SUPPLEMENTAL MATERIALS

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Characterization of the Water Supply of the Rio Grande Project Based on Rio Grande Compact Reports 1940–2020

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1. Introduction

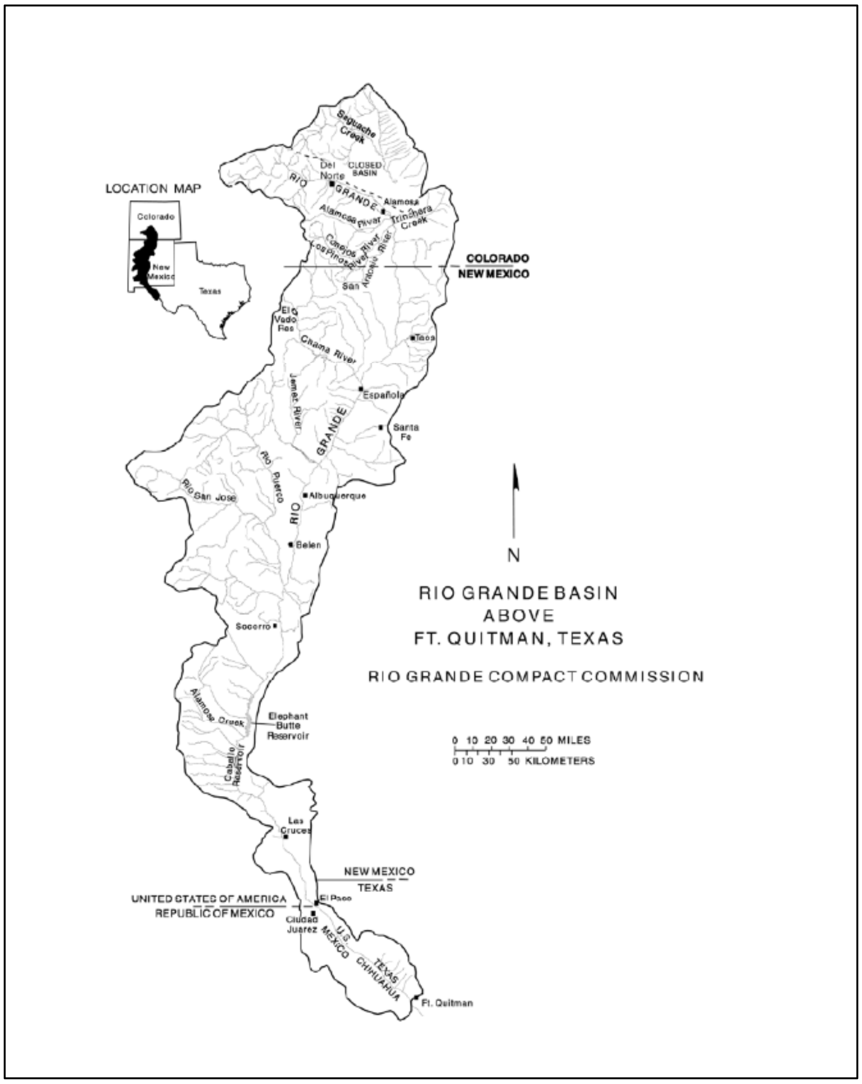

Fig. S1. Map of geographical location encompassed by the Rio Grande. (Reprinted from Rio Grande Compact Report 2020.)

2. Data

For the years of record, 1940 to 2020, we organized the Index Supply, Scheduled Delivery, Actual Delivery, and credits and debits series for Colorado and for New Mexico into Table S1. The units are thousand-acre feet (KAF). The data used in this study for years 2011 to 2020 is the one called Method 1 in the Compact Reports. Since 2011 there has not been consensus regarding the Compact accounting between the engineer advisors who represent the participating States so different methods of accounting have been proposed and used since then. The reasons for the disagreement from 2011 to 2020 are different from each State; however, the main reasons relate to claims from Colorado and New Mexico for the “unauthorized release” of water by the U.S. Bureau of Reclamation, the source of the water, and account for deliveries from Colorado and New Mexico. Details about the lack of consensus between the States are in the addenda to the Compact Commission Reports for those years (Rio Grande Compact Reports, 2011-2020).

Table S1. Index Supply, Scheduled Delivery, Actual Delivery, and credits and debits for Colorado and for New Mexico, 1940 to 2020. Thousand-acre feet (KAF).

Year	Conejos Index	Conejos Scheduled	Rio Grande Index	Rio Grande Scheduled	Total Scheduled	Lobatos Actual+10k	CR/DR	Elephant Butte Scheduled	Elephant Butte Actual	CR/DR
1940	220.5	57.3	312	77.7	135	115.7	-19.3	334.6	276.2	-58.4
1941	583.7	357.7	1025.8	458.4	816.1	964.3	148.2	2318.5	2425.5	107
1942	394.9	183.8	848	290.6	474.4	695.2	220.8	1824.6	1811	-13.6
1943	280.4	95.7	198.2	126.5	222.2	193.5	-28.7	395.6	337.2	-58.4
1944	427.1	211.8	850.4	292.3	504.1	616.3	112.2	956	876.9	-79.1
1945	355.9	151.8	538	139.9	291.7	287	-4.7	785.6	768.4	-17.2
1946	197.7	43.8	128.3	105.9	149.7	125.2	-24.5	220.3	265.9	45.6
1947	306	113.6	639.8	177.9	291.5	240.3	-51.2	429.2	361.4	-67.8
1948	304.2	183.2	907.9	342.11	525.31	674.2	148.9	1033.6	919.7	-113.9
1949	411.5	198.1	919.5	352.6	550.7	582.7	32	941.3	942.5	1.2
1950	226.4	60.8	470.1	118	178.8	142.1	-36.7	281.5	298.1	16.6
1951	162.2	26.1	308.8	76.9	103	84.3	-18.7	204.2	135.5	-68.7
1952	581.2	357.2	826	275.2	632.4	478.4	-154	1019	897.6	-121.4
1953	211.4	51.8	401.3	98.4	150.2	132.1	-18.1	299.2	273.5	-25.7
1954	183.2	36.6	381.1	93.5	130.1	69.6	-60.5	246.2	232	-14.2
1955	186.3	38.2	368.5	90.4	128.6	73.1	-55.5	250.4	269.7	19.3
1956	226.8	61.1	333.5	82.4	143.5	80.6	-62.9	205.1	153	-52.1
1957	547.4	323.5	843.7	287.6	611.1	454.9	-156.2	1068.5	1127.9	59.4
1958	345.3	143.4	723.9	216	359.4	372.5	13.1	1102.1	1103.9	1.8
1959	168.2	29.1	367.2	90.1	119.2	98.4	-20.8	242.4	213.2	-29.2
1960	297.2	107.1	602.4	163	270.1	211	-59.1	470.2	520	49.8
1961	296.8	106.8	500.3	127.1	233.9	179.2	-54.7	463.6	510.3	46.7
1962	390.7	180.4	756.6	232.7	413.1	326.2	-86.9	669.3	721.3	52
1963	156.1	23	329.5	81.5	104.5	82.6	-21.9	237.7	231	-6.7
1964	213.8	53.3	369.3	90.6	143.9	67.6	-76.3	225	158.7	-66.3
1965	501	279	929.1	361.2	640.2	510.6	-129.6	983.6	951.4	-32.2
1966	282.1	96.8	578.8	154.4	251.2	265.4	14.2	467	487.4	20.4
1967	271.7	89.8	399.6	97.9	187.7	170.4	-17.3	325.9	366.9	41
1968	327.8	130.1	669	190.4	320.5	340.8	20.3	521.1	604.6	83.5
1969	383.9	174.8	657.6	185.3	360.1	425.1	65	769.5	882	112.5
1970	316.1	121.2	654.7	184.1	305.3	333.5	28.2	493.9	525.3	31.4
1971	221.2	57.7	484.4	122.3	180	216.8	36.8	325	367.8	42.8
1972	157.9	24	477.3	120.2	144.2	172.3	28.1	271.1	424.7	153.6
1973	447.2	229.5	832.2	279.5	509	530.7	21.7	1171.3	1098.4	-72.9
1974	193.8	41.9	337.5	83.2	125.1	131.5	6.4	257.2	305.9	48.7
1975	416.4	202.4	807.1	262	464.4	476.7	12.3	786.8	849.8	63
1976	272.9	90.6	589.9	158.4	249	259	10	395.3	378.9	-16.4

1977	96.4	0	215.3	61.5	61.5	71.2	9.7	169	201.5	32.5
1978	248.9	74.3	406.1	99.7	174	184.5	10.5	405.4	377.6	-27.8
1979	476.9	256.7	953.7	383.7	640.4	635.8	-4.6	1483.7	1381.9	-101.8
1980	422.7	208	750.1	229.1	437.1	461.7	24.6	988.3	967	-21.3
1981	169.8	29.9	409.3	100.6	130.5	141.5	11	237.8	187.5	-50.3
1982	450	232	697.5	202.9	434.9	449.7	14.8	784.7	810.4	25.7
1983	387.9	178.1	672.8	192	370.1	397.7	27.6	998.5	1044.2	45.7
1984	382.6	173.7	761.6	235.5	409.2	425.1	15.9	939.7	942.1	2.4
1985	577.7	353.7	1007.2	437.9	791.6	887.1	95.5	1764.1	1291.8	-472.3
1986	478.3	258	1032.8	466.1	724.1	814.2	90.1	1400.9	1569	168.1
1987	361.9	156.8	1017	448.7	605.5	843.4	237.9	1257.4	1262.1	4.7
1988	202.1	46.3	434.8	107.7	154	194.7	40.7	623.2	685.6	62.4
1989	247.4	73.4	494.1	125.2	198.6	219.5	20.9	414.7	393.2	-21.5
1990	198	44	524	135.2	179.2	184	4.8	388.6	357.7	-30.9
1991	361	156	605.5	164.2	320.2	321.4	1.2	837.8	942.1	104.3
1992	254.8	78.3	484.5	122.4	200.7	250.6	49.9	679.3	795.5	116.2
1993	440.9	224	655.1	184.2	408.2	409.7	1.5	1084.5	1100.2	15.7
1994	350.3	147.2	539.4	140.4	287.6	296.6	9	834.6	950.3	115.7
1995	469.1	249.6	830.6	278.4	528	537.9	9.9	1287	1172.4	-114.6
1996	190.8	40.4	397.6	97.4	137.8	140.2	2.4	256.5	325.3	68.8
1997	401.5	189.3	946.7	377	566.3	567	0.7	926	969.3	43.3
1998	266.8	86.4	577.6	153.9	240.3	249.2	8.9	536.7	596.9	60.2
1999	313.3	119.1	914.2	347.8	466.9	474.4	7.5	710	744.9	34.9
2000	142.4	17	390.8	95.8	112.8	124.2	11.4	233.3	353.6	120.3
2001	282.4	97	725.4	216.7	313.7	300.3	-13.4	494.9	416.4	-78.5
2002	59.7	0	154.6	46.4	46.4	81	34.6	145.2	284.1	138.9
2003	181.3	35.6	319.2	79.2	114.8	83.8	-31	270.3	222.8	-47.5
2004	265.1	85.3	527.8	136.5	221.8	226.2	4.4	371.5	407	35.5
2005	416.1	202.2	793.3	253.2	455.4	458	2.6	949.5	957.1	7.6
2006	247.9	73.7	570.3	151.3	225	237.1	12.1	329.8	572.9	243.1
2007	280	95.4	710.2	209.1	304.5	298.9	-5.6	513.5	546.3	32.8
2008	402.5	190.2	708.5	208.2	398.4	403.9	5.5	816.2	883.3	67.1
2009	350.4	147.3	592.8	159.4	306.7	299.3	-7.4	540	622.9	82.9
2010	282.9	97.4	538.5	140.1	237.5	239.5	2	535.4	620.4	85
2011	258.6	80.8	502.3	127.8	208.6	210	1.4	328.4	281.3	-47.1
2012	175.2	32.6	404.1	99.1	131.7	136.5	4.8	268.4	239.8	-28.6
2013	153	21.5	458.3	114.5	136	139.6	3.6	249.8	310.1	60.3
2014	225.5	60.3	637.8	177.1	237.4	240.1	2.7	333	284.6	-48.4
2015	243.8	71.3	663.5	187.9	259.2	260.4	1.2	482.1	482.5	0.4
2016	279.7	95.2	664.8	188.5	283.7	285.9	2.2	433	412.4	-20.6
2017	439.5	222.8	688.2	198.8	421.6	415.4	-6.2	853	871.7	18.7
2018	160.4	25.2	277.4	70.5	95.7	99.2	3.5	178.1	184.2	6.1
2019	430.5	214.8	925.8	358.2	573	571.3	-1.7	957.4	914.2	-43.2
2020	167.5	28.8	376.4	92.3	121.1	121.7	0.6	241.3	182.9	-58.4

3. Methods

3.1. Transfer Function Model (TFM). The TFM is explicitly written as:

$$\delta(B)Y_t = \omega(B)X_{t-b} + \eta_t \quad \text{(S1)}$$

where b is the delay parameter in the input system; η_t is the noise component with an autoregressive moving average form; $\delta(B)$ and $\omega(B)$ are components that make up the transfer function, where

$$\delta(B) = 1 - \delta_1 B - \delta_2 B^2 - \cdots - \delta_r B^r \quad \text{(S2)}$$

and

$$\omega(B) = \omega_0 - \omega_1 B - \omega_2 B^2 - \cdots - \omega_s B^s \quad \text{(S3)}$$

where r and s are the orders of the polynomials on B, the backshift operator defined as $B^r Y_t = Y_{t-r}$ (Box and Jenkins 1976). As affirmed by the studies of Quilez et al. (1992) and Salmani and Jajaei (2016), the advantage of this model is that the TFM explains more of the variance especially in cases where the relationship between the time series is not instantaneous and offers more accurate predictions.

3.2. Model selection. The model selection was primarily based on the Akaike Information Criterion (AIC), which estimates the prediction error which is an indicator of the relative quality of statistical models considered.

$$\omega(B) = \omega_0 - \omega_1 B - \omega_2 B^2 - \cdots - \omega_s B^s \quad \text{(S4)}$$

where k is the number of estimated parameters in the model and $\hat{L}$ is the maximum values of the likelihood function for the model. The model with the smallest AIC value is chosen as the best model. Two alternative model selection criteria were considered, the Root Mean Square Error (RMSE) and the Mean Absolute Percentage Error (MAPE), to determine which model was most accurate in prediction. RMSE measures the error of a model in forecasting quantitative data, while MAPE is a measure of prediction accuracy of a forecasting method. The formulas of the RMSE and MAPE are:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(F_i - A_i)^2} \quad \text{(S5)}$$

and

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{A_i - F_i}{A_i}\right| \qquad \text{(S6)}$$

where n is the number of observations, A_i is the i-th actual value, and F_i the forecast value of the i-th observation ($i = 1, 2, \cdots, n$).

4. Results and Discussion

To answer the research question that guided the study, we characterized the Schedule Delivery, Actual Delivery, and their difference, annual credits and debits, as well as accrued debits.

4.1. Water availability

We compared the Scheduled, Actual, and credits/debits figures from technical note, Figure 2 for Colorado and Figure 3 for New Mexico. Visually it seems like for both, Colorado and New Mexico, the available levels of water were higher from 1940 to 1984, or what we called Early; and lower between 1985 and 2020, which we defined as Late. Table S2 for Colorado and Table S3 for New Mexico describe the data statistically for Scheduled and Actual.

In Table S2 for Colorado, the mean for Early and Late for Scheduled (312, 305 KAF, 384,846,333 and 376,211,960 m^3 respectively), and for Actual (309, 322 KAF, 381,145,888 and 397,181,152 m^3) were very similar. The ranges for Early and Late for Scheduled are alike (754, 745 KAF, 930,045,305 and 918,943,968 m^3), however for the Actual are farther apart, (896, 806 KAF, 1,105,199,726 and 994,186,361 m^3). The interquartile range, which represents how far apart the lower and the upper measures of the data are, shows that for Scheduled and Actual, the measures for Early are higher (306 and 326 KAF, 377,445,442 and 402,115,079 m^3) than the measures for Late (257 and 227 KAF, 317,004,832 and 280,000,377 m^3). Considering the coefficient of variation, is about the same for all combinations, Schedule Delivery Early (SchEarly) (0.60), Schedule Delivery Late (SchLate) (0.60), Actual Delivery Early (ActEarly) (0.68), and Actual Delivery Late (ActLate) (0.64).

Table S2. Descriptive Statistics Scheduled Delivery and Actual Delivery, Early and Late, Colorado, thousand-acre feet (KAF)

Stat	Sch CO Early	Sch CO Late	Act CO Early	Act CO Late
Mean	312	305	309	322
Median	270	249	259	255
Stand Dev	186	183	211	208
Min	61	46	67	81
Max	816	791	964	887
Sum	14076	11014	13947	11622
Coeff Var	0.60	0.60	0.68	0.64
Count	45	36	45	36

Table S3. Descriptive Statistics Scheduled Delivery and Actual Delivery, Early and Late, New Mexico, thousand-acre feet (KAF)

Stat	Sch NM Early	Sch NM Late	Act NM Early	Act NM Late
Mean	644	625	644	644
Median	467	524	510	584
Stand Dev	465	386	468	360
Min	169	145	135	182
Max	2318	1764	2425	1569
Sum	28998	22525	28985	23206
Coeff Var	0.72	0.62	0.73	0.56
Count	45	36	45	36

Table S3 demonstrates that the averages for Early and Late for Scheduled (644, 625 KAF, 794,362,304 and 770,926,148 m^3 respectively), and for Actual (644 and 644 KAF) are all very similar. The range for Early for Scheduled (2,149 KAF, 2,650,752,468 m^3) is around 530 KAF (653,745,374 m^3) higher than that for Late (1,618 KAF, 1,995,773,613 m^3), and for Actual the difference is even broader 903 KAF (1,113,834,099 m^3), Early (2,290 KAF, 2,824,673,408 m^3) Late (1,386 KAF, 1,709,605,827 m^3). The interquartile range shows that for the Scheduled and Actual, the measures for Early are higher (705 and 656 KAF, 869,604,695 and 809,164,085 m^3) than the measures for Late (520 and 602 KAF, 641,410,556 and 742,556,066 m^3). Lastly, the coefficient of variation is about the same for Early for Schedule (0.72) and Actual (0.73), and not as close for Late (0.62 for Schedule and 0.56 for Actual).

4.2.Credits and Debits

We looked at the same statistical measures of Early and Late but for the credits and debits, first two columns of Table S4 and Table S5.

Table S4. Descriptive Statistics Summary for Annual Credit/Debit Colorado, thousand-acre feet (KAF)

Stat	Early	Late	High	Low	Early & High (EH)	Early & Low (ELo)	Late & High (LaH)	Late & Low (LaLo)	1940 - 2020
Mean	-2.89	16.89	26.52	-5.59	18.10	-16.88	40.30	6.60	5.90
Median	6.40	3.55	13.10	2.10	18.80	-18.70	5.50	3.50	3.60
Stand Dev	70.74	45.15	92.49	28.23	102.88	32.23	74.97	16.42	61.17
Min	-156.20	-31.00	-156.20	-76.30	-156.20	-76.30	-6.20	-31.00	-156.20
Max	220.80	237.90	237.90	49.90	220.80	36.80	237.90	49.90	237.90
Sum	-129.91	608.20	769.09	-290.80	325.79	-455.70	443.30	164.90	478.29
Coeff Var	24.50	2.67	3.49	5.05	5.68	1.91	1.86	2.49	10.36
Count	45	36	29	52	18	27	11	25	81

Table S5. Descriptive Statistics Summary for Annual Credit/Debit NM, thousand-acre feet (KAF)

Stat	Early	Late	High	Low	Early & High (EH)	Early & Low (ELo)	Late & High (LaH)	Late & Low (LaLo)	1940-2020
Mean	-0.28	18.93	0.76	13.67	-5.41	3.46	8.57	26.32	8.25
Median	1.20	25.75	11.65	6.10	1.20	4.95	34.90	6.10	7.60
Stand Dev	60.97	112.60	110.77	67.00	69.97	54.61	150.04	79.32	87.66
Min	-121.40	-472.30	-472.30	-78.50	-121.40	-68.70	-472.30	-78.50	-472.30
Max	153.60	243.10	168.10	243.10	112.50	153.60	168.10	243.10	243.10
Sum	-12.80	681.40	25.90	642.70	-102.70	89.90	128.60	552.80	668.60
Coeff Var	214.34	5.95	145.41	4.90	12.95	15.79	17.50	3.01	10.62
Count	45	36	34	47	19	26	15	21	81

The mean credit/debit for Early (E) is -2 KAF (2,466,964 m^3) and for Late (L) it is 16 KAF (19,735,709 m^3). The range is 377 KAF (465,022,653 m^3) for E and 268 KAF (330,573,132 m^3) for La while the IQR is 67 KAF (82,643,283 m^3) for E and 9 KAF (11,101,337 m^3) for La. The coefficient of variation, or relative dispersion of the data points around the mean, is much larger in magnitude for E (-24) than for La (2).

The sum of annual credit and debit data for New Mexico for the period of record is -12 KAF (14,801,782 m^3) for E and 681 KAF (840,001,131 m^3) for La. The mean for E is -0.28 and for La 18. The range is 275 KAF (339,207,505 m^3) for E and 715 KAF (881,939,514 m^3) for La while the IQR is 96.85 KAF (119,462,716 m^3) for E and 5.95 KAF (7,339,217 m^3) for La. The coefficient of variation is much higher for E (214) than for La (6). The analysis was expanded to consider all the qualifiers defined in the methods section to make distinctions between hydrological conditions, High (H) and Low (Lo), and Early (E) and Late (La) and their combinations.

Based on the descriptive statistics summary, Table S4 for credits and debits for Colorado, we concluded that the data set EH is the one with the largest spread, suggested by the second highest range (377 KAF, 465,022,653 m^3), SD (102), and IQR (101 KAF, 124,581,666 m^3) values. In contrast, the data set that seems to have the least spread is LoLa with the lowest range (80 KAF, 98,678,547 m^3), SD (16), and IQR (9 KAF, 11,101,337 m^3). LaH has the largest mean (40 KAF, 49,339,274 m^3) and it is actually the shortest series (11 data points). EH has the highest median (18 KAF, 22,202,673 m^3) and it is the second shortest series (18 data points). The series with the largest coefficient of variation (24.50), or largest relative dispersion of data points in the data series around the mean, is E. In contrast to the Colorado credit/debit series, the ones for New Mexico are harder to describe in a summarized way.

4.3. Histograms

To visualize the distribution of the series and their relationships for the High and Low, and Early and Late considerations for the Colorado and New Mexico series, the authors created histograms. Figure S2 for Colorado shows that the H distribution has a larger level of spread than the Lo distribution which is consistent with the values of the descriptive statistics from Table S3. The coefficients of variation are 3 for H and 5 for Lo which means the observations vary similarly in relation to the mean. The H distribution is almost symmetrical and flatter than Lo, while the Lo distribution is skewed to the left, which means the mean (-5 KAF, - 6,167,409 m^3) is smaller than the median (2 KAF, 2,466,964 m^3).

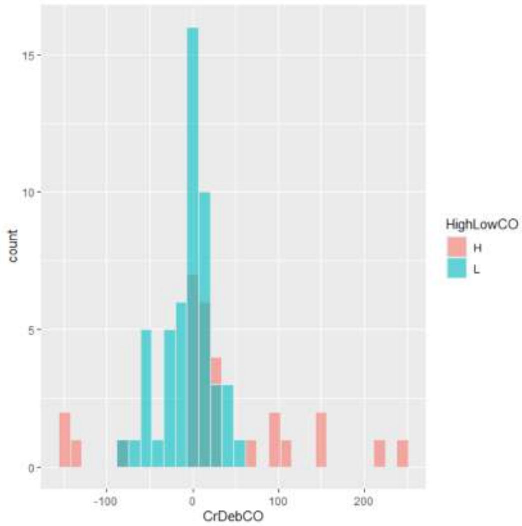

Fig. S2. Histogram Credit/Debit Colorado, High and Low, thousand-acre feet (KAF)

In Figure S3 for New Mexico, the H distribution appears to be more spread out than the Lo one since the debit for 1985 (-472 KAF, 582,203,427 m^3) is three times larger than the second largest debit (-121 KAF, 149,251,302 m^3) in 1952. The SD of the H distribution is 110 and 67 for Lo. The Lo distribution is skewed to the right with a mean (13 KAF, 16,035,264 m^3) larger than the median (6 KAF, 7,400,891 m^3), while H is skewed to the left, with a median (11 KAF, 13,568,300 m^3) much larger than the mean (0.76 KAF, 937,446 m^3). The range of H is almost double that of Lo (640 KAF, 321 KAF, 789,428,376 and 395,947,670 m^3), while the IQRs are similar in size (97 KAF, 95 KAF, 119,647,738 and 117,180,775 m^3).

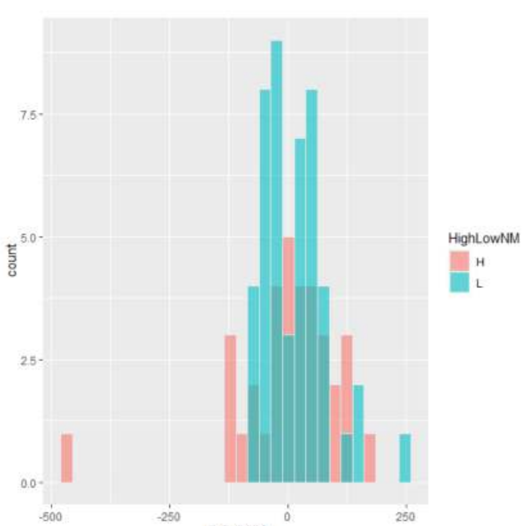

Fig. S3. Histogram Credit/Debit New Mexico, High and Low, thousand-acre feet (KAF)

Considering the hydrological conditions called Early and Late, for Colorado, Figure S4, the E distribution has a larger spread than the La distribution which is consistent with the values of the descriptive statistics of range (377 KAF, 268 KAF, 465,022,653 and 330,573,132 m^3), SD (70, 45), and IQR (67 KAF, 9 KAF, 82,643,283 and 11,101,337 m^3). The IQR for E is almost seven times larger than that of La. The E distribution is almost symmetrical while the La distribution is not.

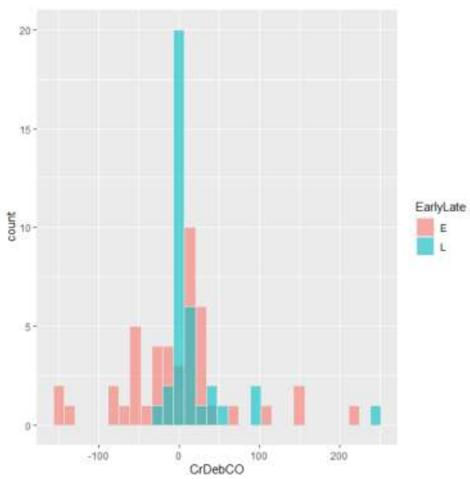

Fig. S4. Histogram Credit/Debit Colorado, Early and Late, thousand-acre feet (KAF)

Studying the same two series, Early and Late, for New Mexico, Figure S5, the La distribution appears to be more spread out than the E distribution since the debit for 1985 (-472 KAF, -582,203,427 m^3) is three times larger than the second largest debit (-114 KAF, -140,616,929 m^3) in 1995. The SD of the La distribution (112) is almost double the SD of E (60). The La distribution is skewed to the left, with a median (25 KAF, 30,837,046 m^3) larger than the mean (18 KAF, 22,202,673 m^3), while E seems symmetrical, with close median (1.2 KAF, 22,202,673 m^3) and mean (-0.28 KAF, -345,375 m^3). The range of La is more than 3 times larger of that of E (715 KAF, 275 KAF, 881,939,514 and 339,207,505 m^3). The IQRs for La and E are109 KAF (134,449,520 m^3) and 96 KAF (118,414,256 m^3), respectively.

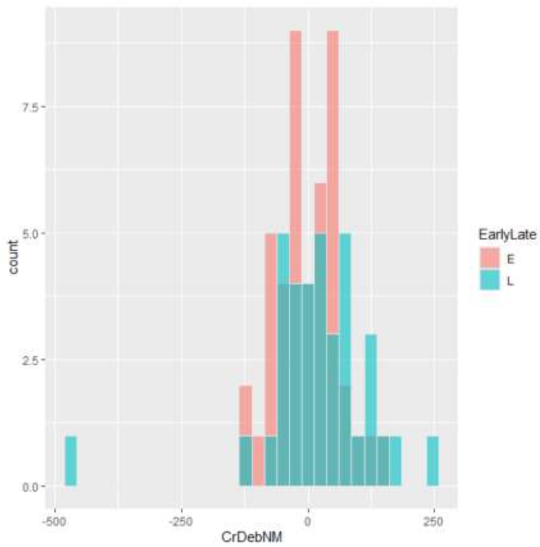

Fig. S5. Histogram Credit/Debit New Mexico, Early and Late, thousand-acre feet (KAF)

4.4. Autocorrelation

The Autocorrelation Function (ACF) gives the values of autocorrelation of the series with its lagged values. The ACF plot uses confidence bands (dotted blue lines) to aid in the identification of significant, or not significant, autocorrelation for specific lags; this is if they are significantly different from zero. Figure S6 illustrates if the present value of the Colorado credit/debit series is related with its past values. The ACF shows that the current series is positively correlated to two past series with lag 1 and lag 2. In turn, Figure S7 is a visual summary of the linear correlations between Scheduled Delivery and credit/debit for Colorado. The significance levels were set at p-values of < 0.05 and <0.01, and the significant correlations were indicated by the larger size of the number and the darker shade of the square. Two lags were considered for each time series.

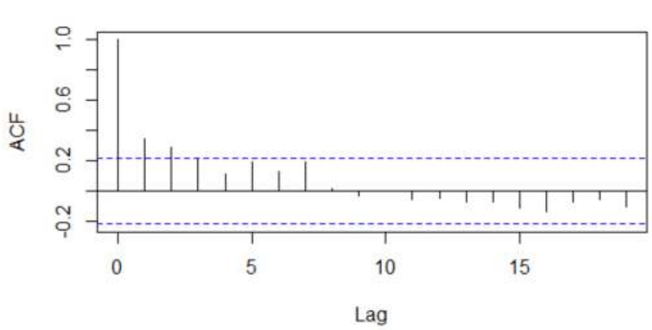

Fig. S6 Autocorrelation Function (ACF) for Colorado Credit/Debit Time Series

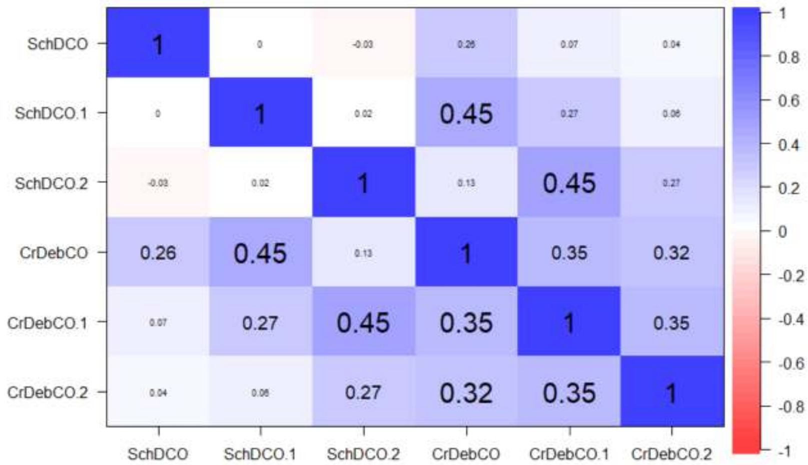

Fig. S7. Correlation plot between Scheduled Delivery and Credit and Debit for Colorado

Figure S8 shows the autocorrelation function for the credit/debit time series for New Mexico. The ACF shows that there is no evidence of autocorrelation of the series with its past values since none of the lags considered are outside of the bands. Figure S9 is the correlation plot between Scheduled Delivery and credit/debit for New Mexico. Two lags were considered for each time series. The plot shows that the series credit/debit for New Mexico (CrDebNM) is not significantly correlated with Schedule Delivery (SchDNM) or its lags (SchDNM.1 and SchDNM.2), nor is it significantly correlated to its own lags (CrDebNM.1, CrDebNM.2). There is only evidence of significant correlation between Schedule Delivery lag 1 (SchDNM.1) and its lag 2 (SchDNM.2).

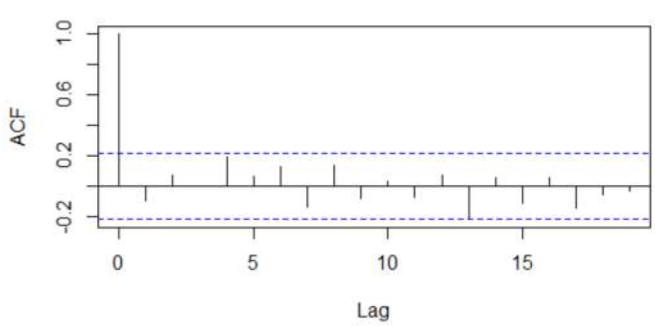

Fig. S8. Autocorrelation Function (ACF) for New Mexico Credit/Debit Time Series

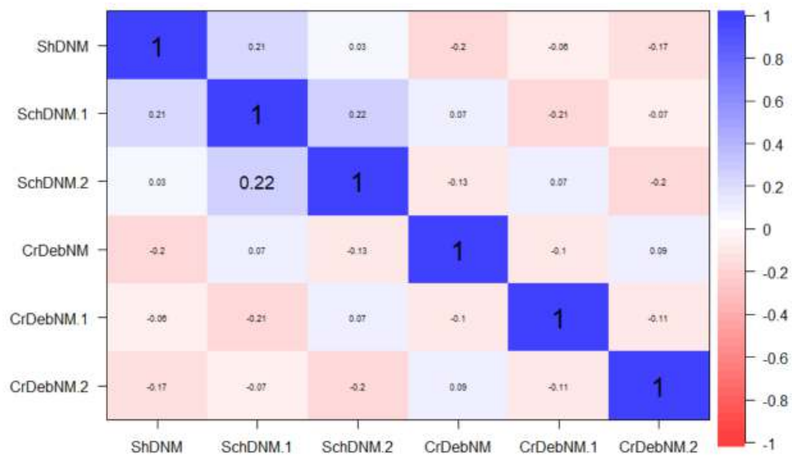

Fig. S9. Correlation plot between Schedule Delivery and Credit/Debit for New Mexico

5. Colorado

5.1. Prewhitening

The pre-whitening process detects the cross-correlation between the input and output series using the plot. The cross-correlation between prewhitened input and output series determined the parameters *b*=1 and *s*=0, Figure S10.

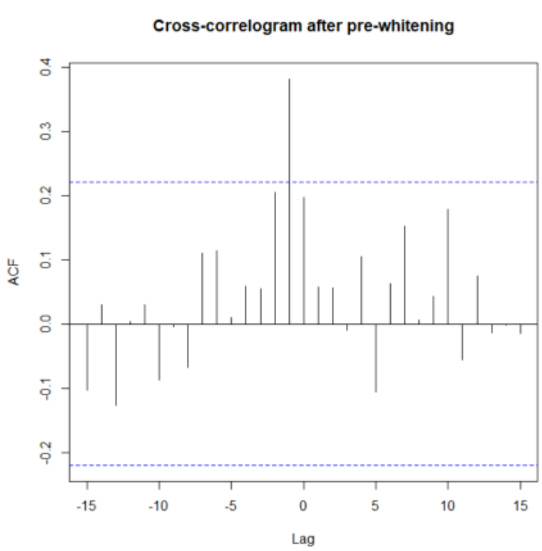

Fig. S10. Cross-correlation between Prewhitened Input and Fitted Output Series Colorado

5.2. Model selection.

Model 1 has the least AIC (863) and MAPE (310), Table S6. For RMSE, model 2 is slightly better (49.81 for model 2, 49.92 for model 1). Two additional variables were added, at a time, to the model 1: High and Low, Early and Late, to determine if there were any changes in parameter estimation. The same three model evaluation criteria were used. The AIC (858), RMSE (48), and MAPE (289) were smaller for model 1 HighLow than for the other models. HighLow is statistically significant as predictor of credit/debit behavior in Colorado. The last model with EarlyLate is not statistically significant for explaining credit/debit behavior for Colorado.

Table S6. Parameter Estimates of Transfer Function Model for Colorado

Model	(b, r, s)	Parameter	Estimate	Standard error	AIC	RMSE	MAPE
Model 1	(1, 1, 0)	ω_0	0.1161	0.0305	**863.06**	49.92	**310.99**
		δ_1	0.1441	0.3068			
		σ^2	2492				
Model 2	(1, 2, 0)	ω_0	0.1196	0.0313	864.68	**49.81**	317.92
		δ_1	0.1075	0.2648			
		δ_2	0.1619	0.2691			
		σ^2	2481				
Model 1 + HighLow	(1, 1, 0)	ω_0	0.1279	0.0293	858.97	48.08	289.89
		δ_1	0.2977	0.2705			
		High vs. Low	27.891	11.2044			
		σ^2	2312				
Model 1 + EarlyLate	(1, 1, 0)	ω_0	0.1138	0.0306	864.24	49.66	329.75
		δ_1	0.1238	0.3137			
		Late vs. Early	23.3012	27.1334			
		σ^2	2467				

6. New Mexico Prewhitening and model selection, refer to Figure S11.

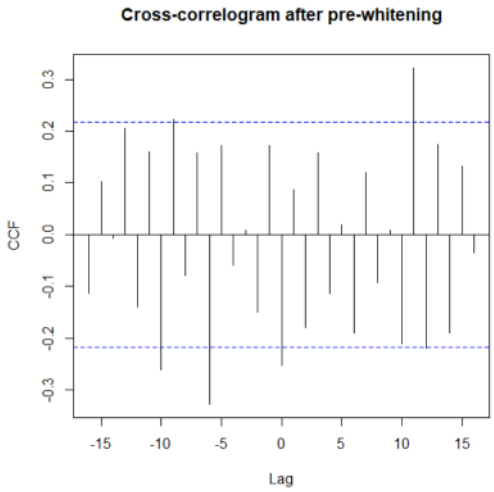

Fig. S11. Cross-correlation between Prewhittened Input and Fitted Output Series New Mexico

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