line here is that by agreeing to a cap on the Above Swanson values, we achieve the exact same effect as running the pipeline water through the model.

The advantage to Colorado is that the variability in the pipeline credits are reduced because the Colorado will receive 100% credit for what is delivered in exchange for limiting the Above Swanson values.

The advantage to Kansas and Nebraska is that by capping the Above Swanson values, Colorado will be required to deliver more water to be in compliance with the Compact and at the same time satisfy the desire expressed by Kansas that the deliveries should be more steady from year to year.

It is my understanding that this is the modeling question Dick Wolfe and David Barfield asked us to address: Does a cap on the Above Swanson cap achieve the same result as running the pipeline water through the model? I submit that Figures 3 to 5 demonstrates exactly that.

NORTH FORK ANALYSIS

A comparison of the No Bonny vs. the Small Bonny results for Kansas Pumping Impacts (200Xnbb.htm & 200Xsbb.htm), Nebraska Pumping (200Xnbc.htm & 200Xsbc) and Nebraska Mound (200Xnbd.htm & 200Xsbd.htm) differ by less than 10 acre-feet. So for purposes of this discussion, we will ignore these results. Note that this is also that for the 200K series simulations.

The difference appears in the Colorado impact runs. In the run with No Bonny, the South Fork plus Bonny impacts are on average 4945 acre-feet, while in the Small Bonny simulation the South Fork plus Bonny impacts average 11737 acre-feet, a difference of 6792 acre-feet.

The reason for these differences are readily understood. Figure 6 shows the baseflow into Bonny. The flow for the base (historical) case is shown in light blue for the Small Bonny and dark blue for the No Bonny simulations. The light blue line is not visible in Figure 6 because it is perfectly overlain by the dark blue line. Similary, the baseflow into Bonny with Colorado pumping off is shown as an orange line for the Small Bonny run and in red for the No Bonny run. Once again the red alone is visible because it overlies the orange. So the baseflow into Bonny remains unchanged as a result of the representation of Bonny, as is to be expected.

Figure 7 shows the baseflow on the South Fork at the confluence with the North Fork near Benkleman, which in the groundwater model is the accounting point for the South Fork.

In Figure 7, the light and dark blue lines do differ at times, indicating that if the baseflow into Bonny is passed under historical (base) conditions then there will at times be a change in flow near Benkleman. However, for most of the period, the flow remains essentially the same.

Comparing the red and orange lines, however, shows that in the absence of Colorado Pumping, a significant difference in the flows occur between the No Bonny and Small Bonny simulations. This is because in the No Bonny simulation, baseflow into Bonny reservoir is passed into the lower reach, and some fraction of that flow will reach Benkleman. However, in the Small Bonny simulation only two cfs is released into the lower reach.

In the absence of transit losses between Bonny and Benkleman due to evapotranspiraton and pumping in Kansas and Nebraska, the Colorado Pumping impact at Bonny shown in Figure 6 would match the Colorado Pumping impact at Benkleman shown in Figure 7. This, however, is not the case.

When Bonny stores water, the Colorado CBCU is calculated as the change in baseflow into Bonny reservoir. The baseflow in the reach below Bonny is then set to the seepage below the dam and additional Colorado CBCU is calculated as the change in baseflow near Benkleman.

However with the baseflow into Bonny is passed through because the reservoir is no longer storing water, Figure 7 shows that some of the water is lost in transit due to evapotransipration and pumping, and so the flow that reaches Benkleman is only a fraction of what had reached Bonny.

As a result, the CBCU calculated at end of the basin is several thousand acre-feet smaller then the CBCU calculated at the peak of the baseflow near Bonny in the middle of the basin.

Steve Larson

From: Alex Spiliotopoulos <alexs@sspa.com>
Sent: Thursday, July 18, 2013 5:00 PM
To: 'Steve Larson'
Subject: FW: Pipeline & Above Swanson Cap Runs
Attachments: fig.pdf; 200Xo.htm; 200Xa.htm; 200Xp.htm

Sam provided a host of files associated with Willem's model runs from last year. The files can be found in:
P:\1414 Republican River Consultation\Task 02 - CCP\from Sam Perkins\Schreuder Model Runs - 2011

Attached is an email Willem sent to Sam with explanations on the model runs.
So far Sam has not found another report besides those I have already located.

Alex Spiliotopoulos
Senior Hydrogeologist
S.S. Papadopulos & Associates, Inc.
7944 Wisconsin Avenue
Bethesda, MD 20814
Office: (301) 718-8900
Direct: (301) 500-2288
Cell: (301) 787-3506
Email: alex@sspa.com

-----Original Message-----
From: Perkins, Sam
Sent: Friday, June 24, 2011 4:07 PM
To: Beightel, Chris; 'Dale Book'
Subject: FW: Pipeline & Above Swanson Cap Runs

Chris and Dale,
Rcvd from Willem
--Sam

-----Original Message-----
From: Willem Schreuder [mailto:willem@prinmath.com]
Sent: Friday, June 24, 2011 10:39 AM
To: Wolfe, Dick; Sullivan, Mike; Jim Slattery; Barfield, David; Perkins, Sam; Steve Larson
Subject: Pipeline & Above Swanson Cap Runs

Howdy!

Attached are the figures and tables summarizing the results of the analysis of the alternatives to model the Colorado pipeline.

The actual runs are on the RRCA web site at
http://www.republicanrivercompact.org/restricted/cap/ccp2011-ks.zip

This simulation evaluates a future scenario where the 2000-2009 conditions are repeated four times (40 years). This represents two 20 year cycles per the proposed pipeline approval.

The current set of simulations is essentially the same as the simulations provided earlier, but with the following modifications:

1) The pipeline deliveries are estimated based on the projected amount Colorado will exceed its allocation in the absence of the pipeline;

2) The 2003 pumping in Nebrsaka was redistributed based on the irrigated acreage by Sam Perkins.

3) We modeled the South Fork with Bonny drained. This has a small impact on the calculations related to the pipeline due to larger flows in the lower reach of the South Fork.

Figure 1 shows the pipeline releases as a purple line and the pipeline credit as a red line. The fraction of the release credited is shown as a blue line. The thin blue line represent the annual values. Note that the credit can be as much as 105% of the amount released and as low as 58% for any individual year. The five year running average is shown as a thick blue line, which varies from 96% to 75%. The long term average is shown as a thick dashed line and averages 89%.

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Please let me know if you have any questions.

Best regards
-Willem

==
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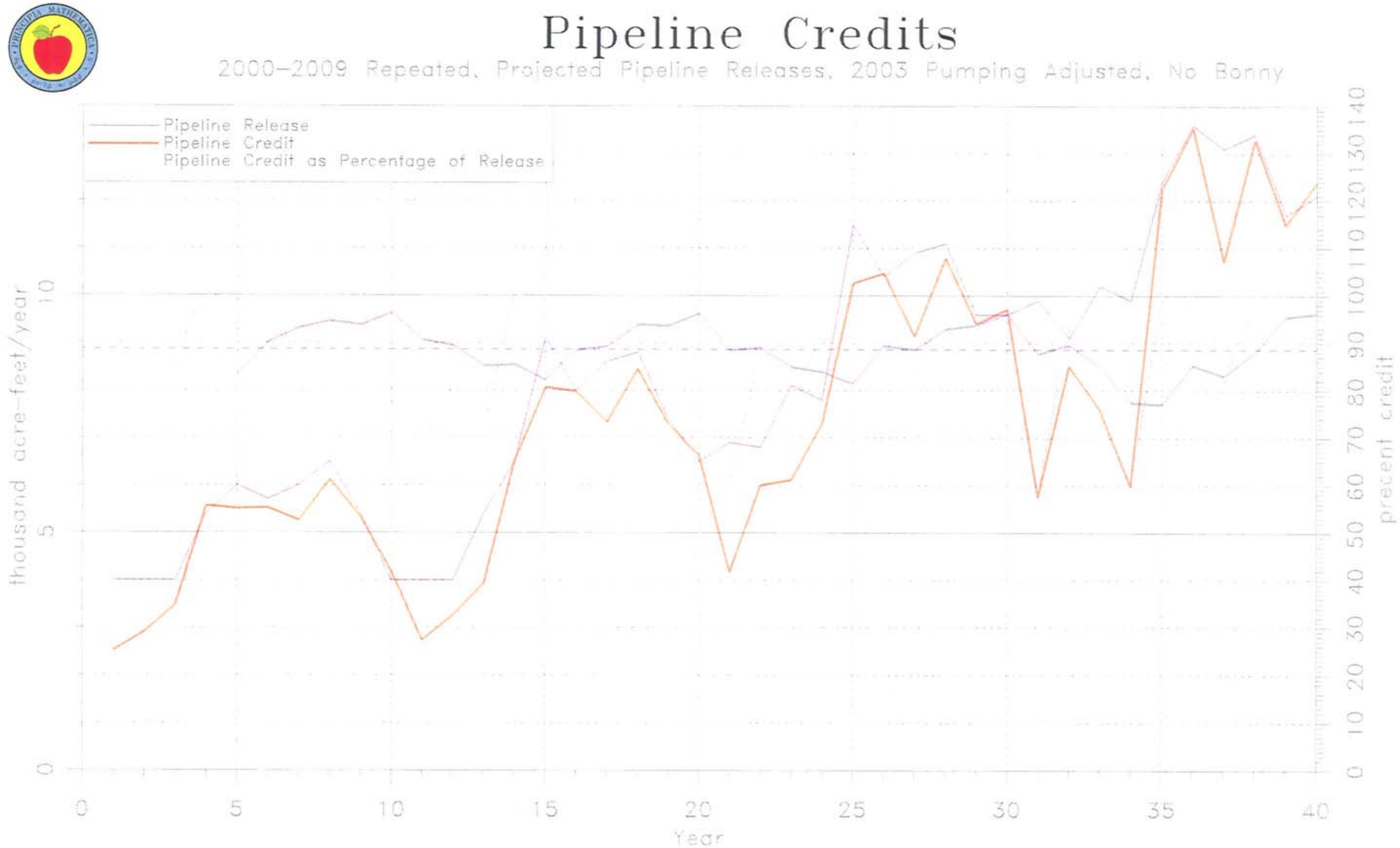
Tel: (303) 716-3573 Fax: (303) 716-3575
WWW: www.prinmath.com Email: Willem.Schreuder@prinmath.com



Pipeline Credits
2000–2009 Repeated, Projected Pipeline Releases, 2003 Pumping Adjusted, No Bonny
Pipeline Release
Pipeline Credit
Pipeline Credit as Percentage of Release
thousand acre-feet/year
precent credit
Year
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

Figure 1

North Fork, Above Swanson and Pipeline Credit

2000-2009 Repeated, Projected Pipeline Releases, 2003 Pumping Adjusted, No Bonny

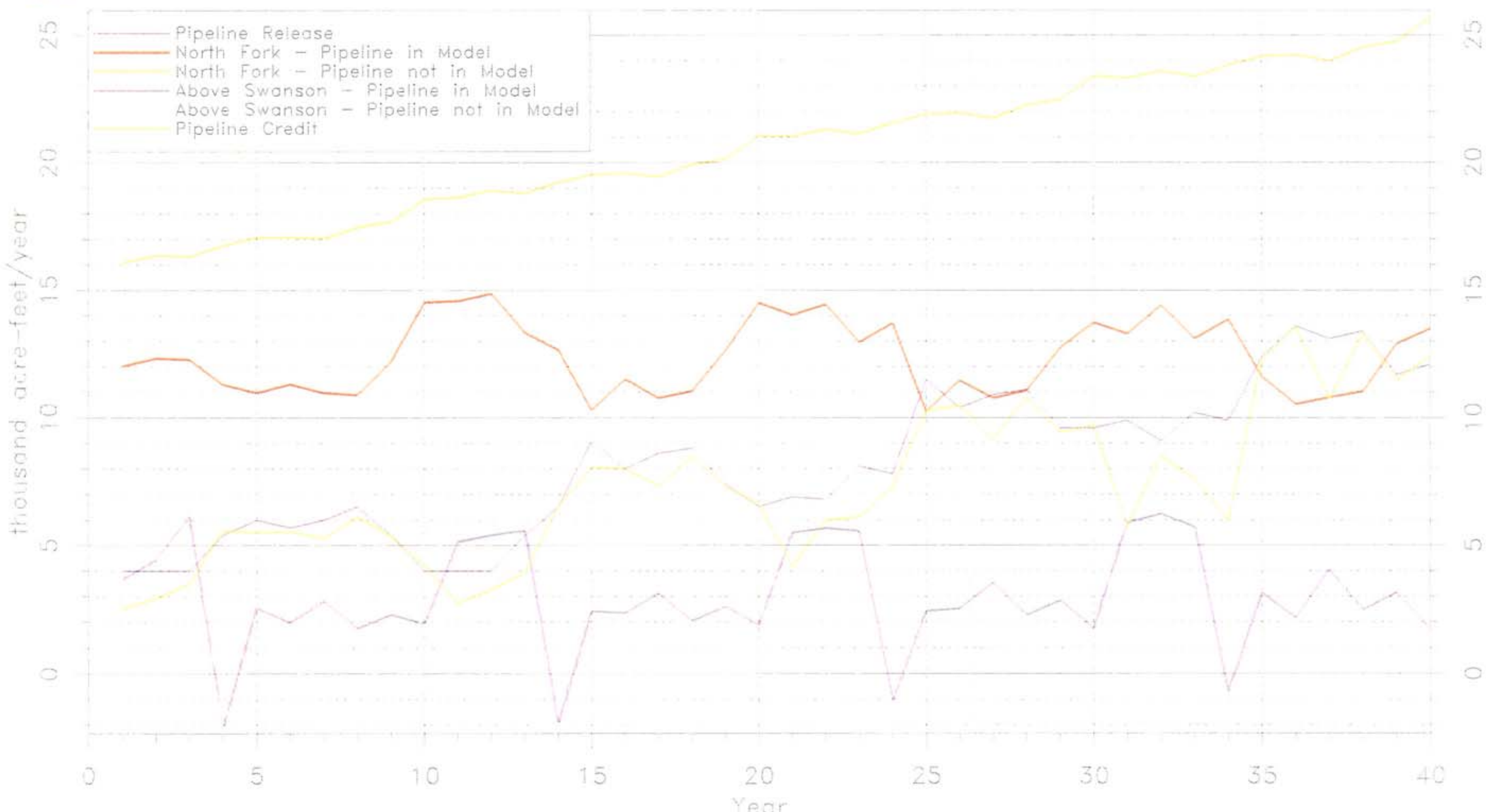


Figure 2

Pipeline Discount and Above Swanson Cap

2000-2009 Repeated, Projected Pipeline Releases, 2003 Pumping Adjusted, No Bonny

Figure 3

Colorado North Fork $CBCU_G$

2000-2009 Repeated, Projected Pipeline Releases, 2003 Pumping Adjusted, No Bonny

Figure 4

Colorado Basin Wide $CBCU_G$

2000-2009 Repeated, Projected Pipeline Releases, 2003 Pumping Adjusted, No Bonny

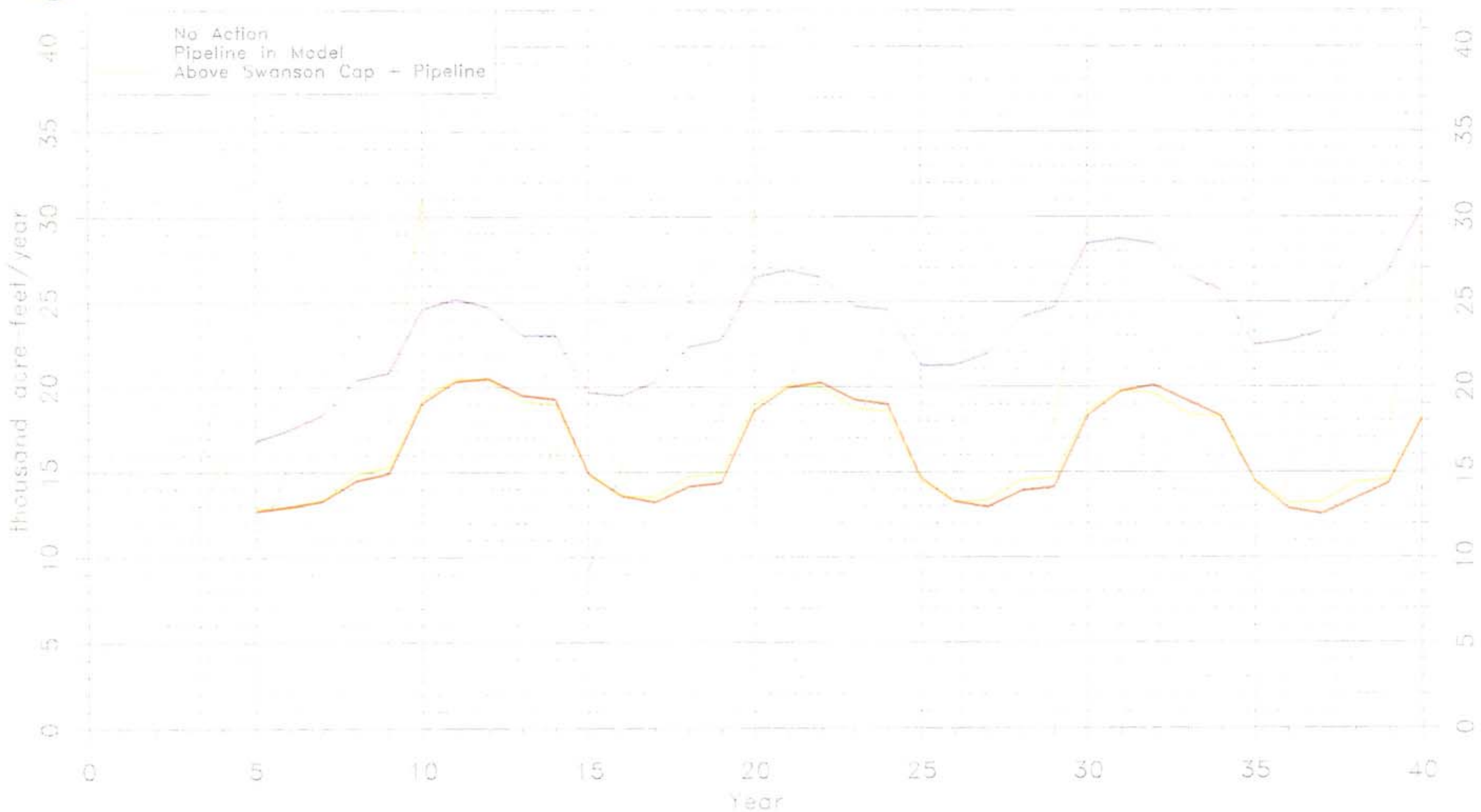


Figure 5

4

Table 1. Colorado Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork			Above Swanson			Swanson - Harlan		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	1248	1248	0	0	0	0	386	386	0	0	0	0	1688	1688	0	16015	16016	1	-5268	-5284	-16	0	11	11
2011	1754	1754	0	0	0	0	318	318	0	0	0	0	120	120	0	16297	16297	0	-5631	-5632	-1	-13	-13	0
2012	580	580	0	0	0	0	192	192	0	0	0	0	100	100	0	16251	16251	0	-6747	-6737	10	0	0	0
2013	347	347	0	0	0	0	173	173	0	0	0	0	87	87	0	16673	16673	0	-1105	-1044	61	0	0	0
2014	414	414	0	0	0	0	200	200	0	0	0	0	84	85	1	16983	16983	0	-889	-821	68	0	0	0
2015	1022	1022	0	0	0	0	216	216	0	0	0	0	85	85	0	16996	16996	0	-2372	-2257	115	0	0	0
2016	1268	1268	0	0	0	0	228	228	0	0	0	0	87	87	0	16953	16953	0	-3890	-3795	95	0	0	0
2017	1300	1300	0	0	0	0	244	244	0	0	0	0	92	93	1	17380	17380	0	-2507	-2307	200	0	0	0
2018	1703	1703	0	0	0	0	281	281	0	0	0	0	96	96	0	17646	17646	0	-2888	-2687	201	0	0	0
2019	4450	4450	0	0	0	0	409	409	0	0	0	0	106	105	-1	18542	18542	0	-1764	-1739	25	0	0	0
2020	1552	1552	0	0	0	0	373	373	0	0	0	0	117	118	1	18593	18593	0	-7114	-6686	428	0	0	0
2021	1877	1877	0	0	0	0	265	265	0	0	0	0	115	115	0	18867	18867	0	-6355	-6248	107	0	0	0
2022	662	662	0	0	0	0	240	240	0	0	0	0	118	118	0	18751	18751	0	-7145	-7086	59	0	0	0
2023	417	417	0	0	0	0	226	226	0	0	0	0	126	126	0	19188	19188	0	-2669	-2557	112	0	0	0
2024	477	477	0	0	0	0	247	247	0	0	0	0	136	136	0	19502	19502	0	-796	-704	92	0	0	0
2025	1158	1158	0	0	0	0	279	279	0	0	0	0	143	143	0	19560	19560	0	-2578	-2460	118	0	0	0
2026	1363	1363	0	0	0	0	284	284	0	0	0	0	151	151	0	19423	19423	0	-4908	-4787	121	0	0	0
2027	1411	1411	0	0	0	0	314	314	0	0	0	0	162	161	-1	19907	19907	0	-2909	-2715	194	0	0	0
2028	1822	1822	0	0	0	0	360	360	0	0	0	0	171	170	-1	20181	20181	0	-3364	-3171	193	0	0	0
2029	4783	4783	0	0	0	0	385	385	0	0	0	0	180	180	0	21095	21095	0	-1865	-1825	40	0	0	0
2030	1962	1962	0	0	0	0	358	358	0	0	0	0	191	191	0	21057	21057	0	-9256	-8818	438	0	0	0
2031	1979	1979	0	0	0	0	322	322	0	0	0	0	196	196	0	21326	21326	0	-6806	-6660	146	0	0	0
2032	730	730	0	0	0	0	306	306	0	0	0	0	188	188	0	21158	21158	0	-7735	-7668	67	0	0	0
2033	480	480	0	0	0	0	321	321	0	0	0	0	145	145	0	21603	21603	0	-5314	-5238	76	0	0	0
2034	544	544	0	0	0	0	334	334	0	0	0	0	106	106	0	21938	21938	0	-1060	-949	111	0	0	0
2035	1273	1273	0	0	0	0	347	347	0	0	0	0	118	118	0	21996	21996	0	-2436	-2319	117	0	0	0
2036	1442	1442	0	0	0	0	353	353	0	0	0	0	114	114	0	21797	21797	0	-6024	-5944	80	0	0	0
2037	1509	1509	0	0	0	0	371	371	0	0	0	0	131	131	0	22308	22308	0	-3049	-2857	192	0	0	0
2038	1930	1930	0	0	0	0	410	410	0	0	0	0	167	167	0	22591	22591	0	-3896	-3715	181	0	0	0
2039	5047	5047	0	0	0	0	461	461	0	0	0	0	387	387	0	23500	23500	0	-1847	-1808	39	0	0	0
2040	2462	2462	0	0	0	0	439	439	0	0	0	0	306	306	0	23399	23399	0	-11284	-10911	373	0	0	0
2041	2070	2070	0	0	0	0	404	404	0	0	0	0	203	203	0	23666	23666	0	-7302	-7112	190	0	0	0
2042	790	790	0	0	0	0	354	354	0	0	0	0	146	146	0	23457	23457	0	-8804	-8735	69	0	0	0
2043	537	537	0	0	0	0	317	317	0	0	0	0	155	155	0	23911	23911	0	-9294	-9194	100	0	0	0
2044	605	605	0	0	0	0	389	389	0	0	0	0	147	147	0	24249	24249	0	-2628	-2562	66	0	0	0
2045	1377	1377	0	0	0	0	473	473	0	0	0	0	157	157	0	24305	24305	0	-1887	-1730	157	0	0	0
2046	1513	1513	0	0	0	0	435	435	0	0	0	0	157	157	0	24061	24061	0	-7361	-7294	67	0	0	0
2047	1596	1596	0	0	0	0	488	488	0	0	0	0	171	171	0	24590	24590	0	-3000	-2823	177	0	0	0
2048	2027	2027	0	0	0	0	496	496	0	0	0	0	178	178	0	24879	24879	0	-4353	-4186	167	0	0	0
2049	5195	5195	0	0	0	0	522	522	0	0	0	0	188	189	1	25776	25776	0	-1545	-1513	32	0	0	0
2010 2049	1616	1616	0	0	0	0	338	338	0	0	0	0	187	187	0	20659	20659	0	-4441	-4314	127	0	0	0

Year	Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog			Red Willow			Rock			Sappa			South Fork			Hugh Butler		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	85	85	0	0	0	0	9567	4820	-4747	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	91	91	0	0	0	0	11076	4296	-6780	0	0	0
2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101	101	0	0	0	0	9211	4106	-5105	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	84	0	0	0	0	10693	3798	-6895	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	60	0	0	0	0	11337	4189	-7148	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	63	63	0	0	0	0	14308	7363	-6945	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67	67	0	0	0	0	11051	7083	-3968	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	72	0	0	0	0	11878	7584	-4294	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	77	0	0	0	0	14036	9057	-4979	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81	81	0	0	0	0	17665	15614	-2051	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	86	86	0	0	0	0	10456	9609	-847	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	93	0	0	0	0	11757	4668	-7089	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102	102	0	0	0	0	8956	3881	-5075	0	0	0
2023	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	109	0	0	0	0	10661	3607	-7054	0	0	0
2024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	106	106	0	0	0	0	11217	4018	-7199	0	0	0
2025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	109	0	0	0	0	14725	7098	-7627	0	0	0
2026	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	112	112	0	0	0	0	11456	6909	-4547	0	0	0
2027	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119	119	0	0	0	0	12183	7356	-4827	0	0	0
2028	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	125	0	0	0	0	14298	8836	-5462	0	0	0
2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	132	132	0	0	0	0	20248	16510	-3738	0	0	0
2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	140	140	0	0	0	0	11292	11501	209	0	0	0
2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	147	147	0	0	0	0	11910	4497	-7413	0	0	0
2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	153	153	0	0	0	0	8908	3727	-5181	0	0	0
2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	160	0	0	0	0	10836	3477	-7359	0	0	0
2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	157	157	0	0	0	0	11254	3945	-7309	0	0	0
2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	156	156	0	0	0	0	14467	6884	-7583	0	0	0
2036	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	159	159	0	0	0	0	12107	6755	-5352	0	0	0
2037	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	167	167	0	0	0	0	12456	7177	-5279	0	0	0
2038	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	172	172	0	0	0	0	14557	8650	-5907	0	0	0
2039	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	177	177	0	0	0	0	21569	16668	-4901	0	0	0
2040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	185	185	0	0	0	0	12219	11721	-498	0	0	0
2041	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	197	197	0	0	0	0	12057	4345	-7712	0	0	0
2042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	204	204	0	0	0	0	9059	3583	-5476	0	0	0
2043	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	190	190	0	0	0	0	10994	3362	-7632	0	0	0
2044	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170	170	0	0	0	0	11470	3911	-7559	0	0	0
2045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	180	0	0	0	0	14162	6724	-7438	0	0	0
2046	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	160	160	0	0	0	0	12201	6611	-5590	0	0	0
2047	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	166	166	0	0	0	0	12874	7046	-5828	0	0	0
2048	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	181	181	0	0	0	0	14848	8480	-6368	0	0	0
2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	235	235	0	0	0	0	21911	16393	-5518	0	0	0
2010 2049	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	133	133	0	0	0	0	12698	7146	-5552	0	0	0

Year	Bonny			Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	1305	-619	-1924	0	0	0	0	0	0	0	0	0	0	0	0	11	11	0	-5260	-5272	-12	25051	18368	-6683
2011	1365	-1082	-2447	0	0	0	0	0	0	0	0	0	0	0	0	12	12	0	-5644	-5645	-1	25394	16167	-9227
2012	1417	-1203	-2620	0	0	0	0	0	0	0	0	0	0	0	0	14	15	1	-6753	-6744	9	21120	13404	-7716
2013	1460	-1570	-3050	0	0	0	0	0	0	0	0	0	0	0	0	25	26	1	-1107	-1045	62	28463	18581	-9882
2014	1500	-1837	-3337	0	0	0	0	0	0	0	0	0	0	0	0	25	26	1	-890	-822	68	29723	19307	-10416
2015	1433	-1722	-3155	0	0	0	0	0	0	0	0	0	0	0	0	16	17	1	-2372	-2258	114	31777	21792	-9985
2016	1430	-1225	-2655	0	0	0	11	11	0	0	0	0	0	0	0	17	18	1	-3890	-3796	94	27222	20694	-6528
2017	1448	-1036	-2484	0	0	0	12	12	0	0	0	0	0	0	0	19	20	1	-2509	-2310	199	29935	23358	-6577
2018	1449	-2016	-3465	0	0	0	12	12	0	0	0	0	0	0	0	17	18	1	-2891	-2690	201	32426	24184	-8242
2019	1381	-927	-2308	0	0	0	13	13	0	0	0	0	0	0	0	14	16	2	-1770	-1745	25	40892	36559	-4333
2020	1466	-581	-2047	0	0	0	14	14	0	0	0	0	0	0	0	14	16	2	-7117	-6685	432	25555	23095	-2460
2021	1538	-1074	-2612	0	0	0	15	15	0	0	0	0	0	0	0	16	17	1	-6356	-6248	108	28188	18595	-9593
2022	1584	-1172	-2756	0	0	0	16	16	0	0	0	0	0	0	0	20	20	0	-7145	-7087	58	23304	15531	-7773
2023	1646	-1542	-3188	0	0	0	17	17	0	0	0	0	0	0	0	33	33	0	-2669	-2557	112	29753	19625	-10128
2024	1666	-1874	-3540	0	0	0	19	19	0	0	0	0	0	0	0	31	32	1	-797	-706	91	32603	21956	-10647
2025	1597	-1757	-3354	0	0	0	20	20	0	0	0	0	0	0	0	23	23	0	-2580	-2461	119	35034	24171	-10863
2026	1593	-1246	-2839	0	0	0	21	21	0	0	0	0	0	0	0	22	23	1	-4909	-4788	121	29516	22252	-7264
2027	1611	-1065	-2676	0	0	0	22	22	0	0	0	0	0	0	0	23	24	1	-2912	-2717	195	32840	25533	-7307
2028	1611	-2076	-3687	0	0	0	24	24	0	0	0	0	0	0	0	21	23	2	-3366	-3173	193	35247	26293	-8954
2029	1566	-1626	-3192	0	0	0	25	25	0	0	0	0	0	0	0	18	20	2	-1868	-1828	40	46564	39675	-6889
2030	1625	-667	-2292	0	0	0	27	27	0	0	0	0	0	0	0	15	19	4	-9262	-8824	438	27405	25764	-1641
2031	1697	-1125	-2822	0	0	0	29	29	0	0	0	0	0	0	0	21	22	1	-6808	-6662	146	30818	20731	-10087
2032	1743	-1219	-2962	0	0	0	31	31	0	0	0	0	0	0	0	28	29	1	-7737	-7670	67	25509	17434	-8075
2033	1806	-1575	-3381	0	0	0	32	32	0	0	0	0	0	0	0	53	54	1	-5314	-5238	76	30122	19461	-10661
2034	1826	-1942	-3768	0	0	0	34	34	0	0	0	0	0	0	0	49	49	0	-1064	-953	111	35178	24213	-10965
2035	1756	-1859	-3615	0	0	0	37	37	0	0	0	0	0	0	0	34	35	1	-2438	-2322	116	37745	26665	-11080
2036	1749	-1286	-3035	0	0	0	39	39	0	0	0	0	0	0	0	31	32	1	-6027	-5947	80	31764	23457	-8307
2037	1767	-1121	-2888	0	0	0	42	42	0	0	0	0	0	0	0	31	32	1	3055	-2863	192	35726	27754	-7972
2038	1767	-2154	-3921	0	0	0	45	45	0	0	0	0	0	0	0	27	29	2	-3900	-3720	180	37766	28119	-9647
2039	1727	-1702	-3429	0	0	0	48	48	0	0	0	0	0	0	0	24	26	2	-1852	-1813	39	51086	42800	-8286
2040	1781	-769	-2550	0	0	0	51	51	0	0	0	0	0	0	0	20	22	2	-11287	-10914	373	29574	26902	-2672
2041	1848	-1189	-3037	0	0	0	54	54	0	0	0	0	0	0	0	27	29	2	-7306	-7116	190	33221	22663	-10558
2042	1895	-1250	-3145	0	0	0	57	57	0	0	0	0	0	0	0	39	41	2	-8807	-8738	69	27193	18643	-8550
2043	1958	-1598	-3556	0	0	0	60	60	0	0	0	0	0	0	0	58	60	2	-9293	-9193	100	28887	17801	-11086
2044	1979	-1981	-3960	0	0	0	63	63	0	0	0	0	0	0	0	74	75	1	-2628	-2562	66	36520	25068	-11452
2045	1907	-1964	-3871	0	0	0	67	67	0	0	0	0	0	0	0	52	53	1	1897	-1739	158	40782	29631	-11151
2046	1899	-1334	-3233	0	0	0	70	70	0	0	0	0	0	0	0	40	41	1	-7366	-7299	67	33168	24414	-8754
2047	1916	-1181	-3097	0	0	0	74	74	0	0	0	0	0	0	0	40	40	0	-3010	-2833	177	38904	30157	-8747
2048	1916	-2237	-4153	0	0	0	77	77	0	0	0	0	0	0	0	33	34	1	-4361	-4194	167	40274	29922	-10352
2049	1874	-1744	-3618	0	0	0	81	81	0	0	0	0	0	0	0	30	33	3	-1554	-1523	31	54259	45156	-9103
2010 2049	1663	-1428	-3091	0	0	0	31	31	0	0	0	0	0	0	0	27	29	2	-4444	-4317	127	32912	24397	-8515

Table 2. Kansas Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree			Beaver			Buffalo			Driftwood			Frenchman			North Fork		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	68	68	0	6893	6893	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	157	157	0	5972	5972	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	100	100	0	2807	2807	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	92	92	0	897	897	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	105	105	0	784	784	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	107	107	0	2143	2143	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	77	77	0	3453	3453	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	91	91	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	86	86	0	7574	7574	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	148	148	0	7925	7925	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	63	63	0	7010	7010	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	153	153	0	6074	6074	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	98	98	0	2849	2849	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	90	90	0	916	916	0	0	0	0	0	0	0	0	0	0	0	0	0
2024	100	100	0	803	803	0	0	0	0	0	0	0	0	0	0	0	0	0
2025	106	106	0	2155	2155	0	0	0	0	0	0	0	0	0	0	0	0	0
2026	75	75	0	3460	3460	0	0	0	0	0	0	0	0	0	0	0	0	0
2027	90	90	0	5503	5503	0	0	0	0	0	0	0	0	0	0	0	0	0
2028	85	85	0	7537	7537	0	0	0	0	0	0	0	0	0	0	0	0	0
2029	148	148	0	8300	8300	0	0	0	0	0	0	0	0	0	0	0	0	0
2030	60	60	0	7206	7206	0	0	0	0	0	0	0	0	0	0	0	0	0
2031	152	152	0	6134	6134	0	0	0	0	0	0	0	0	0	0	0	0	0
2032	96	96	0	2834	2834	0	0	0	0	0	0	0	0	0	0	0	0	0
2033	86	86	0	907	907	0	0	0	0	0	0	0	0	0	0	0	0	0
2034	96	96	0	789	789	0	0	0	0	0	0	0	0	0	0	0	0	0
2035	107	107	0	2138	2138	0	0	0	0	0	0	0	0	0	0	0	0	0
2036	73	73	0	3440	3440	0	0	0	0	0	0	0	0	0	0	0	0	0
2037	90	90	0	5484	5484	0	0	0	0	0	0	0	0	0	0	0	0	0
2038	85	85	0	7506	7506	0	0	0	0	0	0	0	0	0	0	0	0	0
2039	148	148	0	8579	8579	0	0	0	0	0	0	0	0	0	0	0	0	0
2040	56	56	0	7374	7374	0	0	0	0	0	0	0	0	0	0	0	0	0
2041	154	154	0	6142	6142	0	0	0	0	0	0	0	0	0	0	0	0	0
2042	93	93	0	2871	2821	0	0	0	0	0	0	0	0	0	0	0	0	0
2043	83	83	0	899	899	0	0	0	0	0	0	0	0	0	0	0	0	0
2044	93	93	0	776	776	0	0	0	0	0	0	0	0	0	0	0	0	0
2045	107	107	0	2123	2123	0	0	0	0	0	0	0	0	0	0	0	0	0
2046	72	72	0	3429	3429	0	0	0	0	0	0	0	0	0	0	0	0	0
2047	89	89	0	5473	5473	0	0	0	0	0	0	0	0	0	0	0	0	0
2048	86	86	0	7479	7479	0	0	0	0	0	0	0	0	0	0	0	0	0
2049	149	149	0	8816	8816	0	0	0	0	0	0	0	0	0	0	0	0	0
2010 2049	100	100	0	4472	4472	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	Above Swanson			Swanson - Harlan			Harlan - Guide Rock			Guide Rock - Hardy			Medicine			Prairie Dog		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	-199	18	217	-1173	-1173	0	0	0	0	245	245	0	0	0	0	3513	3513	0
2011	13	212	199	48	48	0	0	0	0	44	44	0	0	0	0	5026	5026	0
2012	421	137	-284	344	344	0	0	0	0	54	54	0	0	0	0	3139	3139	0
2013	-317	88	405	-235	-235	0	0	0	0	56	56	0	0	0	0	1690	1690	0
2014	388	241	-147	0	0	0	0	0	0	69	69	0	0	0	0	1873	1873	0
2015	110	198	88	-34	-34	0	0	0	0	63	62	-1	0	0	0	5841	5841	0
2016	244	296	52	-394	-394	0	0	0	0	53	53	0	0	0	0	5564	5564	0
2017	195	344	149	382	382	0	0	0	0	68	68	0	0	0	0	5816	5816	0
2018	146	313	167	154	154	0	0	0	0	41	41	0	0	0	0	12547	12547	0
2019	262	299	37	82	82	0	0	0	0	54	54	0	0	0	0	10357	10357	0
2020	-449	80	529	-1578	-1578	0	12	12	0	245	245	0	0	0	0	3776	3776	0
2021	299	335	36	63	62	-1	0	0	0	44	44	0	0	0	0	5432	5432	0
2022	194	136	-58	542	542	0	0	0	0	54	54	0	0	0	0	3403	3403	0
2023	-448	62	510	-276	-276	0	0	0	0	56	56	0	0	0	0	1914	1914	0
2024	216	176	-40	0	0	0	0	0	0	69	69	0	0	0	0	2143	2143	0
2025	177	243	66	-557	-557	0	0	0	0	62	62	0	0	0	0	6159	6159	0
2026	157	321	164	-1066	-1066	0	0	0	0	53	53	0	0	0	0	5912	5912	0
2027	223	348	125	792	793	1	0	0	0	68	68	0	0	0	0	6190	6190	0
2028	179	295	116	191	191	0	0	0	0	41	41	0	0	0	0	12749	12749	0
2029	186	254	68	81	81	0	0	0	0	54	54	0	0	0	0	10481	10481	0
2030	-447	205	652	-1700	-1700	0	13	13	0	245	245	0	0	0	0	3970	3970	0
2031	275	253	-22	-71	-71	0	10	11	1	44	44	0	0	0	0	5723	5723	0
2032	22	130	108	623	623	0	0	0	0	53	53	0	0	0	0	3591	3591	0
2033	-1633	-793	840	-274	-274	0	0	0	0	56	56	0	0	0	0	2091	2091	0
2034	213	392	179	0	0	0	0	0	0	69	69	0	0	0	0	2358	2358	0
2035	266	254	-12	-622	-622	0	10	0	-10	62	62	0	0	0	0	6438	6438	0
2036	126	291	165	-2223	-2223	0	10	10	0	53	53	0	0	0	0	6164	6164	0
2037	463	429	-34	1334	1333	-1	0	0	0	68	68	0	0	0	0	6501	6501	0
2038	77	258	181	253	253	0	0	0	0	40	40	0	0	0	0	12976	12976	0
2039	157	242	85	70	70	0	10	10	0	54	54	0	0	0	0	10646	10646	0
2040	-305	255	560	-1769	-1769	0	14	14	0	245	245	0	0	0	0	4127	4127	0
2041	232	195	-37	-199	-199	0	11	11	0	44	44	0	0	0	0	5964	5964	0
2042	-484	-113	371	651	651	0	0	0	0	54	54	0	0	0	0	3744	3744	0
2043	-3699	-827	2872	-273	-273	0	10	10	0	56	56	0	0	0	0	2246	2246	0
2044	-581	-533	48	0	0	0	0	0	0	69	69	0	0	0	0	2554	2554	0
2045	511	282	-229	-668	-668	0	10	10	0	62	62	0	0	0	0	6670	6670	0
2046	-124	257	381	-2442	-2443	-1	11	10	-1	53	53	0	0	0	0	6389	6389	0
2047	792	568	-224	1411	1411	0	0	0	0	68	68	0	0	0	0	6768	6768	0
2048	-20	216	236	369	369	0	0	0	0	40	40	0	0	0	0	13155	13155	0
2049	333	259	-74	71	71	0	11	11	0	53	53	0	0	0	0	10846	10846	0
2010 2049	-45	165	210	-202	-202	0	3	3	0	74	74	0	0	0	0	5911	5911	0

Year	Red Willow			Rock			Sappa			South Fork			Hugh Butler			Bonny		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	0	0	0	0	0	0	2482	2482	0	2343	1810	-533	0	0	0	10	0	-10
2011	0	0	0	0	0	0	1540	1540	0	7155	3213	-3942	0	0	0	11	0	-11
2012	0	0	0	0	0	0	266	266	0	4672	1578	-3094	0	0	0	12	0	-12
2013	0	0	0	0	0	0	-661	-661	0	4911	1189	-3722	0	0	0	13	0	-13
2014	0	0	0	0	0	0	-784	-784	0	5441	1858	-3583	0	0	0	14	0	-14
2015	0	0	0	0	0	0	-1700	-1700	0	7814	3951	-3863	0	0	0	14	0	-14
2016	0	0	0	0	0	0	-1038	-1038	0	4631	2911	-1720	0	0	0	15	0	-15
2017	0	0	0	0	0	0	820	820	0	5733	3505	-2228	0	0	0	16	0	-16
2018	0	0	0	0	0	0	3471	3471	0	6006	3932	-2074	0	0	0	18	0	-18
2019	0	0	0	0	0	0	4056	4056	0	8187	8004	-183	0	0	0	19	0	-19
2020	0	0	0	0	0	0	2529	2529	0	2320	3654	1334	0	0	0	20	0	-20
2021	0	0	0	0	0	0	1794	1794	0	6870	2999	-3871	0	0	0	21	0	-21
2022	0	0	0	0	0	0	399	399	0	4494	1406	-3088	0	0	0	22	0	-22
2023	0	0	0	0	0	0	-641	-641	0	4539	1007	-3532	0	0	0	23	0	-23
2024	0	0	0	0	0	0	-803	-803	0	5149	1642	-3507	0	0	0	24	0	-24
2025	0	0	0	0	0	0	-1598	-1598	0	8162	3738	-4424	0	0	0	26	0	-26
2026	0	0	0	0	0	0	-781	-781	0	4943	2775	-2168	0	0	0	27	0	-27
2027	0	0	0	0	0	0	1051	1051	0	5986	3337	-2649	0	0	0	28	0	-28
2028	0	0	0	0	0	0	3627	3627	0	6191	3757	-2434	0	0	0	29	0	-29
2029	0	0	0	0	0	0	3991	3991	0	8575	7636	-939	0	0	0	31	0	-31
2030	0	0	0	0	0	0	2589	2589	0	2340	4157	1817	0	0	0	32	0	-32
2031	0	0	0	0	0	0	1887	1887	0	6628	2824	-3804	0	0	0	33	0	-33
2032	0	0	0	0	0	0	478	478	0	4334	1277	-3057	0	0	0	35	0	-35
2033	0	0	0	0	0	0	-633	-633	0	4212	862	-3350	0	0	0	36	0	-36
2034	0	0	0	0	0	0	-789	-789	0	4895	1492	-3403	0	0	0	38	0	-38
2035	0	0	0	0	0	0	-1517	-1517	0	7919	3559	-4360	0	0	0	39	-11	-50
2036	0	0	0	0	0	0	-633	-633	0	5529	2653	-2876	0	0	0	40	0	-40
2037	0	0	0	0	0	0	1193	1193	0	6214	3205	-3009	0	0	0	42	0	-42
2038	0	0	0	0	0	0	3715	3715	0	6388	3619	-2769	0	0	0	43	-11	-54
2039	0	0	0	0	0	0	4004	4004	0	8956	7469	-1487	0	0	0	45	0	-45
2040	0	0	0	0	0	0	2672	2672	0	2352	3601	1249	0	0	0	46	0	-46
2041	0	0	0	0	0	0	1983	1983	0	6389	2604	-3785	0	0	0	48	0	-48
2042	0	0	0	0	0	0	542	542	0	4179	1164	-3015	0	0	0	49	0	-49
2043	0	0	0	0	0	0	-626	-626	0	3779	740	-3039	0	0	0	51	0	-51
2044	0	0	0	0	0	0	-776	-776	0	4660	1356	-3304	0	0	0	52	0	-52
2045	0	0	0	0	0	0	-1456	-1456	0	7691	3407	-4284	0	0	0	54	-21	-75
2046	0	0	0	0	0	0	-520	-520	0	5596	2555	-3041	0	0	0	56	0	-56
2047	0	0	0	0	0	0	1305	1305	0	6558	3086	-3472	0	0	0	57	-12	-69
2048	0	0	0	0	0	0	3780	3780	0	6626	3498	-3128	0	0	0	59	-16	-75
2049	0	0	0	0	0	0	4043	4043	0	9331	7317	-2014	0	0	0	61	-12	-73
2010 2049	0	0	0	0	0	0	981	981	0	5717	3108	-2609	0	0	0	32	-2	-34

Year	Keith Sebelius			Enders			Harlan			Harry Strunk			Swanson			Mainstem			Total		
	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del	WB	NB	Del
2010	490	490	0	0	0	0	131	131	0	0	0	0	0	0	0	-1117	-900	217	14817	14492	-325
2011	432	432	0	0	0	0	102	102	0	0	0	0	0	0	0	113	313	200	20513	16759	-3754
2012	555	555	0	0	0	0	85	85	0	0	0	0	0	0	0	827	543	-284	12473	9077	-3396
2013	581	581	0	0	0	0	84	84	0	0	0	0	0	0	0	-489	-84	405	7127	3792	-3335
2014	535	535	0	0	0	0	81	81	0	0	0	0	0	0	0	465	318	-147	8523	4772	-3751
2015	547	547	0	0	0	0	78	78	0	0	0	0	0	0	0	148	234	86	14999	11203	-3796
2016	566	566	0	0	0	0	79	79	0	0	0	0	0	0	0	-89	-36	53	13266	11580	-1686
2017	561	561	0	0	0	0	79	79	0	0	0	0	0	0	0	653	802	149	19279	17180	-2099
2018	533	533	0	0	0	0	142	142	0	0	0	0	0	0	0	332	499	167	30714	28786	-1928
2019	476	476	0	0	0	0	165	165	0	0	0	0	0	0	0	406	443	37	31747	31584	-163
2020	517	517	0	0	0	0	137	137	0	0	0	0	0	0	0	-1770	-1241	529	14608	16453	1845
2021	458	458	0	0	0	0	107	107	0	0	0	0	0	0	0	416	451	35	21331	17472	-3859
2022	582	582	0	0	0	0	90	90	0	0	0	0	0	0	0	798	740	-58	12743	9568	-3175
2023	609	609	0	0	0	0	89	89	0	0	0	0	0	0	0	-659	-149	510	6893	3837	-3056
2024	563	563	0	0	0	0	89	89	0	0	0	0	0	0	0	294	254	-40	8374	4792	-3582
2025	575	575	0	0	0	0	89	89	0	0	0	0	0	0	0	-308	-243	65	15376	10982	-4394
2026	593	593	0	0	0	0	89	89	0	0	0	0	0	0	0	-847	-683	164	13480	11444	-2036
2027	589	589	0	0	0	0	88	88	0	0	0	0	0	0	0	1090	1216	126	20623	18065	-2558
2028	561	561	0	0	0	0	155	155	0	0	0	0	0	0	0	403	518	115	31347	28990	-2357
2029	503	503	0	0	0	0	168	168	0	0	0	0	0	0	0	330	399	69	32535	31630	-905
2030	544	544	0	0	0	0	139	139	0	0	0	0	0	0	0	-1888	-1236	652	14998	17439	2441
2031	484	484	0	0	0	0	109	109	0	0	0	0	0	0	0	258	236	-22	21418	17551	-3867
2032	608	608	0	0	0	0	92	92	0	0	0	0	0	0	0	707	815	108	12788	9794	-2994
2033	634	634	0	0	0	0	91	91	0	0	0	0	25	0	-25	-1841	-1002	839	5612	3041	-2571
2034	589	589	0	0	0	0	95	95	0	0	0	0	20	0	-20	291	471	180	8385	5109	-3276
2035	601	601	0	0	0	0	96	96	0	0	0	0	14	0	-14	-284	-296	-12	15556	11126	-4430
2036	619	619	0	0	0	0	95	95	0	0	0	0	11	0	-11	-2033	-1868	165	13310	10551	-2759
2037	614	614	0	0	0	0	92	92	0	0	0	0	10	0	-10	1872	1838	-34	22116	19018	-3098
2038	586	586	0	0	0	0	167	167	0	0	0	0	0	0	0	361	542	181	31841	29193	-2648
2039	528	528	0	0	0	0	169	169	0	0	0	0	0	0	0	291	376	85	33380	31925	-1455
2040	569	569	0	0	0	0	140	140	0	0	0	0	0	0	0	-1814	-1255	559	15532	17295	1763
2041	509	509	0	0	0	0	111	111	0	0	0	0	0	0	0	88	51	-37	21399	17517	-3882
2042	632	632	0	0	0	0	94	94	0	0	0	0	16	0	-16	230	601	371	12404	9701	-2703
2043	658	658	0	0	0	0	92	92	0	0	0	0	0	0	0	-3906	-1034	2872	3289	3069	-220
2044	613	613	0	0	0	0	99	99	0	0	0	0	32	17	-15	-502	-455	47	7606	4282	-3324
2045	625	625	0	0	0	0	102	102	0	0	0	0	23	13	-10	-85	-314	-229	15857	11259	-4598
2046	643	643	0	0	0	0	100	100	0	0	0	0	13	0	-13	-2503	-2123	380	13279	10549	-2730
2047	638	638	0	0	0	0	101	101	0	0	0	0	13	0	-13	2279	2055	-224	23286	19515	-3771
2048	609	609	0	0	0	0	177	177	0	0	0	0	0	0	0	379	616	237	32365	29396	-2969
2049	552	552	0	0	0	0	170	170	0	0	0	0	10	0	-10	468	394	-74	34450	32286	-2164
2010 2049	567	567	0	0	0	0	111	111	0	0	0	0	4	0	-4	-165	45	210	17740	15301	-2439

Table 3. Nebraska Pumping Impacts - NB=No Bonny, WB=With Bonny (acre-feet)

Year	Arikaree WB	Arikaree NB	Arikaree Del	Beaver WB	Beaver NB	Beaver Del	Buffalo WB	Buffalo NB	Buffalo Del	Driftwood WB	Driftwood NB	Driftwood Del	Frenchman WB	Frenchman NB	Frenchman Del	North Fork WB	North Fork NB	North Fork Del
2010	126	126	0	5309	5309	0	3417	3417	0	1185	1185	0	77748	77748	0	978	978	0
2011	320	320	0	5116	5116	0	3602	3602	0	1234	1234	0	80533	80533	0	1023	1023	0
2012	335	335	0	2946	2946	0	3602	3602	0	1278	1278	0	75800	75799	-1	1065	1065	0
2013	514	514	0	1465	1465	0	3650	3650	0	1397	1397	0	81465	81464	-1	1125	1125	0
2014	423	423	0	1816	1816	0	3675	3675	0	1479	1479	0	85962	85962	0	1177	1177	0
2015	242	242	0	3022	3022	0	3741	3741	0	1483	1483	0	80212	80212	0	1219	1219	0
2016	122	122	0	3710	3710	0	3722	3722	0	1426	1426	0	74594	74594	0	1252	1252	0
2017	111	111	0	4964	4964	0	3743	3743	0	1362	1362	0	77253	77253	0	1293	1293	0
2018	124	124	0	6485	6485	0	3783	3783	0	1299	1299	0	78165	78164	-1	1326	1326	0
2019	154	154	0	6225	6225	0	3879	3879	0	1218	1218	0	81309	81309	0	1352	1352	0
2020	125	126	1	5277	5277	0	3924	3924	0	1201	1201	0	79293	79293	0	1379	1379	0
2021	318	318	0	5083	5083	0	3934	3934	0	1251	1251	0	81835	81837	2	1426	1426	0
2022	336	336	0	2938	2938	0	3887	3887	0	1295	1295	0	75961	75960	-1	1468	1468	0
2023	510	510	0	1475	1475	0	3899	3899	0	1413	1413	0	81326	81325	-1	1532	1532	0
2024	422	422	0	1727	1727	0	3942	3942	0	1495	1495	0	86106	86106	0	1587	1587	0
2025	246	246	0	2917	2917	0	4030	4030	0	1500	1500	0	80482	80482	0	1630	1630	0
2026	124	124	0	3613	3613	0	4001	4001	0	1444	1444	0	74581	74580	-1	1661	1661	0
2027	113	113	0	4861	4861	0	4039	4039	0	1383	1383	0	78235	78234	-1	1706	1706	0
2028	126	126	0	6355	6355	0	4114	4114	0	1325	1325	0	78904	78903	-1	1740	1740	0
2029	157	157	0	6473	6473	0	4221	4221	0	1245	1245	0	83156	83156	0	1766	1766	0
2030	124	124	0	5370	5370	0	4226	4226	0	1228	1228	0	79835	79834	-1	1791	1791	0
2031	316	316	0	5068	5068	0	4186	4186	0	1278	1278	0	82032	82033	1	1840	1840	0
2032	336	336	0	2930	2930	0	4114	4114	0	1320	1320	0	76035	76035	0	1878	1878	0
2033	502	502	0	1498	1498	0	4138	4138	0	1435	1435	0	80540	80541	1	1946	1946	0
2034	422	422	0	1703	1703	0	4186	4186	0	1518	1518	0	86498	86498	0	2002	2002	0
2035	251	251	0	2882	2882	0	4262	4262	0	1523	1523	0	80649	80649	0	2045	2045	0
2036	126	126	0	3581	3581	0	4230	4230	0	1468	1468	0	74691	74692	1	2074	2074	0
2037	116	116	0	4828	4828	0	4277	4277	0	1409	1409	0	79075	79074	-1	2123	2123	0
2038	128	128	0	6315	6315	0	4347	4347	0	1354	1354	0	79299	79299	0	2158	2158	0
2039	162	162	0	6718	6718	0	4478	4478	0	1279	1279	0	83798	83799	1	2183	2183	0
2040	121	121	0	5495	5495	0	4468	4468	0	1263	1263	0	80469	80469	0	2205	2205	0
2041	315	315	0	5066	5066	0	4404	4404	0	1311	1311	0	82248	82249	1	2255	2255	0
2042	336	336	0	2957	2957	0	4291	4291	0	1349	1349	0	76128	76127	-1	2290	2290	0
2043	494	494	0	1532	1532	0	4275	4275	0	1463	1463	0	80010	80010	0	2360	2360	0
2044	421	421	0	1700	1700	0	4379	4379	0	1546	1546	0	86665	86664	-1	2419	2419	0
2045	256	256	0	2857	2857	0	4526	4526	0	1551	1551	0	81164	81164	0	2461	2461	0
2046	127	127	0	3562	3562	0	4445	4445	0	1496	1496	0	74875	74875	0	2488	2488	0
2047	120	120	0	4807	4807	0	4529	4529	0	1438	1438	0	79716	79715	-1	2541	2541	0
2048	129	129	0	6279	6279	0	4588	4588	0	1384	1384	0	79724	79723	-1	2577	2577	0
2049	167	167	0	6935	6935	0	4688	4688	0	1312	1312	0	84145	84145	0	2601	2601	0
2010 2049	247	247	0	4096	4096	0	4096	4096	0	1370	1370	0	80012	80012	0	1798	1798	0

Year	Above Swanson WB	Above Swanson NB	Above Swanson Del	Swanson - Harlan WB	Swanson - Harlan NB	Swanson - Harlan Del	Harlan - Guide Rock WB	Harlan - Guide Rock NB	Harlan - Guide Rock Del	Guide Rock - Hardy WB	Guide Rock - Hardy NB	Guide Rock - Hardy Del	Medicine WB	Medicine NB	Medicine Del	Prairie Dog WB	Prairie Dog NB	Prairie Dog Del
2010	9785	9784	-1	35347	35347	0	28926	28926	0	2503	2503	0	20127	20127	0	0	0	0
2011	11608	11608	0	42668	42669	1	28101	28101	0	2695	2695	0	21311	21311	0	0	0	0
2012	10962	10946	-16	23476	23475	-1	29761	29761	0	2633	2633	0	22160	22160	0	0	0	0
2013	18173	18151	-22	28954	28950	-4	31211	31211	0	3346	3346	0	23556	23556	0	0	0	0
2014	15323	15316	-7	35624	35622	-2	32675	32675	0	3224	3224	0	23879	23879	0	0	0	0
2015	11744	11728	-16	40778	40779	1	32616	32616	0	3728	3727	-1	23428	23428	0	0	0	0
2016	9166	9130	-36	40093	40091	-2	30253	30253	0	3140	3140	0	22523	22523	0	0	0	0
2017	10352	10374	22	51227	51226	-1	29999	29999	0	3054	3054	0	22848	22848	0	0	0	0
2018	9805	9832	27	51126	51123	-3	28903	28903	0	2409	2409	0	22319	22319	0	63	63	0
2019	10831	10875	44	59639	59639	0	28785	28785	0	2314	2314	0	22165	22165	0	27	27	0
2020	8361	8394	33	44028	44029	1	33138	33138	0	2590	2590	0	23251	23251	0	13	13	0
2021	11371	11439	68	45288	45292	4	32306	32307	1	2805	2805	0	24322	24322	0	0	0	0
2022	10818	10843	25	26640	26637	-3	33812	33812	0	2711	2711	0	24907	24907	0	0	0	0
2023	17760	17769	9	31013	31011	-2	35225	35225	0	3420	3421	1	26279	26279	0	0	0	0
2024	16045	16057	12	37436	37436	0	36700	36700	0	3316	3316	0	26590	26590	0	0	0	0
2025	12173	12166	-7	43194	43193	-1	36596	36595	-1	3807	3806	-1	26141	26141	0	0	0	0
2026	8864	8858	-6	43065	43064	-1	34188	34188	0	3228	3228	0	25131	25131	0	0	0	0
2027	10617	10627	10	54383	54381	-2	34012	34012	0	3174	3174	0	25652	25652	0	0	0	0
2028	10000	10015	15	54218	54215	-3	32904	32904	0	2523	2523	0	25192	25192	0	45	45	0
2029	11533	11587	54	61289	61289	0	32621	32621	0	2377	2377	0	24960	24960	0	41	41	0
2030	6859	6869	10	46720	46719	-1	36931	36931	0	2675	2675	0	25936	25936	0	16	16	0
2031	11505	11603	98	48463	48467	4	36084	36084	0	2905	2906	1	26949	26949	0	0	0	0
2032	10568	10593	25	29570	29569	-1	37410	37409	-1	2781	2781	0	27311	27311	0	0	0	0
2033	16245	16211	-34	33682	33684	2	38806	38806	0	3491	3491	0	28713	28713	0	0	0	0
2034	16538	16558	20	38927	38927	0	40303	40303	0	3398	3398	0	29027	29027	0	0	0	0
2035	12960	12978	18	44859	44859	0	40132	40132	0	3876	3876	0	28537	28537	0	0	0	0
2036	8495	8456	-39	44838	44840	2	37678	37678	0	3308	3308	0	27425	27425	0	0	0	0
2037	11145	11165	20	57549	57545	-4	37560	37560	0	3272	3272	0	28062	28062	0	0	0	0
2038	10149	10165	16	57339	57336	-3	36572	36573	1	2610	2610	0	27552	27552	0	45	45	0
2039	12351	12419	68	63841	63842	1	36132	36131	-1	2428	2427	-1	27263	27263	0	77	77	0
2040	5509	5428	-81	48549	48550	1	40344	40344	0	2738	2738	0	28153	28153	0	27	27	0
2041	11640	11773	133	51094	51098	4	39527	39527	0	2982	2983	1	29133	29133	0	0	0	0
2042	9928	9943	15	32073	32071	-2	40676	40676	0	2833	2833	0	29356	29356	0	0	0	0
2043	13307	13271	-36	36056	36058	2	41964	41964	0	3548	3548	0	30796	30796	0	0	0	0
2044	15619	15583	-36	40518	40516	-2	43457	43457	0	3460	3460	0	31088	31088	0	0	0	0
2045	14131	14197	66	46105	46104	-1	43228	43228	0	3931	3931	0	30561	30561	0	0	0	0
2046	7821	7779	-42	46410	46411	1	40763	40763	0	3365	3365	0	29379	29379	0	0	0	0
2047	11788	11803	15	60238	60235	-3	41005	41005	0	3338	3338	0	30063	30063	0	0	0	0
2048	10312	10310	-2	60065	60060	-5	40075	40075	0	2676	2676	0	29513	29513	0	62	62	0
2049	13324	13388	64	66087	66085	-2	39451	39451	0	2459	2459	0	29180	29180	0	107	107	0
2010 2049	11637	11649	12	45061	45061	0	35770	35770	0	3026	3026	0	26268	26268	0	13	13	0

Year	Red Willow WB	Red Willow NB	Red Willow Del	Rock WB	Rock NB	Rock Del	Sappa WB	Sappa NB	Sappa Del	South Fork WB	South Fork NB	South Fork Del	Hugh Butler WB	Hugh Butler NB	Hugh Butler Del	Bonny WB	Bonny NB	Bonny Del	Keith Sebelius WB	Keith Sebelius NB	Keith Sebelius Del
2010	6969	6969	0	4362	4362	0	2751	2751	0	719	718	-1	2020	2020	0	0	0	0	0	0	0
2011	7422	7422	0	4400	4400	0	2304	2304	0	681	681	0	2016	2016	0	0	0	0	0	0	0
2012	6032	6032	0	4434	4434	0	1313	1313	0	821	731	-90	2169	2169	0	0	0	0	0	0	0
2013	6842	6842	0	4509	4509	0	867	867	0	1000	873	-127	2175	2175	0	0	0	0	0	0	0
2014	7180	7180	0	4624	4624	0	853	853	0	836	664	-172	2184	2184	0	0	0	0	0	0	0
2015	7340	7340	0	4778	4778	0	949	949	0	1777	613	-1164	2113	2113	0	0	0	0	0	0	0
2016	6730	6730	0	4827	4827	0	1252	1252	0	1159	583	-576	2044	2044	0	0	0	0	0	0	0
2017	8433	8433	0	4934	4934	0	1975	1975	0	1107	586	-521	2054	2054	0	0	0	0	0	0	0
2018	8636	8636	0	5067	5067	0	3841	3841	0	1063	606	-457	2054	2054	0	0	0	0	0	0	0
2019	9235	9235	0	5267	5267	0	3881	3881	0	1360	1114	-246	2062	2062	0	0	0	0	0	0	0
2020	8280	8280	0	5291	5291	0	2682	2682	0	783	1424	641	2393	2393	0	0	0	0	0	0	0
2021	8226	8226	0	5209	5209	0	2471	2471	0	723	725	2	2382	2382	0	0	0	0	0	0	0
2022	6587	6587	0	5104	5104	0	1448	1448	0	755	756	1	2529	2529	0	0	0	0	0	0	0
2023	7347	7347	0	5113	5113	0	967	967	0	965	967	2	2529	2529	0	0	0	0	0	0	0
2024	7695	7695	0	5226	5226	0	950	950	0	713	713	0	2534	2534	0	0	0	0	0	0	0
2025	7904	7904	0	5383	5383	0	1040	1040	0	1850	645	-1205	2457	2457	0	0	0	0	0	0	0
2026	7213	7213	0	5425	5425	0	1358	1358	0	1366	649	-717	2383	2383	0	0	0	0	0	0	0
2027	9047	9047	0	5537	5537	0	2120	2120	0	1185	616	-569	2388	2388	0	0	0	0	0	0	0
2028	9349	9349	0	5672	5672	0	3972	3972	0	1093	636	-457	2385	2385	0	0	0	0	0	0	0
2029	10001	10001	0	5871	5871	0	3785	3785	0	1426	888	-538	2387	2387	0	0	0	0	0	0	0
2030	8990	8990	0	5889	5889	0	2699	2699	0	829	1847	1018	2714	2714	0	0	0	0	0	0	0
2031	8846	8846	0	5797	5797	0	2537	2537	0	752	754	2	2698	2698	0	0	0	0	0	0	0
2032	7058	7058	0	5662	5662	0	1534	1534	0	801	804	3	2841	2841	0	0	0	0	0	0	0
2033	7811	7811	0	5695	5695	0	1027	1027	0	1036	1038	2	2837	2837	0	0	0	0	0	0	0
2034	8195	8195	0	5790	5790	0	1010	1010	0	812	818	6	2839	2839	0	0	0	0	0	0	0
2035	8411	8411	0	5907	5907	0	1099	1099	0	1208	680	-528	2756	2756	0	0	0	0	0	0	0
2036	7674	7674	0	5930	5930	0	1437	1437	0	1810	703	-1107	2679	2679	0	0	0	0	0	0	0
2037	9602	9602	0	6053	6053	0	2222	2222	0	1260	654	-606	2680	2680	0	0	0	0	0	0	0
2038	9918	9918	0	6180	6180	0	4053	4053	0	1139	666	-473	2673	2673	0	0	0	0	0	0	0
2039	10604	10604	0	6373	6373	0	3780	3780	0	1489	783	-706	2671	2671	0	0	0	0	0	0	0
2040	9545	9545	0	6383	6383	0	2744	2744	0	860	2038	1178	2995	2995	0	0	0	0	0	0	0
2041	9346	9346	0	6284	6284	0	2612	2612	0	788	793	5	2975	2975	0	0	0	0	0	0	0
2042	7457	7457	0	6157	6157	0	1601	1601	0	856	859	3	3113	3113	0	0	0	0	0	0	0
2043	8250	8250	0	6184	6184	0	1071	1071	0	1095	1098	3	3106	3106	0	0	0	0	0	0	0
2044	8661	8661	0	6253	6253	0	1055	1055	0	920	925	5	3105	3105	0	0	0	0	0	0	0
2045	8857	8857	0	6370	6370	0	1146	1146	0	759	759	0	3018	3018	0	0	0	0	0	0	0
2046	8090	8090	0	6362	6362	0	1501	1501	0	1691	751	-940	2937	2937	0	0	0	0	0	0	0
2047	10095	10095	0	6478	6478	0	2307	2307	0	1492	729	-763	2935	2935	0	0	0	0	0	0	0
2048	10404	10404	0	6586	6586	0	4112	4112	0	1232	708	-524	2925	2925	0	0	0	0	0	0	0
2049	11116	11116	0	6790	6790	0	3805	3805	0	1555	774	-781	2919	2919	0	0	0	0	0	0	0
2010 2049	8384	8384	0	5603	5603	0	2103	2103	0	1094	834	-260	2566	2566	0	0	0	0	0	0	0

Year	Enders WB	Enders NB	Enders Del	Harlan WB	Harlan NB	Harlan Del	Harry Strunk WB	Harry Strunk NB	Harry Strunk Del	Swanson WB	Swanson NB	Swanson Del	Mainstem WB	Mainstem NB	Mainstem Del	Total WB	Total NB	Total Del
2010	4545	4545	0	1022	1022	0	312	312	0	254	254	0	76560	76560	0	208407	208406	-1
2011	4703	4703	0	878	878	0	322	322	0	273	273	0	85071	85072	1	221210	221211	1
2012	4843	4843	0	956	956	0	333	333	0	311	311	0	66831	66814	-17	195228	195120	-108
2013	5151	5151	0	959	959	0	470	470	0	510	510	0	81683	81657	-26	217337	217182	-155
2014	5236	5236	0	861	861	0	415	415	0	517	517	0	86846	86837	-9	227966	227784	-182
2015	5346	5346	0	950	950	0	371	371	0	450	450	0	88866	88850	-16	226287	225106	-1181
2016	5309	5309	0	911	911	0	346	346	0	403	402	-1	82652	82615	-37	212983	212370	-613
2017	5285	5285	0	888	888	0	341	341	0	358	358	0	94633	94653	20	231581	231081	-500
2018	5261	5261	0	883	883	0	336	336	0	338	339	1	92243	92268	25	233287	232855	-432
2019	5178	5178	0	860	860	0	332	332	0	267	268	1	101568	101612	44	246339	246138	-201
2020	5181	5181	0	1128	1128	0	337	337	0	276	277	1	88117	88151	34	228930	229606	676
2021	5326	5326	0	984	984	0	348	348	0	296	296	0	91771	91843	72	235904	235980	76
2022	5455	5455	0	1064	1064	0	359	359	0	334	334	0	73981	74002	21	208407	208430	23
2023	5752	5752	0	1069	1069	0	497	497	0	535	536	1	87418	87426	8	228626	228635	9
2024	5830	5830	0	977	977	0	443	443	0	544	544	0	93497	93508	11	240279	240291	12
2025	5929	5929	0	1070	1070	0	398	398	0	478	478	0	95770	95761	-9	239224	238010	-1214
2026	5882	5882	0	1030	1030	0	374	374	0	429	430	1	89345	89337	-8	225362	224636	-726
2027	5850	5850	0	1006	1006	0	369	369	0	385	385	0	102186	102194	8	246063	245501	-562
2028	5820	5820	0	999	999	0	365	365	0	364	365	1	99645	99657	12	247465	247020	-445
2029	5728	5728	0	977	977	0	361	361	0	291	292	1	107821	107874	53	260667	260182	-485
2030	5726	5726	0	1244	1244	0	366	366	0	298	300	2	93185	93195	10	240467	241495	1028
2031	5862	5862	0	1100	1100	0	377	377	0	318	319	1	98958	99060	102	248914	249021	107
2032	5985	5985	0	1179	1179	0	389	389	0	360	360	0	80328	80352	24	220061	220087	26
2033	6276	6276	0	1183	1183	0	527	527	0	575	575	0	92224	92193	-31	237964	237936	-28
2034	6349	6349	0	1094	1094	0	473	473	0	581	582	1	99166	99186	20	251667	251692	25
2035	6441	6441	0	1188	1188	0	429	429	0	508	507	-1	101828	101845	17	249925	249414	-511
2036	6390	6390	0	1148	1148	0	404	404	0	457	457	0	94319	94283	-36	235845	234701	-1144
2037	6354	6354	0	1121	1121	0	399	399	0	414	414	0	109526	109542	16	259523	258931	-592
2038	6321	6321	0	1115	1115	0	395	395	0	392	392	0	106671	106682	11	260056	259594	-462
2039	6225	6225	0	1093	1093	0	391	391	0	319	319	0	114751	114820	69	273654	273018	-636
2040	6720	6220	0	1359	1359	0	397	397	0	322	323	1	97140	97061	-79	250166	251266	1100
2041	6351	6351	0	1213	1213	0	408	408	0	345	346	1	105244	105381	137	260299	260444	145
2042	6470	6470	0	1292	1292	0	420	420	0	392	393	1	85510	85523	13	229973	229991	18
2043	6758	6758	0	1295	1295	0	558	558	0	601	602	1	94875	94841	-34	244723	244693	-30
2044	6829	6829	0	1207	1207	0	504	504	0	626	627	1	103054	103016	-38	260434	260400	-34
2045	6918	6918	0	1301	1301	0	460	460	0	545	545	0	107395	107459	64	260144	260208	64
2046	6864	6864	0	1259	1259	0	435	435	0	486	486	0	98359	98318	-41	244358	243378	-980
2047	6826	6826	0	1230	1230	0	430	430	0	442	442	0	116368	116381	13	271817	271065	-752
2048	6793	6793	0	1224	1224	0	426	426	0	419	419	0	113128	113120	-8	271507	270973	-534
2049	6693	6693	0	1208	1208	0	422	422	0	346	348	2	121321	121383	62	285311	284593	-718
2010 2049	5906	5906	0	1088	1088	0	400	400	0	408	409	1	95496	95508	12	240959	240711	-248

1 SI176001SFbloBonny
2 SI132001HughButler
3 SO132012HughButler
4 SI150001Bonny
5 SO150008Bonny
6 SI151001KeithSebeliu
7 SO151022KeithSebeliu
8 SI155001Enders
9 SO155015Enders
10 SI231001Harlan
11 SO233018Harlan
12 SI183001HarryStrunk
13 SO183008HarryStrunk
14 SI203001Swanson
15 SO203011Swanson
16 SI2560046853500
17 SI251003RRGuideRock
18 SI253006RRGuideRock
19 SI234002RRBloHarlan
20 SI2390026850500
21 SI2270026844500
22 SI2170016843500
23 SI212003RRMcCook
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SI258033Dry Creek
SI230005RepRivabvHar
SI202005RepRivabvSwa
SI141004LandsmanabvB
SI153012AcctNFRepubl
SI139003AcctArikaree
SI133001AcctBuffalo
SI131002AcctRock
SI185007AcctSFRepubl
SI197004AcctFrenchma
SI115009AcctDriftwoo
SI160002AcctRedWillo
SI190005AcctMedicine
SI195030AcctBeaver
SI201006AcctSappa
SI172042AcctPrairieD
SI171053AcctPrairieD
SI170017AcctHarryStr
SI178001SFRRStFranci
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1 2010 2049
" Arikaree"               +SI139003AcctArikaree
" Beaver"                 +SI195030AcctBeaver
" Buffalo"                +SI133001AcctBuffalo
' Driftwood"              +SI115009AcctDriftwoo
" Frenchman"              +SI197004AcctFrenchma      +SI1470106831500
" North Fork"             +SI1300286823000
"*Above Swanson"          +SI202005RRAbvSwanson      -SI1300286823000 -SI185007AcctSFRepublican -SI139003
"*Swanson - Harlan"       +SI230005RepRivabvHar      -SI197004AcctFrenchma      -SI115009AcctDriftwoo
"*Harlan - Guide Rock"    +SI251003RRGuideRock       -SI234002RRBloHarlan
"*Guide Rock - Hardy"     +SI2560046853500           -SI251003RRGuideRock
" Medicine"               +SI190005AcctMedicine      +SI170017AcctHarryStrunk
" Prairie Dog"            +SI1710536848500           +SI1460546847900
" Red Willow"             +SI160002AcctRedWillo      +SI0600516837300
" Rock"                   +SI131002AcctRock
" Sappa"                  +SI201006AcctSappa         -SI195030AcctBeaver
" South Fork"             +SI185007AcctSFRepublican  -SI176001SFbloBonny        +SI0970326825000
" Hugh Butler"            +SO132012HughButler
" Bonny"                  +SO150008Bonny             -SI150001Bonny
" Keith Sebelius"         +SO151022KeithSebelius
" Enders"                 +SO155015Enders
" Harlan"                 +SO233018Harlan
" Harry Strunk"           +SO183008HarryStrunk
" Swanson"                +SO203011Swanson
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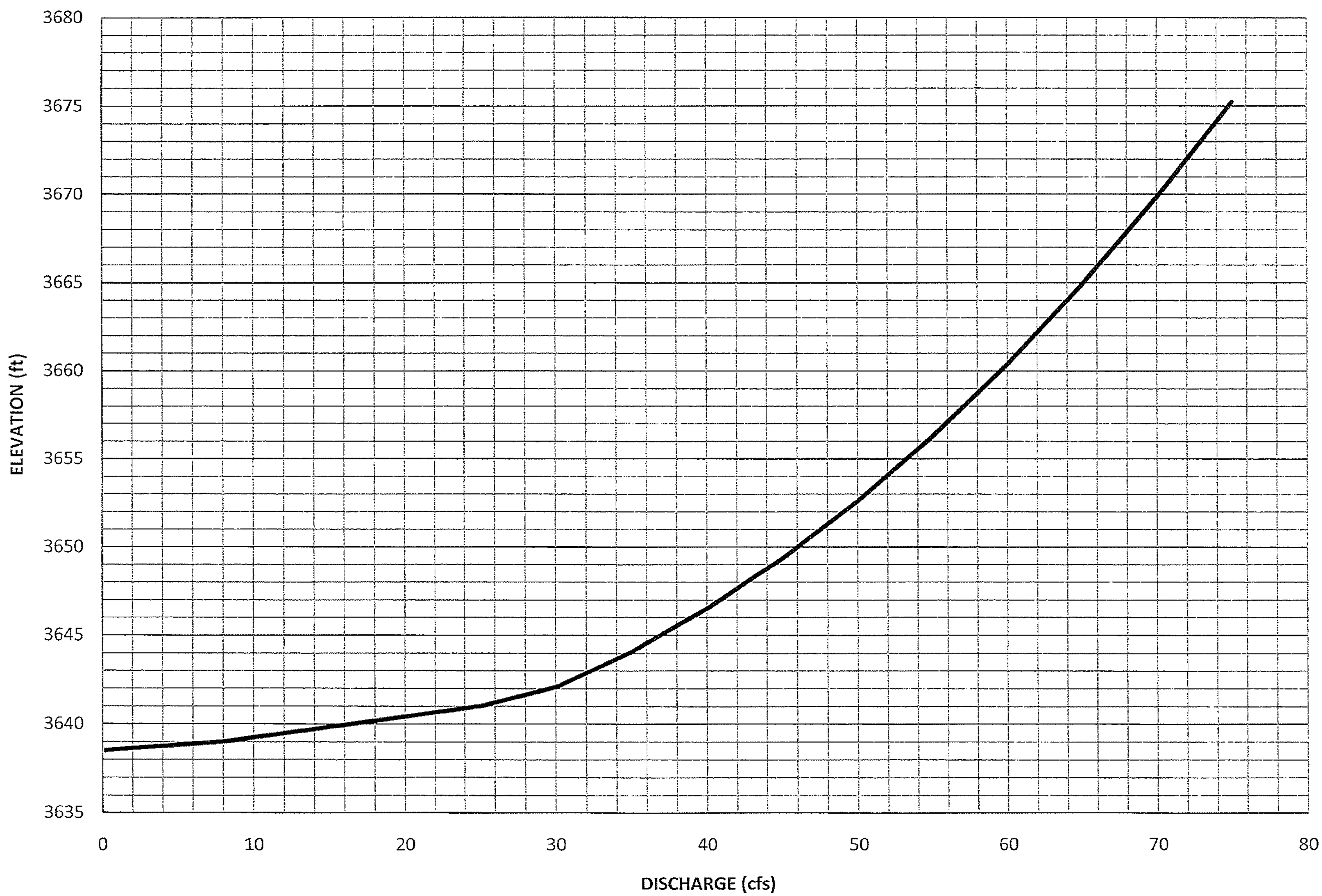
BONNY DISCHARGE CURVE



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1 2010 2049
" Arikaree"              +SI139003AcctArikaree
" Beaver"                +SI195030AcctBeaver
" Buffalo"               +SI133001AcctBuffalo
" Driftwood"             +SI115009AcctDriftwoo
" Frenchman"             +SI197004AcctFrenchma     +SI1470106831500
" North Fork"            +SI1300286823000
"*Above Swanson"         +SI202005RRAbvSwanson     -SI1300286823000 -SI185007AcctSFRepublican -SI139003
"*Swanson - Harlan"      +SI230005RepRivabvHar     -SI197004AcctFrenchma     -SI115009AcctDriftwoo
"*Harlan - Guide Rock"   +SI251003RRGuideRock      -SI234002RRBloHarlan
"*Guide Rock - Hardy"    +SI2560046853500          -SI251003RRGuideRock
" Medicine"              +SI190005AcctMedicine     +SI170017AcctHarryStrunk
" Prairie Dog"           +SI1710536848500          +SI1460546847900
" Red Willow"            +SI160002AcctRedWillo     +SI0600516837300
" Rock"                  +SI131002AcctRock
" Sappa"                 +SI201006AcctSappa        -SI195030AcctBeaver
" South Fork"            +SI185007AcctSFRepublican -SI176001SFbloBonny       +SI0970326825000
" Hugh Butler"           +SO132012HughButler
" Bonny"                 +SO150008Bonny            -SI150001Bonny
" Keith Sebelius"        +SO151022KeithSebelius
" Enders"                +SO155015Enders
" Harlan"                +SO233018Harlan
" Harry Strunk"          +SO183008HarryStrunk
" Swanson"               +SO203011Swanson
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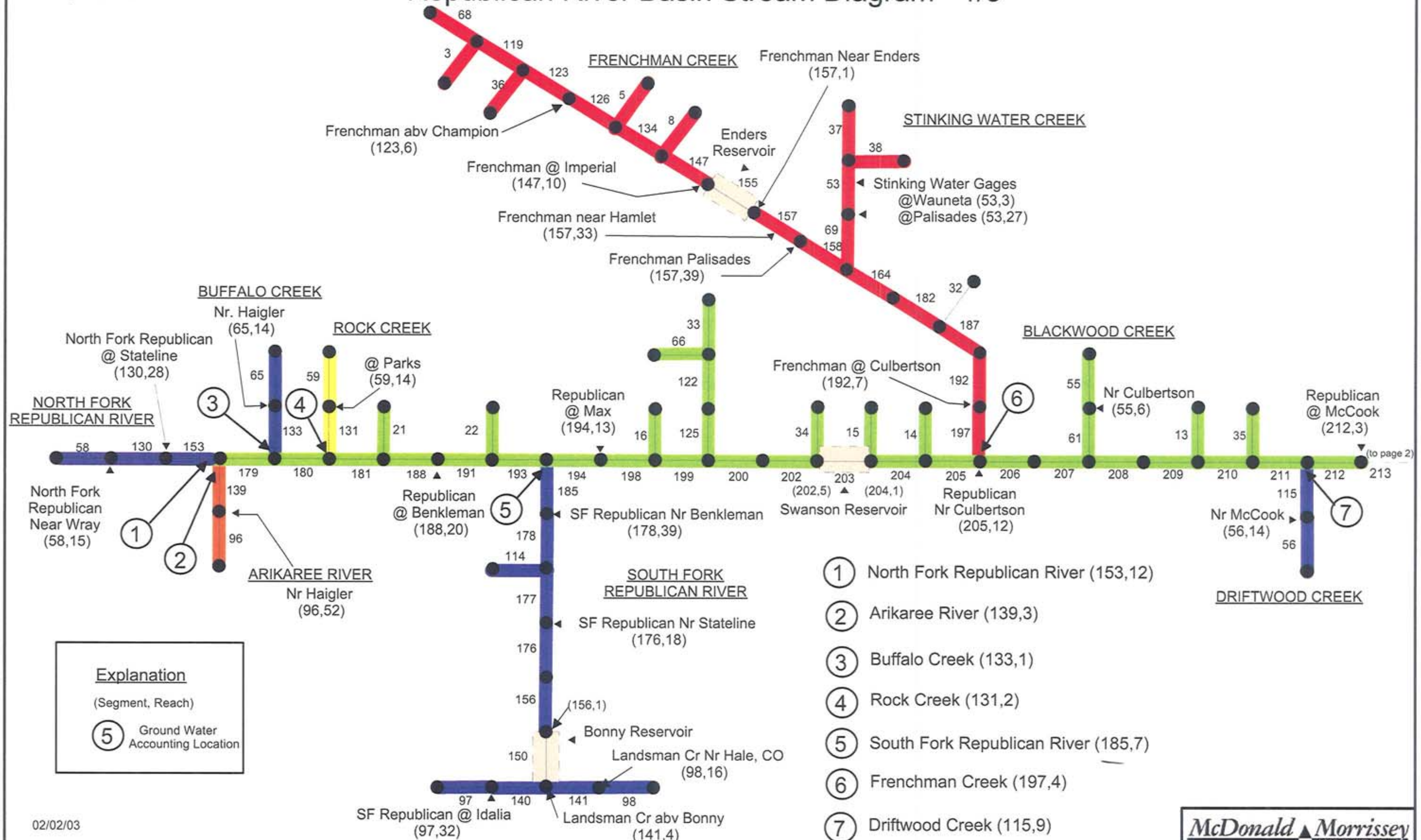
Republican River Basin Stream Diagram - 1/3

DRAFT



1 North Fork Republican River (153,12)
2 Arikaree River (139,3)
3 Buffalo Creek (133,1)
4 Rock Creek (131,2)
5 South Fork Republican River (185,7)
6 Frenchman Creek (197,4)
7 Driftwood Creek (115,9)

Explanation

(Segment, Reach)

5 Ground Water Accounting Location

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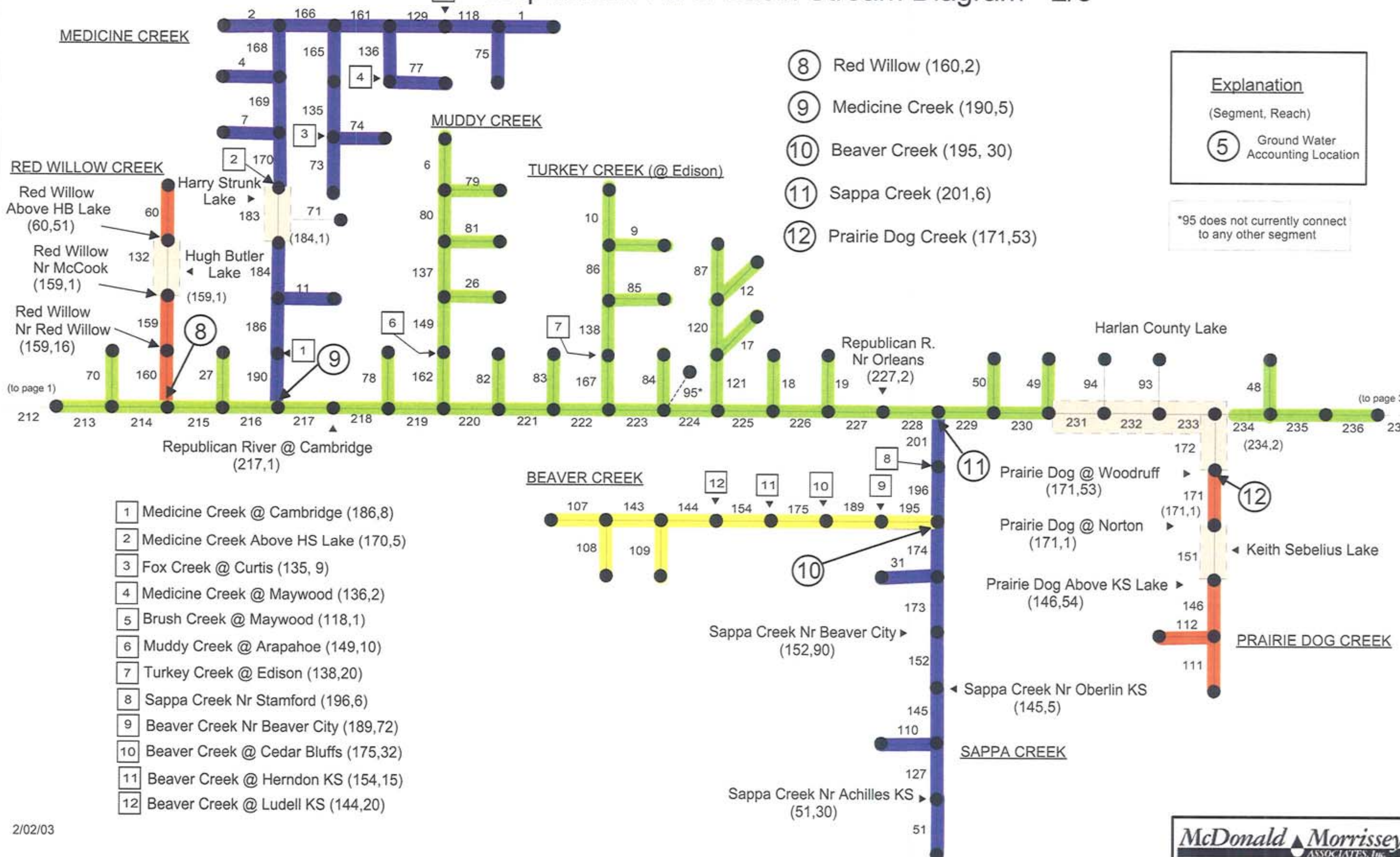
Republican River Basin Stream Diagram - 2/3



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Republican River Basin Stream Diagram - 3/3

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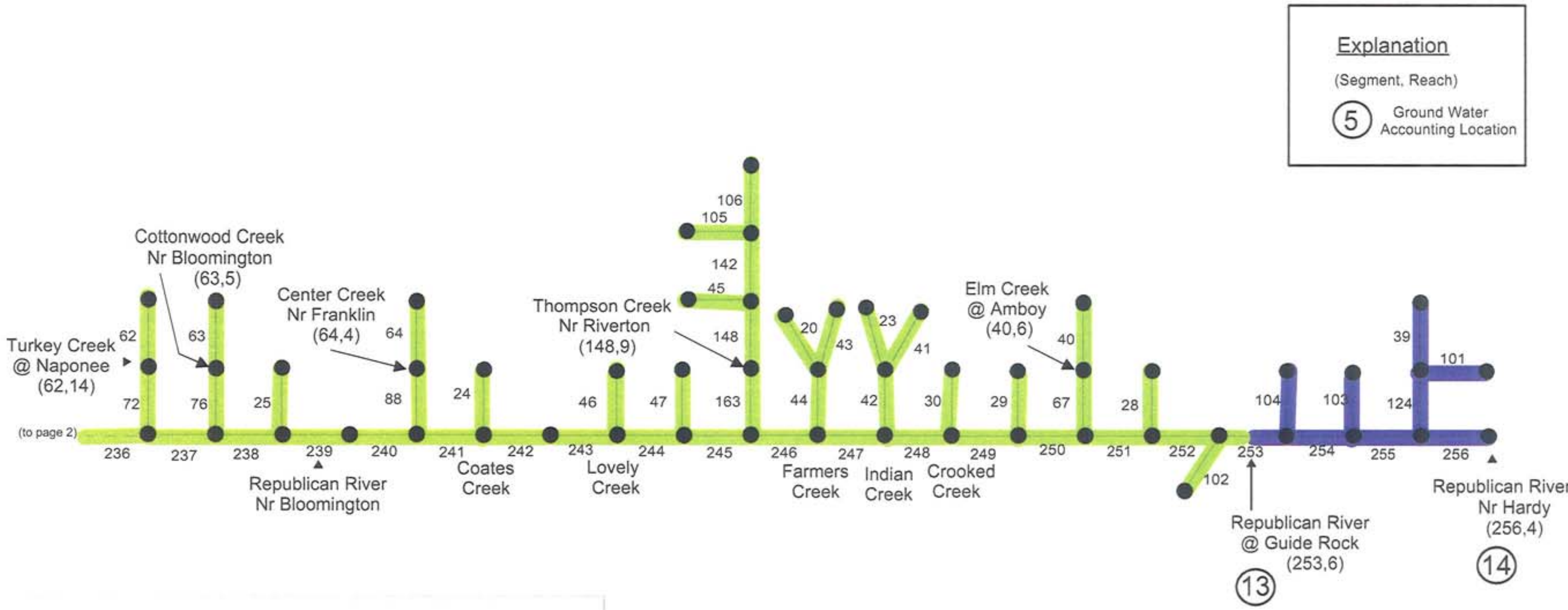

Other Stream Reaches (Names may not be exact)

Kansas		Nebraska	
Bow Creek	Segment(54)	Elk Creek	Segment(100)
North Fork Solomon River	Segment(57)	North Dry Creek	Segment(116)
South Fork Solomon River	Segment(82)	Plum Creek	Segment(117)
Smoky Hill Creek	Segment(89)	Little Blue River	Segment(257)
Smoky Hill Creek	Segment(90)	Dry Creek	Segment(258)
Saline River	Segment(91)		
Hackberry Creek	Segment(92)		
South Fork Solomon River	Segment(99)		
North Fork Smoky Hill Creek	Segment(113)		
South Fork Solomon River	Segment(128)		

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Republican River Basin Stream Diagram - 1/3

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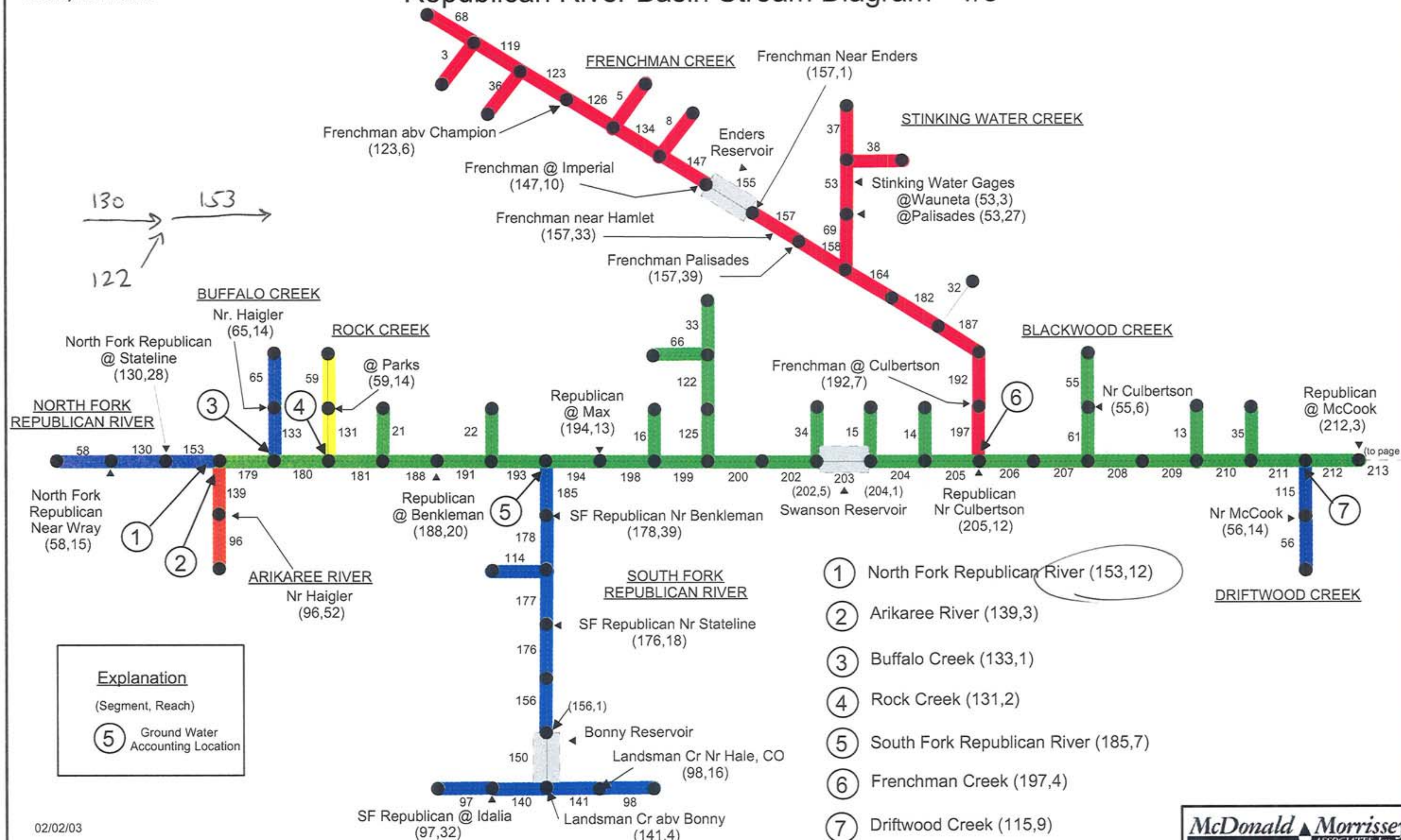

02/02/03

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Republican River Basin Stream Diagram - 2/3

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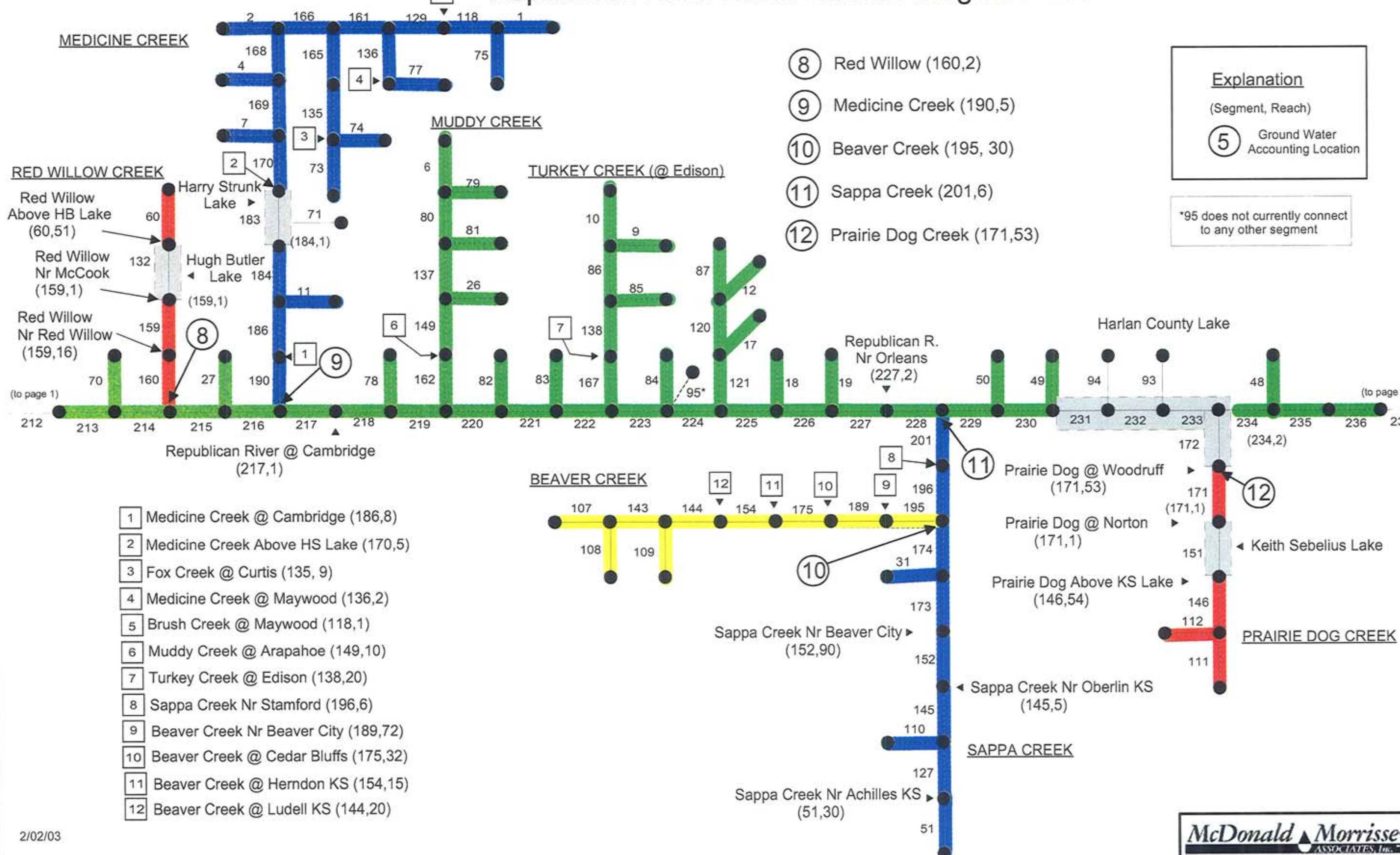

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Republican River Basin Stream Diagram - 3/3

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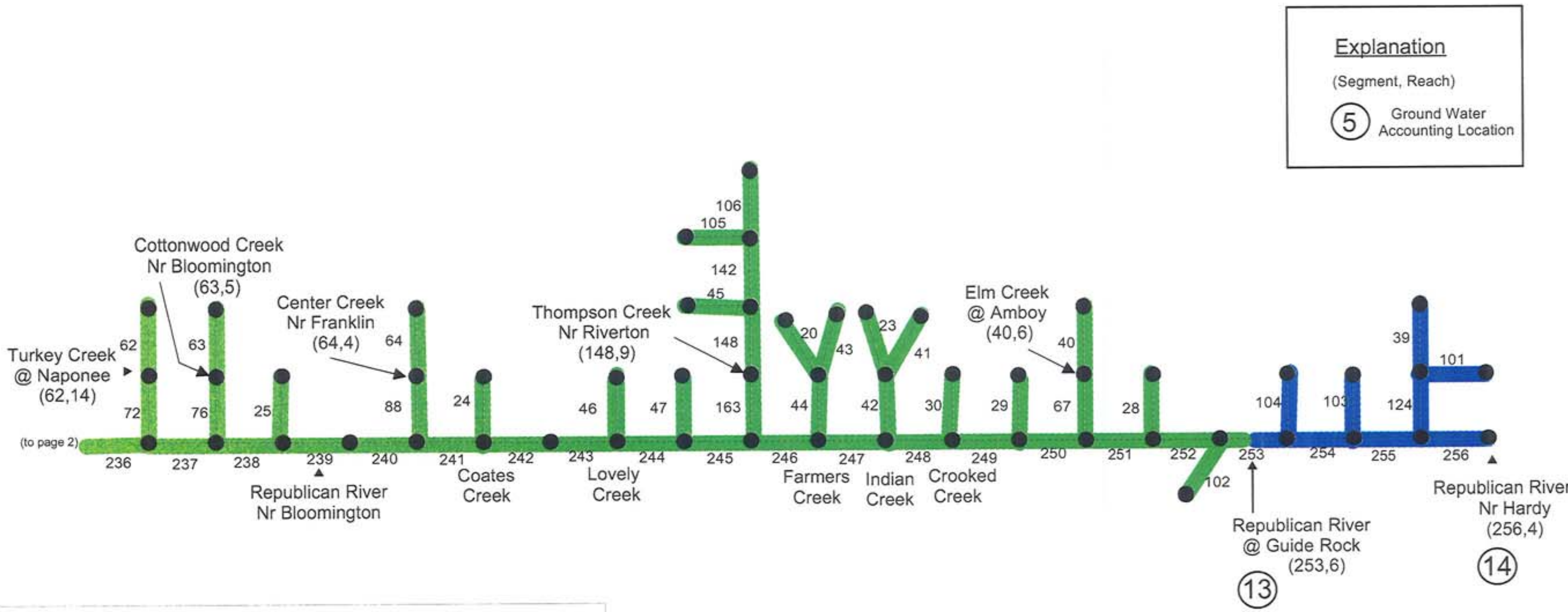

Other Stream Reaches (Names may not be exact)

Kansas		Nebraska	
Bow Creek	Segment(54)	Elk Creek	Segment(100)
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Smoky Hill Creek	Segment(90)	Dry Creek	Segment(258)
Saline River	Segment(91)		
Hackberry Creek	Segment(92)		
South Fork Solomon River	Segment(99)		
North Fork Smoky Hill Creek	Segment(113)		
South Fork Solomon River	Segment(128)		

2/07/03

McDonald Morrissey Associates, Inc.

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IN RE: NON-BINDING ARBITRATION PURSUANT TO THE FINAL SETTLEMENT STIPULATION, *KANSAS v. NEBRASKA AND COLORADO*, NO. 126 ORIGINAL

BEFORE MARTHA O. PAGEL, ARBITRATOR

EXPERT REPORT OF WILLEM SCHREÜDER, Ph.D.

I, Willem A. Schreüder, state the following:

(1) I understand that my role as an expert, both in preparing this report and in giving evidence, is to assist the arbitrator to understand the evidence or to determine facts in issue. The opinions expressed in my report are my own professional opinions.

(2) I have endeavored in my report and disclosures to be accurate and complete, and have addressed matters that I regard as being material to the opinions expressed, including the assumptions that I have made, the bases for my opinions, and the methods that I have employed in reaching those opinions.

(3) I have been advised by the attorney for the State of Colorado of the disclosure requirements of the rules of the arbitration, and I have provided in my report the information required by those rules. I have not included anything in my report and disclosures that has been suggested by anyone, including the attorney for the State of Colorado, without forming my own independent judgment on the matter.

(4) I will immediately notify, in writing, the attorney for the party for whom I am giving evidence if, for any reason, I consider that my existing report requires any correction or qualification; and, if the correction or qualification is significant, will prepare a supplementary report or disclosure to the extent permitted by the applicable rules of the arbitration.

(5) I have used my best efforts in my report and disclosures, and will use my best efforts in any evidence that I am called to give, to express opinions within those areas in which I have been offered or qualified as an expert by the arbitrator, and to state whether there are qualifications to my opinions.

(6) I have made the inquiries that I believe are appropriate and, to the best my knowledge, no matters of significance that I regard as relevant have been withheld from the arbitrator.

(7) I have disclosed any financial or pecuniary interest that I have in the results of this lawsuit or in any property or rights that are the subject of the lawsuit for which my report and disclosures are being submitted.

Dated this 24th day of May, 2010.

____

Willem A. Schreüder

I. Statement of Qualifications

I am the president of Principia Mathematica Inc., a firm that specializes in mathematical modeling, and an assistant professor adjunct in the Department of Computer Science of the University of Colorado at Boulder. I hold a Ph.D in Applied Mathematics (Computational Fluid Mechanics) from the University of Stellenbosch, South Africa (1986), and a Ph.D in Computer Science (Parallel Systems) from the University of Colorado at Boulder (2005). My resume is attached.

I was a member of the Modeling Committee that developed the Republican River Compact Administration (RRCA) Groundwater Model. Since the development of the model, I have hosted the RRCA web site and performed the annual runs of the RRCA Groundwater Model for the RRCA in accordance with the Final Settlement Stipulation (FSS) and the RRCA Accounting Procedures and Reporting Requirements.

I have devoted my professional career to mathematical modeling, with a special emphasis on basin scale groundwater flow models. In addition to the RRCA Groundwater Model, I have worked on many basin scale groundwater models, including models of aquifers or aquifer systems in the San Luis Valley (Rio Grande Basin), the South Platte Basin, the Arkansas River Basin, and the Raton Basin in Colorado, and the Carbonate Rock Province in Nevada, California and Utah, among others.

My professional consulting practice has primarily involved working with a team of experts to translate physical reality into a mathematical model of a system that captures the essential behavior of the physical system. In addition to 25 years of field experience in the quantification of agricultural water use in the western United States and in the Republican River Basin in particular, my academic background includes courses in geology, hydrology, physics, chemistry, mathematics and computer science.

I have previously been qualified by Courts as an expert in the areas of mathematics, mathematical modeling, data analysis, fluid dynamics, computational fluid dynamics including ground and surface water modeling, and the interpretations of related data. My opinions in this report are in those same areas.

II. Opinion

My opinion addresses the Colorado Compact Compliance Pipeline (the "Pipeline"), specifically the extent to which the operation of the Pipeline should be represented in the RRCA Groundwater Model (the "Model").

Opinion: Pumping from wells used to supply water to the Pipeline (the "Pipeline Wells") should be represented in the Model to determine depletion to stream flows caused by the Pipeline Wells, and the Final Settlement Statement expressly states that depletions from such wells will be computed by the Model and included in the State's Computed Beneficial Consumptive Use, but outflow from the Pipeline to the North Fork of the Republican River above the stream flow gage at the Colorado-Nebraska state line should ***not*** be represented in the Model.

Basis for the Opinion: Stream depletions caused by the Pipeline Wells cannot be measured, which is why a groundwater model was developed to determine stream depletions from well pumping, and the Model provides reasonable estimates of stream depletions caused by the Pipeline Wells for the purposes of the RRCA Compact Accounting. Outflow from the Pipeline to the North Fork of the Republican River can be measured and is by definition surface flow. The Model only represents baseflow, i.e., the groundwater contribution to stream flow. Incorporating the outflow from the Pipeline in the Model would be improper and could lead to double counting of stream depletions.

III. Introduction

The Republican River Compact (the "Compact") was written with surface water in mind. The Compact allocated water for beneficial consumptive use among the States of Colorado, Nebraska, and Kansas from the computed average annual virgin water supply originating in designated drainage basins that were calculated using a set of surface water gages. At the time the Compact was signed in 1942, this procedure for allocation of water for beneficial consumptive use was appropriate because the amount of groundwater use was minimal. However, even the original Compact contained some compromise. Although the goal of the Compact was to make allocations of water for beneficial consumptive use from the virgin water supply of designated drainage basins, the method of calculating the virgin water supply was limited by the existence of surface water gages, and the practical reality that surface water gages are limited to places along stream channels where an accurate flow measurement can be made.

Based on the Final Settlement Stipulation (FSS), two additional computations were added to the Compact Accounting: stream depletions caused by well pumping and stream flow accretions due to imported water from outside the basin.

As a result of groundwater withdrawals, the amount of flow in the streams in the basin is decreased. In the absence of groundwater withdrawals, typically called well pumping for short, there would have been more flow in these streams. The goal is therefore to determine what the stream flows would have been in the absence of pumping. This is done by estimating the change in stream flows caused by well pumping, which is called the Computed Beneficial Consumptive Use of groundwater ($CBCU_G$) in the RRCA Accounting Procedures. The $CBCU_G$ is a quantity that cannot be measured or reliably estimated from measurements. The only reasonably reliable method for estimating $CBCU_G$ is a groundwater model.

In the northern part of the Republican River Basin, a large volume of surface water is diverted from the South Platte and Platte Rivers. Some of that water enters the groundwater flow system of the Republican River as seepage from canals or irrigation return flow. This is water imported into the Republican River and Nebraska receives a credit for this water imported into the basin that is not part of the virgin water supply of the basin. The FSS requires that imported water be excluded from the virgin water supply calculation, and consumption of imported water is not be counted as CBCU under the Compact. (FSS, § IV.F). The goal is therefore to determine how much of the gaged flow at streamflow gages used in the Compact accounting is the result of imported water. Again, the only reasonably reliable method for estimating the increase in stream flows from water imported into the basin by Nebraska is a groundwater model.

The States therefore cooperated in the development of the RRCA Groundwater Model (Model). The purpose of the Model is to estimate those quantities that cannot be reliably estimated using measurements. Specifically, the Model is used to estimate the annual $CBCU_G$ and the imported water supply credit that Nebraska is entitled to as the result of water imported into the Basin.

The Model was implemented using the USGS MODFLOW-2000 program. This program is the most widely used groundwater flow program in the world. The Model represents the flow of groundwater using the vertically averaged saturated flow equations, that is, it represents the flow of water between the water table and the bottom of the aquifer. Inflow to the aquifer, such as recharge from applied irrigation water, canal leakage, and precipitation, is applied to the water table. Well pumping from the aquifer and the consumption of groundwater directly from the water table by plants (evapotranspiration) is also represented in the Model.

Quantification of interaction between surface water and groundwater is a key feature of the Model. The MODFLOW stream package is used to track baseflow in surface streams. The Model estimates the flow from the aquifer into surface streams. This flow in a surface stream resulting from groundwater discharge from the aquifer is called baseflow. The Model similarly estimates flows from surface streams to the aquifer. The direction and magnitude of the flow is given by Darcy's law. When the water table is higher than the water level in the stream (called the stage), the stream gains flow from the aquifer, as flow is from the aquifer to the stream. When the stage is higher than the water table, the stream loses flow to the aquifer.

It is important to note that the Model only represents the baseflow of surface streams. In reality, there are other inflows to surface streams, including runoff from precipitation and snowmelt, surface return flows from irrigation (tailwater), and reservoir releases. There are also diversions from streams for irrigation or other uses. These features are not represented in the Model because these quantities are quantified using stream gages or other methods in the RRCA Accounting Procedures. Including these features in the Model would lead to double counting of the depletions or accretions to stream flows caused by these features.

The Model was calibrated in transient mode to the historical period 1918 to 2000. The calibration process established aquifer parameters such as hydraulic conductivity and specific yield, as well as the relationship between recharge and precipitation, based on estimates of historical well pumping and recharge, observed water levels, and stream gains estimated from gaged flows. Gaged surface flows were analyzed to determine the amount of baseflow in the gaged surface flows, that is the amount of flow attributable to groundwater gains. The stream flow predicted in the Model, which is baseflow, was then compared against the baseflow determined from the gaged surface flows. The Model parameters were adjusted until the Model was able to reproduce the baseflow with a reasonable degree of accuracy.

In the construction of the Model, great care was taken to not double count impacts. Specifically, the Model considers only gains and losses to baseflow. By definition, baseflow is the portion of the flow in surface streams that is attributable to discharge of groundwater into the stream. The balance of the flow in surface streams is attributable to runoff from precipitation events, snow melt, reservoir releases and similar mechanisms.

Thus, the Model only considers depletions to those stream flows that have or would have accrued to the surface streams as baseflow. The reason for representing only baseflow in the Model is that the Compact contains explicit accounting for surface water. The purpose of the Model is only to estimate those quantities that cannot be measured, such as the stream flow depletions as a result of well pumping and stream flow accretions due to imported water. In the case of the reservoirs, some or all of the inflow into the reservoir may be baseflow. However, when this water is released from the reservoir, whether immediately or after being stored, that water is no longer considered baseflow. Instead, the flow is considered surface flow and the amount of surface flow is measured as it is released from the reservoir.

In order to estimate the change in stream flow caused by well pumping and due to imported water, the Model is run in a change mode. The Model is first run using the best estimates of the actual stresses that occurred. This run is called the "base" run in the RRCA Accounting Procedures. The Model is then run a second time. This run is called the "no State pumping" run in the RRCA Accounting Procedures, with the pumping and pumping recharge in one of the states shut off. This typically causes stream flows to be greater. The difference between the Model predicted stream flows in the historical and "no State pumping" runs is the Model estimate of the stream flow depletions, caused by well pumping.

IV. Modeling the Colorado Compact Compliance Pipeline

The Colorado Compact Compliance Pipeline (the "Pipeline") will deliver groundwater from wells that have historically been used for irrigation to supply new surface flow to the North Fork of the Republican River to offset stream depletions.

For practical reasons, the pumping from all of the groundwater rights retired from irrigation will be concentrated in eight of the wells, the "Pipeline Wells". Water pumped from these wells will be conveyed through the Pipeline to a point on the North Fork of the Republican River in Colorado just above the stream flow gage on the North Fork of the Republican River at the Colorado-Nebraska State Line.

Pumping from the Pipeline Wells will continue to cause depletions to stream flows. Just like other stream depletions from well pumping, the stream depletions caused by the Pipeline Wells can only be determined and evaluated using the Model. Therefore, the well pumping from the Pipeline Wells will be included in the Model to determine stream depletions from these wells, as provided in the FSS. The pumping from these wells will treated as fully consumptive as the water will be used to offset stream depletions for Compact compliance purposes.

The $CBCU_G$ resulting from the pumping of the Pipeline Wells will be included in Colorado's Computed Beneficial Consumptive use, as provided in the FSS. Specifically, the pumping from the Pipeline Wells will be included in the "base" run, while the pumping will be removed in the "no Colorado pumping" run. Therefore, the stream depletions caused by the Pipeline Wells will be determined using the Model.

The outflow from the Pipeline to the North Fork of the Republican River will be gaged. Since this flow can be directly measured, there is no need to use the Model to evaluate the fate of this flow. Flow at the North Fork gage will consist of baseflow, surface flow, and Pipeline flow. The Model determines to what extent the baseflow is depleted by well pumping however, the Model is not used to determine depletions to other components of surface flows. Therefore, the Model should not be used to determine depletions to the outflow of the Pipeline to the surface flows of the North Fork of the Republican River for the same reason that releases from reservoirs are not included in the Model.

As a result, no changes to the way that the Model is applied are required to account for the discharge from the Pipeline to the North Fork of the Republican River. The pumping from the Pipeline Wells will be included in the historical pumping. In the "no Colorado pumping" run the pumping from all wells in Colorado, including the Pipeline Wells, are removed and therefore impacts from the Pipeline Wells are included as part of Colorado's $CBCU_G$. But the discharge from the Pipeline should not be included in the Model.

V. Kansas Proposal for Modeling the Pipeline

Kansas proposed a modification to the Model for modeling the outflow from the Pipeline to the North Fork of the Republican River. Kansas' proposal was that in addition to using the Model to determine the stream depletions from the Pipeline Wells, the outflow from the Pipeline should also be incorporated in the Model. This would require that the Model be modified to allow the Pipeline outflow to be added to the Model's stream network above the North Fork streamflow gage. Under Kansas' proposal, the gaged outflow from the Pipeline would then be added as inflow to the North Fork in the "base" run. This flow would be tracked down the North Fork to Swanson Reservoir. At that point, the flow would then be removed from the stream network. This flow would then be used in the runs used to evaluate the impacts of Kansas and Nebraska well pumping and the credit for imported water. However, in the run without the Colorado pumping, the outflow from the Pipeline would also be removed.

The Kansas proposal is flawed for several reasons. First, it uses the Model to evaluate a quantity added to surface streamflow that can be directly measured, which is inconsistent with the way other surface flow changes are handled. Second, it selectively adds this flow between the State Line and Swanson Reservoir, but then fails to track it further downstream. Third, it fails to credit Colorado for all of the water delivered to the North Fork of the Republican River at the Colorado-Nebraska State Line for the benefit of the downstream States.

The outflow from the Pipeline will be gaged and will be included in the gaged flow of the stream flow gage on the North Fork of the Republican River at the Colorado-Nebraska state line. This is surface flow just as the surface flow that would be generated from a rainstorm upstream. The Model does not incorporate changes in the surface flow that is measured at the North Fork gage or any other surface water gages. The reason is that the Compact explicitly considers these measured flows. The Model was intended only for the purpose of estimating those quantities that increase or decrease surface flows that cannot be otherwise measured.

If the outflow from the Pipeline were included in the Model, Colorado would receive only partial credit for the water delivered to the North Fork at the State Line. Depending on the volume of water delivered and the time of year, Colorado would receive credit for less than 80% of the water delivered at the State Line. The reason for the difference is that in essence, Colorado only gets credit for the water that reaches Swanson Reservoir, some 50 miles downstream. In the reach between the State Line and Swanson Reservoir, some of the water is lost due to nearby pumping in Nebraska, evapotranspiration and similar losses. At times, especially during the summer, the river actually dries out along this reach. These are factors outside of Colorado's control, yet the Kansas proposal would only credit Colorado for that fraction of the water that actually reaches Swanson Reservoir. Since the Pipeline outflow will replace stream depletions above the streamflow gage on the North Fork at the state line, it is not appropriate to include this water in the Model in the reach below the gage.

The Kansas proposal is also inconsistent with other accounting in the RRCA Accounting Procedures. For example, 100% of all evaporation losses from reservoirs in Colorado are added to Colorado's CBCU because it is assumed that had that water not evaporated from the reservoir, it would have reached the compact accounting streamflow gage. In the case of Bonny Reservoir, there is more than 40 miles between the Reservoir and the gage, and recent experiences with reservoir releases showed that only a fraction of the water released from the reservoir would actually reach the gage. However, the Compact assumes that this is 100% of the evaporation from Bonny is added to Colorado's CBCU, which implies that all of that water would have reached the gage or have been put to beneficial use before it reached the gage and hence accounted for.

In the case of the Pipeline deliveries, water delivered to the North Fork of the Republican River at the state line is available to be put to beneficial use by Nebraska at the state line and will replace stream depletions calculated above the gage. Beyond the state line Colorado has no control over how Nebraska chooses to use its allocation under the Compact.

For example, the State of Nebraska may choose to divert 100% of the Pipeline deliveries one foot from the state line. Such a surface diversion would be accounted for in the surface water accounting under the Compact. However, this would not be represented in the stream network of the RRCA Groundwater Model because the Model considers only baseflow and does not represent diversions. However, under the Kansas proposal, that flow would still be included in the Model and only the fraction of the water that reaches Swanson Reservoir would be credited to Colorado.

VI. Accuracy of the Model

The Model is used to estimate depletions to stream flows due to well pumping and accretions to stream flows due to water imported into the basin by Nebraska that recharges the groundwater system – quantities that cannot be measured. The Model is not perfect, but provides a reasonable method for estimating these quantities. However, the key is that the Model should only be used to estimate those quantities that cannot be directly measured.

Where the Model is used, it should be borne in mind that the Model was calibrated in transient mode to the period 1918-2000, with the intent that it would be used to evaluate annual total $CBCU_G$ and imported water. The Model has not been demonstrated to be reliable on a shorter time scale. In fact, it is my opinion that the Model results are not sufficiently accurate that they could be used on a monthly basis to determine the time, location, and amount of stream flow depletions.

The purpose of the Model is to estimate the depletions to stream flows caused by well pumping and to estimate the accretions to stream flows due to water imported into the basin in Nebraska. Application of the Model for other purposes is not appropriate. Specifically, it is inappropriate to add a surface water inflow such as the Pipeline to the baseflow represented in the Model because the Model was not designed to or intended to represent surface water changes that can be measured.

VII. Conclusion

I base the foregoing opinions on my general knowledge of the Republican River Basin and the Compact Compliance Pipeline, the RRCA Groundwater Model, and my modeling knowledge and expertise. Any specific data that I considered for this report will be posted at *http://www.prinmath.com/ccp.*

My qualifications, a list of all publications authored by me in the previous 10 years, a list of all other cases in which, during the previous four years, I have testified as an expert at trial or by deposition are, and my rate of compensation also attached. My compensation is not dependent upon nor affected by the outcome of this matter.

IN RE: NON-BINDING ARBITRATION PURSUANT TO THE FINAL SETTLEMENT STIPULATION, *KANSAS v. NEBRASKA AND COLORADO*, NO. 126 ORIGINAL

BEFORE MARTHA O. PAGEL, ARBITRATOR

REBUTTAL REPORT OF WILLEM SCHREÜDER, Ph.D.

I, Willem A. Schreüder, state the following:

(1) I understand that my role as an expert, both in preparing this report and in giving evidence, is to assist the arbitrator to understand the evidence or to determine facts in issue. The opinions expressed in my report are my own professional opinions.

(2) I have endeavored in my report and disclosures to be accurate and complete, and have addressed matters that I regard as being material to the opinions expressed, including the assumptions that I have made, the bases for my opinions, and the methods that I have employed in reaching those opinions.

(3) I have been advised by the attorney for my client of the disclosure requirements of the rules of the arbitration, and I have provided in my report the information required by those rules. I have not included anything in my report and disclosures that has been suggested by anyone, including the attorney for my client, without forming my own independent judgment on the matter.

(4) I will immediately notify, in writing, the attorney for the party for whom I am giving evidence if, for any reason, I consider that my existing report requires any correction or qualification; and, if the correction or qualification is significant, will prepare a supplementary report or disclosure to the extent permitted by the applicable rules of the arbitration.

(5) I have used my best efforts in my report and disclosures, and will use my best efforts in any evidence that I am called to give, to express opinions within those areas in which I have been offered or qualified as an expert by the arbitrator, and to state whether there are qualifications to my opinions.

(6) I have made the inquiries that I believe are appropriate and, to the best my knowledge, no matters of significance that I regard as relevant have been withheld from the arbitrator.

(7) I have disclosed any financial or pecuniary interest that I have in the results of this lawsuit or in any property or rights that are the subject of the lawsuit for which my report and disclosures are being submitted.

Dated this 2nd day of July, 2010.

W A Schreüder

____
Willem A. Schreüder

I. Introduction

The following opinions are provided in rebuttal to the opinions of Steven P. Larson in his report titled "Kansas Expert Response to Colorado's Expert Report," dated June 22, 2010 ("Larson Report")

II. Source of Water for the Pipeline

Mr. Larson expresses the opinion that the origin of the augmentation water that will be pumped as part of Colorado's Compact Compliance Pipeline proposal distinguishes it from other water that might be in the surface stream system such as surface runoff, return flows from surface water irrigation, or releases of water in reservoirs that retain surface water for later use (Larson Report p.3). He states that this water should be considered as "short circuited" baseflow because it is water that would ultimately have contributed to stream baseflow but has been intercepted by the augmentation wells and placed in the stream sooner than it would have reached the stream otherwise (Larson Report p. 3).

It is incorrect that groundwater that will be pumped from the Compact Compliance Pipeline Wells (Pipeline Wells) is water that would ultimately have contributed to stream baseflows. Runs of the RRCA Groundwater Model demonstrate that the depletions to stream baseflows caused by the Pipeline Wells are only a small percentage of the total volume of groundwater produced by these wells. The balance of the water comes primarily from groundwater storage. Water that will be placed in the Pipeline is groundwater that was historically used for the irrigation of crops in Colorado and was fully consumed. However, under the Colorado proposal the water will instead be placed in the North Fork of the Republican River to offset stream depletions. To the extent that pumping of the Pipeline Wells will cause stream depletions, the Colorado proposal is to use the RRCA Groundwater Model to compute the net stream depletions caused by the Pipeline Wells and include the resulting stream depletions in Colorado's Computed Beneficial Consumptive Use of groundwater ($CBCU_G$). This procedure complies with Subsection III.B.1.k and Subsection IV.H of the Final Settlement Stipulation (FSS).

Further, the origin of the augmentation water does not distinguish it from other water that might otherwise be in the surface stream system. Stream baseflow in a surface stream that is diverted for irrigation use or stored in reservoirs, such as Swanson Reservoir and Harlan County Reservoir, is considered surface flow when it is diverted or evaporated or released from the reservoirs, and the Computed Beneficial Consumptive Use of such diversions, evaporation, and reservoir releases is calculated using the RRCA Accounting Procedures for calculating the Computed Beneficial Consumptive Use of surface water. *See* RRCA Accounting Procedures, Subsection IV.A.2.a-f. Therefore, the origin of the augmentation water is not a proper basis for determining whether the augmentation credit should or should not be calculated with the RRCA Groundwater Model. If the augmentation water is discharged into a surface stream in the Basin, as in Colorado's proposal, the water should be treated as other surface water is treated in the RRCA Accounting Procedures. If the augmentation water is not discharged directly into a surface stream but is used to recharge the groundwater system, the RRCA Groundwater Model should be used to determine the credit, for the same reason the RRCA Groundwater Model is used to determine the credit for water imported into the basin by Nebraska. The origin of the water imported into the basin by Nebraska was not the reason the credit for the imported water is calculated using the RRCA Groundwater Model. Instead, Nebraska's imported water supply credit is calculated with the model because the imported water recharges the groundwater system and is not delivered to a surface stream. If the imported water had been delivered directly to a surface stream, the RRCA Groundwater Model should not be used to calculate the credit for the imported water.

II. Accuracy of the Model

Mr. Larson states that Colorado asserts that the RRCA Groundwater Model is not sufficiently accurate to calculate changes to surface water that is added to the stream (Larson Report p. 7). This distorts my opinion.

I stated that the RRCA Groundwater Model is sufficiently reliable for the purpose of calculating $CBCU_G$ as provided in the RRCA Accounting Procedures. All Compact accounting, except for determining Nebraska's Compact compliance during water-short year administration, is done on a five-year running average in accordance with the RRCA Accounting Procedures. *See* FSS, Subsection IV.D. The RRCA Groundwater Model was considered calibrated to a sufficient degree that depletions from groundwater pumping and accretions from imported water from the Platte River could be quantified and assigned to prescribed streamflow reaches in accord with the RRCA Accounting Procedures. Final Report of the Special Master with Certificate of Adoption of RRCA Groundwater Model, p. 7. However, the model has not been demonstrated to be reliable when:

1 Operated at a shorter time scale such as, for example, months;

2 Operated at a finer spatial resolution, for example, less than a sub-basin;

3 Operated to quantify impacts other than well pumping or imported water recharge on baseflows, for example, the impact of adding water to a surface stream represented in the model, such as augmentation water.

It should be reiterated that while the RRCA Groundwater Model calculates baseflow at selected points in the Basin, it is only used to quantify ***changes*** in baseflow as a result of well pumping or the recharge resulting from imported water. *See* RRCA Accounting Procedures, Subsections III.D.1 and III.A.3. Use of the model for any other purpose has not been demonstrated to be reliable.

III. Negative Impacts

Mr. Larson devotes much of his report to a discussion of the "negative" pumping impacts that occur in the State Line-Swanson reach on the Main Stem. It appears that Kansas' proposal to include the Pipeline water in the RRCA Groundwater Model is primarily intended to counteract what it views as the "benefit" that Colorado derives in some years from the "negative impacts" that are calculated for the reach from the State Line to Swanson.

It is worth noting that the RRCA Groundwater Model does not predict an increase in baseflows as a result of groundwater pumping, but the values for sub-basins and the Main Stem include depletions as well as accretions because in a losing stream reach the depletions to baseflow will diminish if the baseflow entering that reach diminishes. Subsection III.D.1 of the RRCA Accounting Procedures recognizes that the values calculated for each sub-basin and the Main Stem using the RRCA Groundwater Model will include depletions and accretions:

> 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 of 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.

In the area where the North Fork of the Republican River crosses the Colorado-Nebraska State Line, the Pierre Shale underlying the Ogallala aquifer is very near the ground surface. Therefore, much of the groundwater flowing from west to east in this area appears as baseflow in the North Fork upstream of this location. To the east of the state line, where the aquifer deepens, the stream loses much of this baseflow as it seeps back into the aquifer.

The result is that the Main Stem is a losing reach between the State Line and Swanson Reservoir. While nearby well pumping would exacerbate the losses in this reach, the reach was a losing reach before well development. The RRCA Accounting Procedures quantify the ***change*** in these losses due to well pumping as $CBCU_G$. However, the stream losses that occur through such processes as groundwater storage and evaporation are not an activity of man and are not charged against any State's CBCU.

The State Line-Swanson reach is not unique. Other losing reaches in the model include the South Fork in Kansas and the lower reaches of Sappa Creek.

"Negative impacts," which are nothing more than decreased losses in stream reaches, are not unique to this reach either. Kansas' $CBCU_G$ on Sappa Creek was negative (i.e., decreased losses) from 1999 to 2007. This provided a "benefit" to Kansas. "Negative impacts" were also calculated for Kansas on the Swanson to Harlan reach of the Main Stem, in addition to the State Line-Swanson reach.

The fact that there are "negative impacts," or decreased losses, simply reflects the physical reality that when the basin is subdivided into sub-basins, the impacts do not occur in a simple pattern. The basinwide impacts are the arithmetic sum of the sub-basins and the Main Stem, and the appearance of "negative impacts" or decreased losses simply reflects the physical reality that the losses occurred in another sub-basin because groundwater impacts cross sub-basin boundaries. In every sub-basin where there is a losing reach, losses decrease when baseflows into that reach is decreased by upstream depletions. In most cases, the impacts in these sub-basins are just diminished. However, in the case of the Above Swanson reach, the decrease is sometimes sufficient to result in a negative.

IV. Fate of Augmentation Water

Mr. Larson states that when augmentation water is delivered to the stream system, it will interact with the underlying groundwater system in the same manner as other baseflows as it flows downstream (Larson Report p. 5). He states that the stream baseflow would have experienced this same fate if it had not been depleted by pumping (Larson Report p. 5). His proposal to include the augmentation water in the RRCA Groundwater Model, which is adopted by the other Kansas experts, in essence charges Colorado a transit loss for the Pipeline water from the Colorado-Nebraska State Line to Swanson Reservoir by using the groundwater model to determine how much of the flow will be lost in the reach.

I disagree with including the water discharged from the Colorado Pipeline in the RRCA Groundwater Model for this purpose because this would be inconsistent with how other surface water in the Basin is handled in accordance with the RRCA Accounting Procedures. The RRCA Groundwater Model is not used to calculate the losses on any other surface flows and it would be completely inconsistent to make an exception for water discharged from the Colorado Pipeline simply because there are "negative Impact" in the reach below where the Pipeline water is added. The RRCA Groundwater Model is not used to determine losses on other water in the surface stream, even when the water in the surface stream is consumed or added above a losing reach.

For example, baseflows that are stored in Swanson Reservoir and Harlan County Reservoir are not included in the RRCA Groundwater Model when releases are made from the reservoirs to calculate the losses on the reservoir releases. Once baseflow becomes part of a surface stream, it is accounted for in accordance with the RRCA Accounting Procedures for surface water. The transit losses are indirectly reflected in the diversions in the stream reach, stream gage readings, or the storage contents of a reservoir where a reservoir is at the end of the stream reach.

Evaporation from Bonny Reservoir occurs about 50 miles upstream of the Benkelman streamflow gage (USGS gaging station number 06827500, South Fork of the Republican River near Benkelman, Nebraska). This reach of the South Fork is also a losing reach. It has been well established by releases from Bonny Reservoir in recent years that if the water that evaporated from the reservoir were instead to have been released, only a fraction (if any) of the water would have reached the Benkelman gage. However, the RRCA Accounting Procedures do not provide that the RRCA Groundwater Model will be used to determine how much of that evaporated water would have reached the gage. Instead, 100% of the evaporated water is added to the virgin water supply and Colorado's CBCU.

Furthermore, when a surface water right that was historically used for irrigation is retired, and additional stream flow becomes available as a result, the RRCA Groundwater Model is not used to determine the fate of that water. Nor is the RRCA Groundwater Model used to determine the fate of surface runoff that occurs from rainfall. In all these instances, water is simply accounted for using the RRCA Compact Accounting Procedures for surface water and the specific formulas for each sub-basin and the Main Stem.

It is worth repeating that the RRCA Compact Accounting Procedures were applied for decades with an understanding that streams lose and gain water. What is new since the FSS is that the RRCA Groundwater Model is used to estimate the CBCU of groundwater, which is added to the CBCU from other sources. This is done by estimating the *changes* in the baseflows as a result of turning all well pumping "on" in the "base" run and turning the pumping of one State "off" in the "no State pumping" run. *See* RRCA Accounting Procedures, Subsections III.D.1. In no instance is the RRCA Groundwater Model used to calculate transit losses on surface water as proposed by Kansas and, in my opinion, it would not be appropriate to use the model for that purpose and would be inconsistent with the way other surface water is accounted for in the RRCA Accounting Procedures.

V. Expected Aquifer Life

Mr. Larson states that groundwater levels in Colorado, and especially in the area within and near the proposed augmentation well field, have been steadily declining over the past several decades (Larson Report p. 7). He states that water level data collected by the USGS show that water levels have declined by more than 50 feet since the late 1960s and almost 20 feet in the last decade in the proposed well field area. He expresses the opinion that based on current rates of water level decline, the thickness would be exhausted in about 150 years (Larson Report p. 7).

Mr. Larson's opinion about the expected aquifer life appears to be based on a simple extrapolation of the current rate of decline into the future. While one can make such as extrapolation, it is not reasonable in my opinion to assume that current rates of groundwater level decline in the proposed well field area will continue indefinitely into the future. It is important to note that the Pipeline Wells were specifically chosen because they are located in the area of the aquifer within Colorado with the most saturated thickness. In some parts of the basin in Colorado, the saturated thickness has already been significantly depleted. Under Colorado law, replacement wells must be placed within 200 feet of the original permitted well location. Furthermore, the drilling of additional wells to improve the water supply is prohibited. The result is that as the saturated thickness decreases, it becomes increasingly difficult to produce an adequate water supply. Towards the edge of the Basin in Colorado, this problem is particularly acute. In the southern half of the Basin in Colorado, there is also significantly less remaining saturated thickness than in the northern part of the Basin.

Due to declining water levels and the physical difficulty of obtaining a water supply in areas of limited saturated thickness, the high cost of the power required to lift water to the surface when well production is extremely limited, as well as the fee imposed by the

RRWCD WAE on the diversion of groundwater for irrigation, it is anticipated that the current rate of pumping will decline significantly in the future. The RRWCD WAE has also provided cost sharing for federal programs to convert irrigated lands in the RRWCD to non-irrigated use. Making a projection of when the saturated thickness in the proposed well field area will be exhausted based on the current rates of water level decline is therefore not reasonable, especially because Colorado experienced an extended period of significant drought in the last decade, and in my opinion the 150-year estimate significantly underestimates the expected aquifer life in the vicinity of the Pipeline Wells.

VI. Conclusion

I am not persuaded by Mr. Larson's arguments that it is correct to include the Augmentation water in the model. It remains my opinion that the Colorado proposal is correct and consistent with other procedures in the Compact Accounting procedures.

Non-Binding Arbitration initiated August 21,2009
pursuant to
Decree of May 19, 2003, 538 U.S. 720
Kansas v. Nebraska & Colorado
No. 126, Orig., U.S. Supreme Court

Kansas Expert Response to Colorado's Expert Report, "Expert Report of Willem Schreüder, Ph. D."

Prepared by

Steven P. Larson
S. S. Papadopulos & Associates, Inc.

June 22, 2010

Qualifications

This report was prepared under my supervision and direction. I am a principal and the Executive Vice President of S.S. Papadopulos & Associates, Inc. (SSP&A), a firm that provides consulting services related to environmental and water-resource issues. My area of expertise is hydrology, with emphasis on groundwater hydrology.

I hold a Bachelor of Science in Civil Engineering from the University of Minnesota, conferred in 1969, and a Master of Science in Civil Engineering, also from the University of Minnesota, conferred in 1971. I am a member of the Association of Ground Water Scientists and Engineers (a division of the National Ground Water Association) and the American Institute of Hydrology. I am also certified as a Professional Hydrologist/Ground Water with the American Institute of Hydrology.

Prior to joining SSP&A in 1980, I was employed as a hydrologist with the Water Resources Division of the U.S. Geological Survey (USGS) for almost 9 years. During my tenure with the USGS, I conducted numerous hydrological studies on a variety of groundwater and surface water problems and conducted research into the development of mathematical models to simulate groundwater flow processes. This work included working on the project that ultimately led to the development of the program, MODFLOW, which was the program used to construct the RRCA Groundwater Model. I have spent the last 29 years with SSP&A conducting and managing projects related to a variety of environmental and water-resource issues. During my tenure at SSP&A, I have been involved in numerous projects covering a wide spectrum of technical, environmental, and legal issues including environmental impact evaluations, evaluations of water-resource development, water-rights permitting and adjudication, remedial investigations at CERCLA and other waste-disposal sites, feasibility studies, engineering evaluations/cost analyses, and remedial action plans.

I have also testified as an expert in numerous legal and administrative forums. These cases have included permit and licensing hearings, water-rights adjudications, arbitration hearings, interstate compact claims, toxic torts, liability claims, various legal actions under CERCLA, property damage claims, and insurance claims. A copy of my curriculum vitae appears in the appendix to this report.

As part of my work for the State of Kansas on issues related to the Republican River, I served as an expert on modeling regarding development of the RRCA Groundwater Model. Further, I was a member of the Modeling Committee on behalf of the State of Kansas that was charged with development of the groundwater model. In that capacity, I actively participated in the technical efforts by the three states in development, calibration, and operation of the RRCA Groundwater Model. As a result of that work, I am very familiar with the groundwater Model, its structure, its capabilities, and the manner in which it is applied for use in the RRCA Accounting Procedures.

Opinions

1. Colorado's augmentation credit should be calculated using the RRCA Groundwater Model.

2. The RRCA Groundwater Model is capable of computing the augmentation credit.

3. Augmentation water is intended to replace depletions to stream base flow.

4. Augmentation water added to the stream is analogous to other stream base flow that is calculated with the model and is derived from the same source of water that provides the natural stream base flow.

5. Assertions by Colorado that the RRCA Groundwater Model is either not designed to compute impacts to augmentation water added to the stream or is not sufficiently accurate to compute such impacts are inconsistent with the design and use of the model as approved in the FSS.

6. The current level of groundwater use in Colorado is not sustainable over the long term. At current rates of water level decline in the area within and near the proposed augmentation well field, the aquifer will be dewatered in approximately 150 years.

Bases for Opinions

Introduction

One of the issues regarding Colorado's Compact Compliance Pipeline proposal is determining the appropriate credit to apply to augmentation water that will be added to the stream to replace depletions to stream base flows caused by pumping of groundwater. It is important to distinguish in this determination that, in this case, the source of water for augmentation is the same source of water that sustains stream base flows in the Republican River Basin. That is, groundwater from the Ogallala aquifer is the origin of stream base flows in the basin. The augmentation water will be pumped from this same aquifer and discharged into the stream in an attempt to offset the reductions in stream base flows created by irrigation pumping.

The origin of the augmentation water distinguishes it from other water that might be in the stream system such as surface runoff, return flows from surface water irrigation, or releases of water in reservoirs that retain surface runoff for later use. This augmentation water should be considered as "short circuited" base flow. It is water that would ultimately have contributed to stream base flow but has been intercepted by the augmentation wells and placed into the stream sooner that it would have reached the stream otherwise.

It is also important to recognize that this augmentation water is being taken from the same source that is being depleted by pumping for irrigation water supply and will have commensurate impacts on stream base flows. Consequently, over time, augmentation pumping will impact stream base flows and those impacts will contribute to the amount of replacement water that may be necessary to maintain compliance with the compact.

Negative Pumping Impacts

Another issue that is important to recognize in considering the credit to be applied to augmentation water is the occurrence of what we will call "negative pumping impacts". Negative pumping impacts are, in effect, negative stream depletions caused by pumping. Normally, we expect pumping to cause depletions to stream flows. As pumping proceeds, stored groundwater is depleted and the impact of pumping on groundwater levels spreads until those impacts reach a stream. At this point, stream base flows begin to decline as some of the pumped water is derived from depletion of the stream base flows. Thus, we would normally expect to see decreased stream base flows and/or increased stream losses over time as pumping continues.

In the accounting of impacts due to pumping in the Republican River Basin, calculations of stream impacts are made at various points throughout the stream system. Generally, at points such as the North Fork at the Colorado-Nebraska state line, the calculations reflect changes to stream base flows that accumulate above that accounting point. At other points, such as the reach from the state line to Swanson Reservoir, the calculations reflect changes to the gains or losses in stream base flow that accumulate within a particular reach. Depending on the circumstances, this latter calculation could show that pumping by one state, such as Colorado, decreases the losses in a reach as compared to losses that would have occurred if that pumping had not occurred. This apparent benefit to stream base flow caused by pumping is seemingly counter intuitive and in a sense is a "negative pumping impact" as compared to what would normally be anticipated.

Effect of Negative pumping Impacts on Accounting

While there is an explanation for what is happening in instances where "negative pumping impacts" occur, the net effect in the accounting process is to reduce the overall impact of pumping on stream base flow depletions caused by pumping. The explanation lies in the nature of stream conditions that can occur in certain stream reaches and the nature of the calculations that comprise the accounting process. For example, when stream reaches become "dry", it means that base flows are fully depleted by as they attempt to pass through the reach. When the same reach is considered in a "no pumping" scenario in which one of the states' pumping is turned off, it is possible that the losses in such a reach can be greater than they were in the alternative scenario where the pumping was on.

The stream accounting points include both locations where stream base flows accumulate and reaches over which base flow gain or loss is calculated. In the accounting process at these locations, the difference between the conditions with the pumping on and the conditions with the pumping off are calculated. At most of the locations, the stream base flow conditions with pumping off are larger than the comparable conditions with the pumping on and the difference is positive and is characterized as stream base flow depletion caused by pumping. However, in reaches where "negative pumping impacts" occur, this difference is negative indicating that losses are greater when pumping is on than when pumping is off. When the overall impact is determined in the accounting process, these negative values can offset some of the positive values associated with stream base flow depletion due to pumping.

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<u>Fate of Augmentation Water</u>

When augmentation water is delivered to the stream system, it will interact with the underlying groundwater system in the same manner as other stream base flows as it flows downstream. In stream reaches where the stream base flow is diminishing due to exfiltration, the flow of augmentation water can also diminish. As a practical matter, stream base flow would have experienced this same fate if it had not been depleted by pumping. As a result, some of the augmentation water may not reach downstream accounting points. Losses of augmentation water as it travels downstream can affect groundwater conditions and, as a result, impact the determination of consumptive use and the determination of virgin water supply.

<u>Trend in Negative Pumping Impacts</u>

In some stream reaches of the Republican River system, negative pumping impacts have increased over time as pumping has lowered groundwater levels and have increased the propensity to have "dry" stream segments. As a result, the accounting process for some stream segments shows increasing offsets to stream base flow depletions over time as pumping impacts continue to expand. This increase in offsets has been occurring over time in the reach from the state line to Swanson Reservoir and Colorado has benefited from the reduction in overall stream base flow depletions that are determined in the accounting process that are afforded by these offsets. Furthermore, according to the projections made by Colorado and similar projections made by Kansas, the offsetting effect due to negative pumping impacts will significantly increase in the future if pumping continues to occur at rates similar to those that have occurred in the past.

<u>Colorado's Accounting Proposal for Augmentation Water</u>

Colorado asserts that they should be given credit for augmentation water delivery at the state line. In other words, if the pipeline delivered water to the stream at the state line, the full amount of that delivery should be counted as a credit against Colorado's exceedance of its compact allocation. At the same time, Colorado would also receive the benefit of increased offsets due to negative pumping impacts that occur in the reach from the state line to Swanson Reservoir. This increased offset is the result of increasing depletions to stream base flows that are sustained by a continuation of excess pumping in Colorado. In other words, Colorado would determine impacts to its pumping without considering the effect of augmentation water on groundwater conditions and on the changes in gains and losses to base flows as the augmentation water moves downstream. This approach ignores some of the potential downstream effects of augmentation water on groundwater conditions that can impact the determination of consumptive use and virgin water supply.

Kansas has proposed that the augmentation water be input into the model calculations so it can be considered in the same manner as other stream base flow. This is appropriate in that the augmentation water is replacing stream base flow depletions, the water is derived from the same source of water that provides base flow to streams in the basin, and the impacts to the augmentation water as it moves downstream are considered. This approach is also consistent with the requirements for how augmentation water should be considered under the FSS for the determination of augmentation credit. This approach does not ignore some of the potential downstream effects of augmentation water on groundwater conditions that can impact the determination of consumptive use and virgin water supply.

Colorado has asserted that it is inappropriate to consider reductions in the augmentation credit due to losses that may be incurred to the augmentation water below the state line. Yet, in the agreed upon accounting procedures in the FSS, Colorado receives an offset due to negative pumping impacts in the reach from the state line to Swanson Reservoir. While each of the states agreed to include such offsets in the accounting of stream base flow depletions in the FSS, the Colorado proposal is structured to allow a continuing increase in the offsets below the state line. This continuing increase is caused by a continuation of irrigation pumping that is caused by Colorado exceeding its compact allocation. Consequently, Colorado wants to receive full credit for augmentation water at the state line and, at the same time, receive increases in offsets to stream base flow depletion below the state line that are the result of the continuation of irrigation pumping that the augmentation water is intended address. Thus, Colorado wants to enjoy the benefits of negative pumping impacts below the state but is unwilling to accept the effects of impacts to augmentation water below the state line.

The Kansas proposal treats the overall accounting of Colorado's actions in a balanced manner. It allows for continued offsets due to negative pumping impacts below the state line and, at the same time, subjects the augmentation water to the same conditions below the state line that produce the negative pumping impacts. The Kansas approach is straightforward and easy to apply. The Kansas approach is consistent with the requirements of the FSS that the augmentation credit be determined with RRCA Groundwater Model.

Colorado asserts a number of reasons why it is not appropriate to add augmentation water into the modeling calculations that provide the basis for the accounting in the FSS. None of these reasons are sufficient to reject the concept of including the augmentation water in the modeling process. For example, Colorado asserts that certain components of stream flow are not included in the model and that augmentation water is the same as these other components and should not be included. While it is true that certain components of stream flow such as surface runoff, return flows from surface water irrigation, and reservoir releases are not included in the model calculations, stream base flows and the gains and losses to those flows as they transit through stream system are included. These stream base flows are surface water, just as the augmentation water is surface water. Furthermore, as described previously, augmentation water is derived from groundwater that would have ultimately contributed to stream base flow if it was not intercepted by pumping. Thus the mere labeling of augmentation water or comparing augmentation water to other types of water that are not included in the model is not a basis for excluding augmentation water from being included in the modeling process.

Colorado also asserts that the model was intended to provide determinations of components to the accounting process that cannot be measured and since the augmentation water will be measured it should not be included in the model. Again, the fact that the augmentation water will be measured prior to being placed in the stream system does not preclude consideration of impacts to augmentation water after it is discharged into the stream system and flows downstream from the state line.

Colorado asserts that the model is not sufficiently accurate to calculate changes to surface water that is added to the stream. The accuracy of the model in terms calculating groundwater levels, changes to groundwater levels, stream base flows and changes to stream base flows is a matter of record in the development of the model. The model's ability to simulate these conditions was considered and addressed as part of the model calibration process. Ultimately, the states have agreed that the model can be used to make such calculations including gains and losses to stream base flows as they migrate downstream. Impacts to augmentation water as it migrates downstream would be calculated in exactly the same manner as the calculation of impacts to other stream base flows as they migrate downstream. The results of the these calculations would be incorporated into the accounting process in the same way that results for other stream base flows would be incorporated. Again, the Colorado assertion has no basis.

Groundwater levels in Colorado and especially in the area within and near the proposed augmentation well field have been steadily declining over the past several decades. Water level data collected by the USGS show that water levels have declined more than 50 feet since the late 1960s and almost 20 feet in the last decade in the proposed well field area. Aquifer saturated thickness in this area is on the order of 200 to 300 feet based on data compiled for the RRCA Groundwater Model. Based on current rates of water level decline, this thickness would be exhausted in about 150 years.

Summary

The RRCA Groundwater Model has been approved and adopted by the Supreme Court of the United States to quantify the amount, location, and timing of stream flow depletions to the Republican River. These quantifications include calculations of gains and losses to stream base flows as they transit through the stream network within the Republican River system. These quantifications also include changes in stream flow conditions resulting from changed conditions within Colorado caused by pumping for irrigation, pumping for augmentation and stream flow augmentation.

Colorado receives a credit against stream flow depletions in portions of the stream network where "negative pumping impacts" occur. This credit occurs largely in the main stem reach below the state line above Swanson Reservoir. Colorado receives this credit in spite of the fact that its allocation of the water supply does not extend below the state line. Calculations by the RRCA Groundwater Model of gains and losses to stream base flow in this reach are part of the determination of this credit.

The CCCP proposal will, in effect, be a continuation of pumping from the aquifer system with a portion of that pumping being discharged into the stream system rather than being used for irrigation water supply. The purpose of the stream flow augmentation is to replace stream depletions that are above Colorado's water supply allocation. This augmented stream flow will interact with the aquifer system in the same manner that other stream base flows interact as they transit downstream from the state line. The RRCA Groundwater Model is designed and approved for the purpose of determining gains and losses to stream base flows or augmented stream base flows as they transit downstream.

The RRCA Groundwater Model is the appropriate tool for calculating the augmentation credit associated with groundwater pumped from the aquifer for the purpose of augmenting stream flow to replace stream depletions caused by pumping. The model is fully capable of making this calculation and use of the model for this purpose is consistent with the requirements for determining the augmentation credit under the terms of the FSS.