KANSAS-LOWER REPUBLICAN RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: Republican River from Rice to Clay Center
Water Quality Impairment: Total Phosphorous

1. INTRODUCTION

Subbasin: Lower Republican

Counties: Clay (CY), Cloud (CD), Republic (RP), Washington (WS)

HUC8: 10250017

HUC10 (12): 03 (05, 06, 07, 08, 09, 10), 04 (01, 02, 03, 04, 05, 06, 07, 08, 09), 05 (01, 02, 03, 04, 05, 06, 07, 08), 06 (01, 02, 04)

Ecoregions: Central Great Plains (27), Smoky Hills (a)

Drainage Area: 1,023.2 square miles (mi^2)

Water Quality Limited Segments and Designated Uses (Table 1; Figure 1; Table 2)

Table 1. Main stem and tributary water quality limited segments in the Republican River from Rice to Clay Center. Tributaries denoted with a – indicate there is no tributary.

Main Stem	Tributary	Tributary of Tributary
HUC8 10250017		
Republican R (26)	Oak Cr (58)	Oak Cr, West Br (9058)
Republican R (18)	Salt Cr (23)	Riley Cr (24)
	Salt Cr (22)	Turkey Cr (51)
		Coal Cr (47)
		East Cr (21)
	Salt Cr (19)	West Cr (25)
	Upton Cr (52)	–
	Elm Cr (39)	Elm Cr, W Br (59)
		Elm Cr, E Br (62)
Republican R (17)	Elk Cr (15, 14)	Elk Cr, W Fk (16)
Republican R (13)	Beaver Cr (61)	–
	Mud Cr (63)	–
	Parsons Cr (12)	–
Republican R (11)	Peats Cr (10)	Spring Cr (53)
Republican R (9)	Mulberry Cr (40)	–
Republican R (8)	Five Cr (413)	–
	Huntress Cr (9354)	Spring Cr (1354)
		Dry Cr (1369)
	Finney Cr (64)	–
	Lincoln Cr (65)	–
	Otter Cr (66)	–
Republican R (7)	–	–

Figure 1. Map of contributing area and water quality impaired segments for Kansas Department of Health and Environment stream chemistry (SC), stream probabilistic (SP), and sub-watershed (SW) stations for the Republican River from Rice to Clay Center.

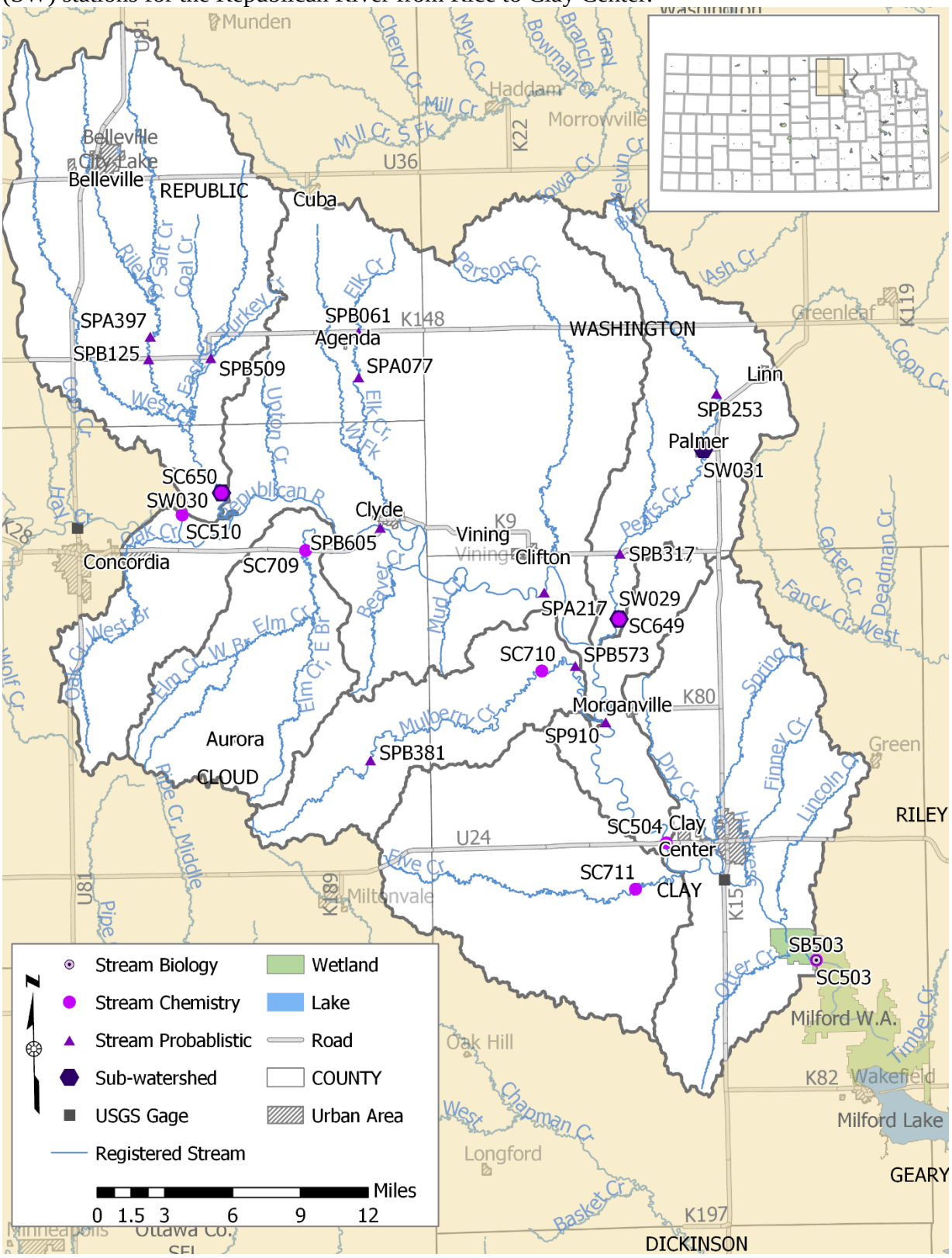


Table 2. Designated uses for main stem and tributary segments for the Republican River from Rice to Clay Center (Kansas Surface Water Register, 2013).

Stream	Segment	Aquatic Life	Contact Recreation	Domestic Supply	Food Procure-ment	Ground-water Recharge	Industrial	Irrigation	Live-stock Watering
HUC8: 10250017									
Oak Cr, West Br	9058	E	b	Y	N	Y	Y	Y	Y
Oak Cr	58	E	b	Y	N	Y	Y	Y	Y
Salt Cr	23	E	C	Y	Y	Y	Y	Y	Y
Riley Cr	24	E	b	N	N	Y	N	Y	Y
Salt Cr	22	E	C	Y	Y	Y	Y	Y	Y
Turkey Cr	51	E	b	N	N	Y	N	N	N
Coal Cr	47	E	b	N	N	Y	N	Y	Y
East Cr	21	E	b	N	N	Y	N	Y	Y
West Cr	25	E	b	N	Y	Y	N	Y	Y
Salt Cr	19	E	C	Y	Y	Y	Y	Y	Y
Upton Cr	52	E	b	N	Y	Y	N	Y	Y
Elm Cr, W Br	59	E	b	Y	N	Y	Y	Y	Y
Elm Cr, E Br	62	E	b	N	N	Y	N	Y	Y
Elm Cr	39	E	C	Y	Y	Y	Y	Y	Y
Republican R	18	E	C	Y	Y	Y	Y	Y	Y
Elk Cr	15	E	b	Y	N	Y	Y	Y	Y
Elk Cr, W Fk	16	E	b	N	N	N	N	Y	Y
Elk Cr	14	E	C	Y	Y	Y	Y	Y	Y
Republican R	17	E	C	Y	Y	Y	Y	Y	Y
Beaver Cr	61	E	b	N	N	Y	N	Y	N
Mud Cr	63	E	b	Y	Y	Y	Y	Y	Y
Parsons Cr	12	E	C	Y	Y	Y	Y	Y	Y
Republican R	13	E	C	Y	Y	Y	Y	Y	Y
Spring Cr	53	E	b	N	N	N	N	Y	Y
Peats Cr	10	E	b	N	Y	Y	N	Y	Y
Republican R	11	E	C	Y	Y	Y	Y	Y	Y
Mulberry Cr	40	E	b	N	Y	Y	N	Y	Y
Republican R	9	E	C	Y	Y	Y	Y	Y	Y
Republican R	8	E	C	Y	Y	Y	Y	Y	Y
Five Cr	413	E	b	N	Y	Y	N	Y	Y
Spring Cr	1354	E	b	Y	Y	Y	Y	Y	Y
Dry Cr	1369	E	b	Y	Y	Y	Y	Y	Y
Huntress Cr	9354	E	B	Y	Y	Y	Y	Y	Y
Finney Cr	64	E	b	Y	Y	Y	Y	Y	Y
Lincoln Cr	65	E	b	Y	N	Y	Y	Y	Y
Otter Cr	66	E	C	N	Y	Y	N	Y	Y
Republican R	7	E	B	Y	Y	Y	Y	Y	Y

Definitions: E - Expected aquatic life use water; b - Secondary contact recreation stream; Y - Referenced stream segment is assigned the indicated designated use; N - Referenced stream segment does not support the indicated designated use; C, B - Primary contact recreation stream

303(d) Listings for Total Phosphorus, Biology, and Dissolved Oxygen
Salt Creek near Hollis (SC650; **Figure 2**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018
Dissolved Oxygen, category 4a: 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018

Elm Creek near Ames (SC709; **Figure 2**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018

Peats Creek near Clifton (SC649; **Figure 3**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018

Mulberry Creek near Clifton (SC710; **Figure 3**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018

Republican River near Clay Center (SC504; **Figures 3** and **4**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018

Five Creek near Clay Center (SC711; **Figure 4**)
Total phosphorus, category 1

Republican River near Clay Center (SC503; **Figure 4**)
Total phosphorus, category 5: 2008, 2010, 2012, 2014, 2016, and 2018
Biology, category 5: 2002, 2004, 2008, 2010, 2012, 2014, 2016, and 2018

Impaired Uses: Expected aquatic life, contact recreation, and domestic water supply

Water Quality Criteria

Narrative Nutrient Criteria

The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life (K.A.R. 28-16-28e(d)(2)(A)).

The introduction of plant nutrients into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(d)(3)(D)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (K.A.R. 28-16-28e(d)(7)(A)).

Taste-producing and odor-producing substances of artificial origin shall not occur in surface waters at concentrations that interfere with the production of potable water by conventional water treatment processes, that impart an unpalatable flavor to edible aquatic or semiaquatic life or terrestrial wildlife, or that result in noticeable odors in the vicinity of surface waters (K.A.R. 28-16-28e(b)(7)).

Numeric Dissolved Oxygen Criteria

The concentration of dissolved oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. The Dissolved Oxygen criterion is 5.0 mg/L (K.A.R. 28-16-28e(e), Table 1g).

Numeric pH Criteria

Artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (K.A.R. 28-16-28e(e), Table 1g).

Figure 2. Map of contributing area and facilities for Kansas Department of Health and Environment stream chemistry (SC) stations on the Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), and Republican River near Clay Center (SC504).

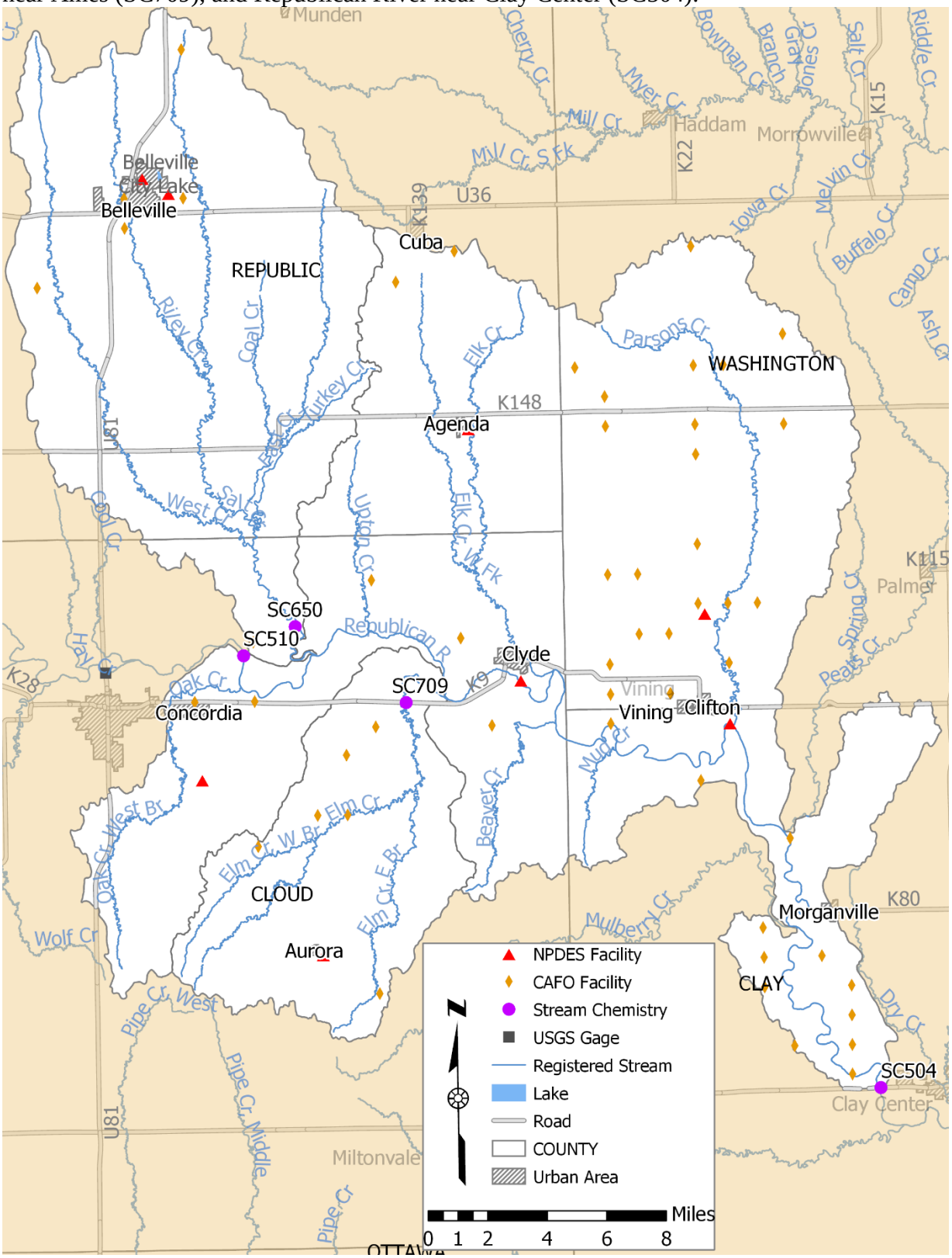


Figure 3. Map of contributing area and facilities for Kansas Department of Health and Environment stream chemistry (SC) stations on the Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), and Republican River near Clay Center (SC504).

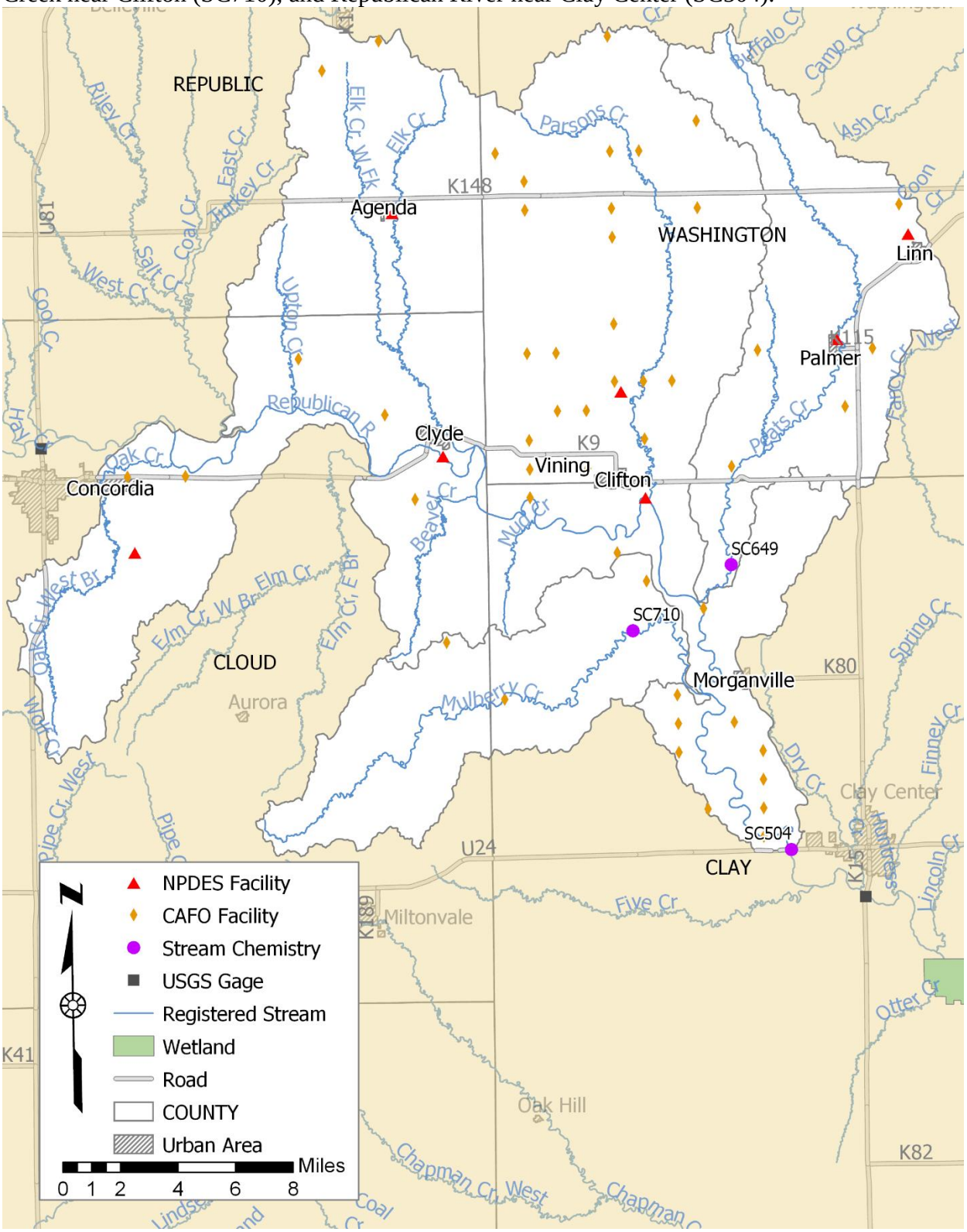
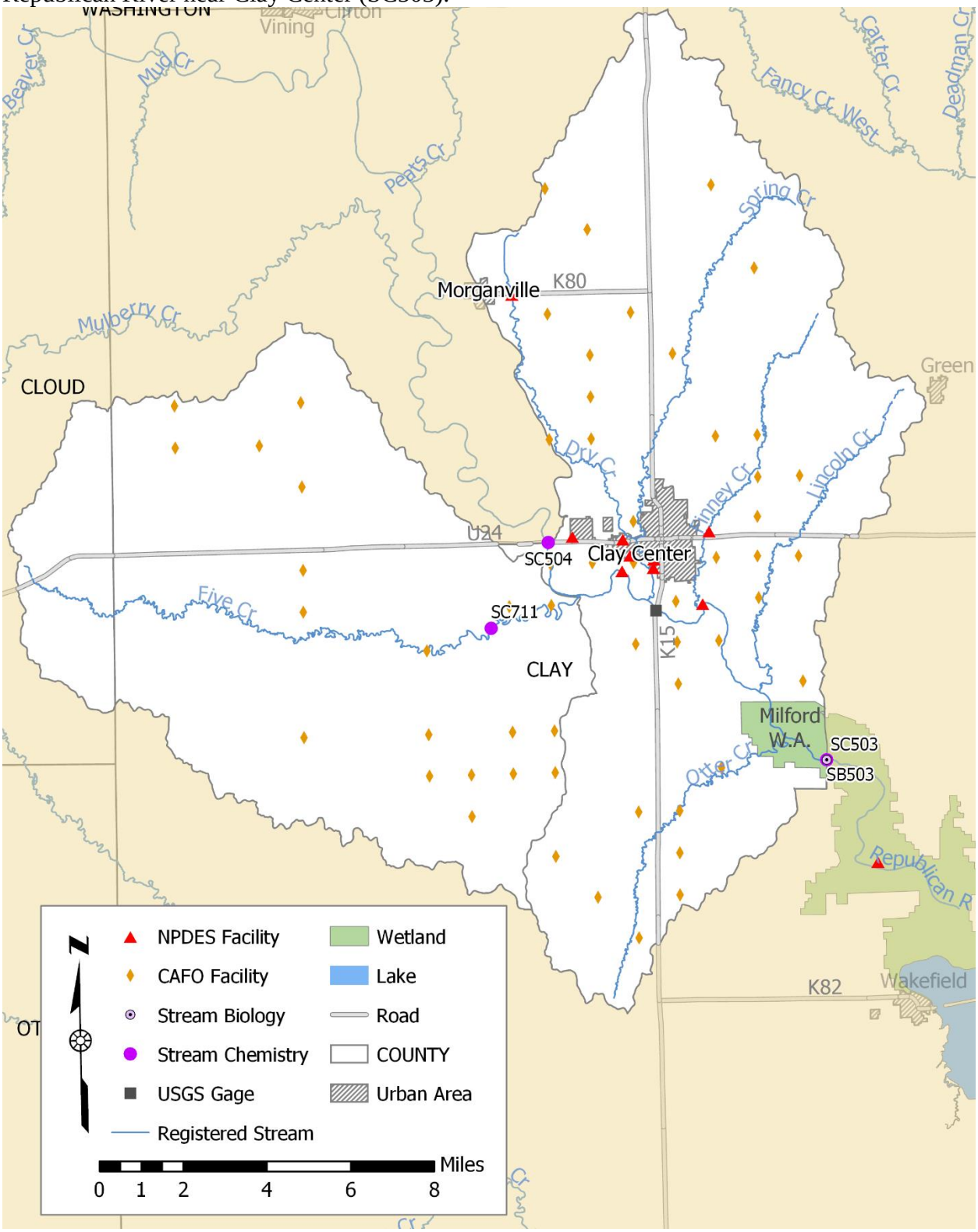


Figure 4. Map of contributing area and facilities for Kansas Department of Health and Environment stream chemistry (SC) stations on the Five Creek near Clay Center (SC711) and the Republican River near Clay Center (SC503).



2. CURRENT WATER QUALITY CONDITIONS AND DESIRED ENDPOINT

Level of Support for Designated Uses under 2018 303(d)

Phosphorus levels in the Republican River from Rice to Clay Center are consistently high. Excessive nutrients are not being controlled and are thus impairing aquatic life, contact recreation, and domestic water supply. The ultimate endpoint of this Total Maximum Daily Load (TMDL) will be to achieve the Kansas Surface Water Quality Standards by eliminating excessive primary productivity and impairment to aquatic life, recreation, and domestic water supply associated with excessive phosphorus.

Station Location and Period of Record

Stream Chemistry (SC) Monitoring Stations

SC510: Active permanent station for the Republican River near Rice, located at latitude 39.596, longitude -97.571. Period of record: March 13, 1990 to October 16, 2018.

SC650: Active rotational station on the Salt Creek near Hollis, located at latitude 39.610, longitude -97.538. Period of record: April 19, 1993 to December 5, 2017.

SC709: Active rotational station on the Elm Creek near Ames, located at latitude 39.572, longitude -97.470. Period of record: April 17, 1995 to July 20, 2015.

SC649: Active rotational station on the Peats Creek near Clifton, located at latitude 39.524, longitude -97.210. Period of record: April 20, 1993 to October 19, 2015.

SC710: Active rotational station on the Mulberry Creek near Clifton, located at latitude 39.492, longitude -97.275. Period of record: April 18, 1995 to October 19, 2015.

SC504: Active rotational station on the Republican River near Clay Center, located at latitude 39.380, longitude -97.175. Period of record: March 13, 1990 to November 16, 2016.

SC711: Active rotational station on Five Creek near Clay Center, located at latitude 39.351, longitude -97.201. Period of record: March 19, 1996 to November 16, 2016.

SC503: Active permanent station on the Republican River near Clay Center, located at latitude 39.303, longitude -97.053. Period of record: May 7, 1990 to October 15, 2018.

Stream Biology (SB) Monitoring Station

SB503: Active permanent station on the Republican River near Clay Center, located at latitude 39.303, longitude -97.053. Period of record: July 19, 1990 to June 28, 2017.

Stream Probabilistic (SP) Monitoring Stations

SPA397: Salt Creek. Period of record: 2009.
SPB125: Salt Creek. Period of record: 2011.
SPB509: East Creek. Period of record: 2016.
SPB253: Peats Creek. Period of record: 2012.
SPB317: Peats Creek. Period of record: 2014.
SPB381: Mulberry Creek. Period of record: 2014.
SPB573: Mulberry Creek. Period of record: 2016.
SPB605: Republican River. Period of record: 2017.
SPB061: Elk Creek. Period of record: 2010.
SPA461: Elk Creek. Period of record: 2009.
SPA077: Elk Creek. Period of record: 2006.
SPA217: Republican River. Period of record: 2008.

SP910: Republican River. Period of record: 2013.

Sub-watershed Monitoring Stations

SW030: Salt Creek near Hollis, located at latitude 39.610, longitude -97.538. Period of record: 2016 to 2018.

SW031: Peats Creek near Palmer, located at latitude 39.632, longitude -97.138. Period of record: 2016 to 2018.

SW029: Peats Creek near Clifton, located at latitude 39.524, longitude -97.210. Period of record: 2016 to 2018.

Streamflow Gage

U.S. Geological Survey gage Republican River at Clay Center (06856600). Period of record: January 1, 1990 to December 31, 2018. Located near Republican River near Clay Center (SC504 and SC503).

Hydrology

Flow conditions for this TMDL were analyzed using U.S. Geological Survey (USGS) streamgage data from the Republican River at Clay Center (06856600). The gage has streamflow data available for the period of record January 1, 1990 to December 31, 2018. Flow conditions for the Kansas Department of Health and Environment (KDHE) stream chemistry (SC) stations Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), Republican River near Clay Center (SC504), Five Creek near Clay Center (SC711), and Republican River near Clay Center (SC503) are based upon streamflow measurements at the USGS Republican River at Clay Center (06856600) streamgage (**Table 3**). Streamflow at all stations was calculated using a watershed area ratio based upon the USGS Republican River at Clay Center (06856600) streamgage and its drainage area. Streamflow for the gage has a low flow exceedance of 59.8 cubic feet per second (cfs), a base flow exceedance of 272 cfs, and a high flow exceedance of 1,460 cfs (**Figure 5**), which is representative of the variability of flow in the main stem KDHE SC Republican River stations. Of the KDHE SC stations, the tributary Mulberry Creek near Clifton (SC710) has the lowest flow and the tributary Salt Creek near Hollis (SC650) has the greatest flow.

Long-term estimated flows for the Republican River and its tributaries can be found in **Table 4** (Perry et al., 2004). The largest tributary to the Salt Creek near Hollis (SC650) is West Creek and to Elm Creek near Ames (SC709) is Elm Creek, East Branch. The largest tributaries to the Republican River near Clay Center (SC504) are Salt Creek, Elk Creek, Parsons Creek, and Peats Creek. The largest tributaries to the Republican River near Clay Center (SC503) are Five Creek and Otter Creek. The terminus of the Republican River discussed in this document is just above Milford Lake. Milford Lake is the largest reservoir in Kansas and serves 800,000 Kansans, approximately one third of the state's population, with drinking water (Milford Watershed Regional Conservation Partnership Program, 2019). This reservoir was built in 1962 by the Army Corp of Engineers and has been in use since it reached capacity in 1967; however, an increasing number of harmful algal blooms since 2011 has made nutrients a primary concern for the use and longevity of Milford Lake.

Table 3. Flow conditions and drainage area at U.S. Geological Survey gages and Kansas Department of Health and Environment stream chemistry (SC) stations for the Republican River from Rice to Clay Center.

Stream	Station	Contributing Drainage Area (mi^2)	Mean Flow (cfs)	Percent Flow Exceedance (cfs)				
				90%	75%	50%	25%	10%
Republican R nr Rice	SC510	16,086	417	44.1	83.5	189	382	913
Salt Cr nr Hollis	SC650	175.1	7.03	0.614	1.33	2.79	6.10	15.0
Elm Cr nr Ames	SC709	74.5	2.99	0.261	0.564	1.19	2.60	6.38
Peats Cr nr Clifton	SC649	85.8	3.44	0.301	0.649	1.37	2.99	7.35
Mulberry Cr nr Clifton	SC710	65.8	2.64	0.231	0.498	1.05	2.29	5.64
Republican R nr Clay Center	SC504	16,670	669	58.5	126	266	581	1,430
Five Cr nr Clay Center	SC711	112.6	4.52	0.395	0.852	1.78	3.93	9.65
Republican R at Clay Center	06856600	17,042	684	59.8	129	272	594	1,460
Republican R nr Clay Center	SC503	17,180	689	60.3	130	274	599	1,470

Figure 5. Flow duration curve for U. S. Geological Survey gage Republican River at Clay Center (06856600).

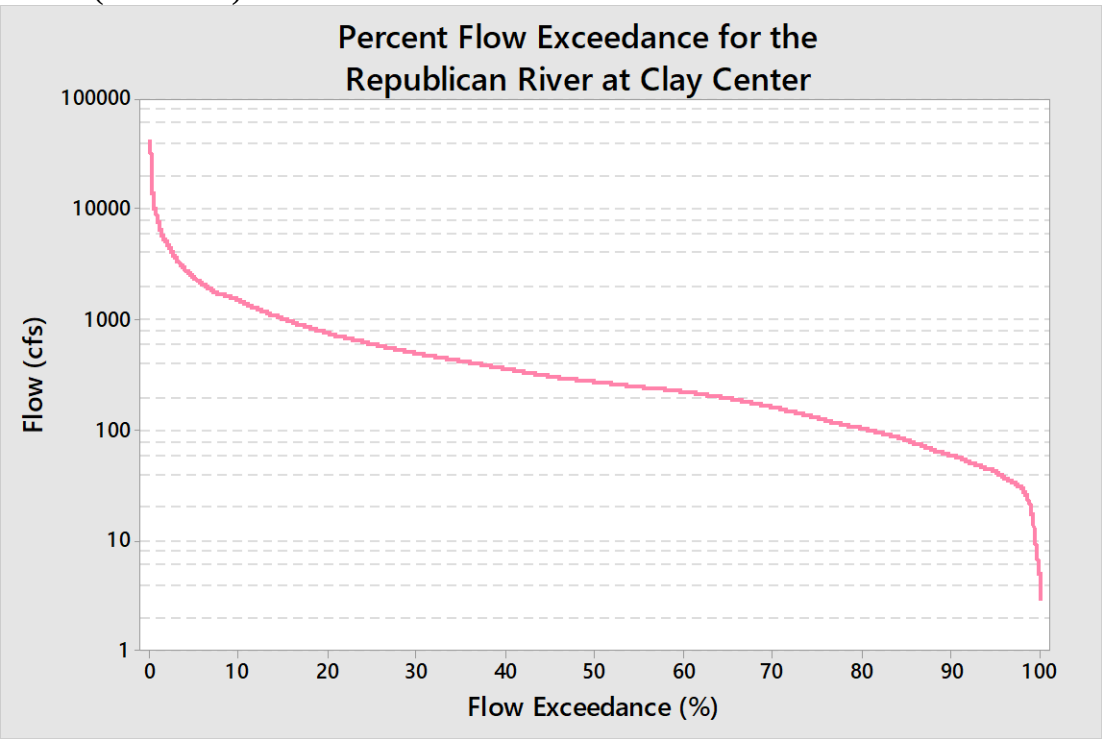


Table 4. Long-term estimated flows from the U.S. Geological Survey (USGS) for the Republican River and its tributaries from Rice to Clay Center (Perry et al., 2004).

Stream	USGS Site	KSWR CUSEGA Number	County	Drainage Area (mi^2)	Mean Flow (cfs)	Percent Flow Exceedance (cfs)					2-year Peak (cfs)
						90%	75%	50%	25%	10%	
Oak Cr	911	1025001758	CD	30.7	8.67	0	0.64	2.16	4.73	10.8	942
Republican R	823	1025001726	CD	21,800	597	115	173	292	595	1,290	7,050
Salt Cr	533	1025001723	RP	31.5	10.5	0	0.28	1.87	4.91	12.7	1,110
Riley Cr	534	1025001724	RP	29.6	9.35	0	0.13	1.50	4.02	10.7	1,370
Salt Cr	685	1025001722	RP	71.2	22.0	0	1.23	4.34	11.4	28.9	1,550
Turkey Cr	593	1025001751	RP	7.73	2.31	0	0	0.32	0.51	1.74	612
Coal Cr	627	1025001747	RP	14.6	4.87	0	0.22	1.11	2.27	5.42	891
East Cr	594	1025001721	RP	18.7	6.19	0	0.05	1.11	2.68	6.94	1,030
West Cr	705	1025001725	CD, RP	70.8	19.0	0	0.91	3.47	9.21	23.8	676
Salt Cr	**794**	**1025001719**	**CD, RP**	**199**	**55.6**	**0.72**	**4.09**	**12.2**	**31.4**	**80.2**	**1,910**
Upton Cr	779	1025001752	CD	19.4	5.87	0	0	0.93	2.30	6.22	1,030
Elm Cr, W Br	1092	1025001759	CD	14.7	4.21	0	0	0.56	1.36	3.98	855
Elm Cr, E Br	1122	1025001762	CD	28.0	8.17	0	0	1.19	3.23	8.90	1,280
Elm Cr	**898**	**1025001739**	**CD**	**77.0**	**21.4**	**0**	**1.26**	**4.24**	**10.9**	**27.6**	**1,610**
Republican R	828	1025001718	CD	22,100	669	121	186	319	658	1,430	8,210
Elk Cr	724	1025001715	CD, RP	45.5	14.6	0	0.69	2.87	7.40	18.6	1,130
Elk Cr, W Fk	725	1025001716	CD, RP	26.8	8.70	0	0.22	1.61	4.05	10.3	1,140
Elk Cr	815	1025001714	CD	85.5	26.3	0	1.78	5.64	14.4	35.8	546
Republican R	833	1025001717	CD	22,100	693	124	190	328	679	1,480	8,600
Beaver Cr	981	1025001761	CD	21.0	5.81	0	0	0.81	2.01	5.71	1,090
Mud Cr	960	1025001763	CY	13.8	4.03	0	0	0.43	1.12	3.59	860
Parsons Cr	856	1025001712	CY, WS	97.7	30.0	0	1.67	5.74	15.5	40.1	1,900
Republican R	883	1025001713	CY	22,300	735	128	197	344	717	1,560	9,290
Spring Cr	825	1025001753	WS	19.9	6.60	0	0	1.03	2.65	7.19	1,110
Peats Cr	**936**	**1025001710**	**CY, WS**	**104**	**33.1**	**0**	**1.94**	**6.47**	**17.4**	**45.0**	**2,020**
Republican R	933	1025001711	CY	22,400	765	130	202	356	743	1,620	9,780
Mulberry Cr	**1058**	**1025001740**	**CY**	**72.1**	**22.0**	**0**	**1.12**	**4.09**	**10.9**	**28.3**	**1,660**
Republican R	1001	102500179	CY	22,500	796	133	207	367	770	1,680	10,300
Republican R	**1207**	**102500178**	**CY**	**22,600**	**826**	**136**	**212**	**378**	**796**	**1,740**	**10,800**
Five Cr	**1256**	**10250017413**	**CY**	**88.0**	**28.9**	**0**	**1.75**	**5.86**	**15.5**	**39.4**	**1,820**
Spring Cr	1188	102500171354	CY	39.0	12.4	0	0.29	1.96	5.40	14.5	1,320
Dry Cr	1189	102500171369	CY	26.4	7.75	0	0.64	1.72	3.61	8.64	1,300
Huntress Cr	1214	102500179354	CY	66.7	20.3	0	1.34	4.10	10.3	25.9	1,700
Finney Cr	1222	1025001764	CY	21.1	7.34	0	0.13	1.29	3.21	8.36	1,170
Lincoln Cr	1290	1025001765	CY	40.0	14.3	0	0.55	2.58	6.90	17.9	1,750
Otter Cr	1492	1025001766	CY	65.0	22.2	0	0.89	3.70	10.4	28.1	2,320
Republican R	**1422**	**102500177**	**CY**	**22,900**	**912**	**103**	**178**	**378**	**919**	**2,090**	**8,640**

Definitions: CD - Cloud; RP - Republic; CY - Clay; WS - Washington

The highest mean and median annual flows for the Republican River at Clay Center (06856600) occurred in 1993, with flows of 3,960 and 1,730 cfs, respectively (**Figure 6**). The lowest mean and median annual flows were in 2006, with flows of 82.9 and 53.3 cfs, respectively. Trends in annual flows for the Republican River at Clay Center (06856600) generally coincide with National Oceanic and Atmospheric Administration (NOAA) annual total precipitation from station USC00141559 at Clay Center. The highest annual precipitation occurred in 1993, corresponding to the year with the highest annual flows, and the lowest annual precipitation occurred in 2006, corresponding to the year with the lowest annual flows. Annual peak flows at this gage also occurred in 1993, with a flow of 41,600 cfs, and ancillary peak flows occurred in 2010 and 2011 (**Figure 7**).

Seasonally for the Republican River at Clay Center (06856600), high flows occur in spring (April through June) and are skewed by high flow events, likely due to increased precipitation and runoff events (**Figure 8**). Summer-fall (July through October) and winter (November through March) flows tend to be lower with similar median flows between the two seasons, though mean summer-fall flows are higher than mean winter flows.

Figure 6. Annual mean and median flows for the Republican River at Clay Center (06856600) and annual total precipitation at National Oceanic and Atmospheric Association station USC00141559 at Clay Center.

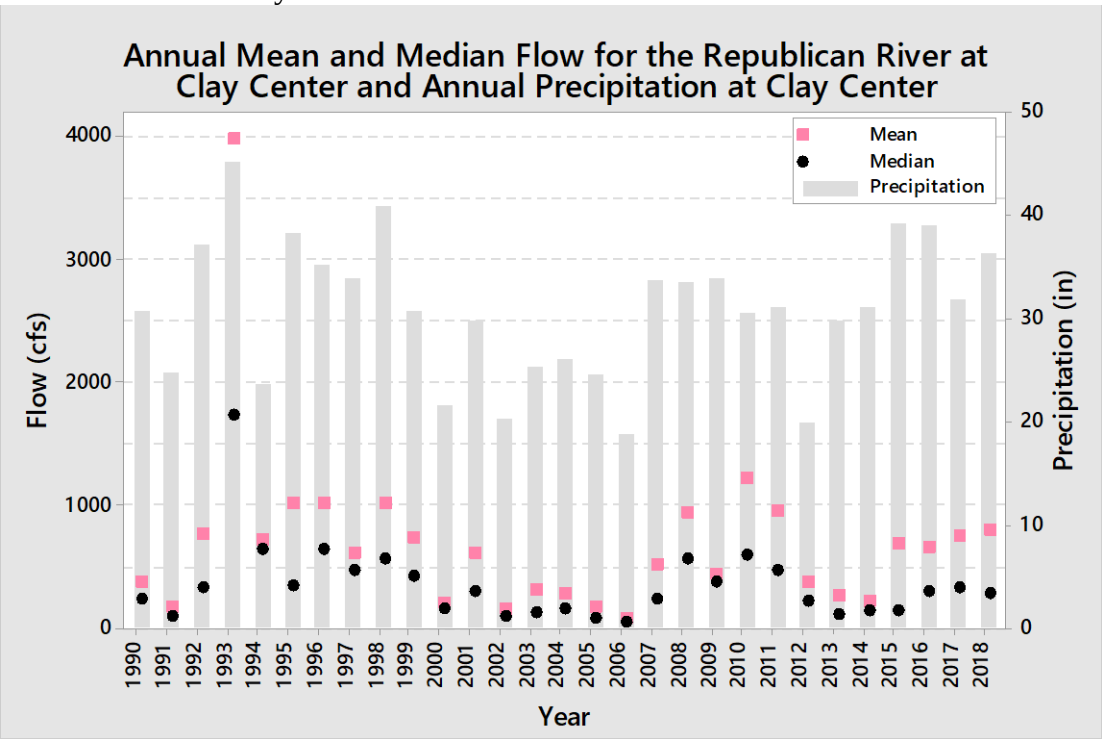


Figure 7. Annual peak flows for the Republican River at Clay Center (06856600).

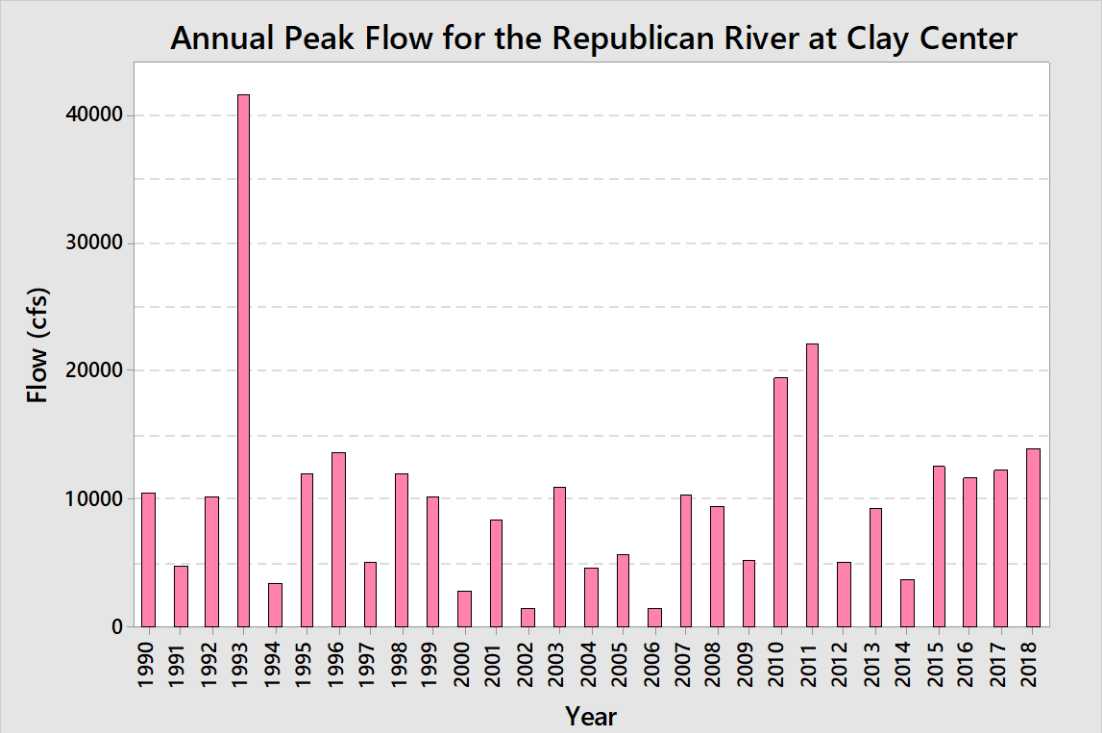
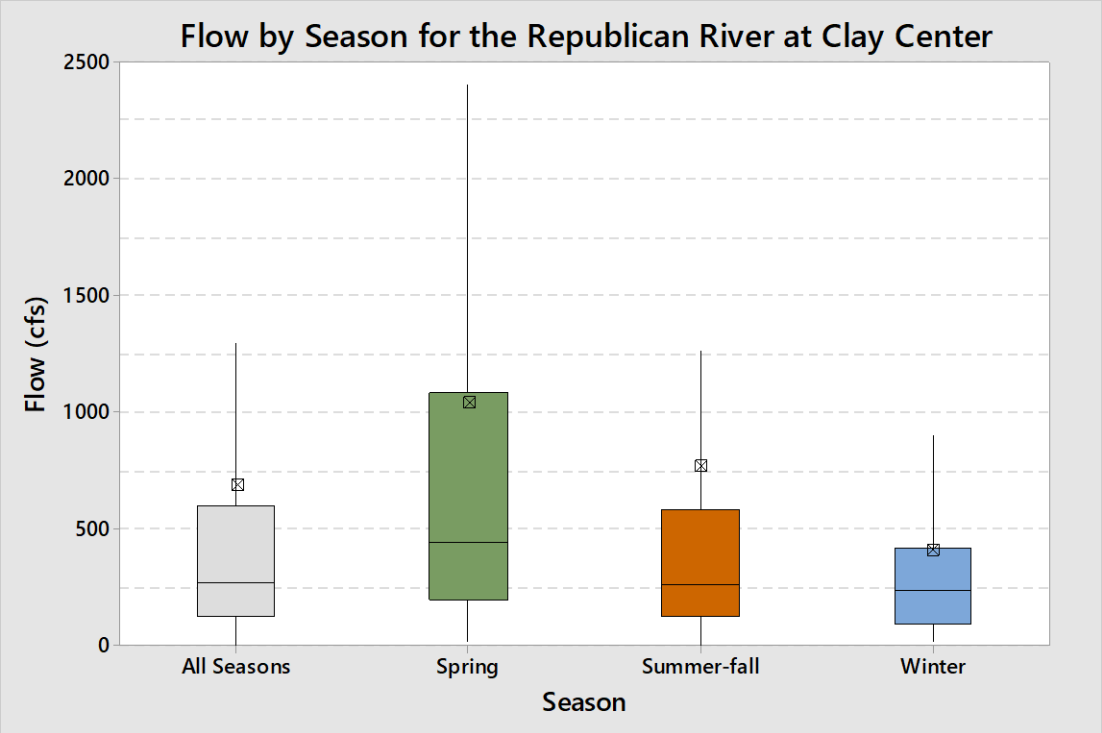


Figure 8. Flow by season for the Republican River at Clay Center (06856600).

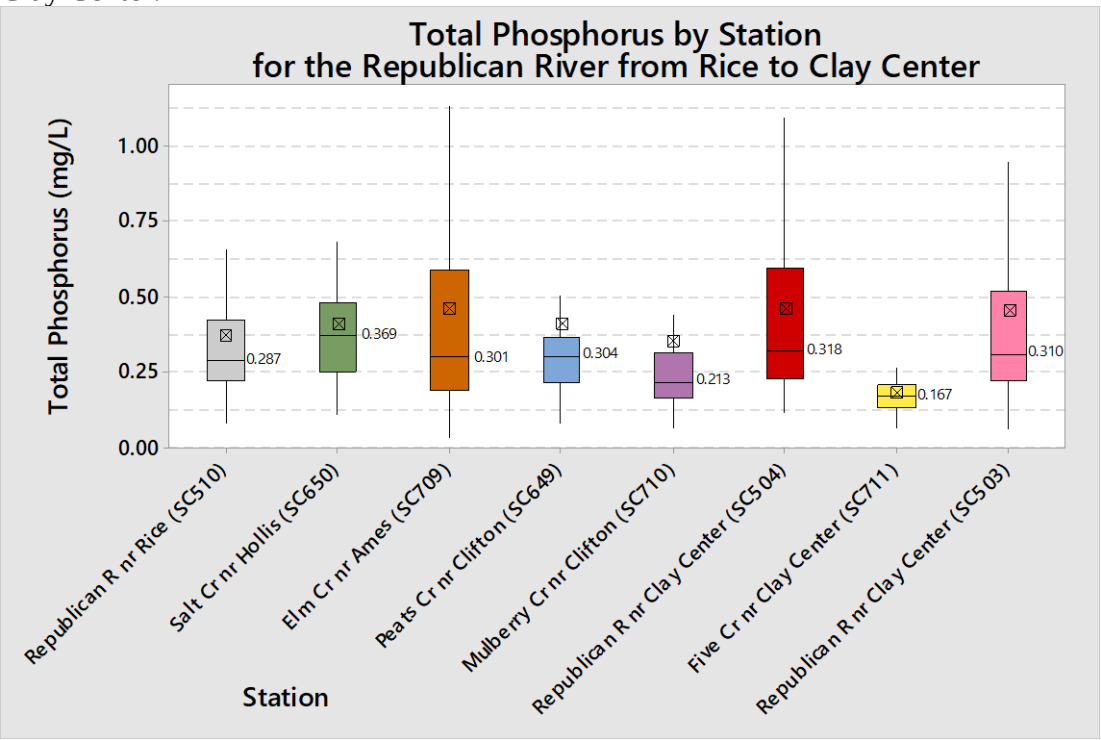


Total Phosphorus Concentrations

Overall, total phosphorus (TP) concentrations for the Republican River from Rice to Clay Center increase among the main stem stations (**Figure 9**). The upstream Republican River near Rice (SC510) has a smaller TP concentration range, a mean of 0.371 milligrams per liter (mg/L), and a median of 0.287 mg/L (**Table 5**). Mean and median TP concentrations increase along the main stem stations Republican River near Clay Center (SC504 and SC503), with the highest mean of 0.456 mg/L and median of 0.318 mg/L occurring at Republican River near Clay Center (SC504). While not addressed by this TMDL, the Republican River near Rice (SC510) is considered in this document for comparison purposes.

Meanwhile, TP concentrations at tributaries to the Republican River vary the most at the upstream tributaries Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709). The Salt Creek near Hollis (SC650) has a median TP concentration of 0.369 mg/L, the highest of any station. The Elm Creek near Ames (SC709) has a mean TP concentration of 0.459 mg/L, the highest of any station. The downstream tributaries to the Republican River, Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), and Five Creek near Clay Center (SC711), have the least TP concentration variability. Mulberry Creek near Clifton (SC710) and Five Creek near Clay Center (SC711) have the lowest TP means and medians of all the stations, with mean concentrations of 0.348 and 0.179 mg/L and median concentrations of 0.213 and 0.167 mg/L, respectively. Despite lower TP concentrations than the upstream tributaries, Mulberry Creek near Clifton (SC710) remains impaired for TP; Five Creek near Clay Center (SC711), however, is not impaired for TP and is discussed in this document in order establish a protective status.

Figure 9. Total phosphorus by station from 1990 to 2018 for the Republican River from Rice to Clay Center.



The range of all SC station TP concentrations throughout the watershed is from 0.030 mg/L for the Elm Creek near Ames (SC709) to 4.92 mg/L for the Republican River near Clay Center (SC503). This maximum TP concentration is considered within the following analyses, although it is an outlier within the data set and is not always displayed graphically for the purpose of clarity.

Table 5. Total phosphorus concentration mean, median, maximum, minimum, and number of samples (N) by station from 1990 to 2018 for the Republican River from Rice to Clay Center.

Station	Mean (mg/L)	Median (mg/L)	Maximum (mg/L)	Minimum (mg/L)	N
Republican R nr Rice (SC510)	0.371	0.287	1.70	0.077	148
Salt Cr nr Hollis (SC650)	0.406	0.369	1.32	0.105	36
Elm Cr nr Ames (SC709)	0.459	0.301	1.80	0.030	20
Peats Cr nr Clifton (SC649)	0.404	0.304	2.30	0.078	33
Mulberry Cr nr Clifton (SC710)	0.348	0.213	1.20	0.059	26
Republican R nr Clay Center (SC504)	0.456	0.318	1.50	0.113	42
Five Cr nr Clay Center (SC711)	0.179	0.167	0.480	0.060	29
Republican R nr Clay Center (SC503)	0.450	0.310	4.92	0.063	149

In addition to routinely sampled SC stations, the Republican River from Rice to Clay Center also contains 13 stream probabilistic (SP) stations and three sub-watershed (SW) stations (**Tables 6** and **7**). Stream probabilistic stations are randomly selected locations throughout the state which are sampled four times per year. Sub-watershed stations are targeted stations monitored by the Watershed Restoration and Protection Strategy (WRAPS) for improvements in the watershed based upon the implementation of best management practices (BMPs).

Available data from the three SP stations in the Salt Creek near Hollis (SC650) Watershed (SPA397, SPB125, and SPB509) suggests that TP concentrations may be declining over time from 2009 to 2016; however, available SW data from 2016 to 2018 in this watershed does not indicate this trend. Rather, mean samples from this station indicate TP concentrations remain more than twice those collected at SC and SP stations. The two SP and two SW stations in the Peats Creek near Clifton (SC649) Watershed range in means from 0.240 in 2012 (SPB253) to 0.994 in 2016 (SW029). Among the SP stations, TP concentrations have increased from 2012 to 2014. Among the SW stations, the upstream station near Palmer (SW031) consistently has lower TP concentrations than the downstream station at Clifton (SW029).

The remaining two watersheds with SP stations are Mulberry Creek near Clifton (SC710), which has two stations, and Republican River near Clay Center (SC504), which has six stations. Available SP data for the Mulberry Creek near Clifton (SC710) Watershed indicates concentrations in this watershed have increased from 2014 to 2016. Available SP data for the Republican River near Clay Center (SC504) Watershed consists of three stations on the main stem Republican River and three stations on Elk Creek. Despite the spatial variability, the three main stem Republican River stations indicate a decline in TP concentrations from 2008 to 2017. Meanwhile, from 2006 to 2010 the tributary Elk Creek does not display any clear trends and has SP station TP concentrations ranging from 0.253 to 0.390 mg/L.

Table 6. Total phosphorus concentration mean and number of samples (N) by stream probabilistic (SP) station from 2006 to 2017 for the Republican River from Rice to Clay Center.

Stream Chemistry Station	Stream Probabilistic Station	Stream Probabilistic Stream	Sample Year	Mean Total Phosphorus (mg/L)	N
Salt Cr nr Hollis (SC650)	SPA397	Salt Cr	2009	0.303	4
	SPB125	Salt Cr	2011	0.272	4
	SPB509	East Cr	2016	0.216	4
Peats Cr nr Clifton (SC649)	SPB253	Peats Cr	2012	0.240	4
	SPB317	Peats Cr	2014	0.533	4
Mulberry Cr nr Clifton (SC710)	SPB381	Mulberry Cr	2014	0.267	4
	SPB573	Mulberry Cr	2016	0.366	4
Republican R nr Clay Center (SC504)	SPB605	Republican R	2017	0.345	4
	SPB061	Elk Cr	2010	0.297	4
	SPA461	Elk Cr	2009	0.253	4
	SPA077	Elk Cr	2006	0.390	3
	SPA217	Republican R	2008	0.469	4
	SP910	Republican R	2013	0.398	4

Table 7. Total phosphorus concentration mean and number of samples (N) by sub-watershed station from 2016 to 2018 for the Salt Creek near Hollis (SC650) and Peats Creek near Clifton (SC649).

Stream Chemistry Station	Sub-watershed Station	Sample Year	Mean Total Phosphorus (mg/L)	N
Salt Cr nr Hollis (SC650)	Salt Cr nr Hollis (SW030)	2016	0.820	6
		2017	0.880	2
		2018	0.756	5
		2016-2018	0.805	13
Peats Cr nr Clifton (SC649)	Peats Cr nr Palmer (SW031)	2016	0.728	6
		2017	0.399	5
		2018	0.676	6
		2016-2018	0.613	17
	Peats Cr nr Clifton (SW029)	2016	0.994	5
		2017	0.445	6
		2018	0.819	7
		2016-2018	0.743	18

To further assess TP load sources for the Republican River from Rice to Clay Center, a mass balance was estimated based upon mean TP concentrations and streamflow for each watershed (Perry, 2004; **Table 8**). The total load is accumulative and reflects the total TP load at each station. The total load by watershed is incremental and reflects the total TP load contributed within each watershed. The mass balance calculation suggests that 53% of the load reaching the Republican River near Clay Center (SC503) originates above the Republican River near Rice (SC510). Of the remaining 47% of TP load, the majority is contributed by the tributary

watershed Salt Creek near Hollis (SC650) and the main stem watersheds Republican River near Clay Center (SC504 and 503), which contribute 6, 26, and 7% of the TP load, respectively.

Table 8. Estimated mass balance for total phosphorus loads based upon drainage area and mean streamflow (Perry, 2004) for the Republican River from Rice to Clay Center.

Station	Drainage Area (mi^2)	Mean Flow (cfs)	Mean Total Phosphorus (mg/L)	Total Phosphorus Load (lbs/day)	Total Phosphorus Load by Watershed (lbs/day)	Percent of Total Load (%)
Republican R (SC510) nr Rice	**21,800**	**588**	**0.371**	**1,180**	**331**	**53**
Salt Cr (SC650)	199	55.6	0.406	122	122	6
Elm Cr (SC709)	77	21.4	0.459	53.1	53.1	2
Peats Cr (SC649)	104	33.1	0.404	72.2	72.2	3
Mulberry Cr (SC710)	72.1	22.0	0.348	41.4	41.4	2
Republican R (SC504) nr Clay Center	**22,600**	**826**	**0.456**	**2,030**	**567**	**26**
Five Cr (SC711)	88	28.9	0.179	28.0	28.0	1
Republican R (SC503) nr Clay Center	**22,900**	**912**	**0.450**	**2,210**	**153**	**7**
Total	**22,900**	**912**	**0.450**	**2,210**	**0**	**100**

Definition: **Bold** - Main stem station

Annually for the SC stations for the Republican River from Rice to Clay Center, the highest mean TP concentrations collected occurred in: 2013 for the Salt Creek near Hollis (SC650), with a mean of 0.575 mg/L; 2007 for the Elm Creek near Ames (SC709), with a mean of 0.712 mg/L (excluding the single sample collected in 2015); 2015 for the Peats Creek near Clifton (SC649), with a mean of 0.953 mg/L; 2015 for the Mulberry Creek near Clifton (SC710), with a mean of 0.563 mg/L; 1998 for the Republican River near Clay Center (SC504), with a mean of 0.707 mg/L; 2016 for the Five Creek near Clay Center (SC711), with a mean of 0.233 mg/L; and 2007 for the Republican River near Clay Center (SC503), with a mean of 1.30 mg/L (**Table 9**). The highest median TP concentrations occurred in: 2005 for the Salt Creek near Hollis (SC650), with a median of 0.554 mg/L; 2007 for the Elm Creek near Ames (SC709), with a median of 0.558 mg/L (excluding the single sample collected in 2015); 2007 for the Peats Creek near Clifton (SC649), with a median of 0.362 mg/L; 2007 for the Mulberry Creek near Clifton (SC710), with a median of 0.292 mg/L; 1998 for the Republican River near Clay Center (SC504), with a median of 0.470 mg/L; 2004 for the Five Creek near Clay Center (SC711), with a median of 0.185 mg/L; and 2005 for the Republican River near Clay Center (SC503), with a median of 0.640 mg/L.

Annually, the lowest mean TP concentrations occurred in: 1993 for the Salt Creek near Hollis (SC650), with a mean of 0.256 mg/L; 1999 for the Elm Creek near Ames (SC709), with a mean of 0.174 mg/L; 2003 for the Peats Creek near Clifton (SC649), with a mean of 0.193 mg/L; 1995 for the Mulberry Creek near Clifton (SC710), with a mean of 0.190 mg/L; 2002 for the Republican River near Clay Center (SC504), with a mean of 0.260 mg/L; 2000 for the Five Creek near Clay Center (SC711), with a mean of 0.143 mg/L; and 2017 for the Republican River near Clay Center (SC503), with a mean of 0.223 mg/L. The lowest median TP concentrations occurred in: 1993 for the Salt Creek near Hollis (SC650), with a median of 0.250 mg/L; 1999 for

the Elm Creek near Ames (SC709), with a median of 0.180 mg/L; 2003 for the Peats Creek near Clifton (SC649), with a median of 0.183 mg/L; 2011 for the Mulberry Creek near Clifton (SC710), with a median of 0.144 mg/L; 2002 for the Republican River near Clay Center (SC504), with a median of 0.252 mg/L; 2012 for the Five Creek near Clay Center (SC711), with a median of 0.130 mg/L; and 2009 for the Republican River near Clay Center (SC503), with a median of 0.213 mg/L.

Available annual data suggests that the highest mean and median TP concentrations typically occurred within the last 15 years (2003 to 2018), with the exception of the mean and median for the Republican River near Clay Center (SC504) which has the highest TP concentrations in 1998. The highest annual means and medians also tend to fall within 2007 or 2015, coinciding with increased annual precipitation after periods of lower streamflow conditions. Samples prior to 2003 generally represent the lowest annual means and medians in the watershed, with the exception of the mean and median for the Republican River near Clay Center (SC503) which has the lowest TP concentrations in 2017 and 2009, respectively. The medians for the Mulberry Creek near Clifton (SC710) and Five Creek near Clay Center (SC711) are also exceptions to this trend, with median annual lows in 2011 and 2012.

When comparing TP concentration medians from 1990 to 1999 with medians from 2000 to 2018, medians for the Republican River from Rice to Clay Center indicate that TP concentrations are increasing for the majority of stations. For these delineations, the only stations with a decrease in median TP concentrations are the Salt Creek near Hollis (SC650) and Republican River near Clay Center (SC503). The Salt Creek near Hollis (SC650) has concentrations of 0.353 mg/L from 1990 to 1999 and 0.325 mg/L from 2000 to 2018. The Republican River near Clay Center (SC503) has concentrations of 0.335 mg/L from 1990 to 1999 and 0.325 mg/L from 2000 to 2018. Over the same periods, the Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), Republican River near Clay Center (SC504), and Five Creek near Clay Center (SC711) have all increased their median TP concentrations by 0.355, 0.034, 0.051, 0.037, and 0.022 mg/L, respectively.

Daily TP samples for the tributary stations Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), and Mulberry Creek near Clifton (SC710) are generally less than 0.75 mg/L (**Figures 10** and **11**). However, samples at these stations can reach concentrations as high as 2.3 mg/L. Meanwhile, the protected tributary station Five Creek near Clay Center (SC711) has no TP samples greater than 0.5 mg/L (**Figure 12**). Daily TP samples are frequently higher than 0.75 mg/L at both the main stem stations for the Republican River near Clay Center (SC504 and SC503), though the former is rotational and does not capture the variability as well as the later (**Figures 12** and **13**).

Table 9. Total phosphorus concentration annual mean, median, and sample number (N) by station for the Republican River from Rice to Clay Center.

Year	Total Phosphorus (mg/L) for Salt Cr nr Hollis (SC650)			Total Phosphorus (mg/L) for Elm Cr nr Ames (SC709)			Total Phosphorus (mg/L) for Peats Cr nr Clifton (SC649)			Total Phosphorus (mg/L) for Mulberry Cr nr Clifton (SC710)		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
1990	–	–	–	–	–	–	–	–	–	–	–	–
1991	–	–	–	–	–	–	–	–	–	–	–	–
1992	–	–	–	–	–	–	–	–	–	–	–	–
1993	0.256	0.250	5	–	–	–	0.390	0.290	5	–	–	–
1994	–	–	–	–	–	–	–	–	–	–	–	–
1995	–	–	–	0.286	0.226	4	–	–	–	0.190	0.174	4
1996	–	–	–	–	–	–	–	–	–	–	–	–
1997	0.465	0.456	6	–	–	–	0.293	0.238	6	–	–	–
1998	–	–	–	–	–	–	–	–	–	–	–	–
1999	–	–	–	0.174	0.180	5	–	–	–	0.327	0.205	6
2000	–	–	–	–	–	–	–	–	–	–	–	–
2001	0.346	0.324	6	–	–	–	0.244	0.226	5	–	–	–
2002	–	–	–	–	–	–	–	–	–	–	–	–
2003	–	–	–	–	–	–	0.193	0.183	4	0.209	0.200	3
2004	–	–	–	–	–	–	–	–	–	–	–	–
2005	0.494	0.554	6	–	–	–	–	–	–	–	–	–
2006	–	–	–	–	–	–	–	–	–	–	–	–
2007	–	–	–	0.712	0.558	6	0.576	0.362	6	0.529	0.292	6
2008	–	–	–	–	–	–	–	–	–	–	–	–
2009	0.371	0.301	5	–	–	–	–	–	–	–	–	–
2010	–	–	–	–	–	–	–	–	–			
2011	–	–	–	0.275	0.299	4	0.330	0.298	4	0.211	0.144	4
2012	–	–	–	–	–	–	–	–	–	–	–	–
2013	0.575	0.435	4	–	–	–	–	–	–	–	–	–
2014	–	–	–	–	–	–	–	–	–	–	–	–
2015	–	–	–	1.80	1.80	1	0.953	0.350	3	0.563	0.280	3
2016	–	–	–	–	–	–	–	–	–	–	–	–
2017	0.340	0.325	4	–	–	–	–	–	–	–	–	–
2018	–	–	–	–	–	–	–	–	–	–	–	–
1990-1999	**0.361**	**0.353**	**11**	**0.230**	**0.203**	**9**	**0.341**	**0.264**	**11**	**0.259**	**0.190**	**10**
2000-2018	**0.425**	**0.325**	**25**	**0.929**	**0.558**	**11**	**0.459**	**0.298**	**22**	**0.378**	**0.240**	**16**

Year	Total Phosphorus (mg/L) for Republican R nr Clay Center (SC504)			Total Phosphorus (mg/L) for Five Cr nr Clay Center (SC711)			Total Phosphorus (mg/L) for Republican R nr Clay Center (SC503)		
	Mean	Median	N	Mean	Median	N	Mean	Median	N
1990	0.344	0.340	5	–	–	–	0.300	0.315	4
1991	–	–	–	–	–	–	0.367	0.280	6
1992	–	–	–	–	–	–	0.515	0.325	6
1993	–	–	–	–	–	–	0.346	0.360	5
1994	0.367	0.290	6	–	–	–	0.297	0.220	9
1995	–	–	–	–	–	–	0.322	0.310	8
1996	–	–	–	0.171	0.148	5	0.452	0.461	5
1997	–	–	–	–	–	–	0.489	0.353	6
1998	0.707	0.470	6	–	–	–	0.668	0.430	6
1999	–	–	–	–	–	–	0.335	0.345	6
2000	–	–	–	0.143	0.155	6	0.297	0.220	6
2001	–	–	–	–	–	–	0.319	0.281	6
2002	0.260	0.252	6	–	–	–	0.260	0.260	3
2003	–	–	–	–	–	–	0.309	0.325	4
2004	0.409	0.377	5	0.211	0.185	4	0.410	0.400	5
2005	–	–	–	–	–	–	0.660	0.640	6
2006	–	–	–	–	–	–	0.401	0.282	5
2007	–	–	–	–	–	–	1.30	0.637	6
2008	0.500	0.303	6	0.188	0.179	6	0.501	0.297	6
2009	–	–	–	–	–	–	0.318	0.213	5
2010	–	–	–	–	–	–	0.566	0.411	4
2011	–	–	–	–	–	–	0.430	0.319	4
2012	0.505	0.459	4	0.147	0.130	4	0.547	0.497	4
2013	–	–	–	–	–	–	0.413	0.379	4
2014	–	–	–	–	–	–	0.623	0.505	4
2015	–	–	–	–	–	–	0.422	0.270	4
2016	0.590	0.415	4	0.233	0.170	4	0.400	0.360	4
2017	–	–	–	–	–	–	0.223	0.230	4
2018	–	–	–	–	–	–	0.425	0.410	4
1990-1999	**0.473**	**0.340**	**17**	**0.171**	**0.148**	**5**	**0.409**	**0.335**	**61**
2000-2018	**0.453**	**0.377**	**25**	**0.184**	**0.170**	**24**	**0.464**	**0.325**	**88**

Definition: – - No data

Figure 10. Total phosphorus by sampling date for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

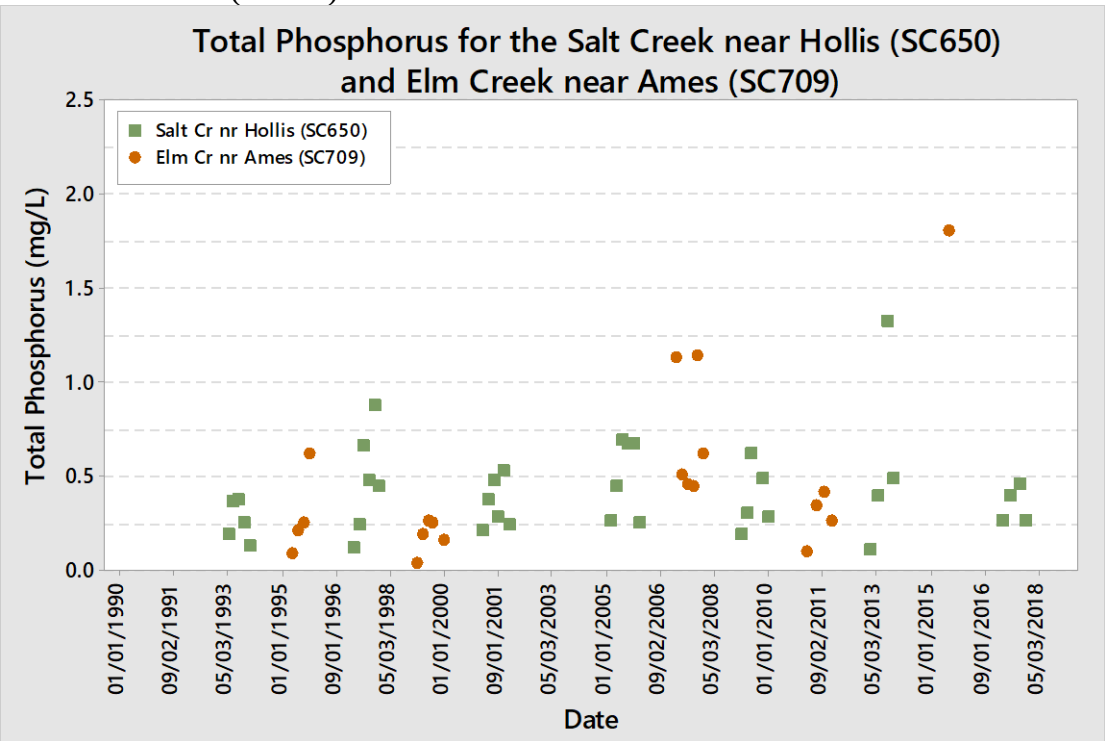


Figure 11. Total phosphorus by sampling date for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

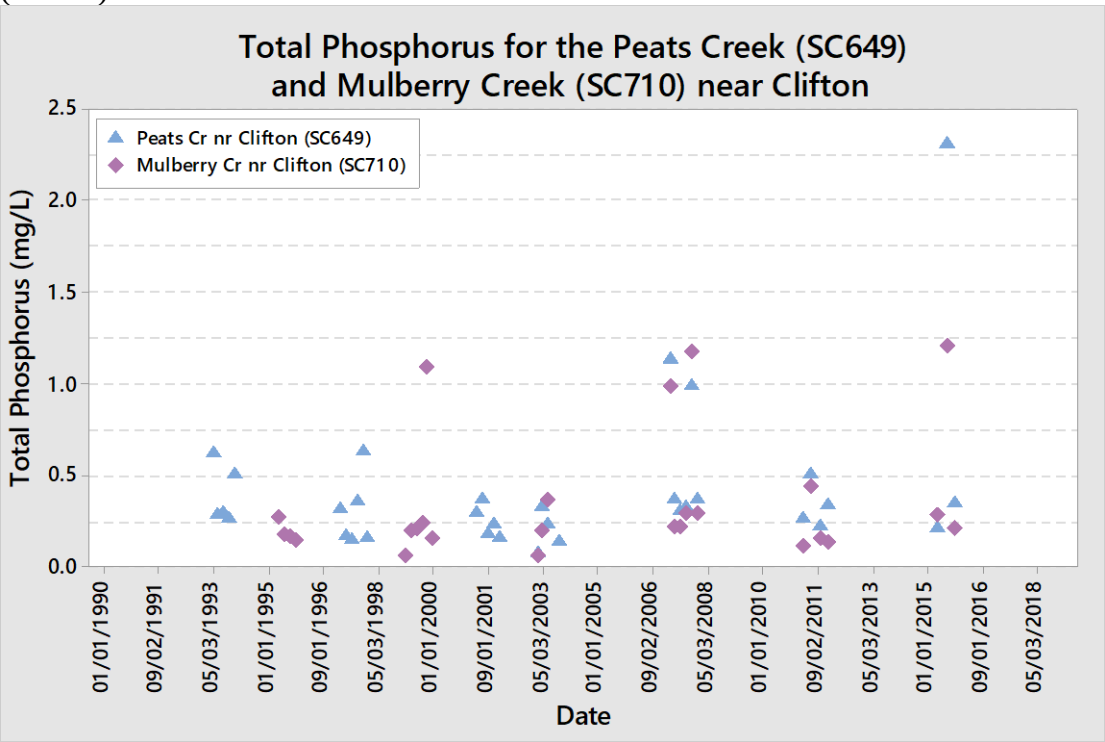


Figure 12. Total phosphorus by sampling date for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

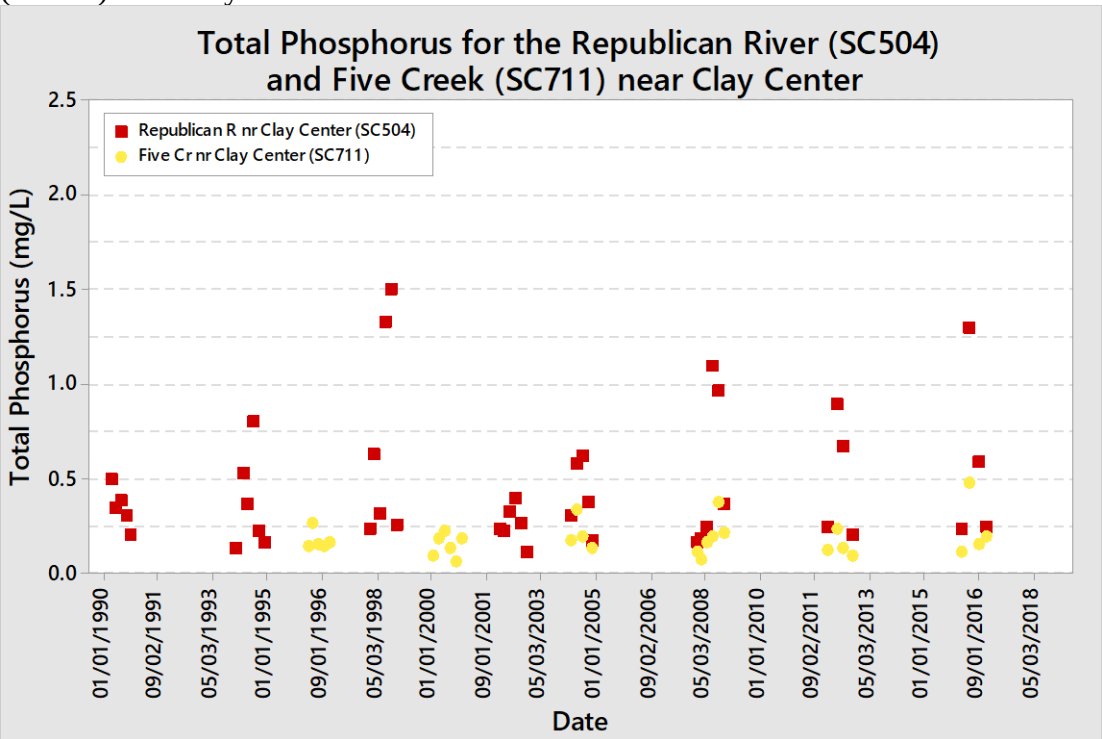
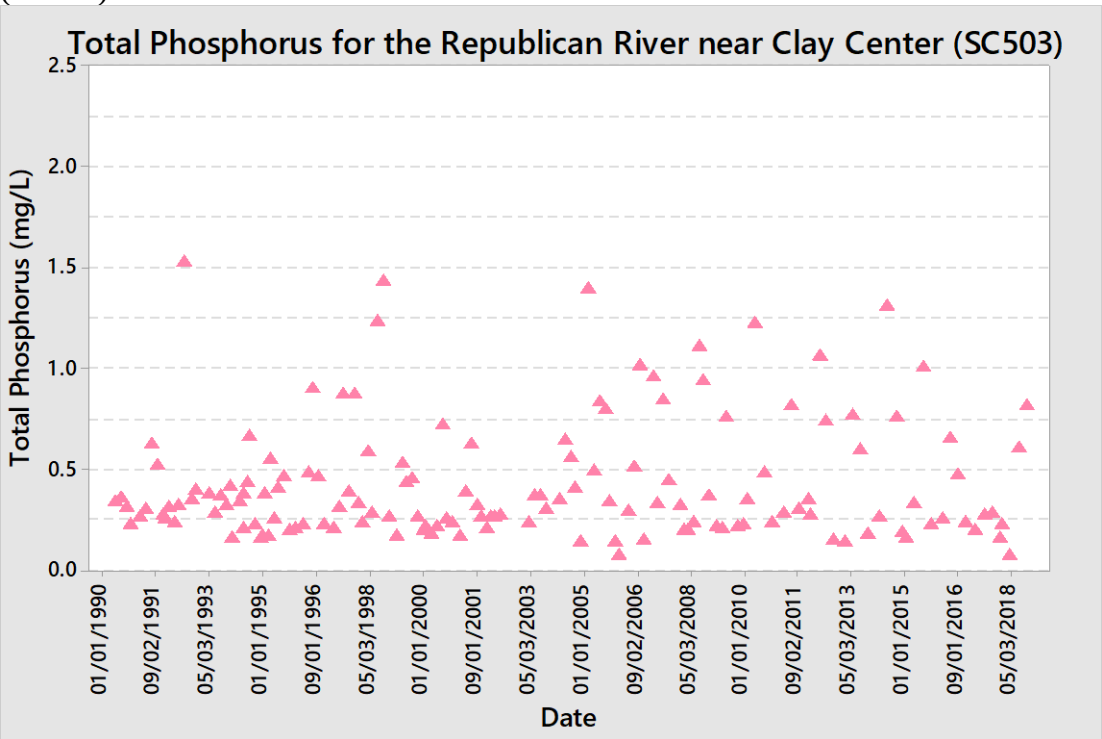
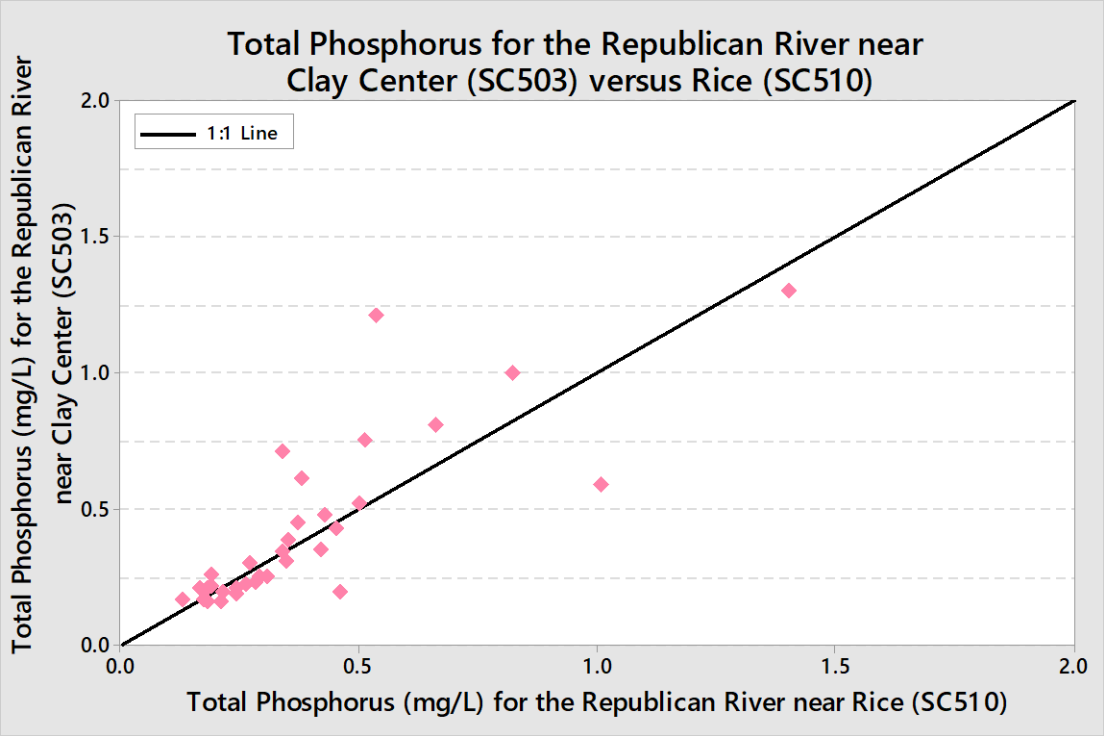


Figure 13. Total phosphorus by sampling date for the Republican River near Clay Center (SC503).



Main stem individual TP samples collected on concurrent days are variable when comparing samples from upstream and downstream stations. The majority of samples collected are below 0.5 mg/L TP and these samples exhibit a clearly defined 1:1 relationship; however, TP concentrations higher than 0.5 mg/L are detected more frequently for the Republican River near Clay Center (SC503) than for the upstream Republican River near Rice (SC510; **Figure 14**). This demonstrates that tributaries between the Republican River near Rice (SC510) and the Republican River near Clay Center (SC503) are contributing to loading within the Republican River.

Figure 14. Total phosphorus at downstream Republican River near Clay Center (SC503) versus upstream Republican River near Rice (SC510) for concurrent day samples, July 17, 1990 to July 20, 2015.

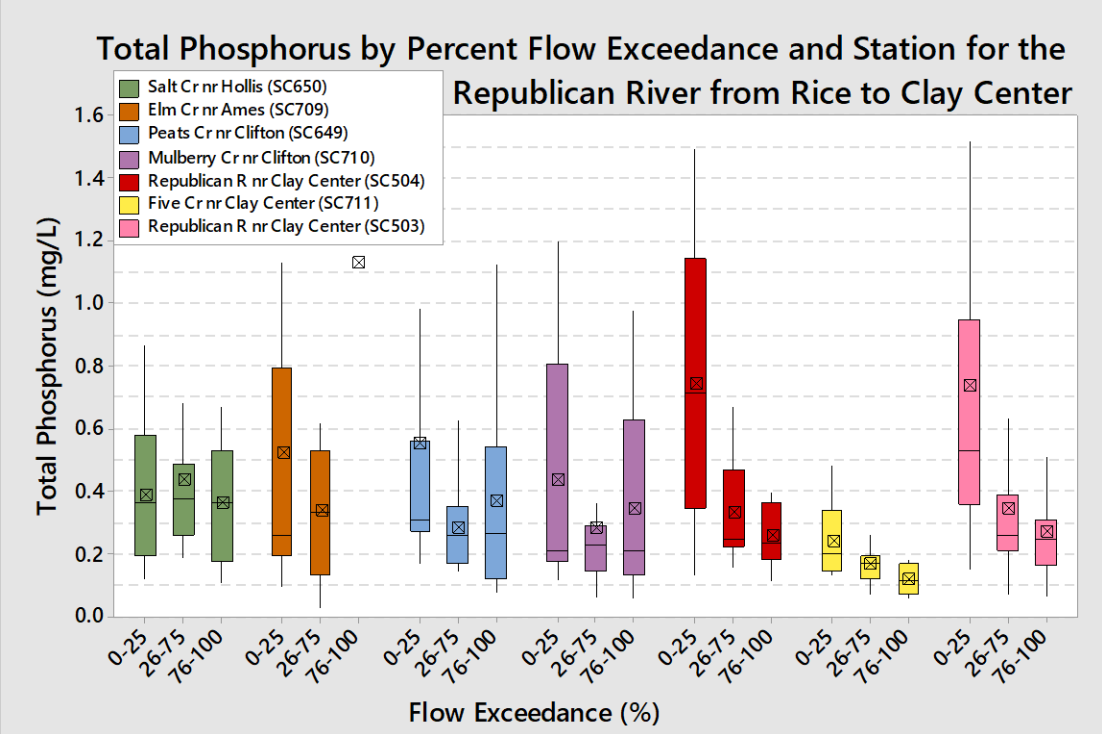


Total phosphorus concentrations for the main stem stations Republican River near Clay Center (SC504 and SC503) and the tributary station Five Creek near Clay Center (SC711) are highest during high flow conditions (0 to 25%; **Figure 15**). These stations exhibit a decline in TP concentrations as flow conditions decrease to normal (26 to 75%) and low (76 to 100%) flow conditions. For example, the Republican River near Clay Center (SC503) has mean and median TP concentrations of 0.739 and 0.530 mg/L, respectively, during high flow conditions (**Table 10**). These concentrations are more than twice the concentrations that occur during low flow conditions, when concentrations decline to a mean and median of 0.273 and 0.250 mg/L, respectively. Higher TP concentrations during high flow conditions, such as those seen at these stations, are indicative of watersheds with a dominant nonpoint source influence.

While the remaining tributaries of Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), and Mulberry Creek near Clifton (SC710) also

exhibit higher TP concentrations during high flow conditions, TP concentrations at these stations do not continue to decline during low flow conditions. Instead, TP concentrations during low flow conditions are similar to or higher than TP concentrations at high and normal flow conditions. For example, Salt Creek near Hollis (SC650) has mean and median TP concentrations of 0.386 and 0.365 mg/L, respectively, during high flow conditions. These concentrations remain elevated during low flow conditions, with a mean and median of 0.363 and 0.362 mg/L, respectively. These variations may be due to streamflow estimation variability for these stations.

Figure 15. Total phosphorus by percent flow exceedance and station for the Republican River from Rice to Clay Center.



Seasonally, summer-fall has considerably greater TP means and medians than spring or winter for all stations except Peats Creek near Clifton (SC649) and Five Creek near Clay Center (SC711; **Table 10**; **Figure 16**). Peats Creek near Clifton (SC649) has a similar TP median in summer-fall (0.306 mg/L) and winter (0.309 mg/L) and Five Creek near Clay Center (SC711) has higher TP concentrations in spring than in summer-fall or winter.

The dominant influence of nonpoint sources for the Republican River from Rice to Clay Center are also evident in individual stream samples through the variability in TP concentration magnitude and seasonal distribution across the range of percent flow exceedances (**Figures 17-20**). The tributary stations Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), and Mulberry Creek near Clifton (SC710) exhibit high TP concentrations during the summer-fall and winter during both high and low flow conditions (**Figures 17** and **18**). These trends likely capture the diffuse nature of nonpoint source. The main stem Republican River near Clay Center (SC504 and SC503) and tributary Five Creek

Table 10. Total phosphorus concentration mean, median, and number of samples (N) by season (spring: April through June, summer-fall: July through October, winter: November through March), flow range, and station for the Republican River from Rice to Clay Center.

Flow Exceedance (%)	Spring			Summer-Fall			Winter			All		
	Mean	Median	N	Mean	Median	N	Mean	Median	N	Mean	Median	N
Total Phosphorus (mg/L) for Salt Cr nr Hollis (SC650)												
0-25	0.415	0.390	7	0.497	0.370	3	0.119	0.119	2	0.386	0.365	12
26-75	0.437	0.392	5	0.619	0.497	6	0.273	0.260	7	0.434	0.380	18
76-100	–	–	–	0.575	0.575	2	0.257	0.224	4	0.363	0.362	6
0-100	**0.424**	**0.391**	**12**	**0.578**	**0.480**	**11**	**0.245**	**0.247**	**13**	**0.406**	**0.369**	**36**
Total Phosphorus (mg/L) for Elm Cr nr Ames (SC709)												
0-25	0.289	0.260	5	1.06	1.13	3	0.094	0.094	1	0.524	0.260	9
26-75	0.290	0.290	2	0.428	0.425	4	0.263	0.204	4	0.335	0.332	10
76-100	–	–	–	–	–	–	1.13	1.13	1	1.13	1.13	1
0-100	**0.289**	**0.260**	**7**	**0.698**	**0.442**	**7**	**0.380**	**0.204**	**6**	**0.459**	**0.301**	**20**
Total Phosphorus (mg/L) for Peats Cr nr Clifton (SC649)												
0-25	0.373	0.335	6	0.959	0.637	4	0.357	0.309	3	0.549	0.309	13
26-75	0.258	0.263	4	0.321	0.274	6	0.253	0.247	4	0.283	0.263	14
76-100	0.269	0.269	2	0.241	0.241	2	0.602	0.602	2	0.370	0.269	6
0-100	**0.317**	**0.298**	**12**	**0.520**	**0.306**	**12**	**0.365**	**0.309**	**9**	**0.404**	**0.304**	**33**
Total Phosphorus (mg/L) for Mulberry Cr nr Clifton (SC710)												
0-25	0.249	0.210	5	0.848	1.18	3	0.115	0.115	1	0.434	0.210	9
26-75	0.284	0.270	3	0.384	0.240	5	0.162	0.147	4	0.285	0.228	12
76-100	0.240	0.240	2	0.210	0.210	1	0.519	0.519	2	0.346	0.210	5
0-100	**0.258**	**0.216**	**10**	**0.519**	**0.240**	**9**	**0.257**	**0.133**	**7**	**0.348**	**0.213**	**26**
Total Phosphorus (mg/L) for Republican R nr Clay Center (SC504)												
0-25	0.716	0.627	4	1.14	1.10	5	0.376	0.363	5	0.745	0.715	14
26-75	0.387	0.340	3	0.463	0.485	6	0.248	0.236	11	0.333	0.248	20
76-100	0.325	0.325	1	0.289	0.268	5	0.143	0.143	2	0.257	0.237	8
0-100	**0.544**	**0.350**	**8**	**0.619**	**0.492**	**16**	**0.272**	**0.233**	**18**	**0.456**	**0.318**	**42**
Total Phosphorus (mg/L) for Five Cr nr Clay Center (SC711)												
0-25	0.356	0.356	2	0.197	0.148	5	0.211	0.211	1	0.238	0.201	8
26-75	0.247	0.241	4	0.160	0.150	3	0.135	0.132	10	0.166	0.167	17
76-100	–	–	–	0.078	0.078	2	0.158	0.158	2	0.118	0.116	4
0-100	**0.283**	**0.247**	**6**	**0.162**	**0.144**	**10**	**0.145**	**0.137**	**13**	**0.179**	**0.167**	**29**
Total Phosphorus (mg/L) for Republican R nr Clay Center (SC503)												
0-25	0.587	0.430	19	1.10	0.891	17	0.453	0.353	10	0.739	0.530	46
26-75	0.435	0.371	16	0.448	0.379	21	0.234	0.218	35	0.341	0.261	72
76-100	0.283	0.286	6	0.310	0.281	12	0.234	0.160	13	0.273	0.250	31
0-100	**0.483**	**0.370**	**41**	**0.628**	**0.455**	**50**	**0.272**	**0.224**	**58**	**0.450**	**0.310**	**149**

Definition: – - No data

Figure 16. Total phosphorus by season and station for the Republican River from Rice to Clay Center.

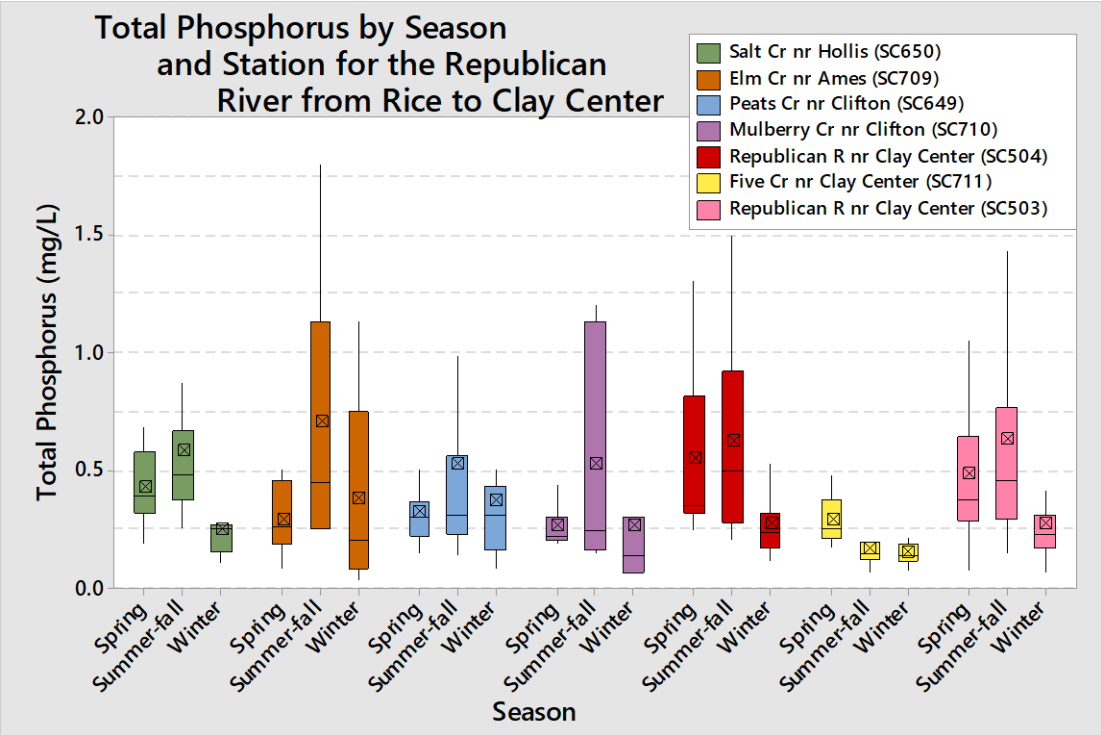


Figure 17. Total phosphorus by percent flow exceedance and season for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

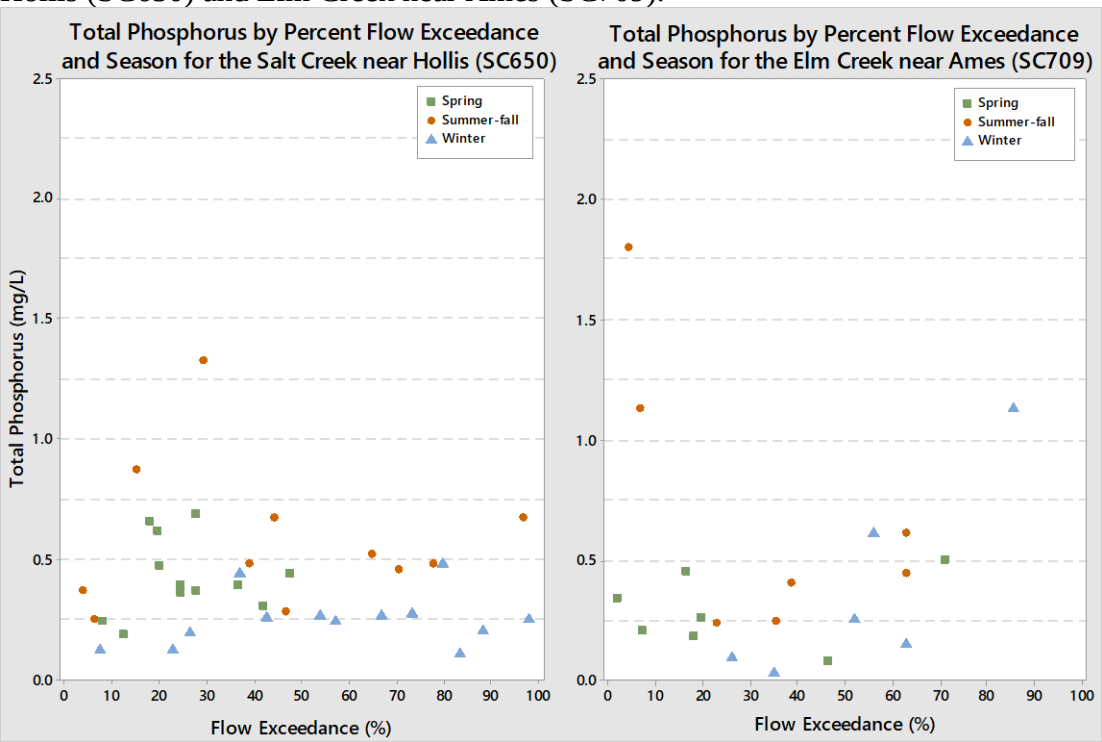


Figure 18. Total phosphorus by percent flow exceedance and season for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

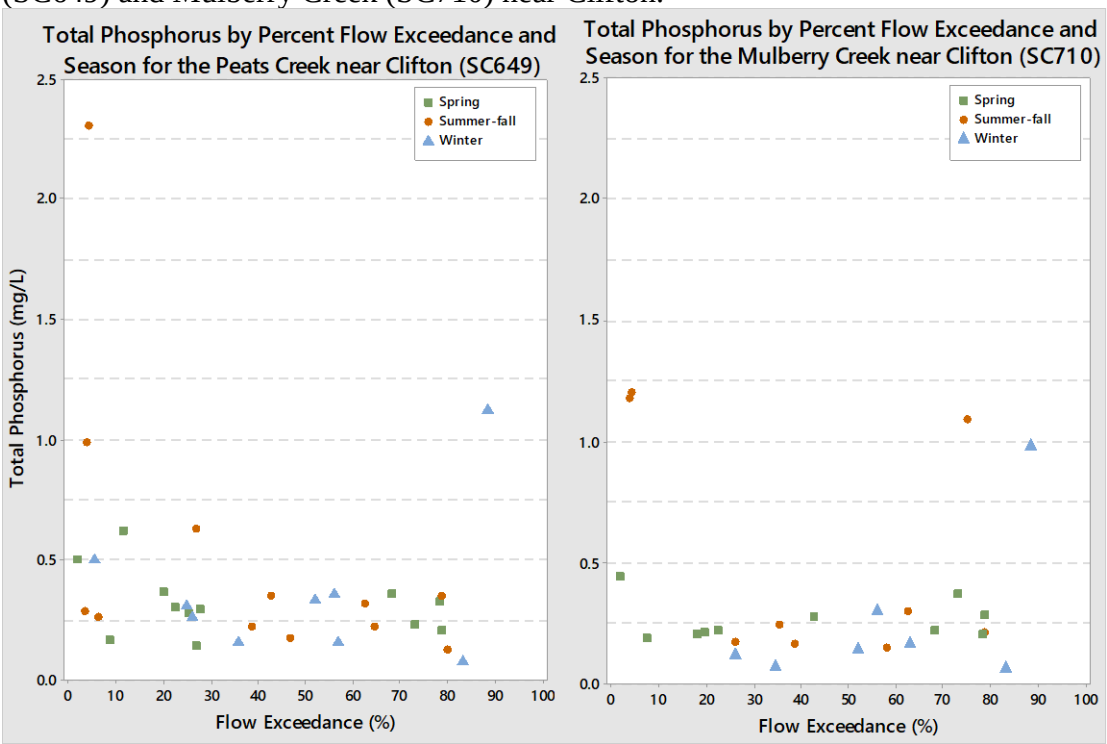


Figure 19. Total phosphorus by percent flow exceedance and season for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

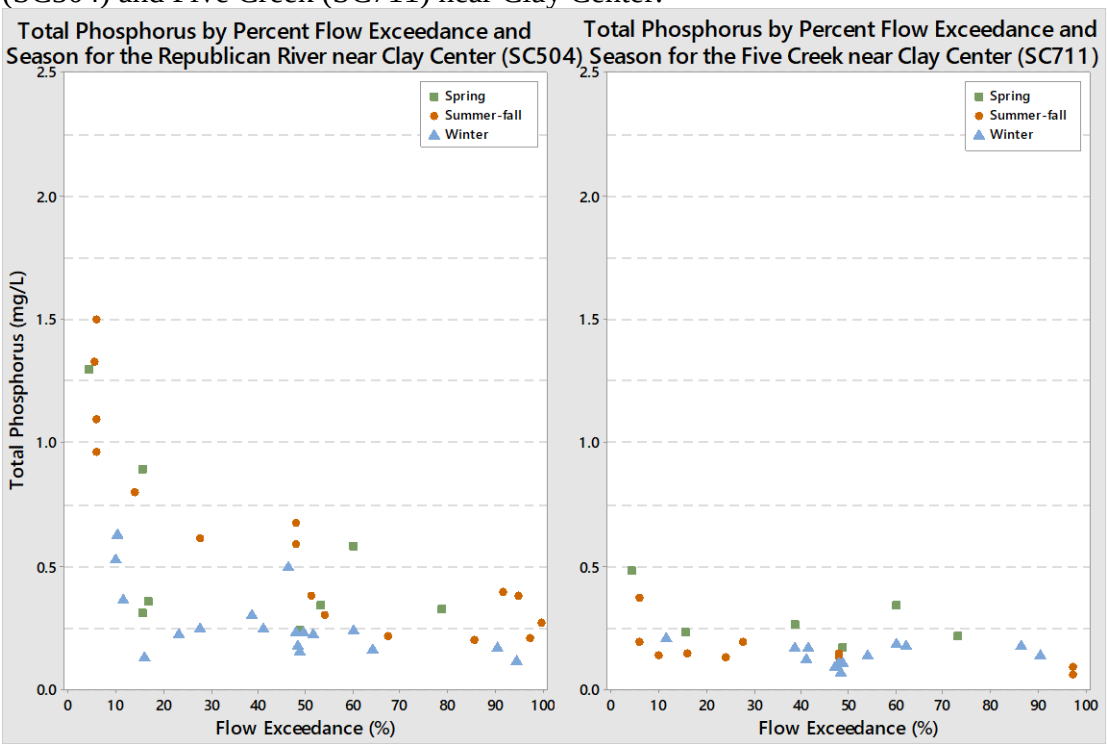
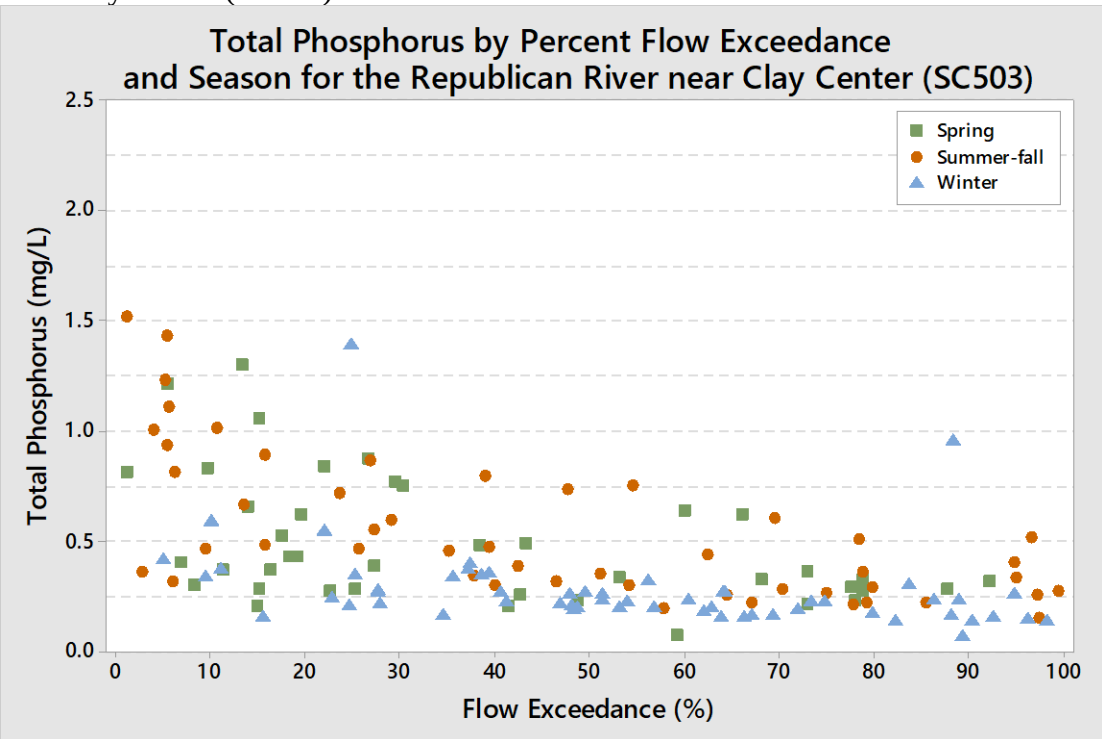


Figure 20. Total phosphorus by percent flow exceedance and season for the Republican River near Clay Center (SC503).



near Clay Center (SC711) display trends of decreasing TP concentrations as flow decreases irrespective of season (**Figures 19** and **20**). Samples with high TP concentrations for these stations were typically collected in the spring and summer-fall during high flow conditions and are likely the result of runoff due to precipitation.

Total Phosphorus and Other Water Quality Parameters

Total phosphorus has well-established and defined relationships with orthophosphate (OP) and total suspended solids (TSS). These relationships are examined further in order to delineate potential sources of TP loading to the Republican River from Rice to Clay Center.

Orthophosphate

The soluble portion of TP that is readily available for biological use is OP. It is commonly found in higher concentrations in effluent, such as the discharge of municipal WWTFs or in runoff from livestock sources. Only samples measuring above the reporting limit are included in the analysis presented, resulting in a left censored data set which may overestimate true OP concentration means (**Table 11**). In addition, reporting limits for OP have changed throughout the period of record: 0.01 mg/L from 1995-1996, 0.02 mg/L from 1997 to February 2002, and 0.25 mg/L from March 2002 to 2018. Of all the stations, Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), and Peats Creek near Clifton (SC649) have the highest percentage of detections, with 52, 67, and 50% of the samples detecting OP, respectively. The Republican River near Clay Center (SC504) has the highest censored mean concentration of 0.34 mg/L OP.

Table 11. Mean of detected orthophosphate (OP) samples, mean ratio of OP and total phosphorous (TP), sample number (N), and percentage of samples greater than the analytical reporting limit (> RL) separated by reporting limit increases for the Republican River from Rice to Clay Center, January 17, 1995 to October 15, 2018.

Station	Sample Information	Orthophosphate Period of Record			
		1995-1996 (0.01 mg/L)	1997-Feb. 2002 (0.02 mg/L)	Mar. 2002-2018 (0.25 mg/L)	1995-2018
Salt Cr nr Hollis (SC650)	Mean (mg/L)	–	0.12	0.35	0.28
	N	–	7	7	14
	Sample Percent > RL (%)	–	70	41	52
	Mean Ratio OP:TP	–	0.49	0.66	0.58
Elm Cr nr Ames (SC709)	Mean (mg/L)	0.14	–	0.43	0.34
	N	3	–	7	10
	Sample Percent > RL (%)	75	–	64	67
	Mean Ratio OP:TP	0.54	–	0.57	0.54
Peats Cr nr Clifton (SC649)	Mean (mg/L)	–	0.10	0.35	0.23
	N	–	7	6	13
	Sample Percent > RL (%)	–	78	35	50
	Mean Ratio OP:TP	–	0.38	0.56	0.47
Mulberry Cr nr Clifton (SC710)	Mean (mg/L)	0.05	–	0.33	0.16
	N	3	–	2	5
	Sample Percent > RL (%)	75	–	13	26
	Mean Ratio OP:TP	0.29	–	0.31	0.29
Republican R nr Clay Center (SC504)	Mean (mg/L)	–	0.10	0.38	0.34
	N	–	1	6	7
	Sample Percent > RL (%)	–	100	26	29
	Mean Ratio OP:TP	–	0.42	0.43	0.43
Five Cr nr Clay Center (SC711)	Mean (mg/L)	0.15	–	0.30	0.22
	N	2	–	2	4
	Sample Percent > RL (%)	40	–	12	14
	Mean Ratio OP:TP	0.66	–	0.75	0.71
Republican R nr Clay Center (SC503)	Mean (mg/L)	0.12	0.10	0.37	0.28
	N	8	5	22	35
	Sample Percent > RL (%)	62	29	31	35
	Mean Ratio OP:TP	0.39	0.26	0.49	0.43

Definition: – - No data

Orthophosphate is detected throughout the period of record at all stations, with OP concentrations consistently exceeding the reporting limit of 0.25 mg/L after 2002 (**Figure 21**). The Republican River near Clay Center (SC503) has the highest OP concentration of 0.74 mg/L in October 2018, as well as the most numerous OP detections of all the stations. This station is influenced by a municipal mechanical WWTF and also has a strong nonpoint source influence. Of the tributaries, Elm Creek near Ames (SC709) has the highest OP concentration of 0.60 mg/L in February 2007 and July 2015. This tributary is primarily influenced by nonpoint sources of OP. The wide range of scatter and the notable lack of OP detections at flow exceedances above 90% indicate that diffuse sources of OP are more prevalent in these watersheds (**Figure 22**).

Figure 21. Orthophosphate samples measuring greater than the reporting limit by station for the Republican River from Rice to Clay Center, January 17, 1995 to October 15, 2018.

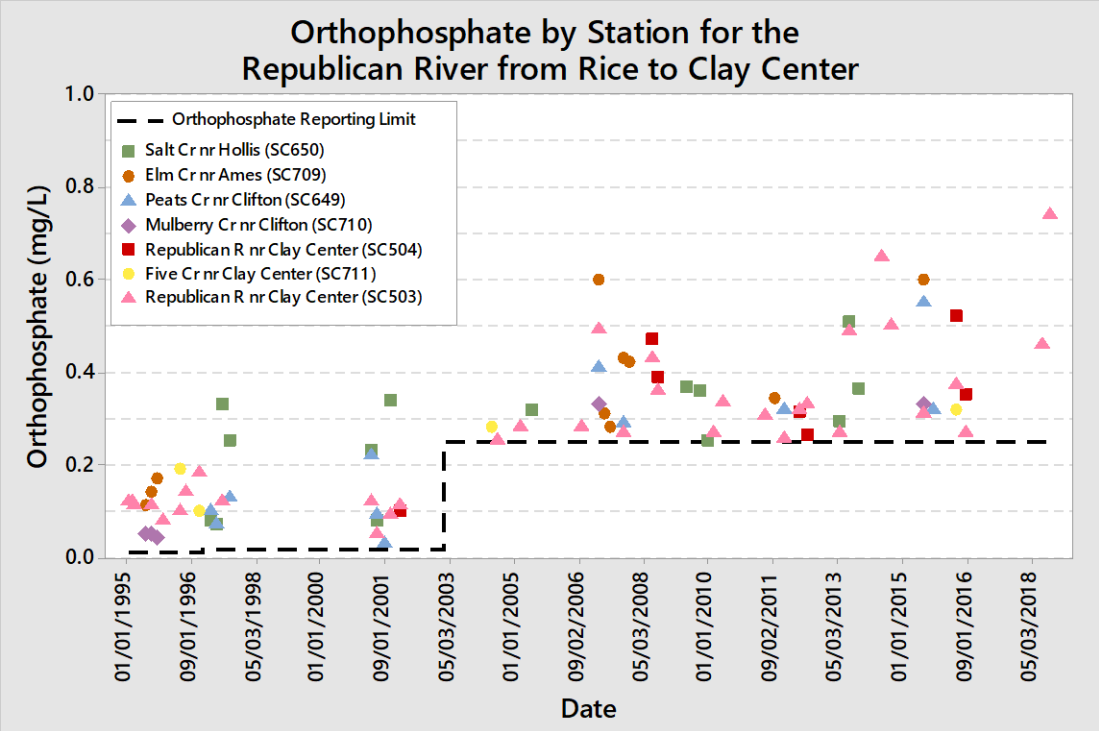
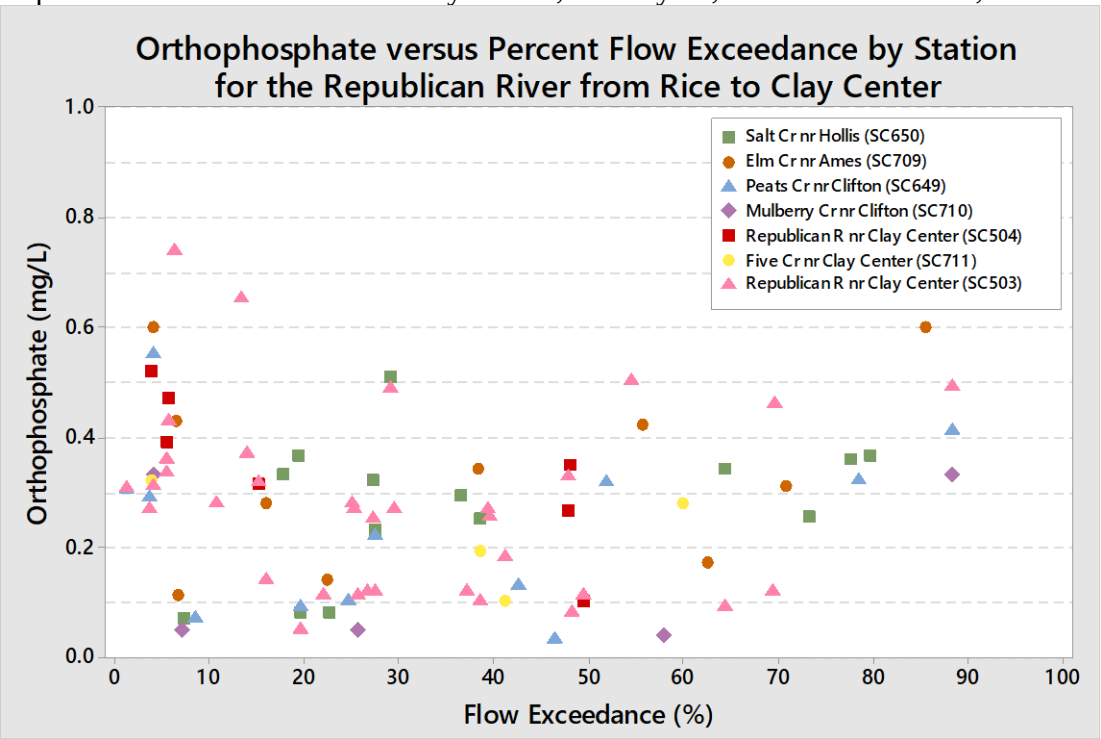


Figure 22. Orthophosphate versus percent flow exceedance by station and season for the Republican River from Rice to Clay Center, January 17, 1995 to October 15, 2018.



Total Suspended Solids

Phosphorus has a high affinity for fixation in soils, where it is adsorbed from soil solution. Erosion of phosphorus-laden soil particles is a common means for phosphorus to enter streams, where it is then desorbed. This natural propensity for adsorbtion and desorbtion to soil particles creates a positively correlated relationship between TP and TSS that is evident at all stations in the watershed (**Figures 23-26**). All stations display a correlation value greater than 0.45 except for Five Creek near Clay Center (SC711). The main stem Republican River stations display the strongest correlation, with the Republican River near Clay Center (SC504 and SC503) having correlations of 0.80 and 0.75, respectively. Furthermore, the relationship between TP and TSS remains fairly well-defined during all flow conditions for all seven stations, where data is available. These well-defined relationships between TP and TSS indicate that nonpoint and runoff sources of TP are more influential in these watersheds as there is no major point source disrupting these trends during lower flow conditions.

Figure 23. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

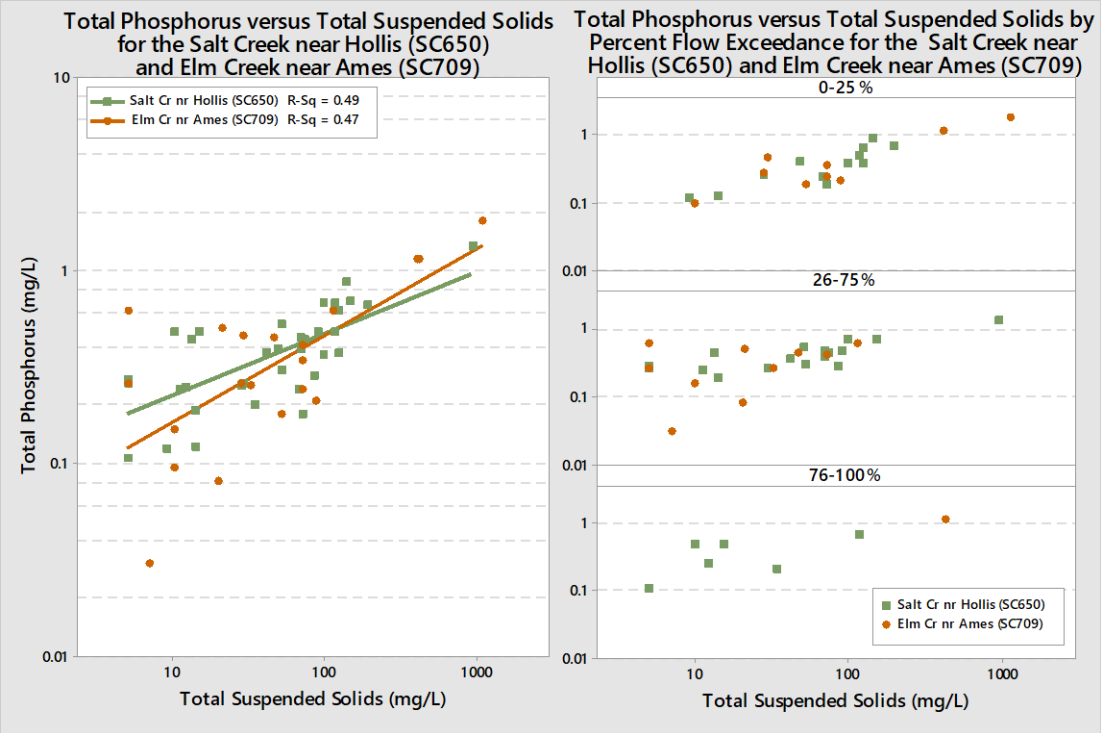


Figure 24. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

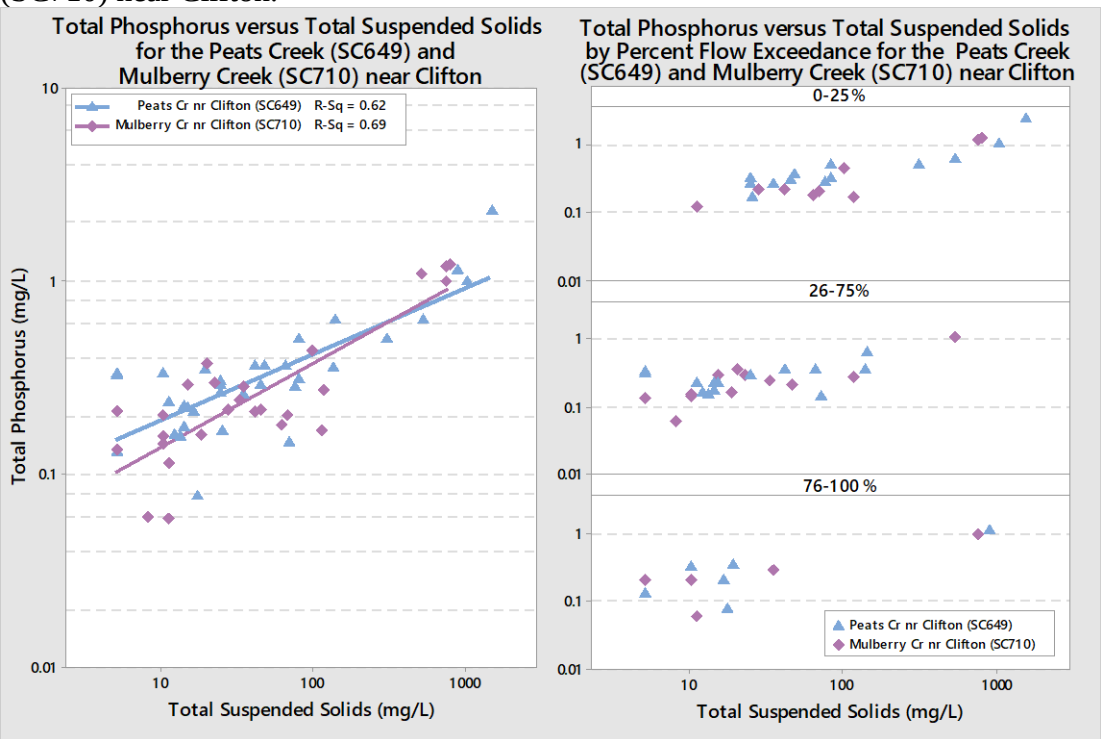


Figure 25. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

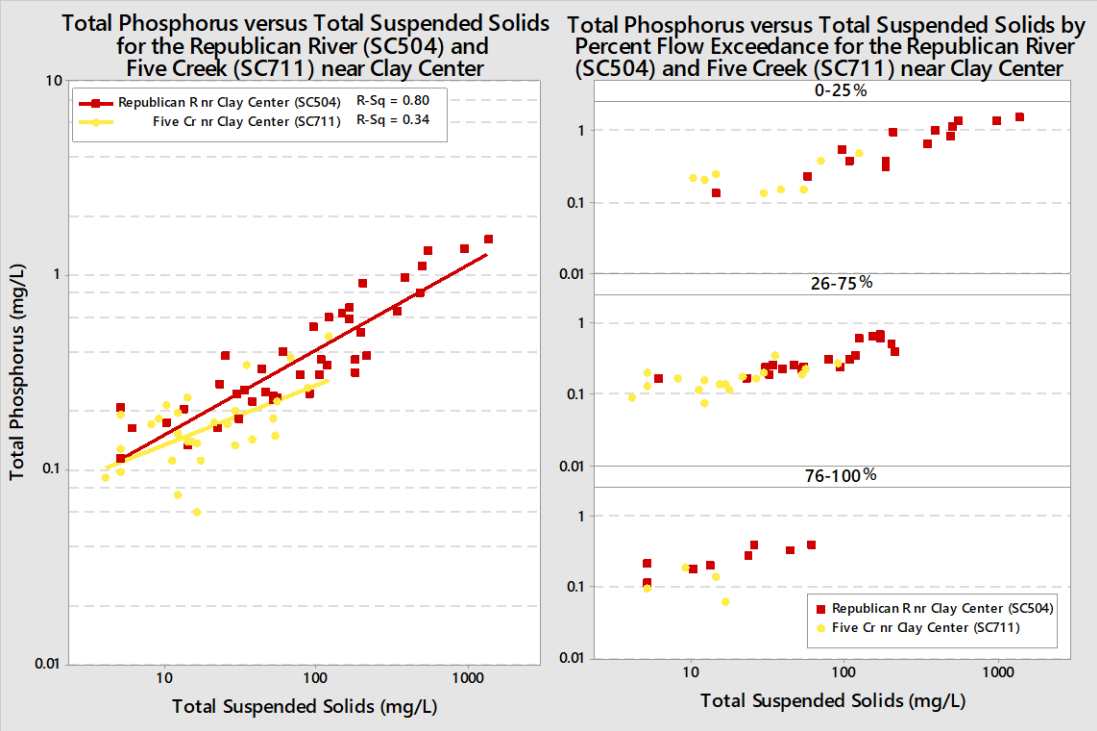
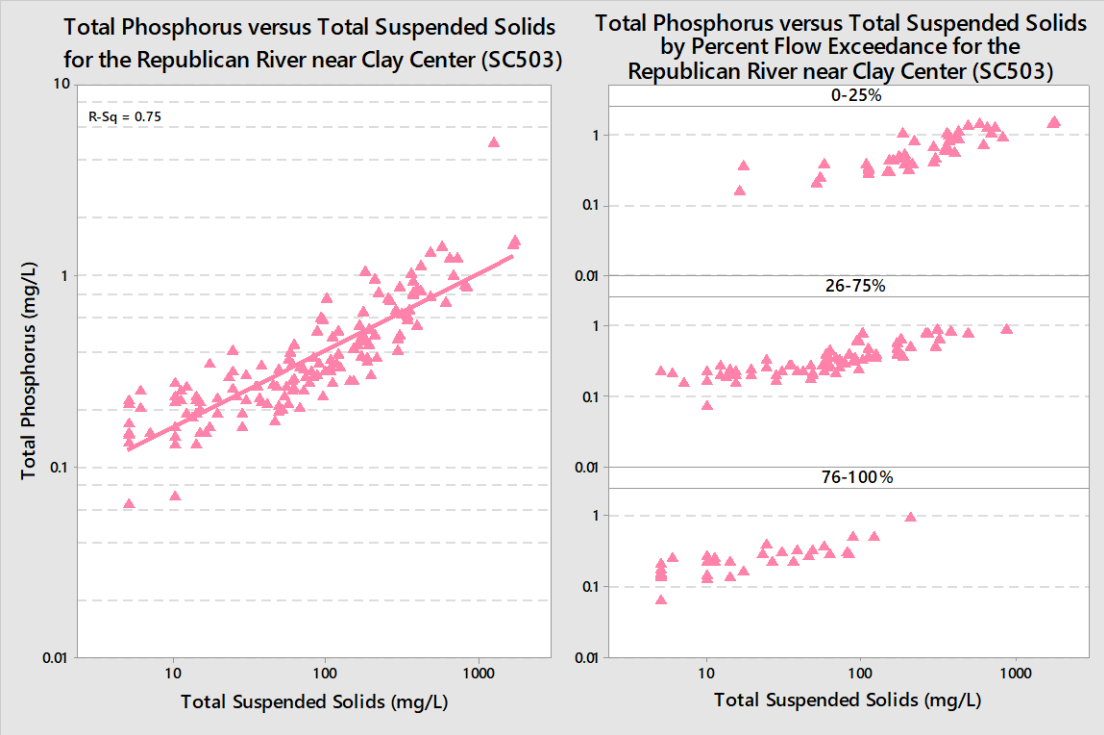


Figure 26. Total phosphorus versus total suspended solids and total phosphorus versus total suspended solids by percent flow exceedance for the Republican River near Clay Center (SC503).



Total Phosphorus and Biological Indicators

The narrative criteria of the Kansas Surface Water Quality Standards are based on conditions of the prevailing biological community. Excessive primary productivity may be indicated by extreme shifts in dissolved oxygen (DO), dissolved oxygen saturation (DO saturation), and pH as the chemical reactions of photosynthesis and respiration alter the ambient levels of oxygen and acid-base balance of the stream. These shifts, in turn, can result in undesirable regime shifts in the algal biomass and biological community within the stream.

Dissolved Oxygen

At all SC stations for the watershed, dissolved oxygen and temperature are inversely related (**Figures 27-30**). This corresponds to seasonal changes in DO and temperature, where low mean DO concentrations occur in spring and summer-fall when temperatures are highest, and high mean DO concentrations occur in winter when temperatures are lowest (**Table 12**). This relationship is expected because oxygen becomes less soluble in water as temperatures increase. Additionally, DO exhibits a diel trend due to daily fluctuations in photosynthetic activity. The presented data captures this daily variability based upon whether a sample was collected in the morning (8:03 to 11:55), afternoon (12:00 to 17:46), or evening (18:05 to 18:52; **Table 13**). Generally, morning and evening samples tend to have lower DO concentrations and afternoon samples tend to have higher DO concentrations; however, Salt Creek near Hollis (SC650) and Peats Creek near Clifton (SC649) are exceptions to this.

Peats Creek near Clifton (SC649), Republican River near Clay Center (SC504), and Five Creek near Clay Center (SC711) have never had a DO excursion below the water quality criterion of 5.0 mg/L. The remaining stations within the watershed have a DO excursion below the water quality criterion of 5.0 mg/L: Salt Creek near Hollis (SC650) has excursions of 3.8 and 4.4 mg/L in August 1997 and October 2005, respectively; Elm Creek near Ames (SC709) has an excursion of 0.78 mg/L in June 2007; Mulberry Creek near Clifton (SC649) has an excursion of 1.1 mg/L in December 2007; and Republican River near Clay Center (SC503) has excursions of 3.6 and 4.9 mg/L in July 1992 and August 1993, respectively.

Dissolved Oxygen Saturation

Primary productivity increases in the spring and summer-fall, when temperatures are higher and DO concentrations are lower. When primary productivity is excessive, oxygen from aquatic photosynthesis can create DO concentrations that exceed the natural oxygen equilibrium of the stream at a given temperature. The stream is considered supersaturated with oxygen when the expected oxygen capacity of the stream at a given temperature exceeds a DO saturation of 110%. Because of the system's diel characteristics, supersaturated conditions are more likely to be detected in the afternoon when photosynthesis and temperatures are at their peak.

All stations within the watershed display supersaturated conditions exceeding 110% DO saturation throughout the period of record, with the exception of Five Creek near Clay Center (SC711; **Figures 31-34**). The tributaries Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709) tend to have DO saturation excursions when temperatures are lower. The remaining stations tend to have excursions when temperatures are higher, with Peats Creek near Clifton (SC649) having the highest DO saturation excursion and Republican River near Clay Center (SC503) having the most frequent DO saturation excursions. Overall, mean DO

Figure 27. Dissolved oxygen and the relationship between dissolved oxygen and temperature for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

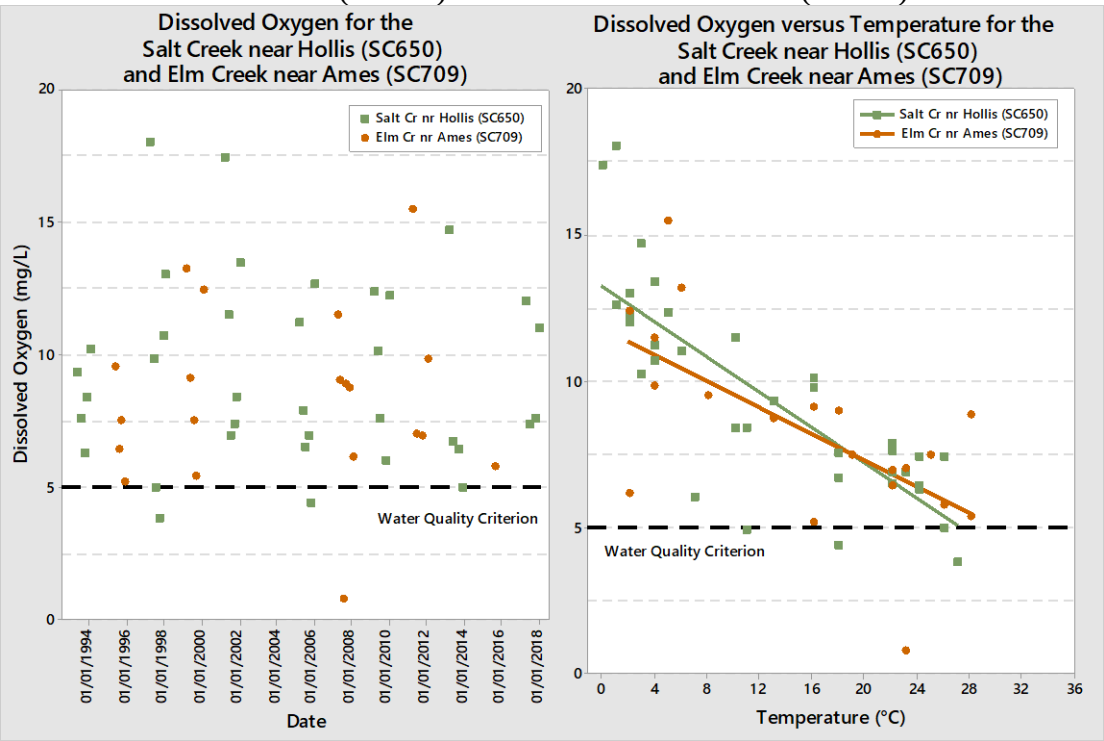


Figure 28. Dissolved oxygen and the relationship between dissolved oxygen and temperature for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

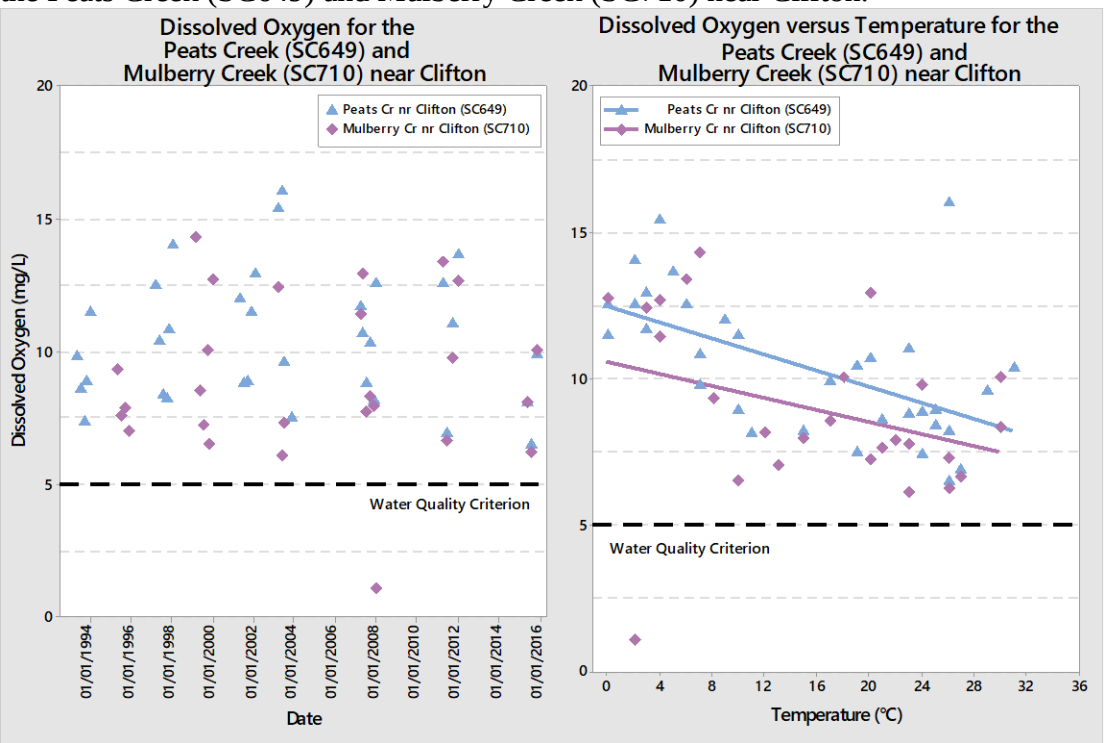


Figure 29. Dissolved oxygen and the relationship between dissolved oxygen and temperature for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

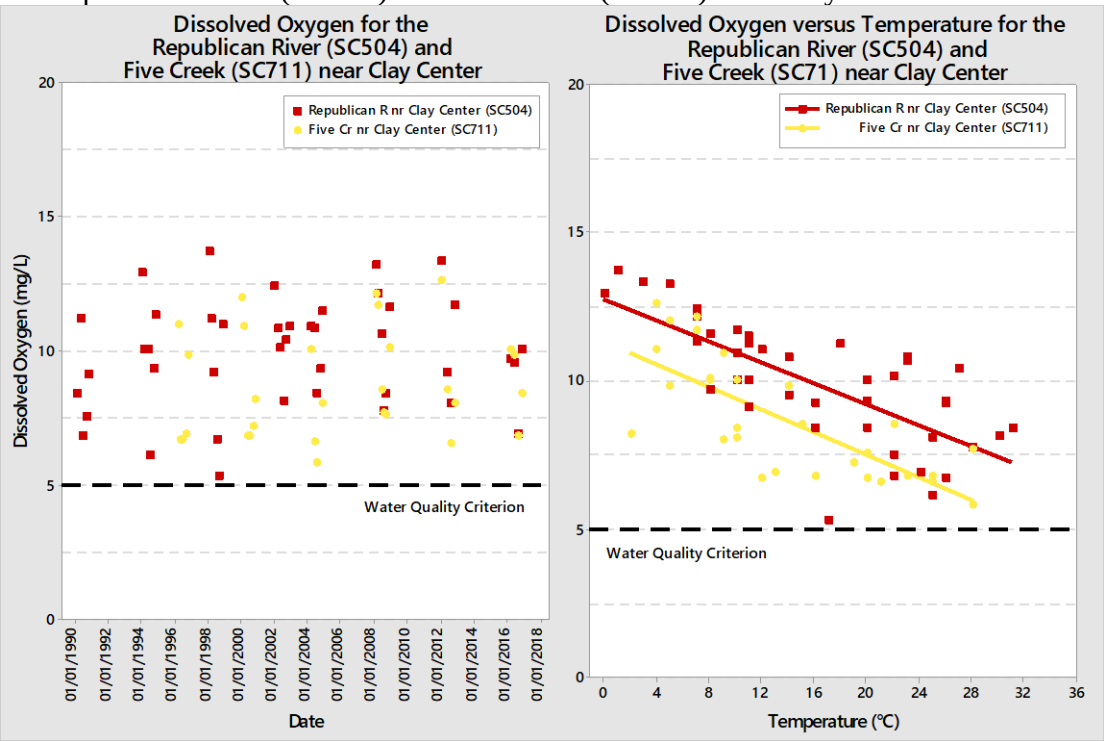
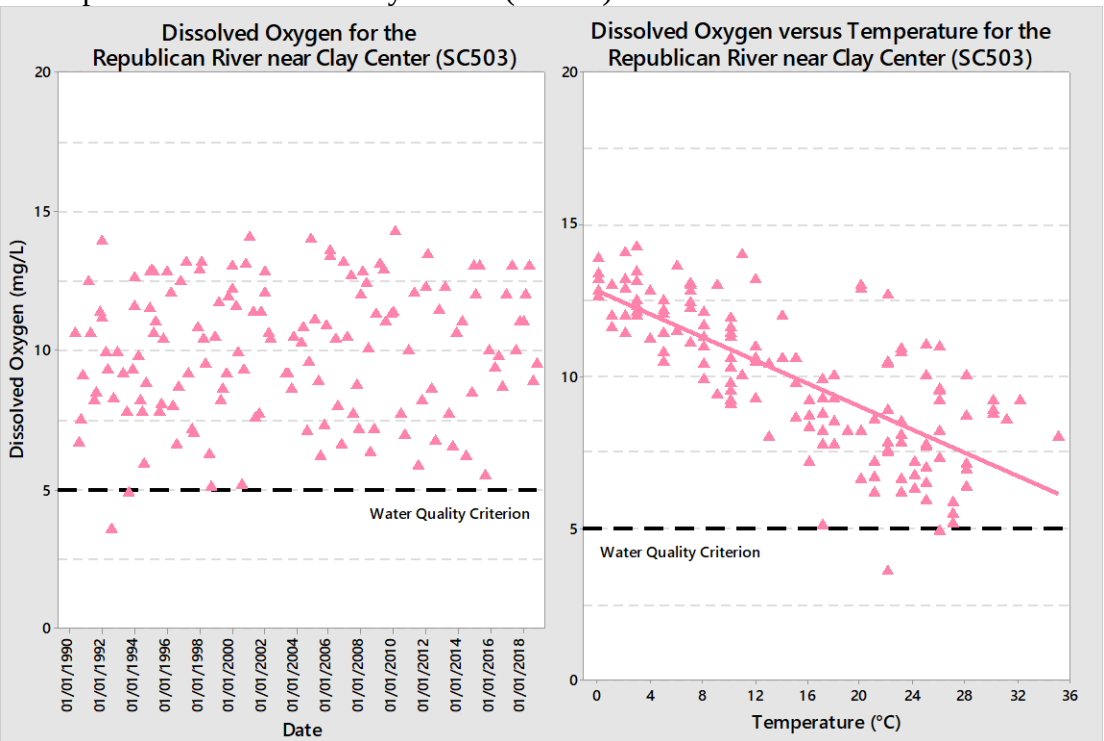


Figure 30. Dissolved oxygen and the relationship between dissolved oxygen and temperature for the Republican River near Clay Center (SC503).



saturation samples at all stations do not exceed 110% and seasonal means are within the range of 71 to 111% throughout all seasons (**Table 12**). The stations with the highest mean DO saturations are Peats Creek near Clifton (SC649), Republican River near Clay Center (SC504), and Republican River near Clay Center (SC503), which have overall mean DO saturations of 101, 98, and 95%, respectively.

Table 12. Mean temperature, dissolved oxygen, and dissolved oxygen saturation, as well as median pH, by season for the Republican River from Rice to Clay Center.

Station	Spring	Summer-Fall	Winter	All Seasons
Temperature (°C)				
Salt Cr nr Hollis (SC650)	19	18	3.4	13
Elm Cr nr Ames (SC709)	18	23	3.8	16
Peats Cr nr Clifton (SC649)	20	19	2.8	15
Mulberry Cr nr Clifton (SC710)	20	21	3.7	16
Republican R nr Clay Center (SC504)	20	23	8.4	16
Five Cr nr Clay Center (SC711)	17	21	6.8	14
Republican R nr Clay Center (SC503)	20	21	5.7	15
Dissolved Oxygen (mg/L)				
Salt Cr nr Hollis (SC650)	8.0	6.9	13	9.3
Elm Cr nr Ames (SC709)	7.0	6.9	11	8.3
Peats Cr nr Clifton (SC649)	9.8	9.1	13	10
Mulberry Cr nr Clifton (SC710)	8.1	8.2	11	9.0
Republican R nr Clay Center (SC504)	10	8.1	11	9.9
Five Cr nr Clay Center (SC711)	7.8	7.0	10	8.7
Republican R nr Clay Center (SC503)	9.3	8.3	12	10
Dissolved Oxygen Saturation (%)				
Salt Cr nr Hollis (SC650)	86	71	93	84
Elm Cr nr Ames (SC709)	73	80	87	80
Peats Cr nr Clifton (SC649)	108	98	96	101
Mulberry Cr nr Clifton (SC710)	88	92	85	89
Republican R nr Clay Center (SC504)	111	94	96	98
Five Cr nr Clay Center (SC711)	80	78	85	82
Republican R nr Clay Center (SC503)	98	91	95	95
pH				
Salt Cr nr Hollis (SC650)	8.0	7.8	7.8	7.8
Elm Cr nr Ames (SC709)	8.1	7.8	7.8	8.0
Peats Cr nr Clifton (SC649)	8.0	8.0	7.7	7.9
Mulberry Cr nr Clifton (SC710)	7.8	7.6	7.5	7.7
Republican R nr Clay Center (SC504)	8.3	8.3	8.2	8.2
Five Cr nr Clay Center (SC711)	7.6	7.7	7.6	7.6
Republican R nr Clay Center (SC503)	8.2	8.1	8.1	8.1

Table 13. Mean dissolved oxygen and dissolved oxygen saturation by diel variability for the Republican River from Rice to Clay Center.

Station	Dissolved Oxygen (mg/L) – Morning	Dissolved Oxygen (mg/L) – Afternoon	Dissolved Oxygen (mg/L) – Evening	Dissolved Oxygen Saturation (%) – Morning	Dissolved Oxygen Saturation (%) – Afternoon	Dissolved Oxygen Saturation (%) – Evening
Salt Cr nr Hollis (SC650)	9.9	9.3	6.4	82	84	76
Elm Cr nr Ames (SC709)	0.8*	9.0	6.4	9	84	76
Peats Cr nr Clifton (SC649)	9.8	11	11	93	107	128
Mulberry Cr nr Clifton (SC710)	8.2	9.2	8.0	83	89	96
Republican R nr Clay Center (SC504)	9.4	10	–	90	104	–
Five Cr nr Clay Center (SC711)	8.7	8.7	–	79	86	–
Republican R nr Clay Center (SC503)	9.8	10	–	88	105	–

Definitions: * - Single sample; – - No data

Figure 31. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

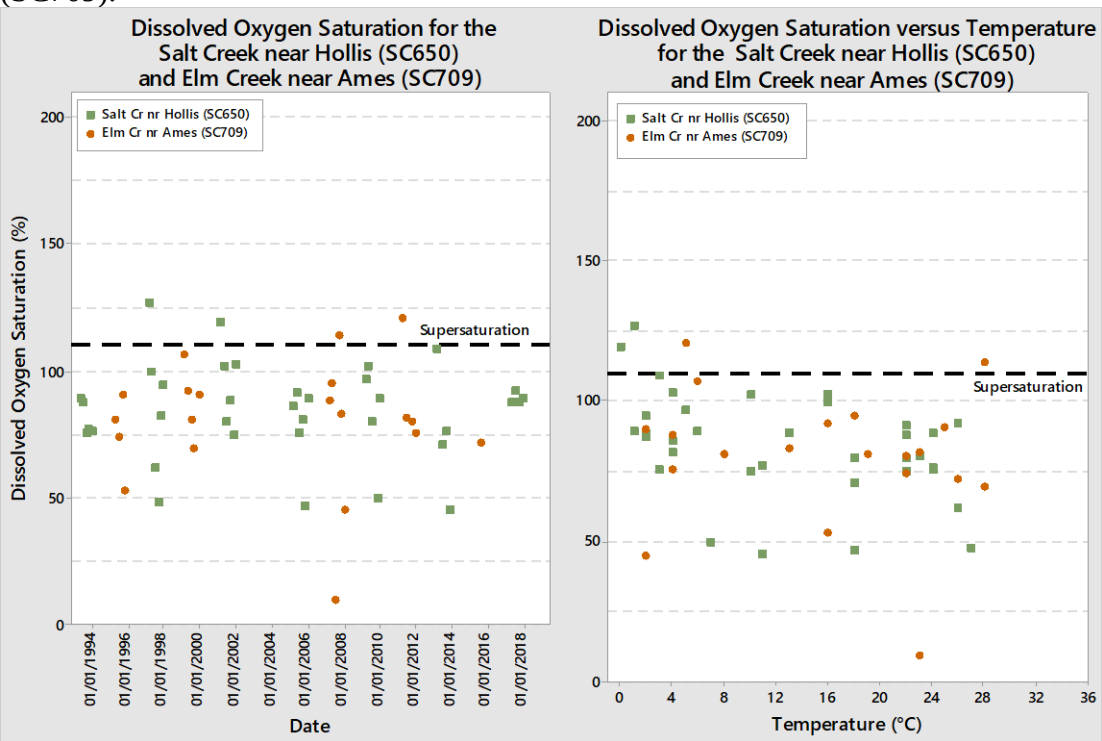


Figure 32. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

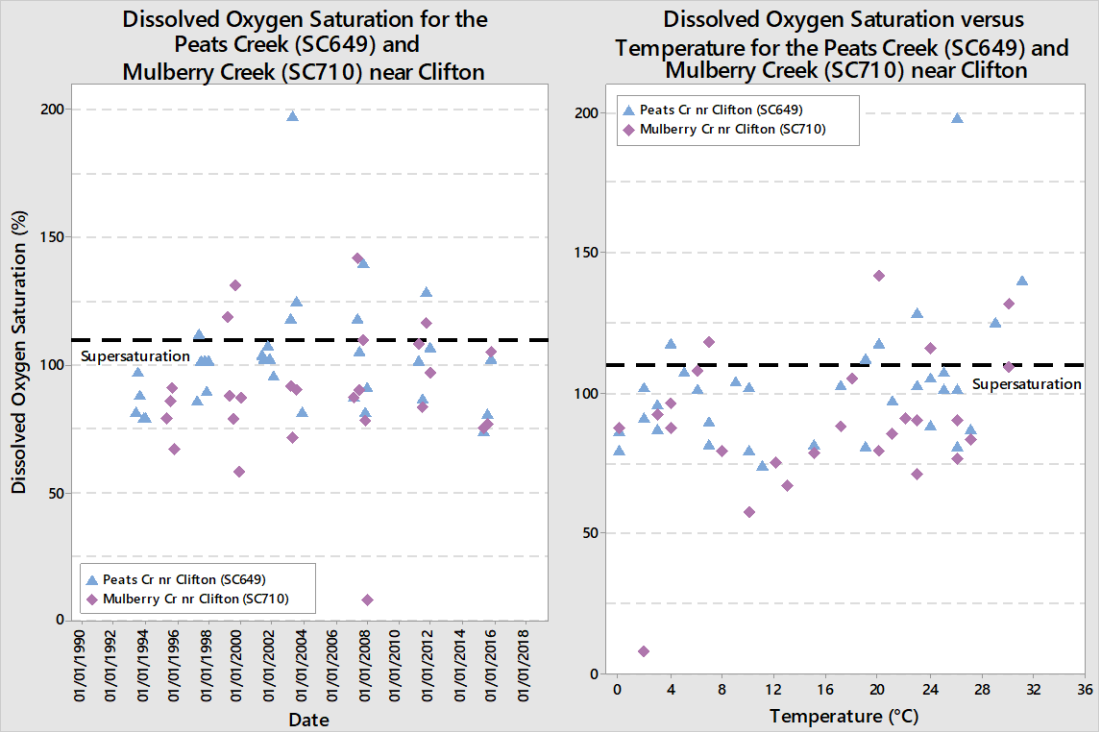


Figure 33. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

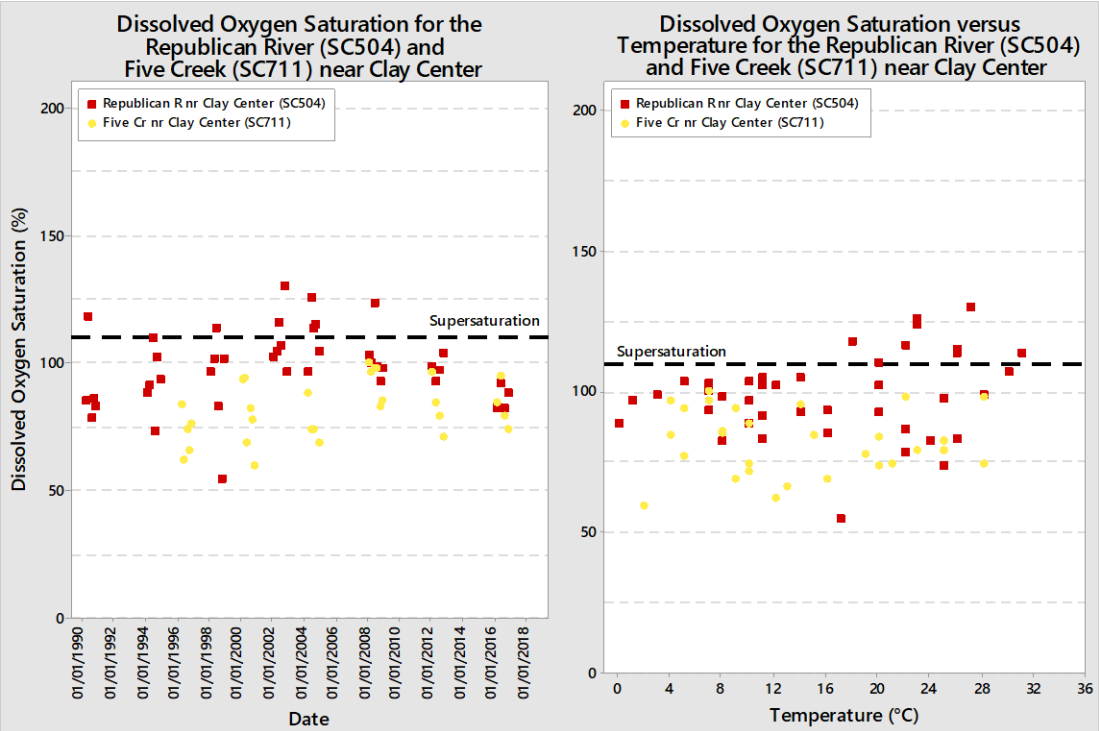
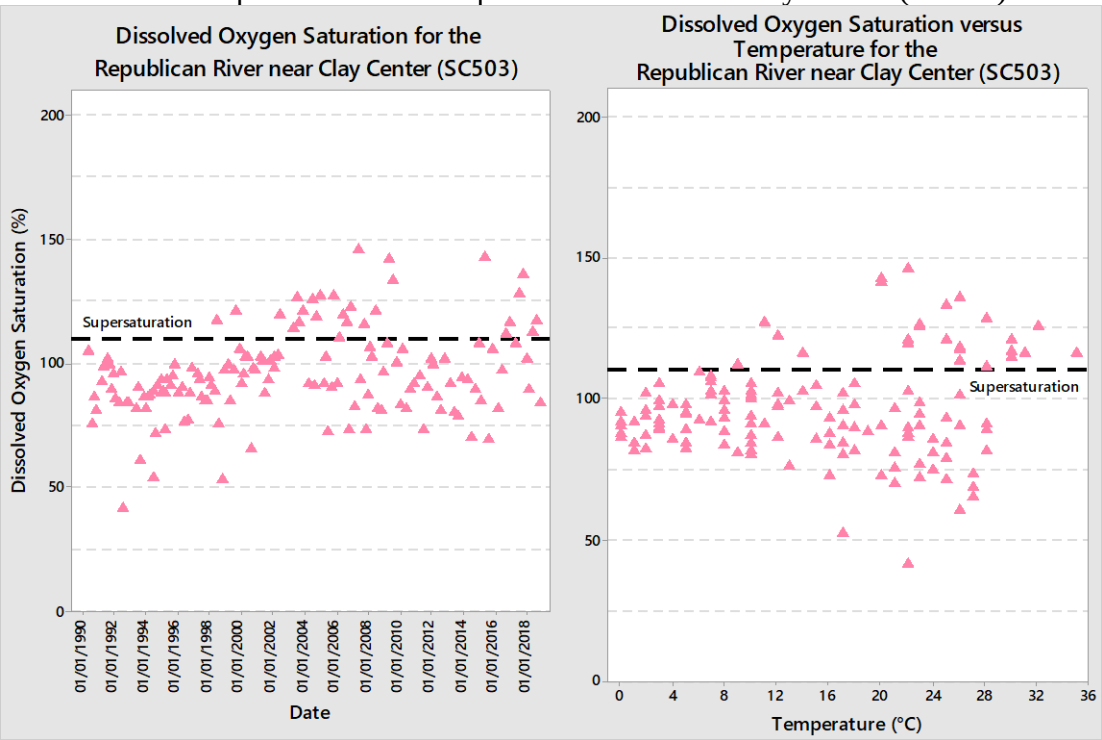


Figure 34. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for the Republican River near Clay Center (SC503).



pH

Another water quality indicator of primary productivity is pH, as photosynthesis can increase pH by removing carbon dioxide from the water. The numeric water quality criteria for pH is a range from 6.5 to 8.5. None of the stations in the watershed have pH values less than 6.5 (**Figures 35-38**). The Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Mulberry Creek near Clifton (SC710), and Five Creek near Clay Center (SC711) have never had an excursion greater than 8.5. The stations with pH values greater than 8.5 are the tributary Peats Creek near Clifton (SC649) and the main stem Republican River near Clay Center (SC504 and SC503). Peats Creek near Clifton (SC649) has a single excursion of 9.2 in April 2003. The Republican River near Clay Center (SC504) has three excursions in May, July, and September 2004 of 8.7, 8.9, and 8.8, respectively. The Republican River near Clay Center (SC503) has five excursions: 8.6 in April 2001, 8.9 in August 2003, 8.7 in October 2003 and May 2004, and 8.8 in September 2004. No station has had a pH excursion since 2004. Median pH remains relatively consistent among all stations and throughout all seasons, ranging from 7.5 to 8.3 (**Table 12**). The stations with the highest mean pH are Republican River near Clay Center (SC504 and SC503), with medians of 8.2 and 8.1, respectively.

Figure 35. The pH and the relationship between pH and temperature for the Salt Creek near Hollis (SC650) and Elm Creek near Ames (SC709).

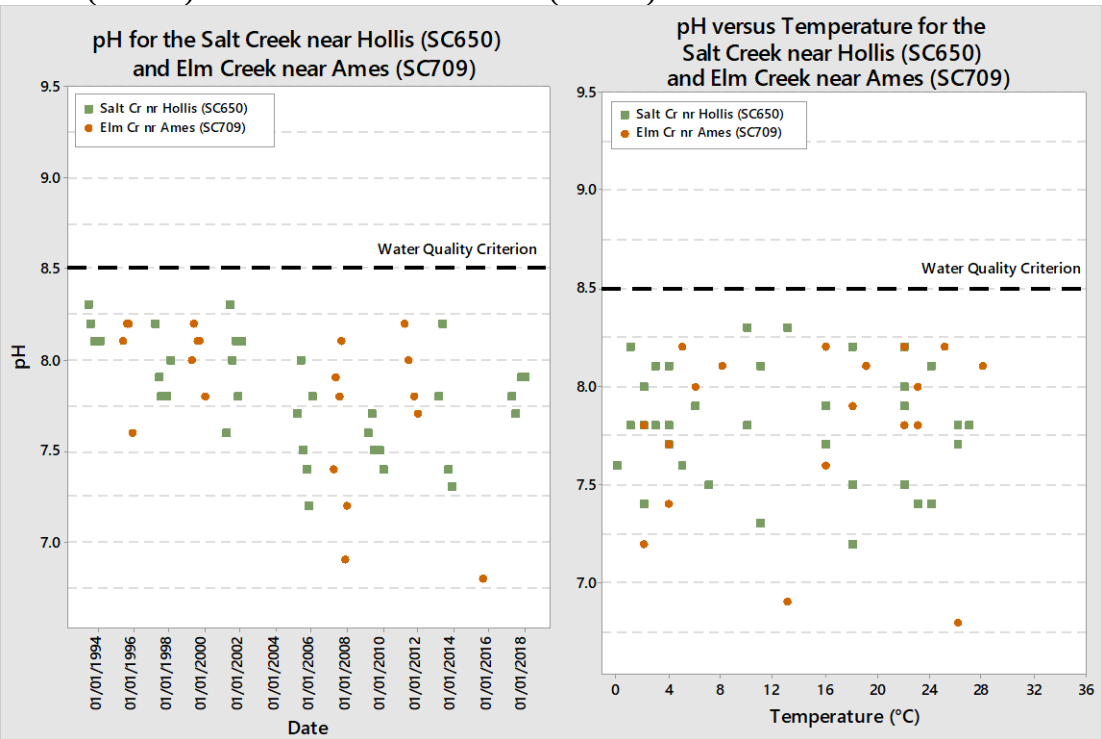


Figure 36. The pH and the relationship between pH and temperature for the Peats Creek (SC649) and Mulberry Creek (SC710) near Clifton.

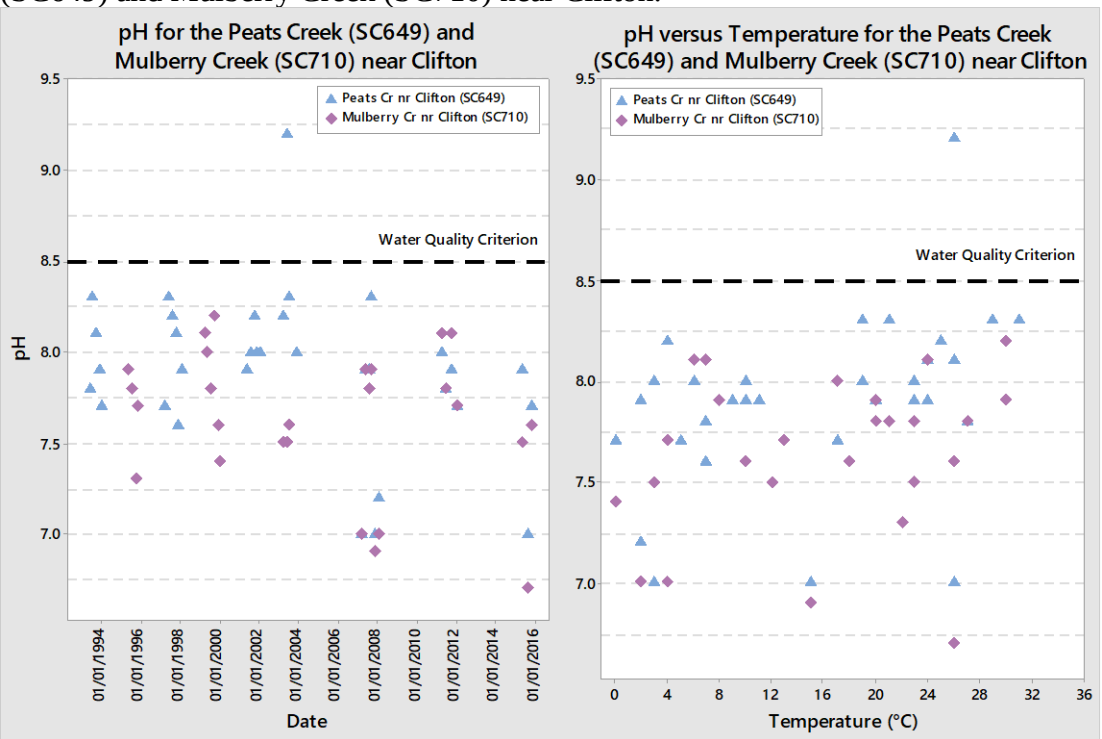


Figure 37. The pH and the relationship between pH and temperature for the Republican River (SC504) and Five Creek (SC711) near Clay Center.

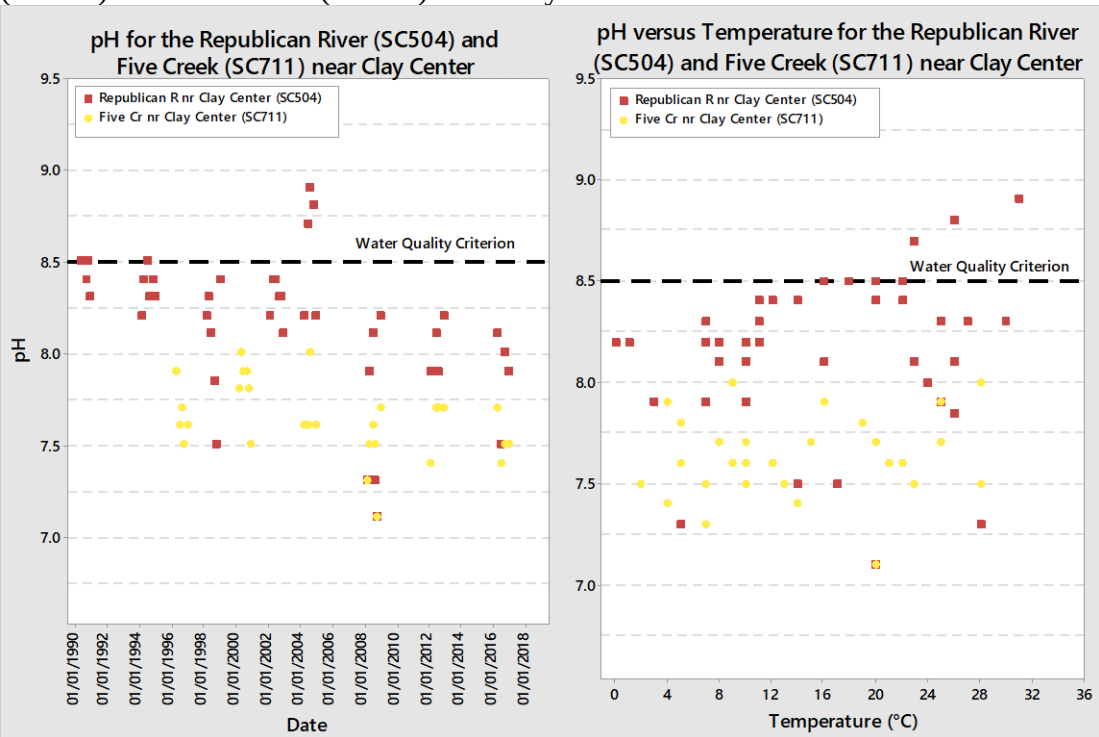
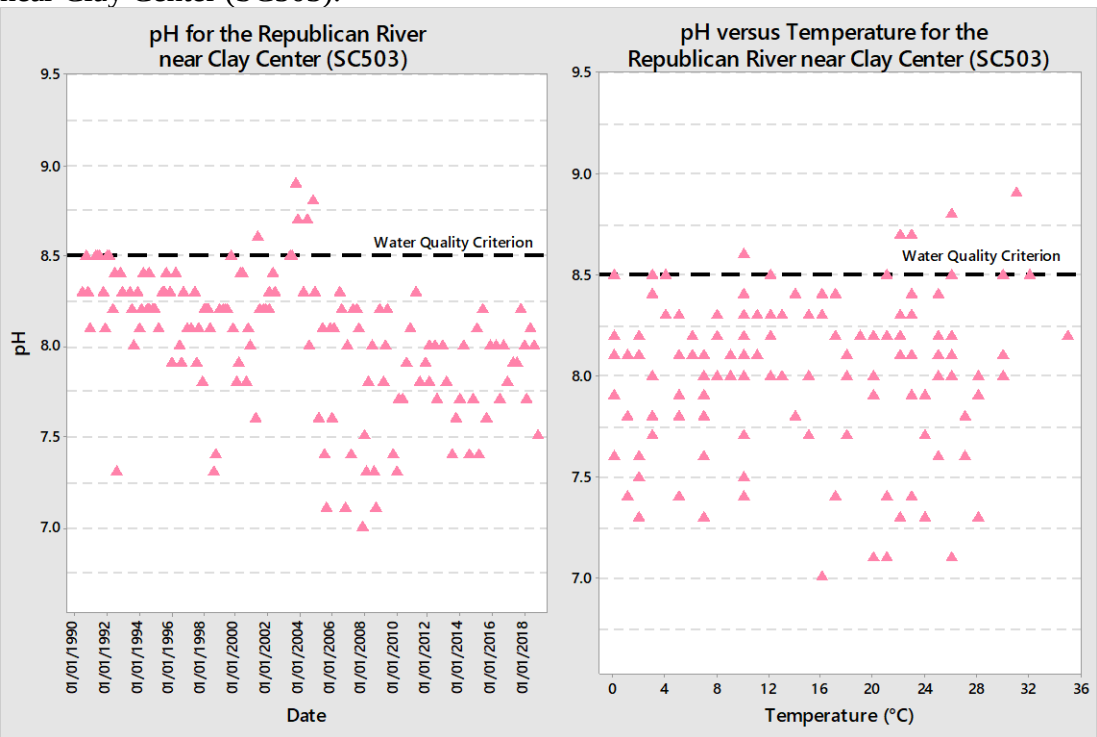


Figure 38. The pH and the relationship between pH and temperature for the Republican River near Clay Center (SC503).



Algal Biomass
Chlorophyll-*a* is a photosynthetic pigment found in algae, and its concentration is commonly used as a measure of the algal biomass present in streams. Because nutrients directly influence primary production, the U.S. Environmental Protection Agency (USEPA) guidance on nutrient criteria for streams establishes a chlorophyll-*a* concentration range of 8 to 15 micrograms per liter (µg/L) before overall biology can become adversely impacted (U.S. Environmental Protection Agency, 2000).

There are a limited number of chlorophyll-*a* samples collected for the Republican River from Rice to Clay Center. There are no main stem chlorophyll-*a* samples, and the only tributary stations with chlorophyll-*a* data are Salt Creek near Hollis (SC650) and Five Creek near Clay Center (SC711). Salt Creek near Hollis (SC650) has four chlorophyll-*a* samples for 2017, with a mean of 9.5 µg/L. Five Creek near Clay Center (SC711) has four chlorophyll-*a* samples for 2008, with a mean of 10 µg/L.

Additionally, several SP and all of the SW stations have chlorophyll-*a* samples. For the SP stations, Salt Creek (SPB509) has a chlorophyll-*a* sample of 55 µg/L, Peats Creek (SPB317) has a chlorophyll-*a* sample of 45 µg/L, Mulberry Creek (SPB381 and SPB573) has chlorophyll-*a* samples of 2.9 and 7.8 µg/L, respectively, and Republican River (SP910) has a chlorophyll-*a* sample of 73 µg/L. For the SW stations, Salt Creek near Hollis (SW030) has six samples with a mean of 15 µg/L, Peats Creek near Palmer (SW031) has 10 samples with a mean of 7.8 µg/L, and Peats Creek near Clifton (SW029) has nine samples with a mean of 10 µg/L.

Available chlorophyll-*a* concentrations vary widely within the watersheds. Although several stations are within the USEPA suggested guidance range, such as Salt Creek near Hollis (SC650) and Five Creek near Clay Center (SC711), there are also stations which drastically exceed the guidance range, such as the Republican River (SP910). Understanding the activity of primary producers and their interaction with and affect upon water quality is imperitive to interpreting the biological health of streams. Available chlorophyll-*a* data from the SP stations for these watersheds suggests that primary productivity may be adversely impacting biology for the Republican River from Rice to Clay Center. Primary productivity can alter ambient levels of oxygen and the acid-base balance in streams through photosynthesis and respiration, resulting in shifts in the biological commnunity within the stream.

Biological Community
Biological data regarding macroinvertebrate organisms and community are collected at KDHE SP stations and stream biology (SB) stations. Macroinvertebrate organisms have been collected at 12 SP stations within the Salt Creek near Hollis (SC650), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), and Republican River near Clay Center (SC504) watersheds. The sampled SB station in the watershed for the Republican River from Rice to Clay Center is the Republican River near Clay Center (SB503). Both SP and SB stations have been assessed using the Aquatic Life Use Support (ALUS) Index as described in Kansas' 2018 303(d) Methodology. The ALUS Index score consists of five categorizations of biotic conditions:

1. Macroinvertebrate Biotic Index (MBI): A statistical measure that evaluates the effects of nutrients and oxygen demanding substances on aquatic and semi-aquatic

maroinvertebrates based on the relative abundance of certain indicator taxa that is specific to the level of order and family.

2. Kansas Biotic Index for Nutrients (KBI-N): A statistical measure mathematically equivalent to the MBI that is restricted to aquatic insect macroinvertebrates and is species specific.
3. Ephemeroptera, Plecoptera, and Trichoptera (EPT): A measure of the richness of the intolerant aquatic EPT taxa wihin a macroinvertebrate sample used to evaluate the diversity within the sample.
4. EPT Percent of Count (EPT% CNT): The percentage of individuals belonging to the EPT orders in a sample of macroinvertebrates.
5. Shannon's Evenness (SHN EVN): A measure of diversity that describes how evenly distributed the numbers of individuals are among the taxa in a sample.

These metrics are used to establish a score (**Table 14**) which is then translated into an indication of the biotic condition and support category available for aquatic life in the stream (**Table 15**).

Table 14. Aquatic Life Use Support Index metrics with scoring ranges and standardized scores.

MBI	KBI-N	EPT	EPT% CNT	SHN EVN	Score
≤ 4.18	≤ 2.52	≥ 16	≥ 65	≥ 0.849	4
4.19-4.38	2.53-2.64	14-15	56-64	0.826-0.848	3
4.39-4.57	2.65-2.75	12-13	48-55	0.802-0.825	2
4.58-4.88	2.76-2.87	10-11	38-47	0.767-0.801	1
≥ 4.89	≥ 2.88	≤ 9	≤ 37	≤ 0.766	0

Table 15. Aquatic Life Use Support (ALUS) Index score range, interpretation of biotic condition, and aquatic life support category.

ALUS Index Score	Biotic Condition	Support Category
> 16-20	Very Good	Supporting
> 13-16	Good	
> 7-13	Fair	Partially Supporting
> 4-7	Poor	Non-supporting
0-4	Very Poor	

Within the four watersheds with SP stations, three are located in the Salt Creek near Hollis (SC650) Watershed, two are located in the Peats Creek near Clifton (SC649) Watershed, two are located in the Mulberry Creek near Clifton (SC710) Watershed, and five are located in the Republican River near Clay Center (SC504) Watershed. Stream probabilistic station locations vary on an annual basis and biotic samples are collected once per year for each station; therefore, samples from these stations cannot indicate changes in aquatic life trends over time for a specific location. However, the samples do offer general insight about the biotic conditions of the streams within watersheds.

Streams within the Salt Creek near Hollis (SC650) Watershed have a range of aquatic life support, from non-supporting for the East Creek in 2016 to supporting for the Salt Creek in 2011 (**Table 16**). The Peats Creek near Clifton (SC649) Watershed ranges from non-supporting to partially supporting from 2012 to 2013, and the Mulberry Creek near Clifton (SC710) Watershed ranges from non-supporting to partially supporting from 2014 to 2016. The Republican River

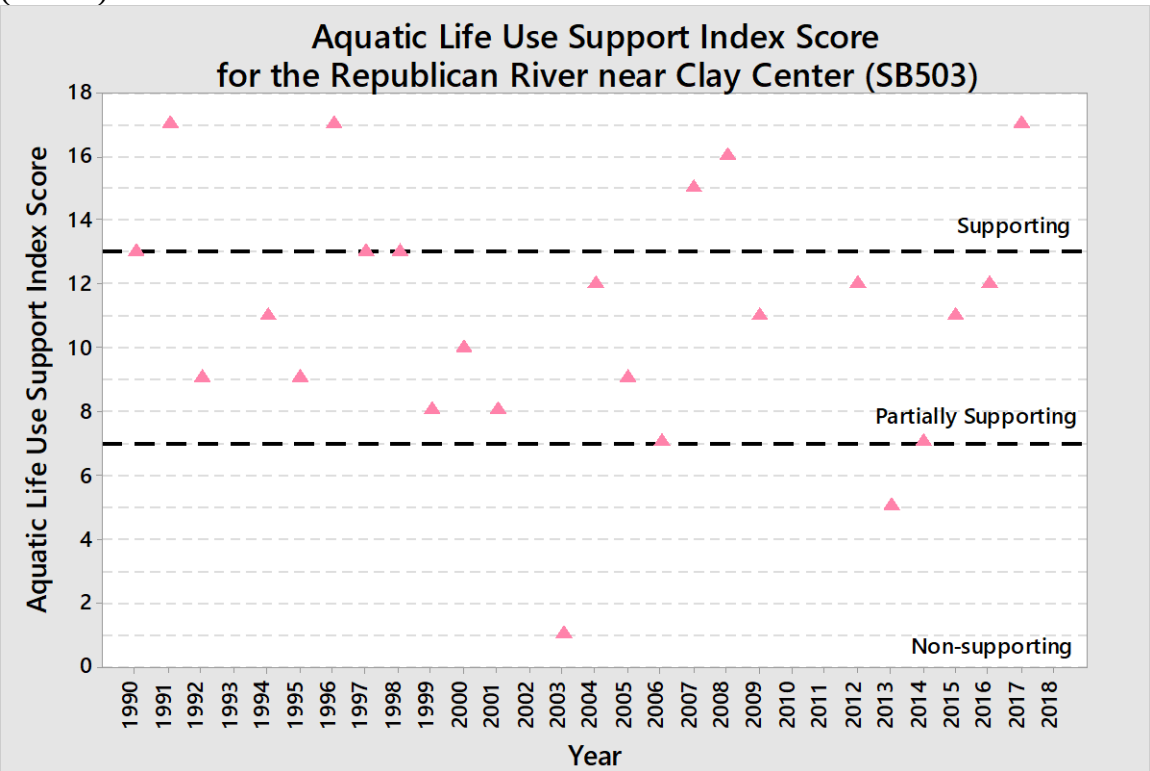
near Clay Center (SC504) Watershed is the only SP station to consistently score as non-supporting of aquatic life from 2006 to 2013, with the only partially supporting sample collected in 2008. The majority of non-supporting samples for this watershed are collected from Elk Creek.

Table 16. Mean Aquatic Life Use Support (ALUS) Index scores for the Republican River from Rice to Clay Center.

Stream Chemistry Station	Stream Biology/Probabilistic Station	Period of Record	Number of Samples	Mean ALUS Index Score	Biotic Condition	ALUS Index Support Category
Salt Cr nr Hollis (SC650)	Salt Cr (SPA397)	July 1, 2009	1	8	Fair	Partially Supporting
	Salt Cr (SPB125)	July 20, 2011	1	15	Good	Supporting
	East Cr (SPB509)	July 11, 2016	1	0	Very Poor	Non-supporting
Peats Cr nr Clifton (SC649)	Peats Cr (SPB253)	May 14, 2012	1	1	Very Poor	Non-supporting
	Peats Cr (SPB317)	August 28, 2013	1	11	Fair	Partially Supporting
Mulberry Cr nr Clifton (SC710)	Mulberry Cr (SPB381)	May 27, 2014	1	1	Very Poor	Non-supporting
	Mulberry Cr (SPB573)	July 11, 2016	1	7	Fair	Partially Supporting
Republican R nr Clay Center (SC504)	Elk Cr (SPA077)	August 14, 2006	1	3	Very Poor	Non-supporting
	Republican R (SPA217)	July 16, 2008	1	10	Fair	Partially Supporting
	Elk Cr (SPA461)	July 1, 2009	1	5	Poor	Non-supporting
	Elk Cr (SPB061)	August 3, 2010	1	3	Very Poor	Non-supporting
	Republican R (SP910)	May 7, 2013	1	2	Very Poor	Non-supporting
Republican R nr Clay Center (SC503)	Republican R nr Clay Center (SB503)	July 19, 1990 to June 28, 2017	24	11	Fair	Partially Supporting

Unlike SP stations, SB stations are routinely sampled at a fixed location on an annual basis and can be assessed for changes in trends over time. Biotic conditions were sampled annually for the Republican River near Clay Center (SB503) from 1990 to 2017 (except for 1993, 2002, 2010, and 2011). The Republican River near Clay Center (SB503) has a total of 24 samples with a mean ALUS Index score of 11, indicating biotic conditions are fair and partially supporting of aquatic life. Although the Republican River near Clay Center (SB503) mean indicates that it is partially supporting of aquatic life, the station has previously had two samples that are non-supporting of aquatic life (**Figure 39**). These samples occurred in 2003 and 2013, which coincide with periods of lower flow.

Figure 39. Aquatic Life Use Support Index scores for the Republican River near Clay Center (SB503).



Desired Endpoints for Water Quality (Implied Load Capacity) for the Republican River from Rice to Clay Center

The ultimate desired water quality (implied load capacity) endpoints of this TMDL for the Republican River from Rice to Clay Center, will be to achieve the Kansas Water Quality Standards by eliminating the impacts to aquatic life, domestic water supply, and contact recreation associated with excessive phosphorus and objectionable flora as described in the narrative criteria pertaining to nutrients. There are currently no existing numeric phosphorus criteria in Kansas.

Current USEPA nutrient philosophy is predicated upon 25th percentile stream TP concentrations within an ecoregion to indicate reference conditions. This generalization is not tied to specific biological conditions but represents water quality protection policy guiding USEPA's administration of clean water programs. The current TMDL comprises several USEPA ecoregions, including the aggregate ecoregions Great Plains Grass and Shrublands (IV), South Central Cultivated Great Plains (V), and Corn Belt and Northern Great Plains (VI). The USEPA suggested 25th percentile TP reference benchmarks for streams within these ecoregions are 0.023, 0.068, and 0.076 mg/L, respectively (U.S. Environmental Protection Agency, 2000 and 2001). Within these ecoregions, the Republican River from Rice to Clay Center primarily falls within the Level IV Ecoregions Smoky Hills (27a), Rolling Plains and Breaks (27b), Flint Hills (28a), and Loess and Glacial Drift Hills (47i). Assessment of 49 KDHE SC stations within these Level IV Ecoregions and the Kansas and Lower Republican River Basin with TP data from 2000 to 2018 indicates a 25th percentile of medians of 0.121 mg/L and a 50th percentile of medians of 0.216 mg/L (**Table 17**).

Table 17. Summary of Kansas Department of Health and Environment (KDHE) stream chemistry stations within the Level IV Ecoregions and Kansas and Lower Republican River Basin from 2000 to 2018.

U.S. EPA Level IV Ecoregions	Number of KDHE Stations	Number of Samples	25th Percentile of Medians (mg/L)	50th Percentile of Medians (mg/L)	75th Percentile of Medians (mg/L)
Smoky Hills (27a)	12	620	0.233	0.303	0.404
Rolling Plains and Breaks (27b)	4	147	0.233	0.274	0.450
Flint Hills (28a)	21	1,120	0.049	0.120	0.177
Loess and Glacial Drift Hills (47i)	12	603	0.188	0.223	0.263
Aggregated Level IV Ecoregions	49	2,490	0.121	0.216	0.307

Within the aggregate ecoregions, there are 54 KDHE stations with biology and chemistry data within the Level III Ecoregions Central Great Plains (27), Flint Hills (28), and Western Corn Belt Plains (47). An analysis of the mean ALUS Index versus the median TP concentration indicates that there is generally a decline in biology with increasing TP concentrations (**Figure 40**). There is one SB station fully supporting biology that is unimpaired for TP, and the majority of unimpaired stations are partially supporting biology. This variability in relationship of the mean ALUS Index versus the median TP concentration is due to the numerous factors impacting biological health. Such variability supports an adaptive management approach to reduce current TP concentrations and loads, rather than establishing a single, definitive threshold. Therefore, this TMDL seeks to establish an adaptive management approach in order to observe and respond to biological metrics to assess the impact of TP reductions. As such, the primary measure of phosphorus load reduction in the TMDL for impaired segments of the Republican River from Rice to Clay Center will be an improved ALUS Index. An ALUS Index score greater than 13 at SB stations will serve to establish that the biological community reflects recovered or renewed diversity and minimal disruption by the impacts described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply.

Of the SC stations within the Level IV Ecoregions and the Kansas and Lower Republican River Basin used for the TP milestone analysis, 13 SC stations with a total of 250 samples have corresponding chlorophyll-*a* data. An analysis of the relationship between chlorophyll-*a* versus TP indicates that there is a positive correlation between the variables (**Figure 41**). In this relationship, the TP 25th percentile of medians of 0.121 mg/L yields a chlorophyll-*a* concentration of 7.8 µg/L, and the TP 50th percentile of medians of 0.216 mg/L yields a chlorophyll-*a* concentration of 13.4 µg/L. These chlorophyll-*a* concentrations bracket the desired chlorophyll-*a* endpoint of 10 µg/L. Likewise, a chlorophyll-*a* concentration of 10 µg/L yields a TP concentration 0.158 mg/L. The chlorophyll-*a* concentration will serve as an additional biological measure of nutrient loading reduction in order to assess improvements in primary productivity and address its impacts as described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply.

Furthermore, secondary indicators of the health of the aquatic biological community will be assessed at SC stations. Dissolved oxygen concentrations will be monitored to ensure concentrations are greater than 5.0 mg/L. According to the Kansas Water Quality Standards,

Figure 40. Aquatic Life Use Support (ALUS) Index versus median total phosphorus for stream biology and stream chemistry stations within the Level III Ecoregions from 2000 to 2018.

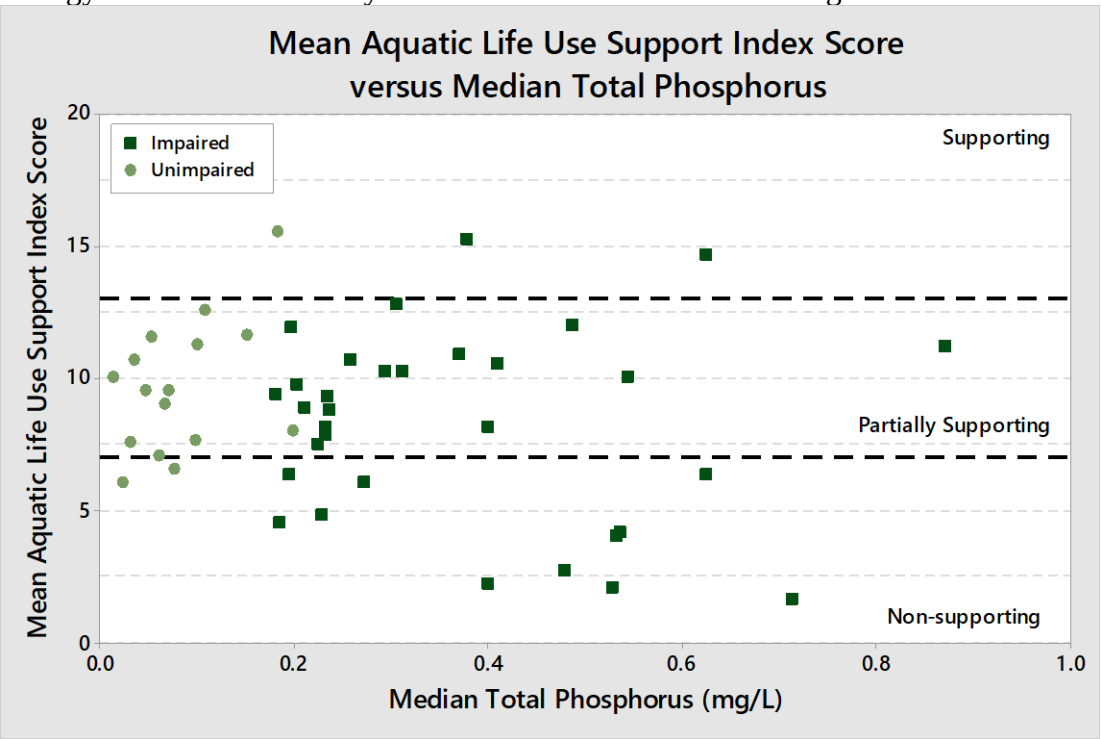
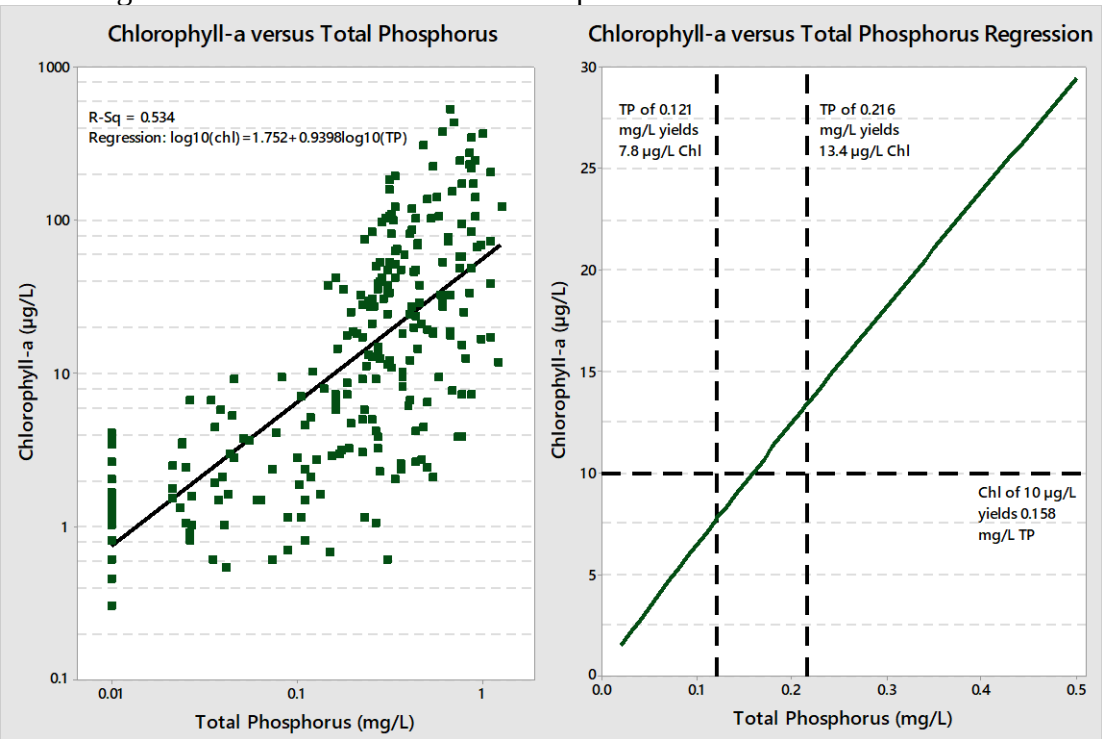


Figure 41. Chlorophyll-*a* versus total phosphorus for stream chemistry stations within the Level IV Ecoregions and the Kansas and Lower Republican River Basin from 2000 to 2018.



concentrations below this are low enough to put aquatic life under stress. Dissolved oxygen saturation will also be monitored for indication of overactive primary productivity, as indicated by supersaturated values greater than 110%. The pH will be monitored, as well, to ensure that overactive primary productivity is not altering stream chemistry; values should remain between 6.5 and 8.5 in order to protect aquatic life according to the Kansas Water Quality Standards.

The numeric endpoints for stream segments in this TMDL, as measured for the Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), Republican River near Clay Center (SC504), Five Creek near Clay Center (SC711), and Republican River near Clay Center (SC503), indicating attainment of water quality standards within the watershed are:

1. An ALUS Index score greater than 13 at SB stations.
2. Median sestonic chlorophyll-*a* concentrations less than or equal to 10 µg/L at SC stations.
3. Dissolved oxygen concentrations greater than 5.0 mg/L at SC stations.
4. Dissolved oxygen saturation less than 110% at SC stations.
5. Values within the range of 6.5 to 8.5 for pH at SC stations.

As there are currently no numeric phosphorus criteria in Kansas, the series of endpoints established by this TMDL will be the measure used to indicate full support of aquatic life, domestic water supply, and contact recreation in the Republican River from Rice to Clay Center. All five endpoints must initially be maintained over three consecutive years to constitute full support of the designated uses of the impaired stream segments in this TMDL, as measured at KDHE stations Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), Republican River near Clay Center (SC504), and Republican River near Clay Center (SC/SB503). Five Creek near Clay Center (SC711) is established as a protective TMDL currently meeting its designated uses, and water quality will be maintained at unimpaired stream segments within this watershed. These endpoints will be evaluated periodically as phosphorus levels decline in the watershed, with achievement of the ALUS Index endpoint indicating the restored status of the aquatic life use in the river. Simultaneous achievement of the chlorophyll-*a*, DO, DO saturation, and pH endpoints will signal that TP reductions are addressing the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae by-products, thereby restoring the domestic water supply and contact recreation uses in the river. After the endpoints are attained, simultaneous digression of these endpoints more than once every three years on average constitutes a resumption of the TP impairment at the respective station unless the TP impairment is delisted through the 303(d) process.

This TMDL seeks to establish an adaptive management approach for TP by establishing phased TP milestones (**Table 18**). The Phase I milestone will be a TP concentration of 0.216 mg/L, reflecting the 50th percentile of medians for KDHE SC stations within Level IV Ecoregions and the Kansas and Lower Republican River Basin. Total phosphorus concentrations approaching the Phase I milestone will cue the examination for altered, improved biological conditions at the SB station within the Republican River. Should aquatic life not respond, a Phase II milestone will commence with a TP concentration of 0.121 mg/L, reflecting the 25th percentile of medians

for KDHE SC stations within the Level IV Ecoregions and the Kansas and Lower Republican River Basin.

Table 18. Current total phosphorus (TP) condition from 2000 to 2018 and Phase I and II TP milestones for the Republican River from Rice to Clay Center.

Station	Current Condition (2000-2018)	Phase I		Phase II	
	Median TP (mg/L)	TP Milestone (mg/L)	TP Reduction (%)	TP Milestone (mg/L)	TP Reduction (%)
Salt Cr nr Hollis (SC650)	0.425	0.216	49	0.121	72
Elm Cr nr Ames (SC709)	0.929	0.216	77	0.121	87
Peats Cr nr Clifton (SC649)	0.459	0.216	53	0.121	74
Mulberry Cr nr Clifton (SC710)	0.378	0.216	43	0.121	68
Republican R nr Clay Center (SC504)	0.453	0.216	52	0.121	73
Five Cr nr Clay Center (SC711)	0.184	0.184	0	0.121	34
Republican R nr Clay Center (SC503)	0.464	0.216	53	0.121	74

3. SOURCE INVENTORY AND ASSESSMENT

The Republican River TMDL Watershed is comprised of the tributary watersheds Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), and Five Creek near Clay Center (SC711), as well as the two main stem watersheds Republican River near Clay Center (SC504 and SC503). These watersheds predominantly lie within Clay, Cloud, Republic, and Washington counties. Within this section, point sources, livestock, land use, water diversions, population, on-site waste systems, and contributing runoff are considered by watershed and county.

Point Sources

There are a total of 20 National Pollution Discharge Elimination System (NPDES) permitted facilities within the Republican River TMDL Watershed (**Table 19**). Of the 20 permitted facilities, two are located in the Salt Creek near Hollis (SC650) Watershed, one is located in the Elm Creek near Ames (SC709) Watershed, two are located in the Peats Creek near Clifton (SC649) Watershed, none are located in the Mulberry Creek near Clifton (SC710) Watershed, five are located in the Republican River near Clay Center (SC504) Watershed, none are located in the Five Creek near Clay Center (SC711) Watershed, and 10 are located in the Republican River near Clay Center (SC503) Watershed. There are no Municipal Separate Storm Sewer System (MS4) permits within the Republican River TMDL Watershed.

Dischargers to the Salt Creek near Hollis (SC650) Watershed

There are a total of two NPDES permitted facilities within the Salt Creek near Hollis (SC650) Watershed (**Figure 2**). Of the two permitted facilities, one is a concrete operation pit dewatering facility and one is a municipal mechanical WWTF.

The concrete operation pit dewatering facility is operated by Abram Ready Mix, Inc. – Belleville Plant. This facility is a dry batch concrete plant that generates wastewater by washing concrete trucks. It is permitted to discharge to Riley Creek, but this system does not monitor for TP and is not expected to contribute to the TP impairment in the watershed.

The municipal mechanical WWTF is operated by the City of Belleville. According to the facility's Discharge Monitoring Report (DMR) period of record (October 2004 to December 2018), this facility currently operates at 0.194 million gallons per day (MGD). The WWTF is not designed for nutrient removal, but it is allowed to use reclaimed wastewater effluent for irrigating a golf course, allowing nutrient rich waters to be utilized more efficiently. When discharging, this facility discharges to an unnamed tributary to the Salt Creek. Currently, the City of Belleville WWTF has a monthly monitoring requirement for TP. From 2004 to 2018, the discharge from this facility has a mean TP concentration of 1.78 mg/L, or 2.89 pounds per day (lbs/day). The City of Belleville WWTF will be assigned a TP wasteload allocation (WLA) under this TMDL.

Dischargers to the Elm Creek near Ames (SC709) Watershed
There is one NPDES permitted facility within the Elm Creek near Ames (SC709) Watershed (**Figure 2**). This facility is a two-cell, non-discharging lagoon operated by the City of Aurora. This system is prohibited from discharging, does not monitor for TP, and is not expected to contribute to the TP impairment in the watershed.

Dischargers to the Peats Creek near Clifton (SC649) Watershed
There are a total of two NPDES permitted facilities within the Peats Creek near Clifton (SC649) Watershed (**Figure 3**). Both of the permitted facilities are non-discharging lagoons. The City of Linn operates a three-cell lagoon, and the City of Palmer operates a two-cell lagoon. These systems are prohibited from discharging, do not monitor for TP, and are not expected to contribute to the TP impairment in the watershed.

Dischargers to the Republican River near Clay Center (SC504) Watershed
There are a total of five NPDES permitted facilities within the Republican River near Clay Center (SC504) Watershed (**Figures 2** and **3**). Of the five permitted facilities, one is a pit dewatering facility, two are non-discharging lagoons, and two are municipal discharging lagoons.

The pit dewatering facility is operated by Cloud Ceramics - #C-77 & #C-78. This facility is a clay mine for brick manufacturing and operates settling ponds for pit water and stormwater. It is permitted to discharge to Oak Creek, a tributary to the Republican River. This system does not monitor for TP and is not expected to contribute to the TP impairment in the watershed.

The two non-discharging lagoons are operated by the City of Agenda and Mid-Kansas Electric – Clifton Station. The former is a two-cell lagoon for a municipality and the latter is a one-cell lagoon for cooling water from a standby electrical generator. These systems are prohibited from discharging, do not monitor for TP, and are not expected to contribute to the TP impairment in the watershed.

The two municipal discharging lagoons are operated by the cities of Clifton and Clyde. Both cities treat domestic waste in a three-cell lagoon system. The City of Clyde updated its facility in 2015 in order to repair erosion and damage to the existing lagoons and to install a wetland for treatment. Both facilities are required to monitor for TP quarterly, when discharging. According to the facility's DMR period of record (July 2004 to October 2018), the City of Clifton discharged to the Republican River during approximately 86% of the quarters. The City of Clifton reported discharging a mean concentration of 2.65 mg/L TP from December 2010 to October 2018. According to the facility's DMR period of record (June 2004 to December 2018), the City of Clyde discharged to the Republican River during all of the quarters. The City of Clyde reported discharging a mean concentration of 2.88 mg/L TP from July 2011 to December 2018. The discharging lagoons for the cities of Clifton and Clyde will be assigned TP WLAs under this TMDL.

Dischargers to the Republican River near Clay Center (SC503) Watershed
There are a total of 10 NPDES permitted facilities within the Republican River near Clay Center (SC503) Watershed (**Figure 4**). Of the 10 permitted facilities, two are pit dewatering facilities, one is a non-discharging lagoon, one is an industrial pretreatment facility, one is a non-contact cooling facility, two are groundwater remediation facilities, one is a water treatment plant (WTP), one is a municipal discharging lagoon, and one is a municipal mechanical WWTF.

The two pit dewatering facilities are operated by Midwest Products - Clay Center and Bayer Construction – Ebert Quarry. Midwest Products – Clay Center is a dry batch concrete operation retaining process water and stormwater runoff. Settled solids are removed and used for erosion control. Bayer Construction – Ebert Quarry is a limestone quarrying and crushing operation retaining pit water and stormwater runoff. These systems do not monitor for TP and are not expected to contribute to the TP impairment in the watershed.

The non-discharging lagoon is operated by Hawks Landing Mobile Home Park. This facility treats domestic waste in a two-cell lagoon system. The Hawks Landing Mobile Home Park system is considered a temporary facility and must connect to the city service when it becomes available. This system is prohibited from discharging, does not monitor for TP, and is not expected to contribute to the TP impairment in the watershed.

The industrial pretreatment facility is operated by Global Industries, Inc. – Hutchinson/Mayrath. Global Industries, Inc. – Hutchinson/Mayrath generates wastewater from metal finishing operations. The discharge is required to meet pretreatment standards for metal finishing before discharging to the City of Clay Center WWTF. This facility does not discharge to the watershed, does not monitor for TP, and is not expected to contribute to the TP impairment in the watershed.

The non-contact cooling facility is operated by the City of Clay Center – Power Plant. The City of Clay Center – Power Plant generates wastewater from well water used for cooling engines for a standby electrical generator that is operative seasonally from June to September. The water is discharged primarily to the sanitary sewer and discharges to Huntress Creek via the industrial park drainage channel are used as a bypass. This facility monitors its discharge daily and its TP annually. According to the facility's DMR period of record (July 2006 to December 2018), the City of Clay Center – Power Plant currently discharges 0.0510 MGD. From July 2012 to

December 2018, the discharge from this facility has a mean TP concentration of 0.471 mg/L, or 0.201 lbs/day. The City of Clay Center – Power Plant will be assigned a TP WLA under this TMDL.

The two groundwater remediation facilities are operated by the City of Clay Center – Groundwater Remediation Project PWS #2 and Valley Fertilizer. The City of Clay Center – Groundwater Remediation Project PWS #2 is remediating tetrachloroethylene contaminated groundwater with an air stripper prior to discharging to the Republican River via Huntress Creek. According to the facility's DMR period of record (September 2004 to December 2018), the City of Clay Center – Groundwater Remediation Project PWS #2 has a mean discharge of 0.350 MGD. Since 2017, this facility is required to monitor annually for TP; however, since this time, it has not discharged. Valley Fertilizer is diluting nitrate contaminated groundwater from a former agricultural chemical distributor prior to discharging to the Republican River via a pipeline. According to the facility's DMR period of record (January 2008 to December 2018), Valley Fertilizer has a mean discharge of 0.178 MGD. This facility has monitored annually for TP from 2016 to 2018; during this time, it discharged a mean of 0.447 mg/L TP. In total, the facility discharged 0.665 lbs/day. The City of Clay Center – Groundwater Remediation Project PWS #2 and Valley Fertilizer will both be assigned a TP WLA under this TMDL.

The WTP is operated by the City of Clay Center - PUC Water Treatment Plant. This facility treats and processes well water as drinking water for the City of Clay Center using reverse osmosis and filtration. Backwash from filters and rejected water is discharged to the Republican River. This facility is required to monitor their discharge daily. According to the DMR period of record (July 2010 to December 2018), the City of Clay Center – Public Water Supply has a mean discharge of 0.239 MGD. Currently, this facility is not required to monitor for TP. The City of Clay Center – Public Water Supply will be assigned a TP WLA under this TMDL.

The municipal discharging lagoon is operated by the City of Morganville. This facility is a two-cell lagoon system treating domestic waste and discharges to the Republican River via Dry Creek. It is required to monitor for TP quarterly, when discharging; however, it is currently not required to report the discharge volume. According to the facility's DMR period of record (January 2005 to December 2018), the City of Morganville discharged to the Republican River via Dry Creek during approximately 25% of the quarters. The city has not reported discharging since it began reporting TP in April 2017. The discharging lagoon for the City of Morganville will be assigned a TP WLA under this TMDL.

The municipal mechanical WWTF is operated by the City of Clay Center. According to the facility's DMR period of record (July 2004 to December 2018), this facility currently operates at 0.437 MGD, making it the largest discharger to the Republican River TMDL Watershed. The influence of the City of Clay Center WWTF effluent was evaluated by comparing the monthly TP concentrations in the WWTF effluent to the monthly TP concentrations at the Republican River station, where concomitant data were available (**Figure 42**). Additionally, the WWTF does show a trend of decreasing TP loading on a rolling annual average throughout the period of record. The WWTF is not designed for nutrient removal and discharges directly to the Republican River. Currently, the City of Clay Center WWTF has a monthly monitoring requirement for TP. From September 2005 to December 2018, the discharge from this facility

has a mean TP concentration of 3.04 mg/L, or 11.1 lbs/day. The City of Clay Center WWTP will be assigned a TP WLA under this TMDL.

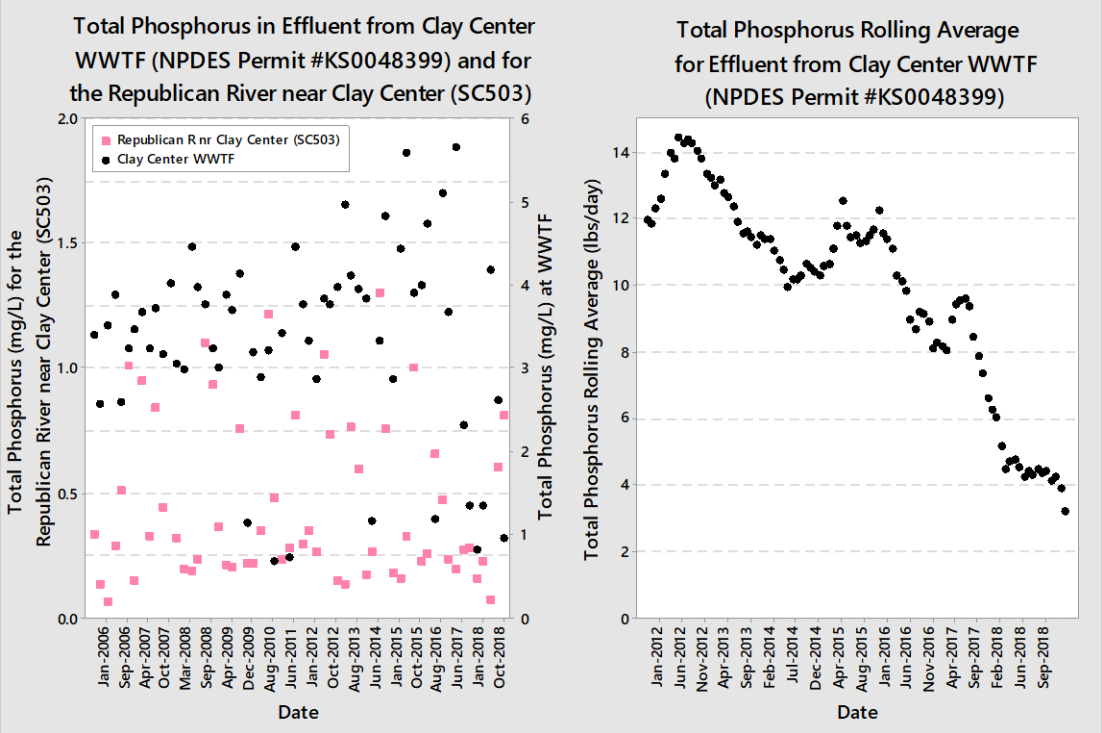
Table 19. National Pollution Discharge Elimination System (NPDES) facilities in the Republican River TMDL Watershed.

Permittee	Kansas Permit Number	NPDES Permit Number	Facility Type	Receiving Stream	Permit Expiration	Monitoring Frequency	Current Flow (MGD)	Current Total Phosphorus Mean (mg/L)
Salt Creek near Hollis (SC650)								
Abram Ready Mix, Inc. - Belleville Plant	I-LR03-PR01	KSG110084	Concrete operation pit dewatering	Riley Creek	September 30, 2022	NA	–	–
City of Belleville	M-LR03-OO01	KS0027529	Municipal wastewater treatment facility	Salt Creek via Unnamed Tributary	June 30, 2020	Monthly	0.194	1.78
Elm Creek near Ames (SC709)								
City of Aurora	M-LR02-NO01	KSJ000379	Non-discharging lagoon	NA	December 31, 2021	NA	0	NA
Peats Creek near Clifton (SC649)								
City of Linn	M-LR14-NO01	KSJ000375	Non-discharging lagoon	NA	April 30, 2024	NA	0	NA
City of Palmer	M-LR19-NO01	KSJ000365	Non-discharging lagoon	NA	October 31, 2019	NA	0	NA
Republican River near Clay Center (SC504)								
Cloud Ceramics - #C-77 & #C-78	I-LR08-PO02	KS0002682	Industrial pit dewatering	Lower Republican River via Oak Creek	December 31, 2022	NA	–	–
City of Agenda	M-LR01-NO01	KSJ000378	Non-discharging lagoon	NA	April 30, 2023	NA	0	NA
Mid-Kansas Electric - Clifton Station	I-LR06-NO03	KSJ000500	Non-discharging lagoon	NA	December 31, 2019	NA	0	NA
City of Clifton	M-LR06-OO01	KS0048437	Municipal discharging lagoon	Republican River	June 30, 2020	Quarterly	–	2.65
City of Clyde	M-LR07-OO01	KS0022403	Municipal discharging lagoon	Republican River	December 31, 2020	Quarterly	–	2.88

Permittee	Kansas Permit Number	NPDES Permit Number	Facility Type	Receiving Stream	Permit Expiration	Monitoring Frequency	Current Flow (MGD)	Current Total Phosphorus Mean (mg/L)
Republican River near Clay Center (SC503)								
Midwest Products - Clay Center	I-LR05-PR02	KSG110216	Concrete operation pit dewatering	Republican River	September 30, 2022	NA	–	–
Bayer Construction - Ebert Quarry	I-KS66-PO02	KS0098086	Industrial quarry pit dewatering	Kansas River via Rock Creek via Pleasant Run Creek via Hopkins Creek via unnamed tributary	December 31, 2020	NA	–	–
Hawks Landing Mobile Home Park	C-LR05-NO02	KSJ000557	Non-discharging lagoon	NA	October 31, 2019	NA	0	NA
Global Industries, Inc. - Hutchinson/Mayrath	P-LR05-IO02	KSP000052	Industrial pretreatment	Wastewater treatment facility	October 31, 2022	NA	–	–
City of Clay Center - Power Plant	I-LR05-CO02	KS0093459	Non-contact cooling	Huntress Creek via Drainage Channel	December 31, 2021	Annually	0.0510	0.471
City of Clay Center - Groundwater Remediation Project PWS #2	I-LR05-PO02	KS0093351	Groundwater remediation	Republican River via Huntress Creek	December 31, 2021	Annually	0.350	–
Valley Fertilizer	I-LR05-PO01	KS0090018	Groundwater remediation	Republican River via Pipeline	November 30, 2020	Annually	0.178	0.447
City of Clay Center - PUC Water Treatment Plant	I-LR05-PO04	KS0098477	Water treatment plant	Republican River	December 31, 2021	NA	0.239	–
City of Morganville	M-LR18-OO01	KS0024678	Municipal discharging lagoon	Republican River via Dry Creek	June 30, 2020	Quarterly	–	–
City of Clay Center	M-LR05-OO01	KS0048399	Municipal wastewater treatment facility	Republican River	June 30, 2020	Monthly	0.437	3.04

Definitions: NA - Not applicable; – - Data not available

Figure 42. Total phosphorus (TP) in effluent from the wastewater treatment facility (WWTF) operated by the City of Clay Center (NPDES Permit # KS0048399) contributed to the Republican River near Clay Center (SC503), October 2005 to October 2018, and rolling TP average for the WWTF.



Livestock and Waste Management Systems

There are 125 certified or permitted Animal Feeding Operations (AFOs) and Concentrated Animal Feeding Operations (CAFOs) within the Republican River TMDL Watershed. Of these, five are located in the Salt Creek near Hollis (SC650) Watershed, six are located in the Elm Creek near Ames (SC709) Watershed, seven are located in the Peats Creek near Clifton (SC649) Watershed, three are located in the Mulberry Creek near Clifton (SC710) Watershed, 39 are located in the Republican River near Clay Center (SC504) Watershed, 21 are located in the Five Creek near Clay Center (SC711) Watershed, and 44 are located in the Republican River near Clay Center (SC503) Watershed (**Appendix A**). There are 10 CAFOs large enough to require a federal permit (A-LRCD-H002, A-LRWS-D001, A-LRWS-H007, A-BBWS-H005, A-LRCY-H004, A-LRWS-H002, A-LRWS-H005, A-LRWS-H006, A-LRWS-H008, and A-LRWS-H009). In addition to certified or permitted AFOs and CAFOs, there are unregistered operations below the permitting threshold in the Republican River TMDL Watershed. While these operations are smaller than AFOs and CAFOs, they are unregulated, frequently grazing cattle which have access to in-stream watering. As such, these facilities may contribute to TP loading in the watershed.

All of these livestock facilities have waste management systems designed to retain an anticipated two weeks of normal wastewater from their operations and contain a 25-year, 24-hour rainfall/runoff event, as well. Typically, this rainfall event coincides with streamflow that occurs less than 1 to 5% of the time. Additionally, facility waste management systems are designed to

minimize runoff entering operations and detain runoff emanating from operations. It is unlikely TP loading would be attributable to properly operating permitted facilities, though extensive loading may occur if any of these facilities were in violation and discharged.

The total number of livestock within Clay, Cloud, Republic, and Washington counties is approximately 346,000 head (**Table 20**; U.S. Department of Agriculture, 2019). The primary livestock industries are cattle and calves in Cloud and Republic counties and hogs and pigs in Clay and Washington counties. Cattle and calves number approximately 32,000 in Cloud County and 50,000 in Republic County. Hogs and pigs number approximately 54,000 in Clay County and 95,000 in Washington County. From 2012 to 2017, there is an overall increase of 23% in livestock. However, poultry are declining in Clay and Republic counties and goats are declining in Republic and Washington counties.

Table 20. Agricultural census results for livestock by county from 2007, 2012, and 2017 (U.S. Department of Agriculture, 2019).

Livestock	Total, 2007	Total, 2012	Total, 2017	Percent Change (%), 2012 to 2017
Clay County				
Cattle and Calves	35,053	30,552	32,673	7
Sheep and Lambs	–	98	490	400
Poultry	546	2,393	704	-71
Hogs and Pigs	35,486	21,957	54,035	146
Goats	416	175	485	177
Cloud County				
Cattle and Calves	33,234	31,067	31,821	2
Sheep and Lambs	93	131	–	–
Poultry	1,084	551	804	46
Hogs and Pigs	3,071	–	–	–
Goats	282	744	237	-68
Republic County				
Cattle and Calves	45,092	34,253	50,498	47
Sheep and Lambs	3,069	–	3,457	–
Poultry	693	544	251	-54
Hogs and Pigs	94	21	–	–
Goats	348	271	179	-34
Washington County				
Cattle and Calves	75,725	70,551	71,976	2
Sheep and Lambs	807	531	932	76
Poultry	878	778	1,332	71
Hogs and Pigs	125,191	86,002	95,046	11
Goats	220	675	622	-8

Land Use

Clay, Cloud, Republic, and Washington counties have an approximate total of 2,000 farms and 1,070,000 acres of cropland (**Table 21**; U.S. Department of Agriculture, 2019). Of the four

counties, Washington County contains the largest number of farms and the greatest acreage of cropland. From 2012 to 2017, the number of farms in cropland has decreased by 6% and the number of acres in cropland has increased by 7%.

The 2011 National Land Cover Database indicates the dominant land use in the watershed is cultivated crops, with 51% of the watershed currently used for crop cultivation (**Table 22**; **Figure 43**). Cultivated cropland has an increased potential for nutrient runoff from fertilizers, which can contribute to TP loads in the watershed. Grassland, including pastureland and hay fields, is the second most prevalent land use in the watershed, with 38% of the watershed in grassland.

Table 21. Agricultural census results for farms and cropland by county from 2007, 2012, and 2017 (U.S. Department of Agriculture, 2019).

County	Year	Total Farms in Cropland	Total Cropland (acres)
Clay	2017	465	259,735
	2012	503	230,795
	2007	500	216,556
	Percent Change (%), 2012 to 2017	-8	13
Cloud	2017	360	203,186
	2012	384	208,841
	2007	428	253,789
	Percent Change (%), 2012 to 2017	-6	-3
Republic	2017	509	269,090
	2012	533	258,537
	2007	616	282,884
	Percent Change (%), 2012 to 2017	-5	4
Washington	2017	607	336,673
	2012	653	298,156
	2007	714	326,005
	Percent Change (%), 2012 to 2017	-7	13

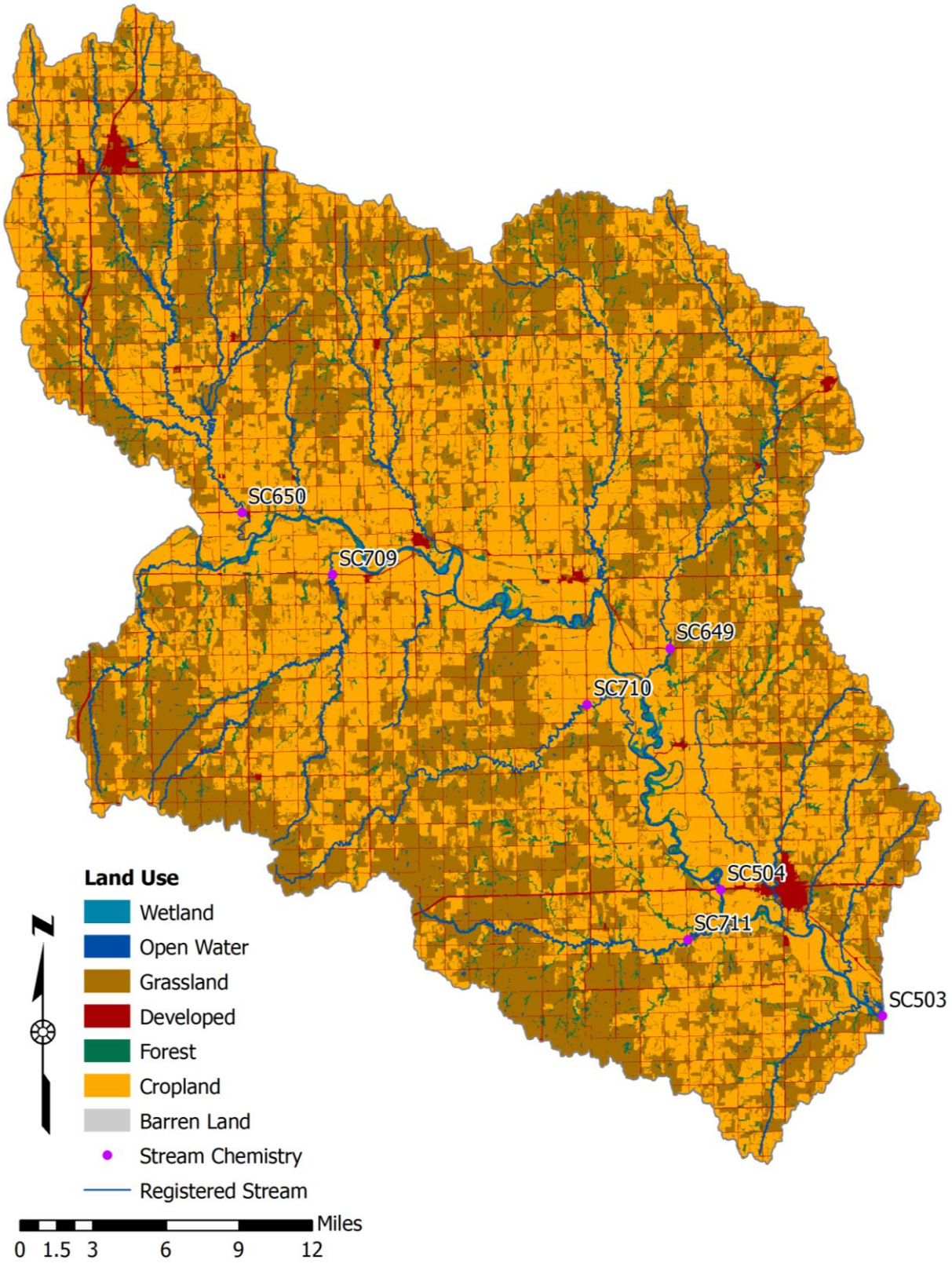
Table 22. Data from the 2011 National Land Cover Database for land cover by percent in the Republican River TMDL Watershed.

Land Use (percent)						
Open Water	Developed	Barren	Forest	Grassland	Cultivated Crops	Wetlands
1	5	0	4	38	51	1

Diversions

Within Clay, Cloud, Republic, and Washington counties, groundwater is diverted in greater quantities than surface water (**Figure 44**; Water Information Management and Analysis System, 2019). This trend occurs irrespective of dry years, such as 2012, and normal years, such as 2017; however, during wetter years, less water is consumed overall. The predominant use for diverted water in these counties is irrigation and municipal drinking water. Ancillary uses for water diversions in these areas include stockwater, recreational, industrial, and domestic uses which

Figure 43. The 2011 National Land Cover Database map for land cover in the Republican River TMDL Watershed.



tend to remain stable regardless of environmental conditions; irrigation, however, is the dominant source of increased water diversions during dry years, as demonstrated in 2012.
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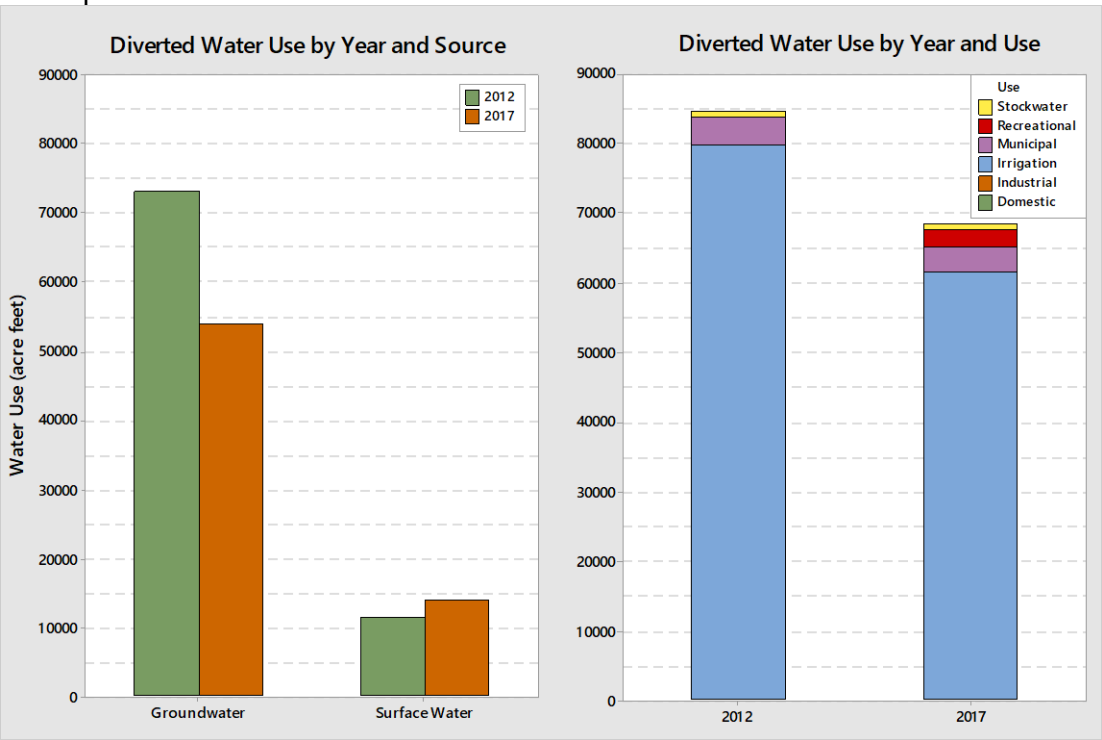
Figure 44. Diverted water by source and use according to the Water Information Management and Analysis System (WIMAS; 2019) for a dry (2012) and normal (2017) year for counties in the Republican River TMDL Watershed.



There are a total of 2,841 diversions among all the counties, and Republic County has the greatest number of diversions, with 777 diversions (**Table 23**; Water Information Management and Analysis System, 2019). These four counties have an approximate total of 469,000 acres of irrigated land as of 2017, a decrease of 6% since 2012 (U.S. Department of Agriculture, 2019). Clay and Republic counties both have the most irrigated acres, but Republic County has decreased its irrigated land by 8% since 2012. While Cloud County has decreased its irrigated land by 18% since 2012, as well, Washington County has increased its irrigated acreage by 6% from 2012 to 2017.

The U.S. Department of Agriculture collects census data for the cost of fertilizer, lime, and soil conditioners applied to agricultural land (**Table 24**). Overall, the cost of fertilizer, lime, and soil conditioners within the counties totaled approximately $44 million in 2017 and has decreased by 18% since 2012. All counties in the watershed have decreases in the cost of fertilizer, lime, and soil conditioners ranging from 12 to 22%.

Table 23. Agricultural census results for irrigated land by county from 2007, 2012, and 2017 (U.S. Department of Agriculture, 2019) and permitted water diversions according to the Water Information Management and Analysis System (WIMAS; 2019).

County	Category	2007	2012	2017	Percent Change (%), 2012 to 2017
Clay	Irrigated Land (acres)	77,214	125,030	125,826	1
	Number of Diversions	–	707	707	0
Cloud	Irrigated Land (acres)	147,922	136,299	111,209	-18
	Number of Diversions	–	689	689	0
Republic	Irrigated Land (acres)	154,564	153,091	141,166	-8
	Number of Diversions	–	777	777	0
Washington	Irrigated Land (acres)	91,480	85,991	90,790	6
	Number of Diversions	–	668	668	0
Total	Irrigated Land (acres)	471,180	500,411	468,991	-6
	Number of Diversions	–	2,841	2,841	0

Definition: – - Data not presented

Table 24. Agricultural census results for cost of fertilizer, lime, and soil conditioners by county from 2007, 2012, and 2017 (U.S. Department of Agriculture, 2019).

County	Cost ($), 2007	Cost ($), 2012	Cost ($), 2017	Percent Change (%), 2012 to 2017
Clay	7,893,000	13,066,000	10,877,000	-17
Cloud	9,935,000	9,122,000	7,984,000	-12
Republic	12,233,000	15,711,000	12,215,000	-22
Washington	9,786,000	15,255,000	12,734,000	-17
Total	39,847,000	53,154,000	43,810,000	-18

Population Density

According to the 2010 U.S. Census, the total population of all four counties in the watershed is approximately 29,000 and has decreased by 8% since 2000 (**Table 25**). Clay County encompasses the cities of Clay Center and Morganville, Cloud County encompasses the cities of Aurora and Clyde, Republic County encompasses the cities of Agenda and Belleville, and Washington County encompasses the cities of Clifton, Linn, Palmer, and Vining. Of these, the City of Clay Center is the largest urban center. In general, populations are declining in all counties and in the majority of these cities, with populations falling near or below the Kansas Water Office projections for 2040.

Table 25. City and county census results from 2000 and 2010 (U.S. Census Bureau, 2010) and population projections for 2040 (Kansas Water Office, 2002).

Location	Population, 2000	Population, 2010	Population Projection, 2040	Population Change, 2000 to 2010 (%)
Clay County	8,822	8,535	9,588	-3
Clay Center	4,564	4,334	5,843	-5
Morganville	198	192	205	-3
Cloud County	10,268	9,533	10,625	-7
Aurora	79	60	78	-24

Location	Population, 2000	Population, 2010	Population Projection, 2040	Population Change, 2000 to 2010 (%)
Clyde	740	716	649	-3
Republic County	5,835	4,980	4,606	-15
Agenda	81	68	48	-16
Belleville	2,239	1,991	2,206	-11
Washington County	6,483	5,799	5,430	-11
Clifton	557	554	395	-1
Linn	425	410	471	-4
Palmer	108	111	89	3
Vining	58	45	55	-22

On-Site Waste Systems

The populations of Republic and Washington counties are entirely rural, with 100% of their populations classified as rural (**Table 26**; U.S. Census Bureau, 2010). The populations of Clay and Cloud counties are more diverse, with 50 and 44% of the counties classified as rural, respectively. Urban populations are typically served by municipal sewer systems; however, rural populations do not have access to this service and use septic systems. According to the U.S. Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Load (STEPL), there are a total of 1,777 septic systems located in the Republican River TMDL Watershed. Septic systems in the state of Kansas typically have an estimated 10-15% failure rate (Electric Power Research Institute, 2000). Failing on-site septic systems have the potential to contribute to nutrient loading in the watershed. However, because of their small flows and the proclivity of phosphorus to adsorb to soil, failing on-site septic systems are considered a minor source of TP loading within the watershed and are not expected to significantly contribute to TP impairment in the Republican River.

Table 26. Census results by urban and rural population and county from 2010 (U.S. Census Bureau, 2010).

County	Classification	Population, 2010	Percent
Clay	Rural	4,228	50
	Urban	4,307	50
Cloud	Rural	4,193	44
	Urban	5,340	56
Republic	Rural	4,980	100
	Urban	0	0
Washington	Rural	5,799	100
	Urban	0	0

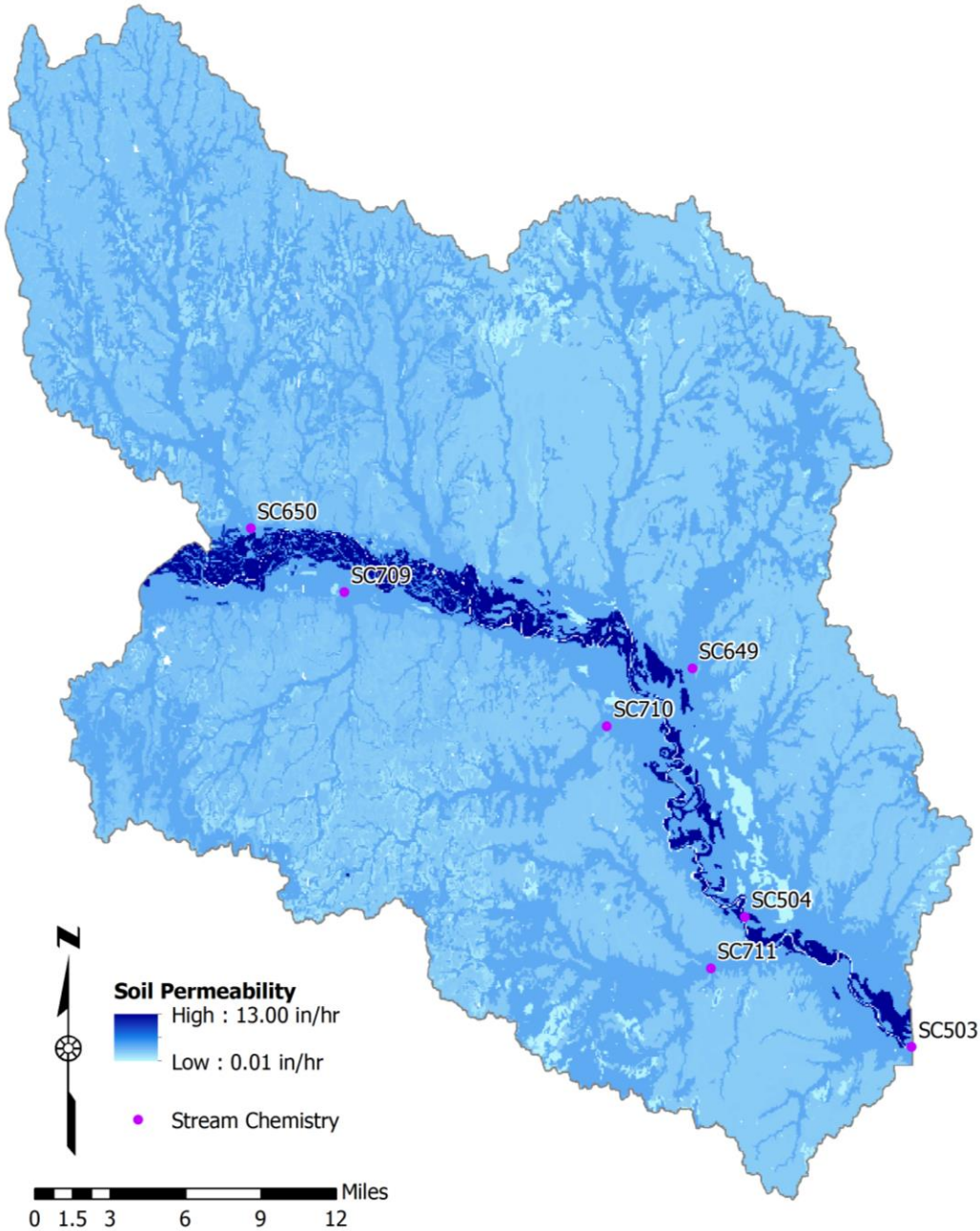
Contributing Runoff

Runoff conditions can occur as a result of either infiltration-excess (precipitation exceeds the infiltration rate of the soil) or saturation-excess (precipitation falls on soils saturated due to an elevated water table), causing overland flow (Juracek, 2000). Overland flow can impact the quality of water entering streams, thereby impacting water-quality loads. Soil permeability categories in Kansas have been defined by the following criteria in inches per hour (in/hr): very

high (3.43 in/hr), high (2.86 in/hr), moderate (2.29 in/hr), low (1.71 in/hr), very low (1.14 in/hr), and extremely low (0.57 in/hr).

According to the Natural Resources Conservation Service (NRCS) State Soil Geographic Database (STATSGO), the Republican River TMDL Watershed has a soil permeability range of 0.01 to 13 in/hr (**Figure 45**). Within the watershed, 44% of the area has a soil permeability less than 1.14 in/hr. Overall, the watershed has a mean soil permeability of 1.11 in/hr, placing the watershed in the very low soil permeability category.

Figure 45. Map of Natural Resources Conservation Service State Soil Geographic Database soil permeability in the Republican River TMDL Watershed.



Background Levels
Phosphorus is present over the landscape and in the soil profile. It is also present in terrestrial and aquatic biota. Wildlife can contribute to phosphorus loadings, particularly if they congregate to a density that exceeds the assimilative capacity of the land or water.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The following TMDLs, or load capacities (LC), are based upon the desired endpoints for aquatic life condition, chlorophyll-*a* concentration, dissolved oxygen concentration, dissolved oxygen saturation, and pH. All of these endpoints should improve to a level that provides full attainment of designated uses as phosphorus concentrations decrease in the Republican River. The LC is based on TP management milestones and the estimated flow conditions in the river. Once TP loading for the upstream station Republican River near Rice (SC510) is accounted for, incremental loading for the Republican River TMDL Watershed can be estimated by subtracting the upstream load from downstream loading capacity.

Load Capacity
These TMDLs are established in two phases to reduce TP concentrations and loadings within the river and will require periodic assessment of aquatic life conditions to determine compliance with the narrative nutrient criteria as TP concentrations and loadings decline. The Phase I TP milestone is set at 0.216 mg/L, which is the 50th percentile of the median concentrations of KDHE SC stations within the Level IV Ecoregions and Kansas and Lower Republican River Basin. Presuming one or more of the endpoints are not met at the end of Phase I, Phase II will commence with a TP milestone of 0.121 mg/L, which is the 25th percentile of the median concentrations of KDHE SC stations within the Level IV Ecoregions and Kansas and Lower Republican River Basin. Further reductions in TP concentrations and loads for Phase II will be accomplished through enhanced implementation of controls of both point and nonpoint sources in the watershed. For both Phase I and Phase II, total LCs are calculated according to the previously described TP milestones and the flow conditions in the Republican River TMDL Watershed.

For purposes of comparing current TP loading conditions in the river to the expected reduction in TP loading, the current condition was evaluated using the median TP concentration at each SC station from 2000 to 2018. Sampled TP concentrations at all stations were converted to loads for seasonal comparison with their respective TMDLs.

Wasteload Allocations
The total Phase I TP WLA for point sources for the Republican River TMDL Watershed is 15.8 lbs/day (**Table 27**). Under Phase II, the total TP WLA for point sources will be 11.1 lbs/day. The TP WLAs in this TMDL are calculated using concentrations for each facility according to the following: concrete operations, quarries, and non-discharging lagoons are calculated at a TP concentration of 0 mg/L; the industrial pretreatment facility is not assigned a TP concentration; industrial facilities with reported DMR TP data are calculated at a TP concentration equal to each facility's mean TP concentration; industrial facilities without reported DMR TP data that are not expected to contribute substantial TP concentrations are calculated at a nominal TP

concentration of 0.200 mg/L; municipal discharging lagoons are calculated at a TP concentration of 2.00 mg/L, an effluent concentration common in Kansas lagoons; Phase I municipal mechanical WWTF are calculated at 1.00 mg/L; Phase II municipal mechanical WWTF are calculated at 0.500 mg/L. The TP WLAs assigned to all municipal facilities are based upon current design flows for each facility. The TP WLAs assigned to all industrial facilities are based upon their current discharge rate.

Salt Creek near Hollis (SC650) Watershed
The Phase I and Phase II TP WLA assigned to Abram Ready Mix, Inc. – Belleville Plant is 0 lbs/day. The municipal WWTF in this watershed is operated by the City of Belleville. The design flow for this facility is 0.400 MGD. The Phase I TP WLA concentration for this facility is a concentration of 1.00 mg/L. Accordingly, the Phase I TP WLA assigned to the City of Belleville WWTF is 3.34 lbs/day, or 1,220 pounds per year (lbs/year). The Phase II TP WLA concentration for this facility will be calculated at a concentration of 0.500 mg/L.

Elm Creek near Ames (SC709) Watershed
The Phase I and Phase II TP WLA assigned to the non-discharging lagoon operated by the City of Aurora is 0 lbs/day.

Peats Creek near Clifton (SC649) Watershed
The Phase I and Phase II TP WLA assigned to the two non-discharging lagoons operated by the cities of Linn and Palmer are 0 lbs/day.

Republican River near Clay Center (SC504) Watershed
The Phase I and Phase II TP WLA assigned to the three facilities operated by Cloud Ceramics - #C-77 & #C-78, the City of Agenda, and Mid-Kansas Electric – Clifton Station are 0 lbs/day. The Phase I and Phase II TP WLA for the discharging lagoon systems operated by the cities of Clifton and Clyde are calculated with the TP WLA concentration of 2.00 mg/L at design flow. Accordingly, the Phase I and Phase II TP WLA assigned to the City of Clifton lagoon is 1.47 lbs/day, or 537 lbs/year, and the Phase I and Phase II TP WLA assigned to the City of Clyde lagoon is 1.31 mg/L, or 479 lbs/year.

Republican River near Clay Center (SC503) Watershed
The Phase I and Phase II TP WLA assigned to the four facilities operated by Midwest Products – Clay Center, Bayer Construction - Ebert Quarry, Hawks Landing Mobile Home Park, and Global Industries, Inc. - Hutchinson/Mayrath are 0 lbs/day. The Phase I and Phase II WLA for the non-contact cooling facility operated by the City of Clay Center – Power Plant is calculated with the current mean DMR reported TP WLA concentration of 0.471 mg/L at the facility's current discharge rate. Accordingly, the Phase I and Phase II TP WLA assigned to this facility is 0.201 lbs/day, or 73 lbs/year. The Phase I and Phase II WLA for the municipal groundwater remediation facility operated by the City of Clay Center - Groundwater Remediation Project PWS #2 is calculated with the TP WLA concentration of 0.200 mg/L at the facility's current discharge rate. Accordingly, the Phase I and Phase II TP WLA assigned to this facility is 0.585 lbs/day, or 213 lbs/year. The Phase I and Phase II WLA for the industrial groundwater remediation facility operated by Valley Fertilizer is calculated with the current mean DMR reported TP WLA concentration of 0.447 mg/L at the facility's current discharge rate.

Accordingly, the Phase I and Phase II TP WLA assigned to this facility is 0.665 lbs/day, or 243 lbs/year. The Phase I and Phase II WLA for the WTP operated by the City of Clay Center - PUC Water Treatment Plant is calculated with the TP WLA concentration of 0.200 mg/L at the facility's current discharge rate. Accordingly, the Phase I and Phase II TP WLA assigned to this facility is 0.414 lbs/day, or 151 lbs/year. The Phase I and Phase II WLA for the discharging lagoon system operated by the City of Morganville is calculated with the TP WLA concentration of 2.00 mg/L at design flow. Accordingly, the Phase I and Phase II TP WLA assigned to the City of Morganville lagoon is 0.368 lbs/day, or 134 lbs/year. The remaining facility within this watershed is the municipal mechanical WWTF operated by the City of Clay Center. The design flow for this facility is 0.715 MGD. The Phase I TP WLA concentration for this facility is a concentration of 1 mg/L. Accordingly, the Phase I TP WLA assigned to this facility is 5.97 lbs/day, or 2,180 lbs/year. The Phase II TP WLA concentration for this facility will be calculated at a concentration of 0.500 mg/L.

Reserve Wasteload Allocation

A reserve WLA is calculated at 10% for the entirety of the Republican River TMDL Watershed in order to accommodate future development within the watershed. The Phase I WLA is 14.3 lbs/day, resulting in a reserve WLA of 1.43 lbs/day. Reserve WLAs apply to the watershed terminus at Republican River near Clay Center (SC503) and may be apportioned throughout the Republican River TMDL Watershed from Rice to Clay Center.

Table 27. Phase I total phosphorus wasteload allocations for discharging National Pollution Discharge Elimination System (NPDES) permitted facilities for the Republican River TMDL Watershed.

Permittee	Kansas Permit Number	NPDES Permit Number	Facility Type	Design Flow (MGD)	Anticipated Total Phosphorus Wasteload Allocation Concentration (mg/L)	Total Phosphorus Daily Wasteload Allocation (lbs/day)	Total Phosphorus Annual Wasteload Allocation (lbs/year)
Abram Ready Mix, Inc. - Belleville Plant	I-LR03-PR01	KSG110084	Concrete operation pit dewatering	–	0	0	0
City of Belleville	M-LR03-OO01	KS0027529	Municipal wastewater treatment facility	0.400	1	3.34	1,220
Total Phosphorus Wasteload Allocation for the Salt Creek near Hollis (SC650)						**3.34**	**1,220**
Cloud Ceramics - #C-77 & #C-78	I-LR08-PO02	KS0002682	Industrial pit dewatering	–	0	0	0
City of Clifton	M-LR06-OO01	KS0048437	Municipal discharging lagoon	0.088	2.00	1.47	537

Permittee	Kansas Permit Number	NPDES Permit Number	Facility Type	Design Flow (MGD)	Anticipated Total Phosphorus Wasteload Allocation Concentration (mg/L)	Total Phosphorus Daily Wasteload Allocation (lbs/day)	Total Phosphorus Annual Wasteload Allocation (lbs/year)
City of Clyde	M-LR07-OO01	KS0022403	Municipal discharging lagoon	0.0786	2.00	1.31	479
Total Phosphorus Wasteload Allocation for the Republican River near Clay Center (SC504)						**2.78**	**1,016**
Midwest Products - Clay Center	I-LR05-PR02	KSG110216	Concrete operation pit dewatering	–	0	0	0
Bayer Construction - Ebert Quarry	I-KS66-PO02	KS0098086	Industrial quarry pit dewatering	–	0	0	0
City of Clay Center - Power Plant	I-LR05-CO02	KS0093459	Non-contact cooling	0.051	0.471	0.201	73
City of Clay Center - Groundwater Remediation Project PWS #2	I-LR05-PO02	KS0093351	Groundwater remediation	0.350	0.200	0.585	213
Valley Fertilizer	I-LR05-PO01	KS0090018	Groundwater remediation	0.178	0.447	0.665	243
City of Clay Center - PUC Water Treatment Plant	I-LR05-PO04	KS0098477	Water treatment facility	0.248	0.200	0.414	151
City of Morganville	M-LR18-OO01	KS0024678	Municipal discharging lagoon	0.022	2.00	0.368	134
City of Clay Center	M-LR05-OO01	KS0048399	Municipal wastewater treatment facility	0.715	1.00	5.97	2,180
Total Phosphorus Wasteload Allocation for the Republican River near Clay Center (SC503)						**8.21**	**2,100**
Total Phosphorus Sub-watershed Total Wasteload Allocation						**14.3**	**5,231**
Total Phosphorus Total Reserve Wasteload Allocation						**1.43**	**523**
Total Phosphorus Total Wasteload Allocation						**15.8**	**5,754**

Definition: – - Data not available

Livestock

All AFOs and CAFOs within the Republican River TMDL Watershed are assigned a WLA of 0 lbs/day.

Load Allocation
The LA is established to account for nonpoint sources of TP in the watershed. The LA is the remainder of the LC after all other allocations are accounted for. Loads from nonpoint source TP are assumed to be minimal during low flow conditions and grow proportionately as flow conditions increase, thereby accounting for increased runoff during precipitation events. The application of agricultural BMPs in riparian zones near cropland and livestock areas should continue in order to abate and reduce nonpoint source TP loading in the Republican River TMDL Watershed.

Defined Margin of Safety
The margin of safety safeguards against the uncertainty in TP loading in the Republican River. This TMDL incorporates conservative assumptions to establish an implicit margin of safety. First, five endpoints are established which must be met for three consecutive years before achieving attainment of the water quality standards. Second, concurrently reducing TP and nitrogen discharged from municipal WWTPs is emphasized in order to diminish the often synergistic effects these nutrients have on aquatic life. Third, design flows are used for all point source WLAs, despite the current operation of most facilities under design flow. Fourth, some facilities are assigned WLAs when it is likely that they do not contribute nutrient loads.

The described TMDLs, or LCs, are delineated below for the Salt Creek near Hollis (SC650; **Figure 46**; **Table 28**), Elm Creek near Ames (SC709; **Figure 47**; **Table 29**), Peats Creek near Clifton (SC649; **Figure 48**; **Table 30**), Mulberry Creek near Clifton (SC710; **Figure 49**; **Table 31**), Republican River near Clay Center (SC504; **Figure 50**; **Table 32**), Five Creek near Clay Center (SC711; **Figure 51**; **Table 33**), and Republican River near Clay Center (SC503; **Figure 52**; **Table 34**) watersheds.

Figure 46. Total phosphorus Phase I Total Maximum Daily Load for the Salt Creek near Hollis (SC650).

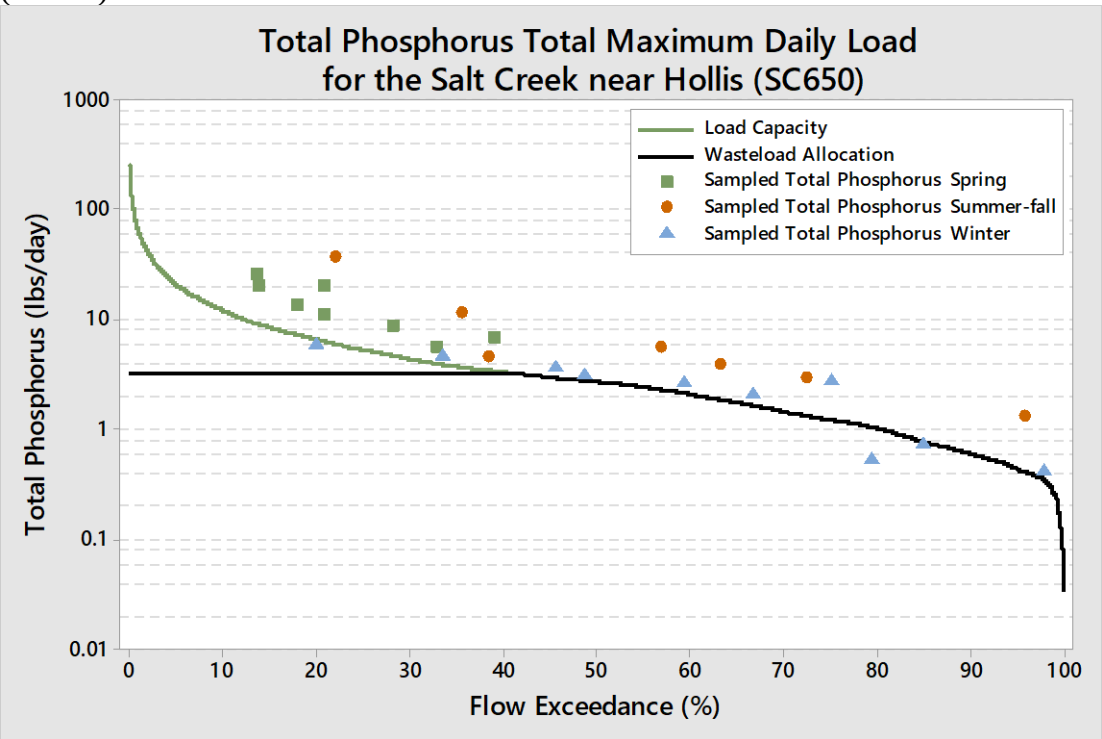


Table 28. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load capacity apportionment for the Salt Creek near Hollis (SC650).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I					
90	0.5	1	0.6	0.6	0.0
75	1.1	2	1.3	1.3	0.0
50	2.4	4	2.8	2.8	0.0
25	4.6	8	5.4	3.34	2.06
10	10.5	18	12.2	3.34	8.86
Phase II					
90	0.5	1	0.3	0.3	0.0
75	1.1	2	0.7	0.7	0.0
50	2.4	4	1.6	1.6	0.0
25	4.6	8	3.0	1.67	1.34
10	10.5	18	6.8	1.67	5.13

Figure 47. Total phosphorus Phase I Total Maximum Daily Load for the Elm Creek near Ames (SC709).

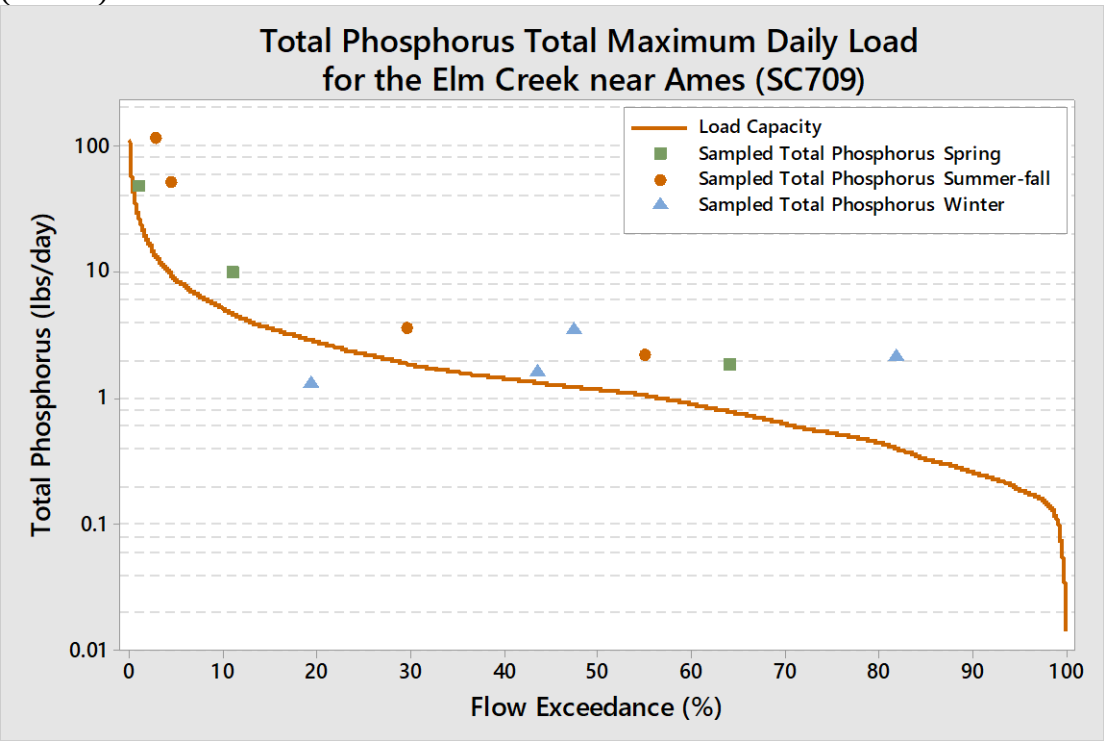


Table 29. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load allocation for the Elm Creek near Ames (SC709).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Load Allocation (lbs/day)
Phase I				
90	0.2	0.7	0.3	0.3
75	0.5	1.4	0.5	0.5
50	1.0	3.0	1.2	1.2
25	2.0	5.9	2.3	2.3
10	4.5	13	5.2	5.2
Phase II				
90	0.2	0.7	0.1	0.1
75	0.5	1.4	0.3	0.3
50	1.0	3.0	0.7	0.7
25	2.0	5.9	1.3	1.3
10	4.5	13	2.9	2.9

Figure 48. Total phosphorus Phase I Total Maximum Daily Load for the Peats Creek near Clifton (SC649).

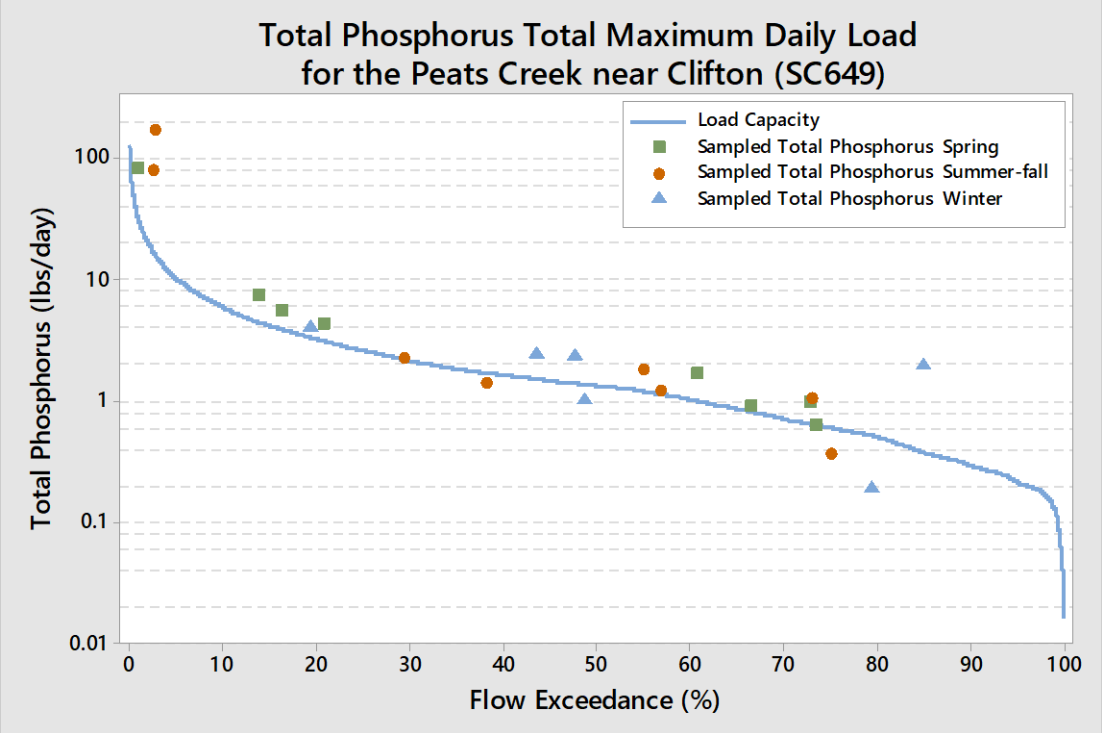


Table 30. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load allocation for the Peats Creek near Clifton (SC649).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Load Allocation (lbs/day)
Phase I				
90	0.3	0.4	0.3	0.3
75	0.5	0.9	0.6	0.6
50	1.2	2	1.4	1.4
25	2.3	4	2.6	2.6
10	5.1	8	6.0	6.0
Phase II				
90	0.3	0.4	0.2	0.2
75	0.5	0.9	0.3	0.3
50	1.2	2	0.8	0.8
25	2.3	4	1.5	1.5
10	5.1	8	3.4	3.4

Figure 49. Total phosphorus Phase I Total Maximum Daily Load for the Mulberry Creek near Clifton (SC710).

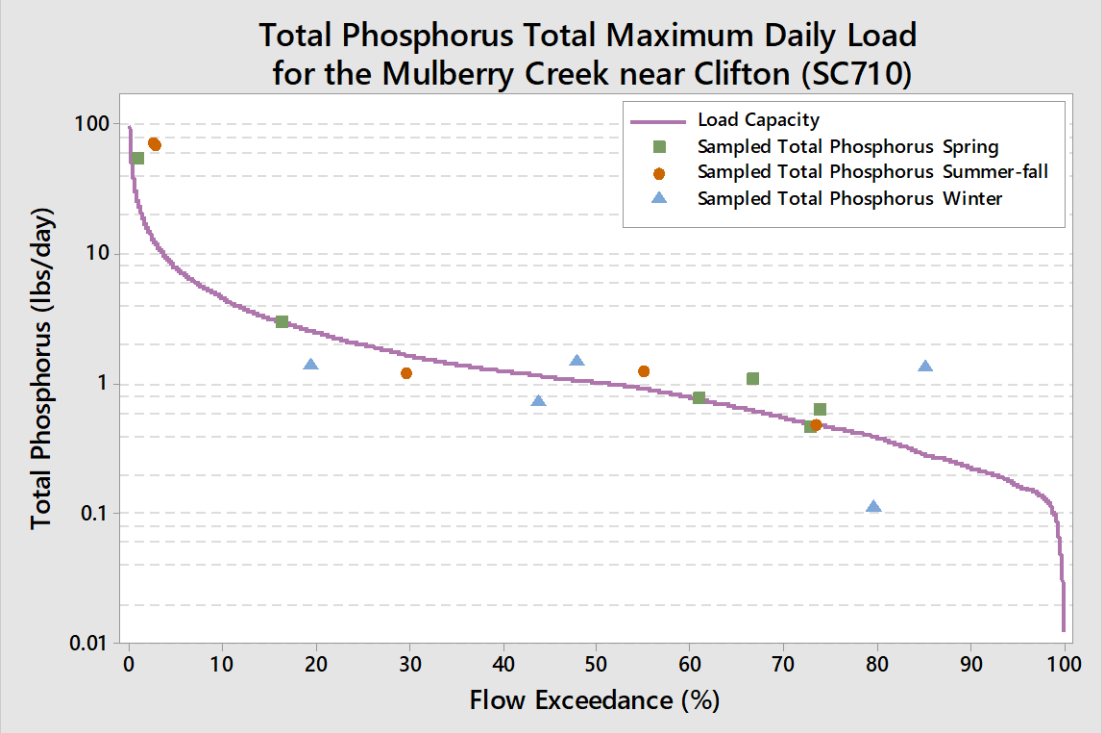


Table 31. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load allocation for the Mulberry Creek near Clifton (SC710).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Load Allocation (lbs/day)
Phase I				
90	0.2	0.3	0.2	0.2
75	0.4	0.5	0.5	0.5
50	0.9	1.2	1.0	1.0
25	1.7	2.3	2.0	2.0
10	4.0	5.1	4.6	4.6
Phase II				
90	0.2	0.3	0.1	0.1
75	0.4	0.5	0.3	0.3
50	0.9	1.2	0.6	0.6
25	1.7	2.3	1.1	1.1
10	4.0	5.1	2.6	2.6

Figure 50. Total phosphorus Phase I Total Maximum Daily Load for the Republican River near Clay Center (SC504).

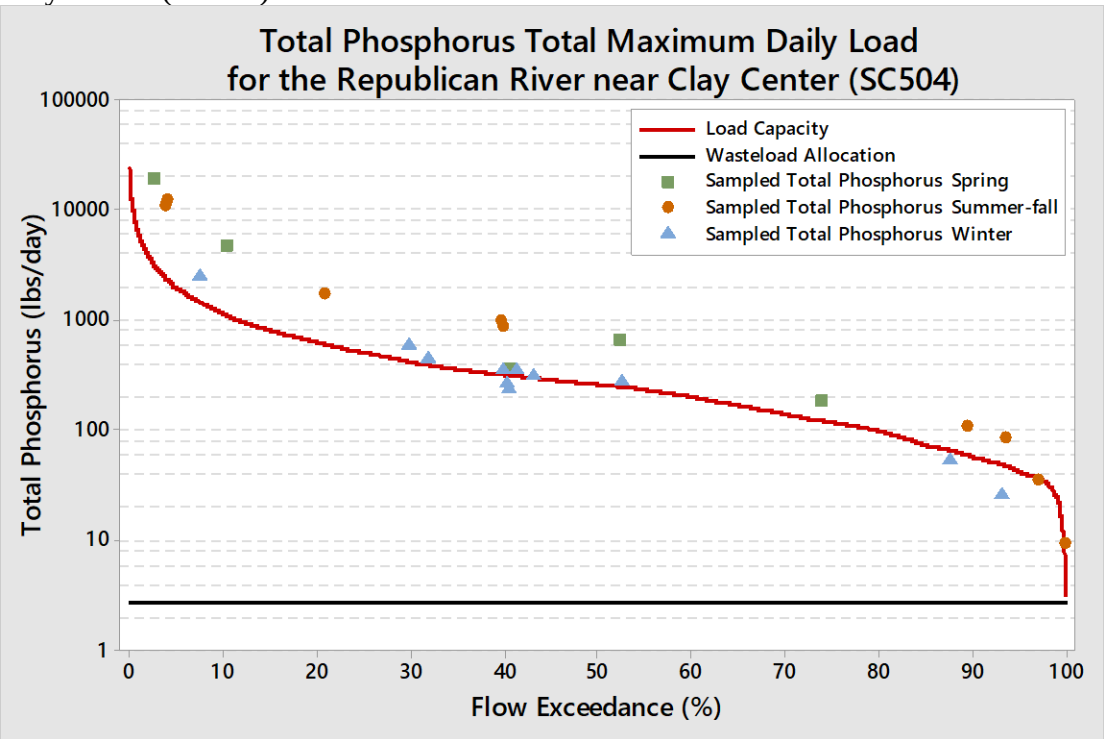


Table 32. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load capacity apportionment for the Republican River near Clay Center (SC504).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I					
90	50	102	58	2.78	55.22
75	103	209	120	2.78	117.22
50	226	460	264	2.78	261.22
25	439	894	512	2.78	509.22
10	998	2,031.2	1,164	2.78	1,161.22
Phase II					
90	50	102	33	2.78	30.22
75	103	209	67	2.78	64.22
50	226	460	148	2.78	145.22
25	439	894	287	2.78	284.22
10	998	2,031.2	652	2.78	649.22

Figure 51. Total phosphorus Phase I Total Maximum Daily Load for the Five Creek near Clay Center (SC711).

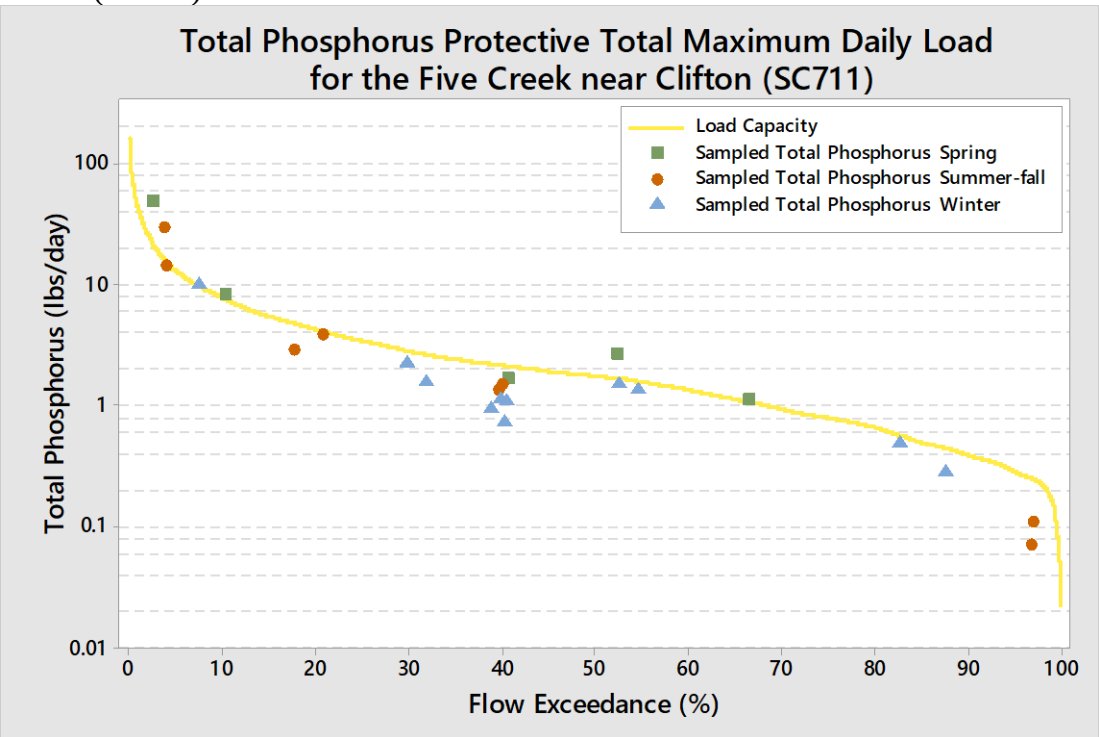


Table 33. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load allocation for the Five Creek near Clay Center (SC711).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Load Allocation (lbs/day)
Phase I				
90	0.34	0.31	0.39	0.39
75	0.69	0.64	0.81	0.81
50	1.53	1.40	1.78	1.78
25	2.97	2.72	3.46	3.46
10	6.74	6.19	7.86	7.86
Phase II				
90	0.34	0.31	0.22	0.22
75	0.69	0.64	0.45	0.45
50	1.53	1.40	1.00	1.00
25	2.97	2.72	1.94	1.94
10	6.74	6.19	4.40	4.40

Figure 52. Total phosphorus Phase I Total Maximum Daily Load for the Republican River near Clay Center (SC503).

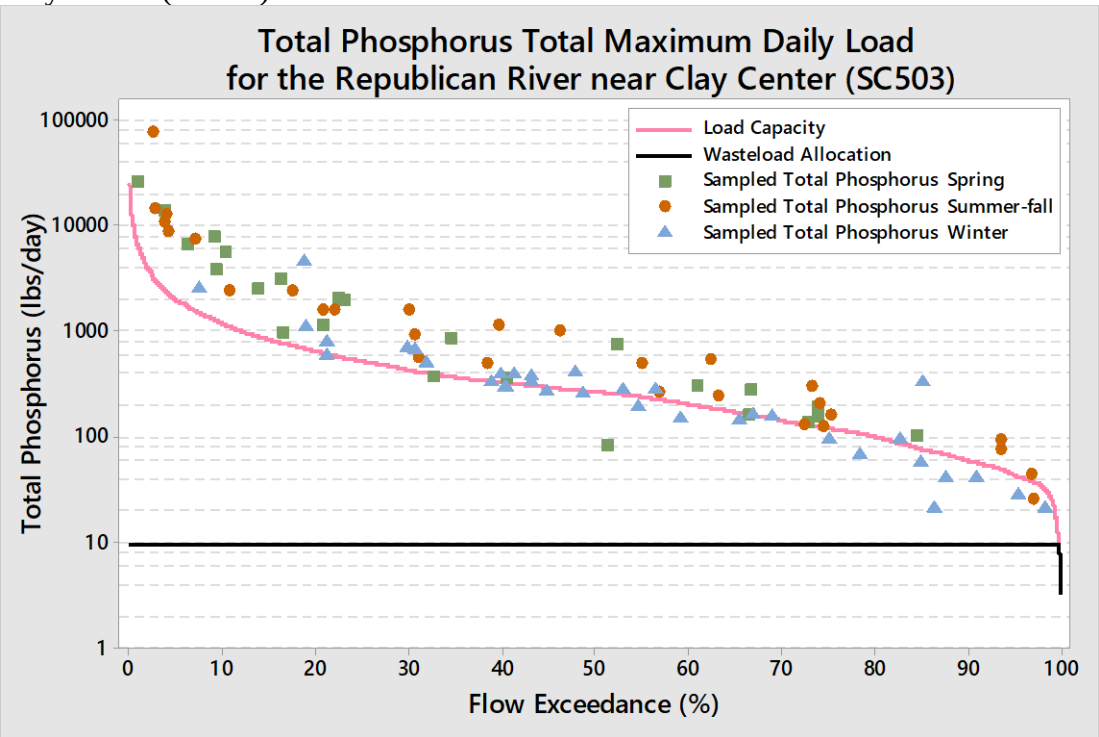


Table 34. Phase I and phase II current load conditions (based upon the median total phosphorus concentration from 2000 to 2018), total load capacity, and load capacity apportionment for the Republican River near Clay Center (SC503).

Flow Exceedance (%)	Flow at Terminus (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	Reserve Wasteload Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I						
90	51	90	60	8.21	1.43	50.36
75	106	186	123	8.21	1.43	113.36
50	233	409	272	8.21	1.43	262.36
25	453	794	528	8.21	1.43	518.36
10	1,028	1,805	1,199	8.21	1.43	1,189.36
Phase II						
90	51	90	34	5.22	1.43	27.35
75	106	186	69	5.22	1.43	62.35
50	233	409	152	5.22	1.43	145.35
25	453	794	296	5.22	1.43	289.35
10	1,028	1,805	672	5.22	1.43	665.35

Priority HUC12s

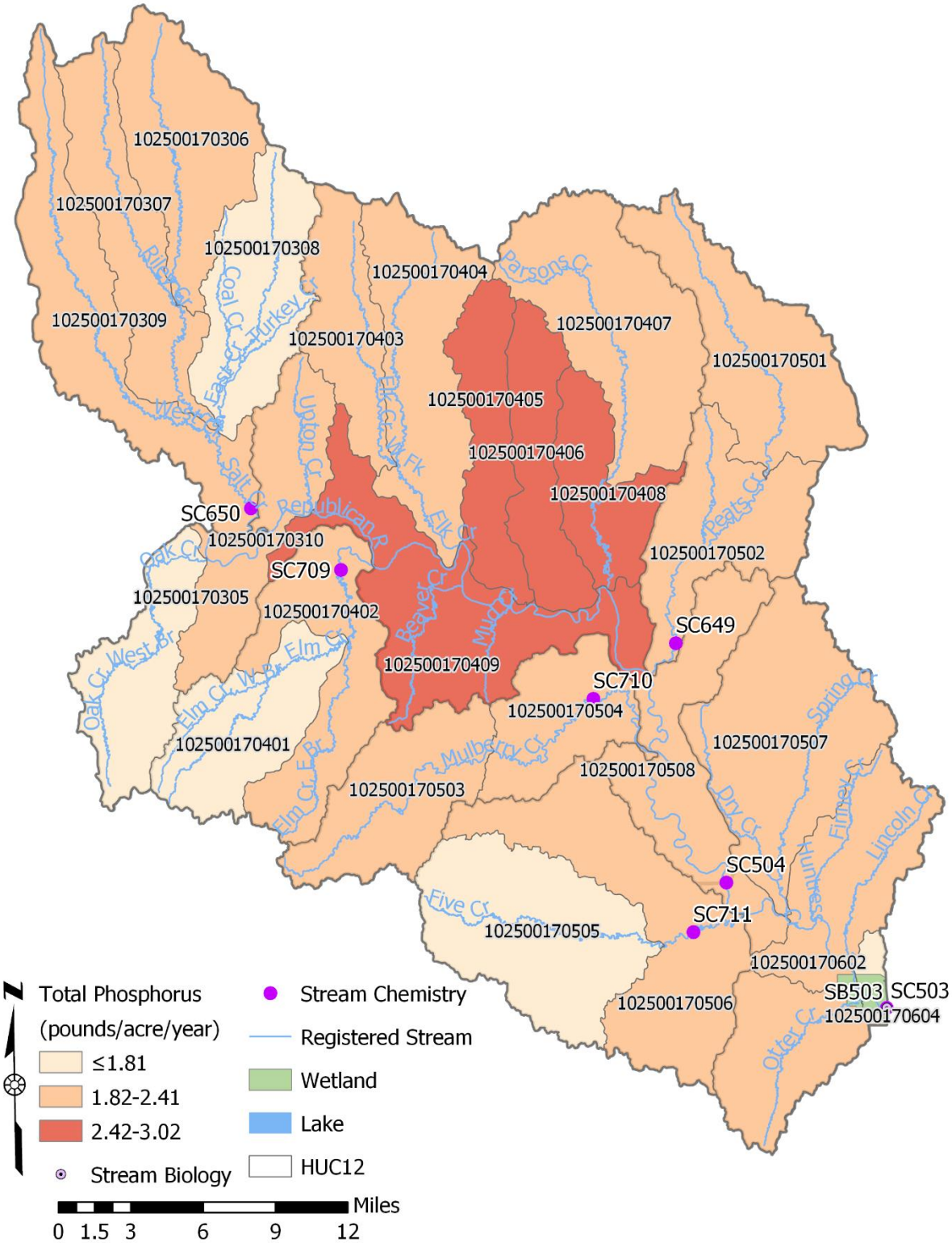
Although this TMDL does require implementation of point source treatment improvements, reductions in nonpoint sources from BMP implementation in those HUC12s most impacted by TP loading will be necessary to achieve the TMDL (**Table 35**; **Figure 53**). The Republican River TMDL Watershed consists of 26 HUC12s. According to STEPL, the Republican River TMDL Watershed high priority HUC12s are 102500170405, 102500170406, 102500170408, and 102500170409, all of which are located in the Republican River near Clay Center (SC504) Watershed. Proactive entities may implement BMPs at any time, with an emphasis on priority HUC12s likely yielding the greatest TP reductions to the Republican River TMDL Watershed.

Table 35. Priority HUC12s by total phosphorus load according to estimations from the Spreadsheet Tool for Estimating Pollutant Load for the Republican River TMDL Watershed.

Watershed	Land Area (acres)	Total Phosphorus (lbs/year)	Total (lbs/year/acre)
102500170505	19,201	27,843	1.45
102500170305	26,430	52,149	1.97
102500170401	23,069	47,571	2.06
102500170604	23,250	41,718	1.79
102500170308	33,887	69,060	2.04
102500170503	21,504	43,658	2.03
102500170403	20,764	35,683	1.72
102500170407	25,176	57,772	2.29
102500170306	16,449	31,442	1.91
102500170310	28,218	60,007	2.13
102500170309	15,770	41,495	2.63
102500170307	16,124	48,672	3.02
102500170404	35,118	69,084	1.97
102500170504	15,403	43,257	2.81
102500170502	36,379	94,438	2.60
102500170602	29,156	68,048	2.33
102500170506	23,946	51,724	2.16
102500170507	23,098	43,630	1.89
102500170402	17,693	37,873	2.14
102500170601	33,436	44,407	1.33
102500170508	36,099	79,049	2.19
102500170501	38,132	86,919	2.28
102500170409	**25,361**	**58,828**	**2.32**
102500170405	**18,017**	**41,602**	**2.31**
102500170408	**22,894**	**49,977**	**2.18**
102500170406	**27,834**	**49,339**	**1.77**

Definition: **Bold** - Priority HUC12s

Figure 53. Map of priority HUC12s by total phosphorus load according to estimations from the Spreadsheet Tool for Estimating Pollutant Load for the Republican River TMDL Watershed.



State Water Plan Implementation Priority
Due to the prevalence of high TP concentrations in the Republican River, this TMDL initially focuses on reducing TP loading from point sources, such as permitted NPDES municipal WWTFs. However, further reductions in TP loadings will need to be achieved through effective riparian and land management. Due to the need to reduce the high nutrient loads in the Republican River, this TMDL will be **High Priority** for implementation.

Nutrient Reduction Framework Priority Ranking
This watershed lies within the Lower Republican (HUC8 10250017) subbasin. This subbasin contributes to the Middle Kansas (HUC8 10270102) and Lower Kansas (HUC8 10270104) subbasins, which are among the top 16 HUC8s targeted for state action to reduce nutrients.

5. IMPLEMENTATION

Desired Implementation Activities

1. Make operational changes in municipal WWTFs to reduce the phosphorus load.
2. Facilitate wastewater reuse for treated municipal wastewater.
3. Renew state and federal permits and inspect permitted facilities for permit compliance.
4. Improve riparian conditions along stream systems by installing grass and/or forest buffer strips along the streams and drainage channels in the watershed.
5. Implement and maintain conservation farming practices—including conservation rotation, no-till farming, and contour farming—in order to reduce runoff and cropland erosion of agricultural areas in the watershed.
6. Perform extensive soil testing to ensure excess phosphorus is not unnecessarily applied.
7. Ensure labeled application rates for chemical fertilizers are followed to reduce runoff.
8. Implement nutrient management plans and ensure that land-applied manure is properly managed to reduce runoff.
9. Establish pasture management practices, including proper stock density, to reduce soil erosion and storm runoff.
10. Ensure proper on-site waste system operations in proximity to main stem and tributary segments.
11. Install alternative livestock watering systems and relocate livestock feeding areas away from riparian areas.
12. Establish alternative livestock foraging areas, collaborate with producers to develop areas for grazing cover crops, and implement rotational grazing systems.
13. Provide education and outreach opportunities on topics such as soil health, nutrient management, and livestock management.
14. Support BMP implementation efforts of the Milford Lake WRAPS and Milford Lake Watershed Regional Conservation Partnership Program (RCPP).

Implementing these practices will reduce nutrient loading in the Republican River; however, an emphasis on agricultural BMPs will be needed in this watershed in order to address nonpoint sources of loading and meet Phase I of this TDML (**Table 36**).

Table 36. Nonpoint source load reduction required to meet the Phase I TMDL for the Republican River from Rice to Clay Center for base flow conditions.

Station	Current Condition (lbs/year)	Load Capacity (lbs/year)	Wasteload Allocation (lbs/year)	Load Allocation Reduction (lbs/year)	Load Allocation Reduction (%)
Republican R nr Clay Center (SC503)	149,169	99,280	3,519	53,408	36

Implementation Program Guidance

NPDES and State Permits – KDHE

a. Continue to monitor influent to and effluent from the permitted discharging WWTFs, encourage wastewater reuse and irrigation disposal, and ensure compliance and proper operation of WWTFs to control phosphorus in wastewater effluent.
b. Establish permit limits after 2019, as determined by KDHE, with the initial implementation of goals and appropriate schedules of compliance for permits issued prior.
c. Manage the WLA for the watershed to accommodate growth as needed.
d. Manure management plans, detailing proper land application rates and practices, will be implemented to prevent runoff of applied manure.
e. Inspect permitted livestock facilities to ensure compliance.
f. Inspect new permitted livestock facilities for integrity of applied pollution prevention technologies.
g. Apply pollution prevention technologies to new registered livestock facilities with less than 300 animal units.

Nonpoint Source Pollution Technical Assistance – KDHE

a. Support Section 319 and Milford Lake Watershed RCPP implementation projects for nutrient management through reduction of phosphorus runoff from agricultural activities.
b. Provide technical assistance on practices to establish vegetative buffer strips.
c. Support implementation efforts of the Milford Lake WRAPS, and incorporate long term objectives of this TMDL into their 9-element watershed plans.
d. Provide technical assistance on nutrient management for livestock facilities and practices which minimize impacts of small livestock operations in the watershed to reduce impacts to stream resources.

Milford Lake Watershed Regional Conservation Partnership Program (RCPP)

a. Support implementation of BMPs, including nutrient management planning, cover crop planting, fencing, and improving access controls, through grants awarded by the Natural Resources Conservation Service (NRCS) and administered with the partnership of the Kansas Water Office.

Water Resource Cost Share and Nonpoint Source Pollution Control Program – Kansas Department of Agriculture-Division of Conservation (KDA-DOC)

a. Apply conservation farming practices—including no-till, terraces, and contours—and erosion control structures, including sediment control basins and constructed wetlands.
b. Provide sediment control practices to minimize erosion and sediment transport from cropland and grassland in the watershed.
c. Encourage residue management to reduce phosphorus loss and transport from cropland runoff in the watershed.
d. Implement manure management plans.
e. Install livestock waste management systems for manure storage.

Riparian Protection Program – KDA-DOC

a. Protect, establish, or re-establish natural riparian systems, including vegetative filter strips and streambank vegetation.
b. Develop riparian restoration projects along targeted stream segments, especially those areas with base flow.
c. Promote wetland construction to reduce runoff and assimilate loadings.
d. Coordinate riparian management within the watershed and develop riparian restoration projects.

Buffer Initiative Program – KDA-DOC

a. Install grass buffer strips near streams.
b. Leverage Conservation Reserve Enhancement Programs to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

a. Educate agricultural producers on sediment, nutrient, and pasture management.
b. Provide technical assistance on buffer strip design and minimizing cropland runoff.
c. Encourage annual soil testing to determine capacity of field to hold phosphorus.
d. Educate residents, landowners, and watershed stakeholders about nonpoint source pollution.
e. Promote and utilize the WRAPS efforts for pollution prevention, runoff control, and resource management.
f. Educate livestock producers on livestock waste management, land applied manure applications, and nutrient management plans.
g. Provide technical assistance on livestock waste management systems and nutrient management plans.
h. Repair or replace failing septic systems which are located within 100 feet of the Republican River or its tributaries.

Timeframe for Implementation

Rural runoff management should expand from 2020 to 2029 to ensure nutrients are addressed. Pollutant reduction practices should be installed within the priority sub-watersheds after 2019 with follow-up implementation and monitoring continuing through 2029.

Targeted Participants
The primary participants for implementation of this TMDL are the municipal WWTFs for the City of Belleville (KS0027529) and City of Clay Center (KS0048399) and the Milford Lake WRAPS and RCPP. Agricultural operations immediately adjacent to the Republican River and its tributaries will be encouraged to implement appropriate practices to further reduce phosphorus loads. Watershed coordinators, technical staff of the WRAPS group, conservation district personnel, and county extension agents should coordinate to assess possible nutrient sources adjacent to streams. Implementation activities to address nonpoint sources should focus on those areas with the greatest potential to impact nutrient loading to the river.

Targeted agricultural activities to focus attention toward include:
1. Denuded riparian vegetation and poor riparian areas along the stream.
2. Conservation compliance on highly erodible areas.
3. Unbuffered cropland adjacent to the stream.
4. Total row crop acreage and gully locations.
5. No till or residue management on cropland.
6. Increasing no-till and precision agricultural practices, including cover crops.
7. Sites where drainage runs through or adjacent to livestock areas.
8. Sites where livestock have full access to the stream and it is their primary water supply.

Milestone for 2025
By 2025, advancement of necessary and appropriate measures to decrease phosphorus effluent from the municipal WWTFs should be implemented. The Milford Lake WRAPS is currently (2019) beginning a three-year funding cycle to mitigate nutrient and sediment loads to the watershed, as well. This initiative specifically seeks to reduce livestock impacts for Salt Creek, demonstrate the integration of livestock grazing with cover crops for Peats Creek, and implement agricultural BMPs over this time frame. By 2025, TP data from the station Republican River near Clay Center (SC503) should show indication of declining TP concentrations relative to the pre-2018 data.

Delivery Agents
The primary delivery agents for program participation will be the municipal WWTFs, KDHE, and the Milford Lake WRAPS and RCPP.

Reasonable Assurances
Authorities
The following authorities may be used to direct activities in the watershed to reduce pollution:
1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.
2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.

4. K.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.
5. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation, and management of soil and water resources in the state, including riparian areas.
6. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.
7. K.S.A. 82a-901, et. seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*, including selected WRAPS.
9. The *Kansas Water Plan* provides the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding
The State Water Plan annually generates $12-13 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watershed and water resources by priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are located within a **High Priority** area and should receive support for pollution abatement practices that lower the loading of sediment and nutrients.

Effectiveness
Use of Biological Nutrient Removal technology in WWTFs has been well established to reduce nutrients, including phosphorus, in wastewater. Agricultural nutrient control has been proven effective through conservation tillage, contour farming, and use of grass waterways and buffer strips; additionally, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities. Presuming the Phase I milestone is not met, this TMDL will be evaluated after 2025 to assess the reductions in phosphorus loads that have taken place with guidance provided to targeted participants regarding follow-up implementation activities.

6. MONITORING

Monitoring for TP will continue at KDHE stations for the Salt Creek near Hollis (SC650), Elm Creek near Ames (SC709), Peats Creek near Clifton (SC649), Mulberry Creek near Clifton (SC710), Republican River near Clay Center (SC504), Five Creek near Clay Center (SC711), and Republican River near Clay Center (SC503). Biological monitoring will also continue for the Republican River near Clay Center (SB503) to assess compliance with the narrative nutrient

criteria in the river. Based on the sampling data, the status of the watershed will be re-evaluated during the Section 303(d) listing process in 2030.

7. FEEDBACK

Public Notice

An active website is established at http://www.kdheks.gov/tmdl/planning_mgmt.htm to convey information to the public on the general establishment of TMDLs and to provide specific TMDLs by river basin. This TMDL was posted to the Kansas-Lower Republican River Basin on this site on August 22, 2019 for public review.

Public Hearing

A public hearing on this TMDL was held on September 6, 2019 in Topeka, Kansas to receive public comments. No comments were received.

Milestone Evaluation

In 2029, evaluation will be made as to the degree of implementation that occurred within the watershed. Subsequent decisions will be made through consultation with local stakeholders and the WRAPS team regarding implementation of nonpoint source reduction strategies and development of additional implementation strategies for the watershed.

Consideration for Section 303(d) Delisting

The segments covered by this TMDL will be evaluated for delisting under Section 303(d) based on the monitoring data from 2020 to 2029. Therefore, the decision for delisting will ensue in the preparation for the 2030 Section 303(d) list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL, and implementation activities may be adjusted accordingly.

Incorporation into the TMDL Vision Process, Water Quality Management Plan, and the Kansas Water Planning Process

Under the current version of the Kansas TMDL Vision Process, the next anticipated revision of this TMDL will be after 2025. The revision will emphasize implementation of WRAPS activities and further reduction of nutrients in wastewater discharged by NPDES facilities. At that time, incorporation of this TMDL will be made into the WRAPS plan. Recommendations for this TMDL will be considered in the *Kansas Water Plan* implementation decisions under the State Water Planning Process for fiscal years 2020 to 2029.

Developed: September 24, 2019

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APPENDIX A

Certified or permitted Animal Feeding Operations and Concentrated Animal Feeding Operations in the Republican River TMDL Watershed.

Kansas Permit Number	County	Livestock Type	Livestock Total
Salt Creek near Hollis (SC650)			
*	Republic	Beef	651
A-LRCD-BA07	Cloud	Beef	290
A-LRRP-B002	Republic	Beef	999
A-LRRP-B005	Republic	Beef	998
A-LRRP-MA02	Republic	Dairy	25
Elm Creek near Ames (SC709)			
*	Cloud	Beef	300
A-LRCD-H002	**Cloud**	**Swine**	**7,200**
A-LRCD-MA02	Cloud	Dairy	60
A-LRCD-MA04	Cloud	Dairy	50
A-LRCD-S006	Cloud	Swine	1,000
A-LRCD-S007	Cloud	Beef/Swine	776
Peats Creek near Clifton (SC649)			
A-LRWS-B002	Washington	Beef	999
A-LRWS-D001	**Washington**	**Dairy**	**1,900**
A-LRWS-H007	**Washington**	**Swine**	**8,000**
A-LRWS-MA01	Washington	Dairy	50
A-LRWS-S013	Washington	Beef/Swine	535
A-LRWS-S024	Washington	Swine	1,600
A-LRWS-S041	Washington	Swine	2,490
Mulberry Creek near Clifton (SC710)			
A-LRCD-S009	Cloud	Swine	1,800
A-LRCY-B001	Clay	Beef	450
A-LRCY-BA21	Clay	Beef	200
Republican River near Clay Center (SC504)			
*	Republic	Beef	500
A-BBWS-H005	**Washington**	**Swine**	**7,200**
A-LRCD-BA02	Cloud	Beef	750
A-LRCD-BA03	Cloud	Beef	400
A-LRCD-BA04	Cloud	Beef	300
A-LRCD-BA09	Cloud	Beef	800
A-LRCD-M002	Cloud	Dairy	270
A-LRCY-B009	Clay	Beef	650
A-LRCY-B010	Clay	Beef	500

Kansas Permit Number	County	Livestock Type	Livestock Total
Republican River near Clay Center (SC504; continued)			
A-LRCY-BA04	Clay	Beef	500
A-LRCY-BA09	Clay	Beef	150
A-LRCY-BA17	Clay	Beef	150
A-LRCY-BA48	Clay	Beef	60
A-LRCY-BA50	Clay	Beef	80
A-LRCY-BA57	Clay	Beef	50
A-LRCY-H004	**Clay**	**Swine**	**4,820**
A-LRCY-S043	Clay	Swine	750
A-LRCY-S050	Clay	Swine	2,115
A-LRRP-B004	Republic	Beef	999
A-LRWS-B001	Washington	Beef	999
A-LRWS-B003	Washington	Beef	999
A-LRWS-BA04	Washington	Beef	150
A-LRWS-H002	**Washington**	**Swine**	**14,522**
A-LRWS-H005	**Washington**	**Swine**	**3,940**
A-LRWS-H006	**Washington**	**Swine**	**4,800**
A-LRWS-H008	**Washington**	**Swine**	**8,000**
A-LRWS-H009	**Washington**	**Swine**	**7,450**
A-LRWS-S028	Washington	Swine	2,770
A-LRWS-S029	Washington	Swine	3,400
A-LRWS-S030	Washington	Swine	2,400
A-LRWS-S031	Washington	Swine	2,400
A-LRWS-S032	Washington	Swine	2,400
A-LRWS-S033	Washington	Swine	2,400
A-LRWS-S034	Washington	Swine	2,400
A-LRWS-S035	Washington	Swine	2,400
A-LRWS-S036	Washington	Swine	2,400
A-LRWS-S038	Washington	Swine	2,490
A-LRWS-S039	Washington	Swine	1,216
A-LRWS-S040	Washington	Swine	2,490
Five Creek near Clay Center (SC711)			
A-LRCY-B004	Clay	Beef	180
A-LRCY-B007	Clay	Beef	160
A-LRCY-B008	Clay	Beef	300
A-LRCY-BA11	Clay	Beef	250
A-LRCY-BA12	Clay	Beef	250
A-LRCY-BA18	Clay	Beef	130

Kansas Permit Number	County	Livestock Type	Livestock Total
Five Creek near Clay Center (SC711; continued)			
A-LRCY-BA19	Clay	Beef	50
A-LRCY-BA22	Clay	Beef	250
A-LRCY-BA24	Clay	Beef	200
A-LRCY-BA30	Clay	Beef	275
A-LRCY-BA43	Clay	Beef	325
A-LRCY-BA44	Clay	Beef	200
A-LRCY-BA45	Clay	Beef	500
A-LRCY-BA56	Clay	Beef	225
A-LRCY-BA64	Clay	Beef	60
A-LRCY-BA67	Clay	Beef	765
A-LRCY-BA73	Clay	Beef	350
A-LRCY-M004	Clay	Dairy	126
A-LRCY-MA02	Clay	Dairy	50
A-LRCY-MA03	Clay	Dairy	30
A-LRCY-S054	Clay	Beef/Swine	1,866
Republican River near Clay Center (SC503)			
A-LRCY-B002	Clay	Beef	300
A-LRCY-B003	Clay	Beef/Horse/Goat/Sheep	117
A-LRCY-B005	Clay	Beef	280
A-LRCY-B006	Clay	Beef	299
A-LRCY-BA08	Clay	Beef/Swine	450
A-LRCY-BA10	Clay	Beef	400
A-LRCY-BA14	Clay	Beef	250
A-LRCY-BA15	Clay	Beef	100
A-LRCY-BA25	Clay	Beef	200
A-LRCY-BA26	Clay	Beef	200
A-LRCY-BA28	Clay	Beef	150
A-LRCY-BA29	Clay	Beef	200
A-LRCY-BA31	Clay	Beef	150
A-LRCY-BA32	Clay	Beef	550
A-LRCY-BA35	Clay	Beef	400
A-LRCY-BA36	Clay	Beef	125
A-LRCY-BA37	Clay	Beef	150
A-LRCY-BA38	Clay	Beef	10
A-LRCY-BA40	Clay	Beef	70
A-LRCY-BA42	Clay	Beef	175
A-LRCY-BA46	Clay	Beef	125

Kansas Permit Number	County	Livestock Type	Livestock Total
Republican River near Clay Center (SC503; continued)			
A-LRCY-BA47	Clay	Beef	130
A-LRCY-BA49	Clay	Beef	50
A-LRCY-BA51	Clay	Beef	80
A-LRCY-BA53	Clay	Beef	600
A-LRCY-BA54	Clay	Beef	500
A-LRCY-BA58	Clay	Beef	250
A-LRCY-BA59	Clay	Beef	250
A-LRCY-BA60	Clay	Beef	700
A-LRCY-BA61	Clay	Beef	120
A-LRCY-BA66	Clay	Beef	448
A-LRCY-BA68	Clay	Beef	100
A-LRCY-BA69	Clay	Beef	50
A-LRCY-BA71	Clay	Beef	250
A-LRCY-EA03	Clay	Exotic	300
A-LRCY-S012	Clay	Swine	1,404
A-LRCY-S017	Clay	Beef/Swine	2,880
A-LRCY-S023	Clay	Swine	2,100
A-LRCY-S037	Clay	Beef/Swine	2,464
A-LRCY-S056	Clay	Swine	2,349
A-LRCY-SA03	Clay	Swine	357
A-LRCY-SA04	Clay	Swine	500
A-LRCY-SA05	Clay	Swine	250
A-LRCY-SA06	Clay	Swine	50

Definitions: * - Application or registration submitted; **Bold** - Federal permit