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**To:** Peter Ampe – Hill & Robbins, P.C. – Counsel for the Republican River Water Conservation District  
Deb Daniel – Republican River Water Conservation District Manager

**From:** Randy L. Hendrix  
Willem Schreuder – Principia Mathematica

**Date:** September 7, 2018

**Subject:** September 2018 Projected Delivery for the Colorado Compact Compliance Pipeline

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The RRCA approved the “Resolution by the Republican River Compact Administration Approving Operation and Accounting for the Colorado Compact Compliance Pipeline and Colorado’s Compliance Efforts in the South Fork Republican River Basin” August 24, 2016. Colorado is operating the Compact Compliance Pipeline (CCP) in 2018 under the provisions described in that resolution.

The projected CCP delivery requirement to meet Colorado’s obligation under the Compact in 2018 is approximately 13,400 ac-ft under the approximate delivery obligation of:

Time Period	Amount of CCP Delivery (ac-ft)
January - March	5,538
April	1,652
September	615
October - December	5,595
Total	13,400

January through April values represent actual deliveries and September through December are estimated at a delivery rate of 31 cfs per day. Therefore, our recommendation is to start the winter deliveries for the pipeline on September 20<sup>th</sup>. The attached Tables 1 and 2 summarizes the calculations used to derive the delivery amount. The following section briefly describe the data and the estimated data used to develop the projections.

## Data Utilized to Determine Delivery Amount

The Republican River Compact Administration (RRCA) Groundwater Model was run to obtain an estimate of the Groundwater Computed Beneficial Consumptive Use (CBCU). For groundwater pumping the 2017 data was repeated for 2018. Historical precipitation data and streamflow data was utilized when available. Long term average data was used when historical data was not available. Reservoir stages and potential evapotranspiration values were estimated to be the same as the 2017 values. Streamflow records for 2018 were estimated using engineering judgement and historical streamflow records.

The projections were made using water short year administration on Harlan County Reservoir. The 5-run model approach was utilized in these projections. Bonny Reservoir was modeled as an accounting point for all years.

**Table 1** (page 1 of 3)  
**Operation of the Colorado Compact Compliance Pipeline**  
(units of ac-ft)

Jan - Dec Calendar Year	North Fork Basin Accounting									Arikaree Basin Accounting					
	North Fork Gaged Flow	Consumptive Use								Gaged Flow	Consumptive Use				Virgin Flow
		CCP Deliveries	Net North Fork Gaged Flows for Virgin Flow Calculations	0.40 x Haigler Canal Divs Measured at Stateline	CO SW and Small Res Evap	CO GW Con Use	KS GW Con Use	NE GW and SW Con Use	Virgin Flow		CO SW	CO GW	KS GW and Non- Fed Res Evap	NE GW	Virgin Flow
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
2000	19,435	0	19,435	2,368	3,122	13,173	15	4,709	42,822	3,631	0	1,918	128	196	5,873
2001	19,752	0	19,752	2,004	2,809	13,534	18	4,683	42,800	553	0	1,288	190	341	2,372
2002	15,904	0	15,904	2,258	3,172	13,562	14	5,324	40,234	231	0	401	114	351	1,097
2003	17,700	0	17,700	1,986	2,615	14,023	17	4,381	40,722	1,060	0	242	100	507	1,909
2004	19,759	0	19,759	1,493	3,022	14,373	16	3,685	42,348	341	0	353	157	431	1,282
2005	21,060	0	21,060	1,898	3,171	14,359	17	4,290	44,795	1,151	0	811	163	250	2,375
2006	17,608	0	17,608	1,767	3,140	14,301	12	4,017	40,845	404	0	1,116	130	125	1,775
2007	20,333	0	20,333	1,809	3,014	14,790	0	3,612	43,559	1,308	0	1,143	117	112	2,680
2008	21,638	0	21,638	1,998	671	15,004	0	3,925	43,235	1,567	0	1,536	106	124	3,333
2009	24,405	0	24,405	1,677	265	15,783	0	3,468	45,598	779	0	4,011	162	153	5,106
2010	20,418	0	20,418	2,016	325	15,479	0	3,999	42,238	2,358	49	1,446	109	73	4,035
2011	19,722	0	19,722	1,930	354	15,689	0	3,899	41,594	1,074	33	1,830	170	93	3,200
2012	14,376	0	14,376	2,452	583	15,309	0	4,698	37,418	494	63	1,558	116	78	2,309
2013	18,433	0	18,433	1,536	377	15,649	0	3,362	39,357	91	45	458	214	126	934
2014	26,707	7,448	19,259	1,244	285	16,283	0	2,962	40,034	0	21	1,141	236	128	1,526
2015	27,895	10,760	17,135	1,467	512	16,424	0	3,324	38,862	142	23	2,829	192	108	3,294
2016	28,091	10,130	17,961	1,596	419	16,820	0	3,550	40,346	397	37	2,638	196	147	3,415
2017	26,046	11,330	14,716	1,893	297	16,906	0	4,013	37,825	646	12	2,102	168	77	3,005
2018	28,000	13,400	14,600	1,893	297	17,345	0	4,044	38,179	700	12	2,297	195	54	3,258
2019	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	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
2022	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
2024	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

**Table 1** (page 2 of 3)  
**Operation of the Colorado Compact Compliance Pipeline**  
(units of ac-ft)

	South Fork Basin Accounting							CO Compact Allocation				
		Consumptive Use						22.4% 78.5% 44.4%				All Basins
Jan - Dec Calendar Year	Gaged Flow at Benkelman	CO SW + CO Small Res Evap	CO GW + Bonny Res Seepage	CO Bonny Res Evap	KS GW, Non-Fed Res Evap, SW CU	NE GW	Virgin Flow	North Fork	Arikaree	South Fork	Colorado Allocation of Beaver Creek (See Table 5F in Water Short Year)	Total of All Basins
(1)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)
2000	4,855	2,732	10,450	5,557	6,333	982	30,909	9,592	4,610	13,723	1,940	29,866
2001	3,097	980	10,964	3,972	7,515	641	27,170	9,587	1,862	12,063	1,500	25,012
2002	1,579	2,288	10,765	5,750	4,933	1,282	26,598	9,012	861	11,809	0	21,683
2003	905	598	12,115	3,375	5,390	1,347	23,730	9,122	1,499	10,536	0	21,156
2004	0	770	12,874	3,158	6,091	1,202	24,094	9,486	1,006	10,698	0	21,190
2005	0	275	14,952	3,430	7,525	1,372	27,553	10,034	1,864	12,233	0	24,131
2006	0	0	11,757	3,031	4,723	1,040	20,551	9,149	1,394	9,124	0	19,667
2007	674	266	12,511	2,428	5,670	1,055	22,605	9,757	2,104	10,036	1,576	23,473
2008	1,397	52	14,707	1,766	5,933	1,021	24,876	9,685	2,617	11,045	3,080	26,426
2009	8,407	101	14,976	1,020	7,856	1,302	33,661	10,214	4,008	14,946	3,100	32,268
2010	12,756	919	11,938	1,921	3,016	625	31,174	9,461	3,167	13,841	2,890	29,360
2011	9,916	177	13,092	1,965	6,164	941	32,256	9,317	2,512	14,322	2,580	28,730
2012	6,441	107	9,321	67	2,568	810	19,314	8,382	1,813	8,575	1,860	20,630
2013	0	52	12,321	0	5,190	473	18,036	8,816	733	8,008	76	17,633
2014	0	150	13,868	0	8,552	1,027	23,597	8,968	1,198	10,477	22	20,665
2015	4,819	408	13,865	0	5,528	918	25,537	8,705	2,586	11,339	724	23,353
2016	3,898	331	13,883	0	5,835	904	24,851	9,037	2,681	11,034	780	23,532
2017	2,385	444	13,537	0	4,734	699	21,799	8,473	2,359	9,679	2,450	22,960
2018	1,980	370	13,908	0	5,121	741	22,120	8,552	2,558	9,821	538	21,469
2019	0	0	0	0	0	0	0	0	0	0	0	0
2020	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
2022	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
2024	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

**Table 1** (page 3 of 3)  
**Operation of the Colorado Compact Compliance Pipeline**  
(units of ac-ft)

	CO Consumptive Use							Colorado Compact Compliance Accounting				
	Instate			GW Con Use in Nebraska								
Jan - Dec Calendar Year	North Fork	Arikaree	South Fork	Buffalo and Rock Creek	French- man Creek	Rep River Mainstem	Total Colorado Con Use	Annual Amount Colorado Exceeded Compact Entitlement <b>BEFORE</b> <b>CCP Delivery</b>	CCP Deliveries	Annual Amount Colorado Exceeded Compact Entitlement after Accounting for CCP Delivery	5-year Running Average of the Amount Colorado Exceeded Compact Entitlement after Accounting for CCP Delivery	
(1)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	
2000	16,295	1,918	18,739	276	599	-4,242	33,585	3,719	0	3,719		
2001	16,343	1,288	15,917	293	569	-4,166	30,244	5,231	0	5,231		
2002	16,734	401	18,804	298	619	-6,155	30,700	9,017	0	9,017		
2003	16,638	242	16,088	324	37	132	33,460	12,304	0	12,304		
2004	17,395	353	16,802	348	39	-1,269	33,668	12,478	0	12,478	8,550	
2005	17,530	811	18,656	367	42	-1,954	35,452	11,321	0	11,321	10,070	
2006	17,441	1,116	14,788	383	43	-3,009	30,762	11,094	0	11,094	11,243	
2007	17,804	1,143	15,205	406	55	-2,062	32,552	9,079	0	9,079	11,255	
2008	15,675	1,536	16,525	429	370	-2,487	32,048	5,621	0	5,621	9,919	
2009	16,048	4,011	16,097	451	2,917	-1,549	37,975	5,707	0	5,707	8,564	
2010	15,804	1,495	14,777	472	3,030	-2,698	32,880	3,520	0	3,520	7,004	
2011	16,043	1,863	15,234	492	2,554	-2,305	33,881	5,151	0	5,151	5,816	
2012	15,892	1,621	9,495	513	1,485	-6,712	22,294	1,664	0	1,664	4,333	
2013	16,026	503	12,373	531	1,125	-1,919	28,639	11,005	0	11,005	5,410	
2014	16,568	1,162	14,018	554	951	-1,162	32,092	11,427	7,448	3,979	5,064	
2015	16,936	2,852	14,273	584	1,769	-2,649	33,765	10,411	10,760	-349	4,290	
2016	17,239	2,675	14,214	608	1,600	-2,436	33,900	10,368	10,130	238	3,307	
2017	17,203	2,114	13,981	614	1,206	-3,316	31,802	8,841	11,330	-2,489	2,477	
2018	17,642	2,309	14,278	622	989	-2,356	33,485	12,015	13,400	-1,385	-1	
2019	0	0	0	0	0	0	0	0	0	0	-797	
2020	0	0	0	0	0	0	0	0	0	0	-727	
2021	0	0	0	0	0	0	0	0	0	0	-775	
2022	0	0	0	0	0	0	0	0	0	0	-277	
2023	0	0	0	0	0	0	0	0	0	0	0	
2024	0	0	0	0	0	0	0	0	0	0	0	
2025	0	0	0	0	0	0	0	0	0	0	0	

**Table 2**  
**Surface Water Data Used in Accounting**  
(units of acre-feet)

Calendar Year	Streamflow Gages					Colorado Surface Water Diversions			Reservoir Evaporation					Beaver Creek		
	North Fork at CO-KS Stateline Gage	Measured Compact Compliance Pipeline Delivery	Haigler Canal Stateline Flume	Arikaree at Haigler, NE Gage	South Fork at Benkelman Gage	Total North Fork Divs including CO Pioneer	Colorado Arikaree Divs	Colorado South Fork Divs	Colorado Non-Fed Res Evap in North Fork	Colorado Non-Fed Res Evap in South Fork	Kansas Non-Fed Res Evap in Arikaree	Kansas Non-Fed Res Evap and Small SW Div Con Use in South Fork	Bonny Res Evap	Colorado Compact Entitlement in non-water short years	Colorado Beaver Creek Reduced Allocation' Water Short Years	Water Short Year (Yes/No) CO receives no Beaver Creek Allocation in Water Short Year
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
2000	19,435	0	5,921	3,631	4,855	5,203	0	4,554	0	0	0	13	5,557	1,940	0	
2001	19,752	0	5,011	553	3,097	4,682	0	1,634	0	0	0	65	3,972	1,500	0	
2002	15,904	0	5,646	231	1,579	5,286	0	3,814	0	0	0	41	5,750	770	770	Yes
2003	17,700	0	4,965	1,060	905	4,358	0	996	0	0	0	39	3,375	260	260	Yes
2004	19,759	0	3,732	341	0	4,960	0	1,283	46	0	41	310	3,158	360	360	Yes
2005	21,060	0	4,745	1,151	0	5,213	0	458	43	0	41	298	3,430	910	910	Yes
2006	17,608	0	4,418	404	0	5,150	0	0	50	0	46	325	3,031	1,420	1,420	Yes
2007	20,333	0	4,522	1,308	674	4,961	0	444	38	0	18	143	2,428	2,320	744	Yes
2008	21,638	0	4,995	1,567	1,397	1,056	0	87	37	0	14	121	1,766	3,080	0	No
2009	24,405	0	4,193	779	8,407	394	0	169	28	0	7	65	1,020	3,100	0	No
2010	20,418	0	5,041	2,358	12,756	474	81	1,336	41	117	11	98	1,921	2,890	0	No
2011	19,722	0	4,826	1,074	9,916	530	55	39	36	154	14	119	1,965	2,580	0	No
2012	14,376	0	6,129	494	6,441	886	105	0	51	107	24	213	67	1,860	0	No
2013	18,433	0	3,839	91	0	553	75	0	45	52	17	147	0	1,130	1,054	Yes
2014	26,707	7,448	3,110	0	0	412	35	184	38	40	11	100	0	1,250	1,228	Yes
2015	27,895	10,760	3,668	142	4,819	792	38	616	37	38	14	124	0	2,130	1,406	Yes
2016	28,091	10,130	3,991	397	3,898	636	62	510	37	25	13	118	0	2,430	1,650	Yes
2017	26,046	11,330	4,732	646	2,385	432	20	716	38	14	11	97	0	2,450	0	No
2018	28,000	13,400	4,732	700	1,980	432	20	594	38	14	11	97	0	2,390	1,852	Yes
2019																
2020																
2021																
2022																
2023																
2024																
2025																

USGS, BOR, and RRCA Accounting records used when available. Missing data estimated from historical values using engineering judgement.