UPPER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit (AU): Walnut Creek

Water Quality Impairments: Dissolved Oxygen

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower and Upper Walnut Cr

Counties: Barton, Rush, Ness, Lane

HUC8: 11030008	**HUC10 (HUC12)**:	01 (01, 02, 03, 04, 05, 06, 07, 08) 02 (01, 02, 03, 04, 05, 06, 07) 03 (01, 02. 03, 04)
11030007		02 (01, 02, 03, 04, 05, 06, 07)

Ecoregion: Western High Plains, Flat to Rolling Cropland (25d)
Central Great Plains, Rolling Plains and Breaks (27b)

Drainage Area: Approximately 1,130 square miles

Water Quality Limited Segments:

Main Stem	**Tributaries**
Walnut Cr (2)	Boot Cr (15) Dry Cr (14) Sand Cr (3)
Walnut Cr (4)	Otter Cr (12)
Walnut Cr (5)	Sandy Cr (11)
Walnut Cr (6)	Alexander Dry Cr (7)
Walnut Cr (8)	Bazine Dry Cr (9)
Walnut Cr (10)	Darr Cr (12) Walnut Cr, S. Fk (10) Walnut Cr, N. Fk (1)

Designated Uses: For Main Stem Walnut Cr (2, 4) and Otter Cr (12); Expected Aquatic Life Support; Primary Contact Recreation Class C; Domestic Water Supply; Food Procurement; Groundwater Recharge; Industrial Water Supply Use; Irrigation Use; and Livestock Watering.

Main Stem Walnut Cr (8, 10), Sand Cr (3), Alexander Dry Cr (7), S. Fk Walnut Cr (10) and N Fk Walnut Cr (1); Expected Aquatic Life Support; Secondary Contact Recreation Class b; Domestic Water Supply; Food Procurement; Groundwater Recharge; Industrial Water Supply Use; Irrigation Use; and Livestock Watering.

Walnut Cr (5, 6) and Sandy Cr (11); Expected Aquatic Life Support; Secondary Contact Recreation Class b; Domestic Water Supply; Groundwater Recharge; Industrial Water Supply Use; Irrigation Use; and Livestock Watering. Additionally Food Procurement for Walnut Cr segments 5 and 6.

Dry Cr (14); Expected Aquatic Life Support; Secondary Contact Recreation Class b; Food Procurement; Groundwater Recharge; Industrial Water Supply Use; and Irrigation Use.

Boot Cr (15); Expected Aquatic Life Support; Secondary Contact Recreation Class b; Groundwater Recharge; Irrigation Use; and Livestock Watering.

Darr Cr (12); Expected Aquatic Life Support; Secondary Contact Recreation Class b; and Food Procurement.

Bazine Dry Cr (9); Expected Aquatic Life Support; and Secondary Contact Recreation Class b.

303(d) Listings: Kansas stream segments monitored by Station SC596 (Walnut Cr near Alexander) cited as impaired by Dissolved Oxygen deficiency in the 2008 and 2010-303(d) list for the Upper Arkansas River Basin. Kansas Stream segments monitored by Station SC597 (Walnut Cr near Heizer) cited as impaired for Dissolved Oxygen deficiency in the 2010-303(d) list for the Upper Arkansas Basin.

Impaired Use: Expected Aquatic Life Support.

Water Quality Criteria: The concentration of Dissolved Oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. Dissolved Oxygen (DO): 5 mg/L (K.A.R. 28-16-28e(d), Table 1g).

2.0 CURRENT WATER QUALITY CONDITION AND DESIRED ENPOINT

Level of Support for Designated Uses under 2010-303(d): Not supporting Aquatic Life

Stream Monitoring Sites: Active KDHE permanent Stream Chemistry sampling stations SC596 located on Walnut Creek near Alexander and SC597 on Walnut Creek near Heizer as seen in Figure 1.

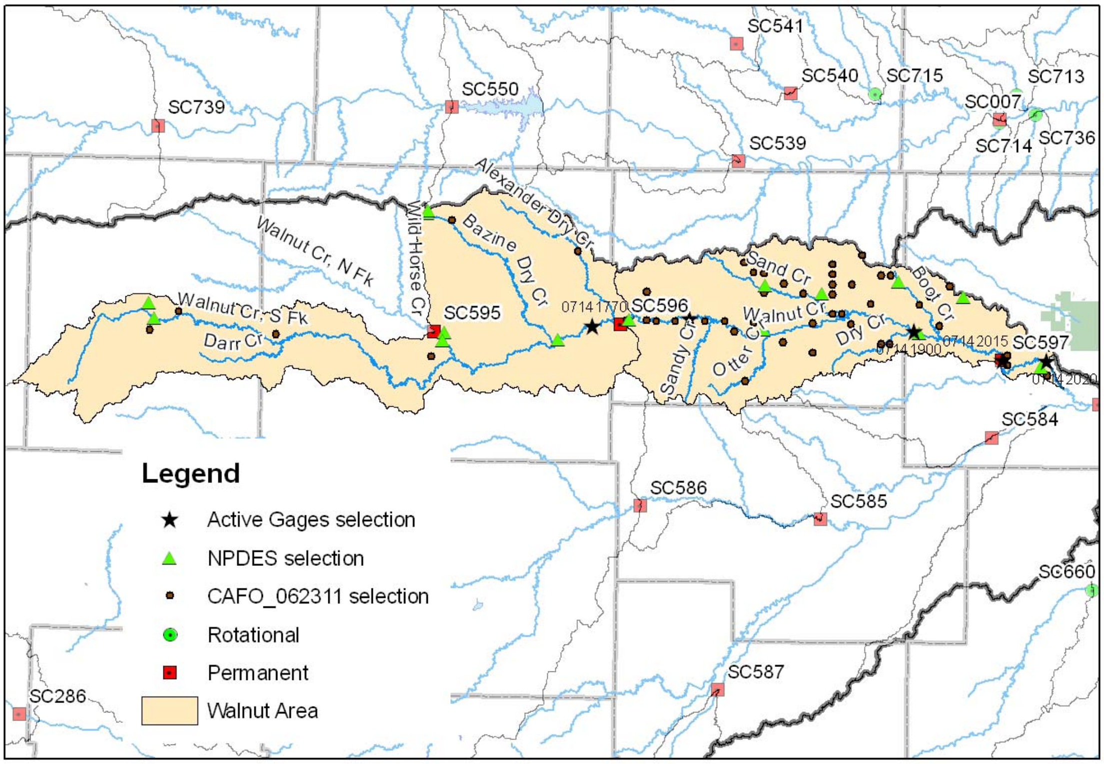
Period of Record: SC596 and SC597: 1990-2011

Flow Record: USGS Gage 07141770 on Walnut Creek near Alexander (1994-2011), USGS Gage 07141780 (1990-2011) on Walnut Creek at Nekoma and USGS Gage 07141900 (1990-2011) on Walnut Creek at Albert were utilized to establish long term flow conditions for SC596 and SC597. Flow conditions at SC596 were derived from USGS Gage 07141770, with adjustments made based on the watershed size of the sampling station relative to the watershed size of gage 07141770. Flow values were established at gage 07141770 from 1990 thru 1994 based on a cubic regression calculation derived from the common flow period of October of 1994 through the end of 2010 between this gage and gage 07141780 (see Appendix A). Flow conditions at SC597 were derived from USGS Gage 07141900, with adjustments made based on the watershed size of the sampling station relative to the watershed size of gage 07141900.

Table 1. Long Term Flow Conditions in the Walnut Creek Watershed.

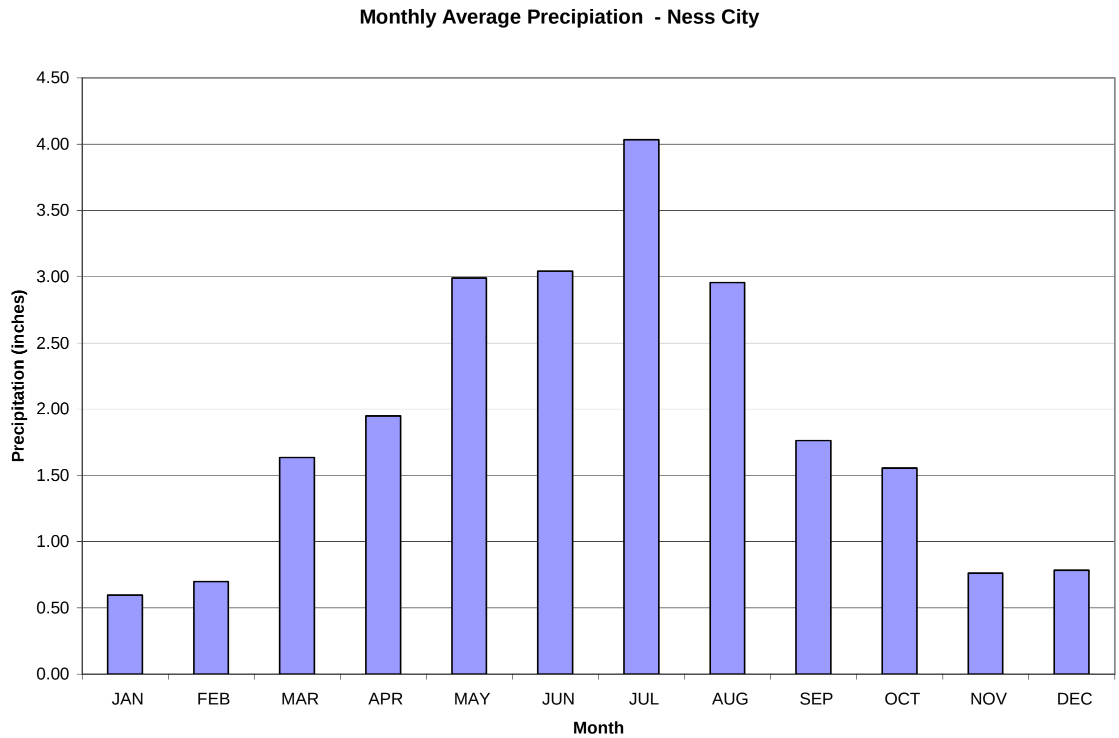
Stream Location	Avg. Q	90%	75%	50%	25%	10%
USGS Gage 07141770, Walnut Cr nr Alexander	17.4	0.22	1.5	5.0	11	22.4
SC596, Walnut Cr near Alexander	18.6	0.23	1.6	5.3	11.8	23.9
USGS Gage 07141900, Walnut Cr at Albert	49.8	0.0	1.2	14.0	32.0	78.0
SC597, Walnut Cr nr Heizer	51.8	0.0	1.25	14.56	33.29	81.1

Figure 1. Walnut Cr Watershed Base Map .



Precipitation: The average annual rainfall in the watershed is approximately 22.7 inches per year (NCDC, 1990-2010). The average monthly precipitation for the watershed is observed in Figure 2.

Figure 2. Average monthly precipitation as reported at Ness City, KS by National Climatic Data Center (1990-2010).
http://www.ncdc.noaa.gov/oa/climate/stationlocator.html



Current Conditions: Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired concentrations over all flow conditions, rather than fixed at a single value. Sampling data from station SC596 and SC597 was categorized into three defined seasons: Spring (April-June), Summer-Fall (July-October) and Winter (November-March). The DO data was also categorized into three flow conditions, based on the flow condition of when the sample was obtained. The three flow conditions consist of; the high flow condition consisting of flows in 0-10% flow exceedance range; normal flow condition consisting of flows in the 11-59% flow exceedance range; and the low flow condition consisting of flows in the 60-100% exceedance range.

Dissolved Oxygen (DO) concentrations on Walnut Creek are observed in Figure 3 and summarized in Table 2. The majority of the impairments associated with the DO deficiency are observed in the Spring and Summer-Fall seasons during high or low flow conditions. More specifically the majority of the impairments occur during July as seen in Figure 4. The monthly average DO concentrations are the lowest at both stations during the months June, July, and August as seen in Figure 5 and Tables 3 and 4.

Table 2. Seasonal Dissolved Oxygen violations relative to flow.

Station	Season	High Flow (0-10% flow exceedance)	Normal Flow (11-59% flow exceedance)	Low Flow (60-100% flow exceedance)	Cum Frequency
SC596 near Alexander	Spring	0/6	1/16	2/10	3/32 = 9%
	Sum-Fall	2/6	3/16	4/14	9/36 = 25%
	Winter	0/0	0/30	1/16	1/46 = 2%
	All Data	2/12 = 17%	4/62 = 6%	7/40 = 18%	13/114 = 11%
SC597 near Heizer	Spring	0/9	1/15	1/3	2/27 = 7%
	Sum-Fall	2/7	1/16	2/9	5/32 = 16%
	Winter	0/0	0/28	2/9	2/37 = 5%
	All Data	2/16 = 13%	2/59 = 3%	5/21 = 24%	9/96 = 9%

Figure 3. Walnut Creek DO Concentrations.

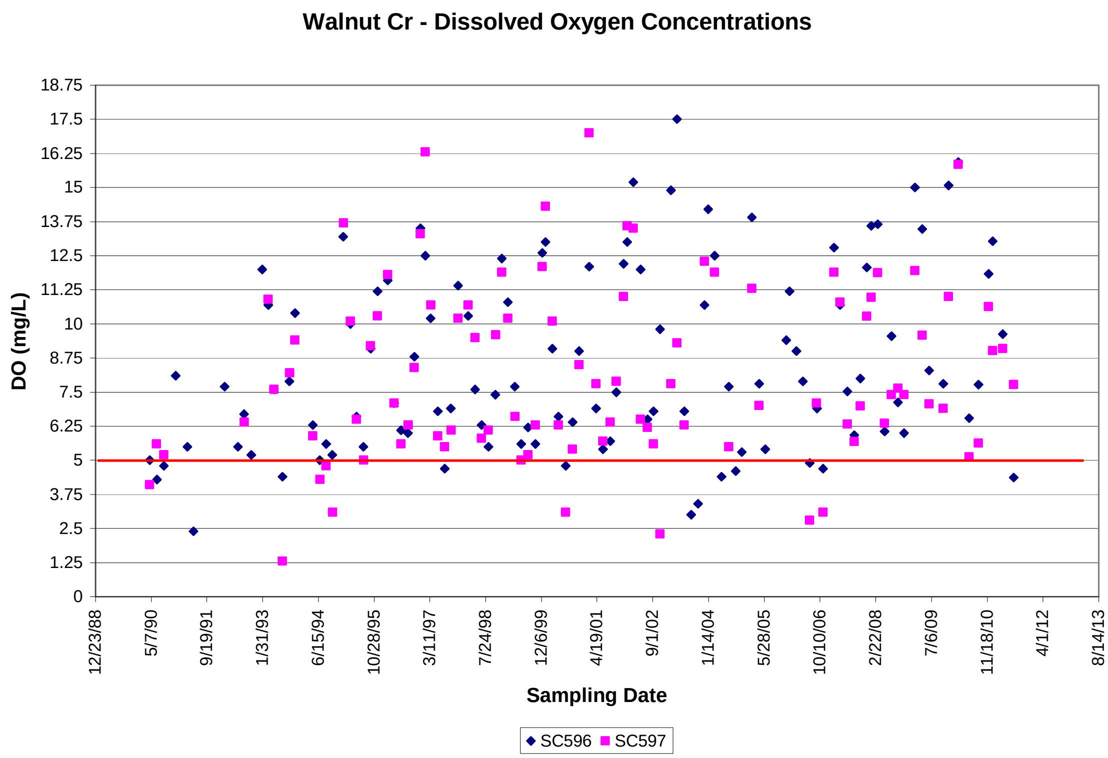


Figure 4. Walnut Creek DO concentrations relative to sampling month.

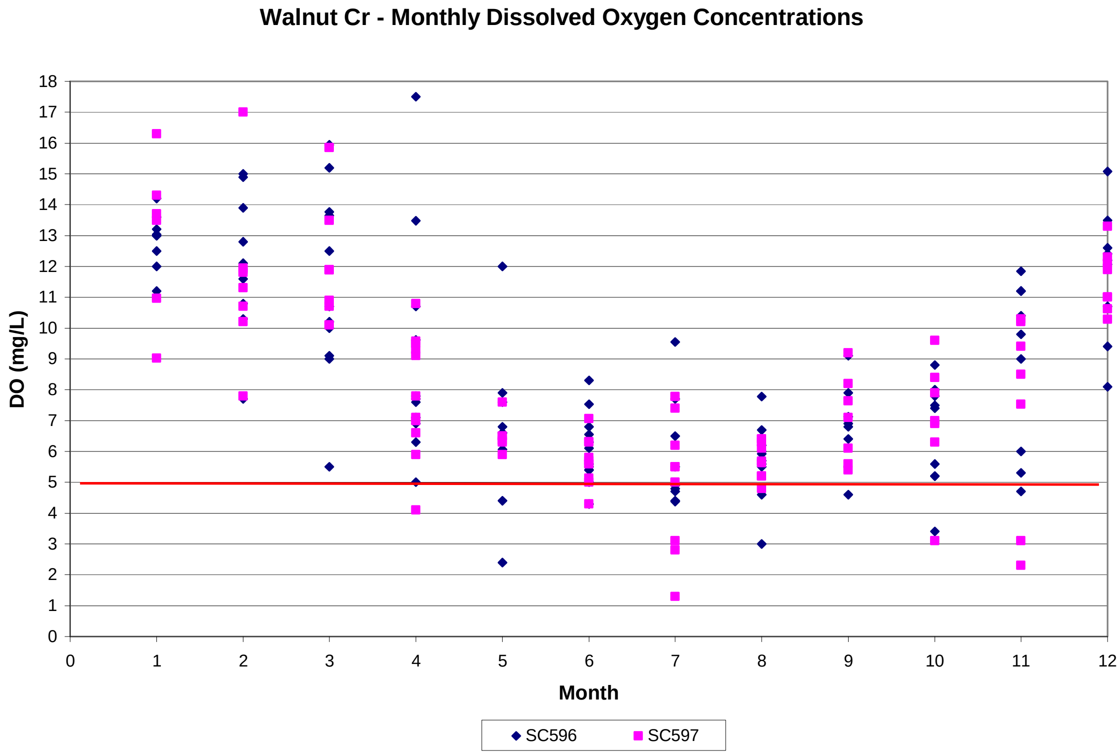


Figure 5. Monthly average DO concentrations.

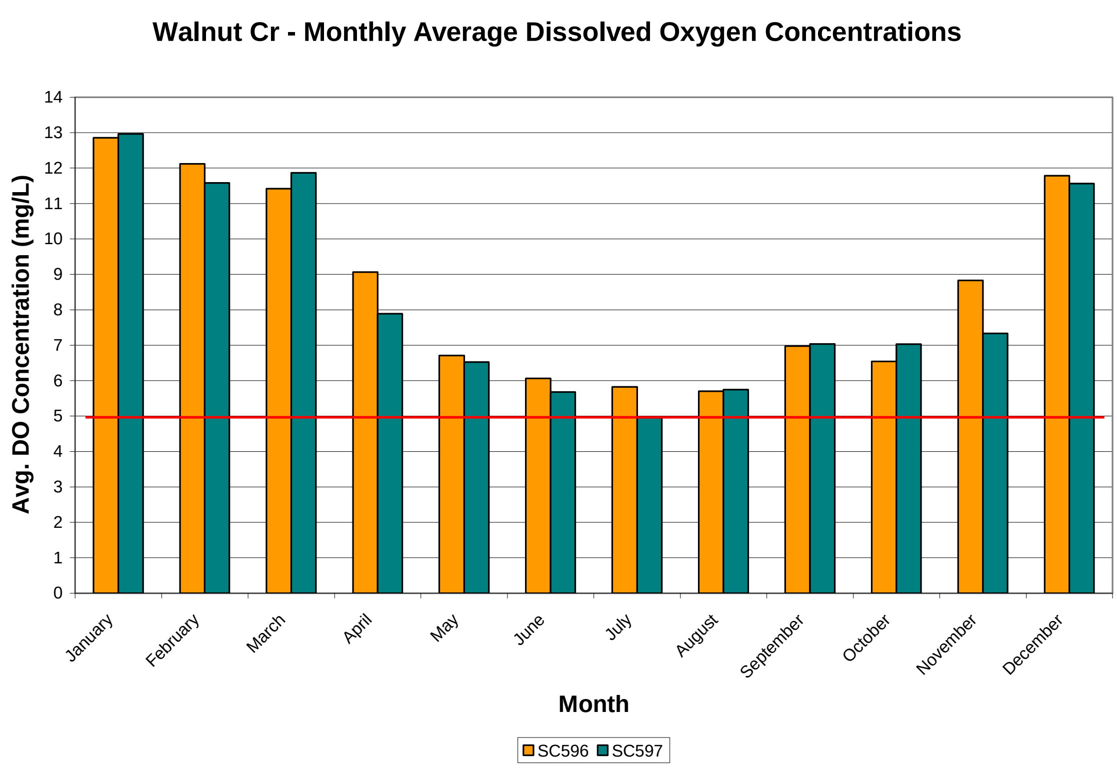


Table 3. Monthly Average DO concentrations and frequency of impairment at SC596.

Month	DO Average	Number of Samples	DO Violations	Frequency of Impairment
January	12.9	9	0	0%
February	12.1	9	0	0%
March	11.4	11	0	0%
April	9.1	11	0	0%
May	6.7	9	2	22%
June	6.1	12	1	8%
July	5.8	9	5	56%
August	5.7	10	2	20%
September	7.0	7	1	11%
October	6.5	9	1	11%
November	8.8	9	1	11%
December	11.8	9	0	0%

Table 4. Monthly Average DO concentrations and frequency of impairment at SC597,

Month	DO Average	Number of Samples	DO Violations	Frequency of Impairment
January	13.0	6	0	0
February	11.6	8	0	0
March	11.9	8	0	0
April	7.9	11	1	9%
May	6.5	6	0	0
June	5.7	10	1	10%
July	5.0	9	3	33%
August	5.7	9	1	11%
September	7.0	7	0	0%
October	7.0	7	1	14%
November	7.3	7	2	29%
December	11.6	8	0	0%

Seasonal annual average DO concentrations are very similar between the two sampling stations and are the lowest in the Summer-Fall season. DO concentrations relative to the percent of flow exceedance are detailed in Figures 6 and 7. Overall annual averages for the Spring season were below 5 mg/L during the sampling years of 1990, 1991, and 2004 at station SC596 and during 1990 at station SC597. DO annual averages during the Summer-Fall season were below 5 mg/L during the years of 1990, 2003 and 2011 at SC596 and during 1993, 1994, 2000 and 2006 at station SC597.

Figure 6. Walnut Creek at SC596, DO concentrations relative to the % of flow exceedance.

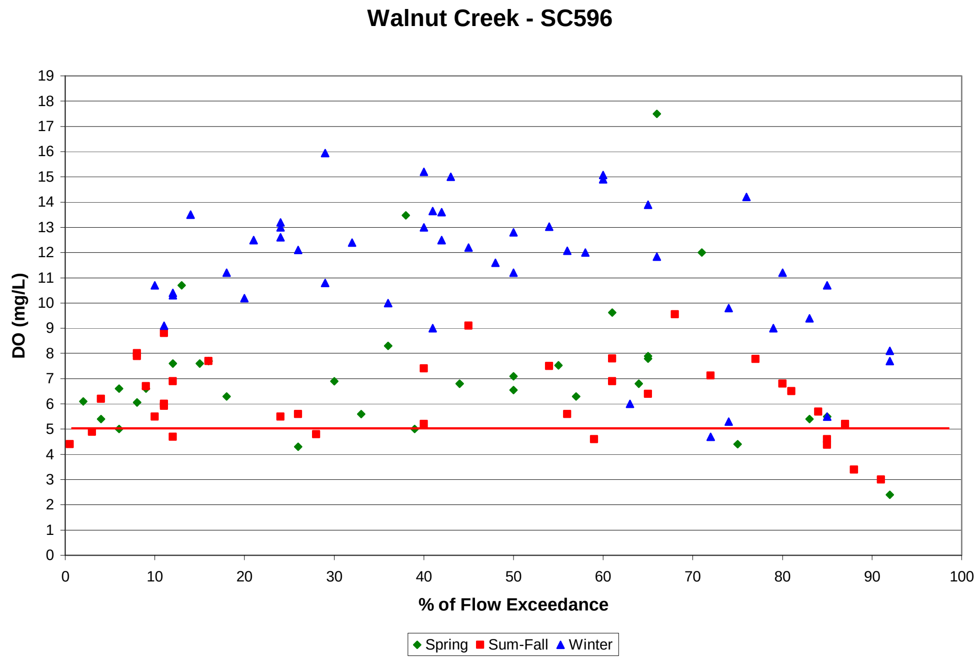
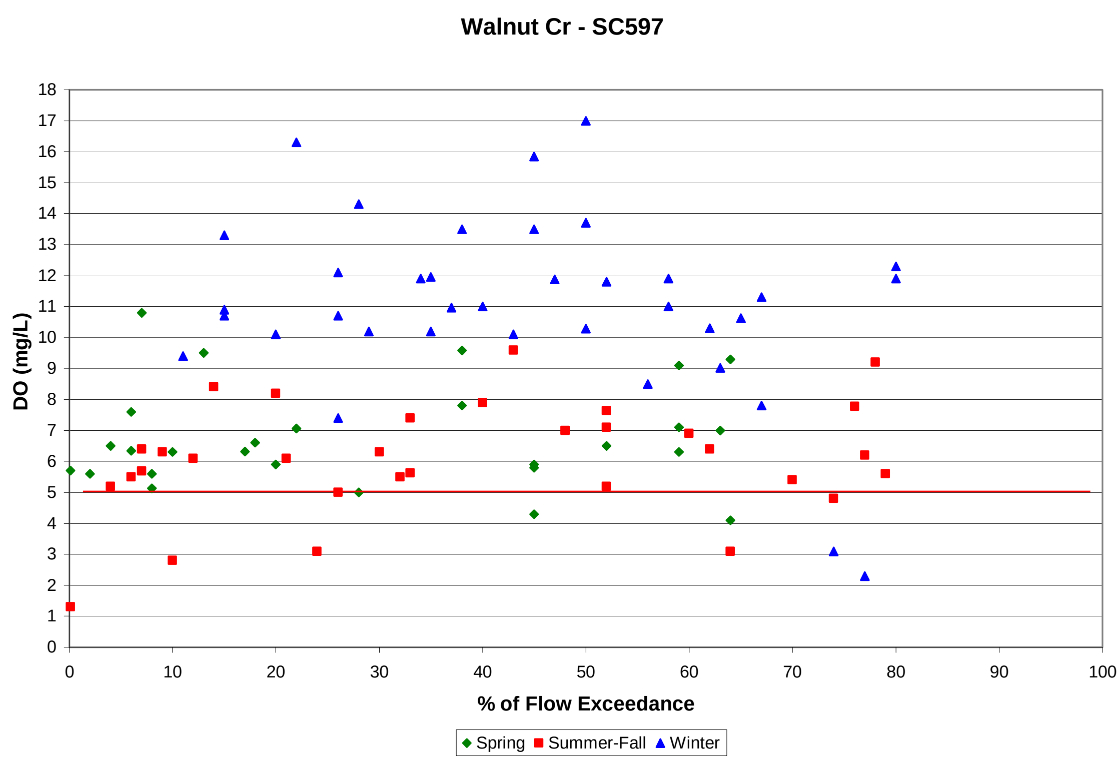
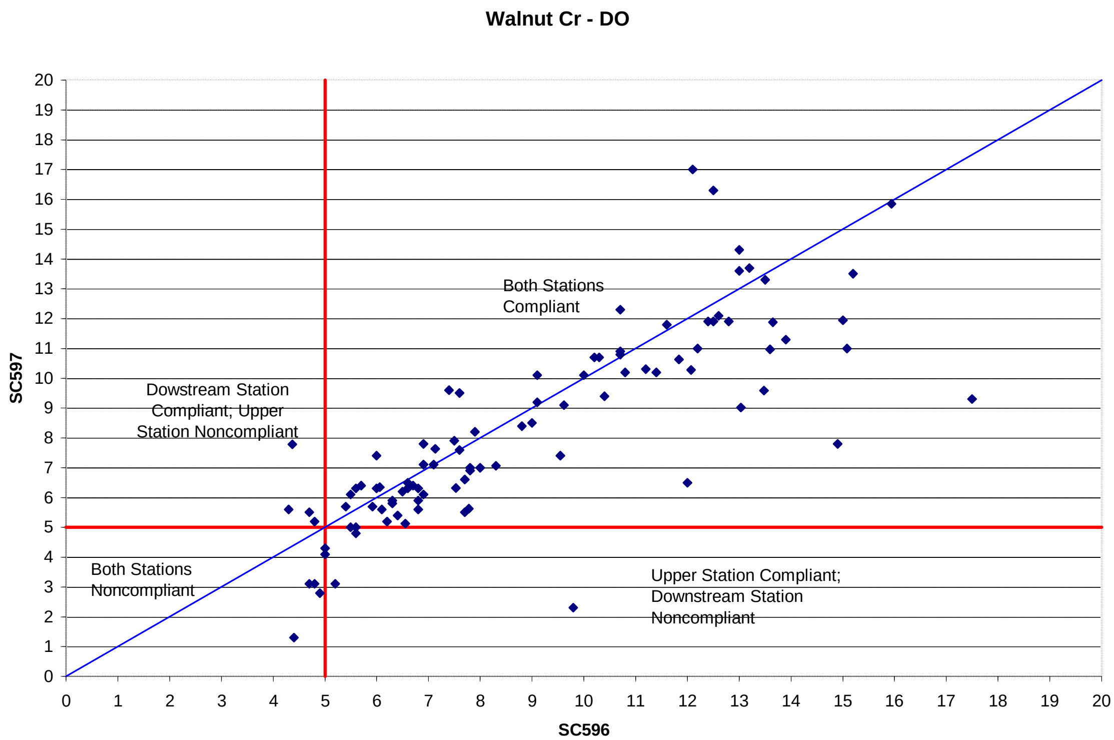


Figure 7. Walnut Creek at SC597, DO concentrations relative to the % of flow exceedance.



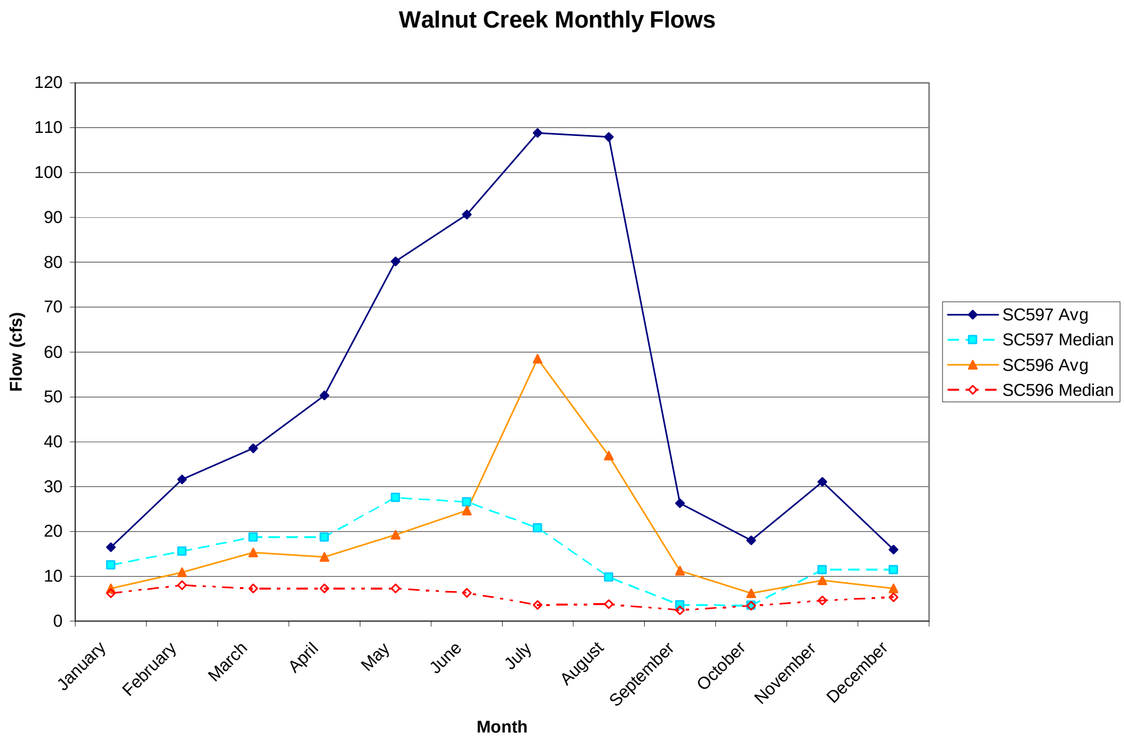
The overall seasonal annual averages at both stations is very similar. Comparative data of the samples collected within one day on one another on Walnut Creek at these stations suggest the DO concentrations are higher at SC596 for 64 of the 96 common samples. Of the 96 common sampling dates where samples were collected within one day of each other at both stations, the DO averages at SC596 and SC597 were 8.9 mg/L and 8.2 mg/L respectively. Figure 8 details the common sampling concentrations on a 1:1 scale. There are five common sampling events when both stations violated the water quality standard. The upstream station, SC596, had six noncompliant samples compared to compliant samples on the same sampling date at the downstream station, SC597. The downstream station, SC597, had four noncompliant samples that compared to compliant samples at the upstream station.

Figure 8. Walnut Creek Common DO samples at SC596 and SC597.



As seen in Figure 9, the average and median monthly streamflow values in Walnut Creek are higher at the downstream station, SC597, for all months throughout the year. Average streamflows are the highest during June, July, and August at both stations. Median flow values at SC596 range from a low of 2.46 cfs during September to a high of 8.02 cfs during February. Monthly median flow values at SC597 range for a low of 3.5 cfs in October to a high median flow value of 27.6 cfs in May.

Figure 9. Walnut Creek Monthly average and median flows.



Flow conditions for each noncompliant sample was analyzed and it is apparent that DO violations are more likely to occur during low flow conditions or during unstable flow conditions when the stream is either aggressively gaining or losing flow within the 5-day period prior to the sampling date (see Appendix B). A summary of the DO violations based on these two flow conditions is summarized in Table 5.

Table 5. Summary of noncompliant DO samples in Walnut Creek.

Station	Sampling Dates for DO Violations Attributed to Unstable Flow Conditions	Sampling Dates for DO Violations Attributed to Low Flow Conditions
SC596	6/27/90 8/29/90 7/27/93 7/22/97 7/11/00 7/10/06	5/21/91 8/11/03 10/13/03 5/10/04 9/13/04 11/6/06 7/12/11
SC597	4/25/90 7/28/93 6/29/94 8/24/94 10/19/94 7/11/00 7/10/06	11/4/02 11/6/06

Stream temperatures also influence DO concentrations in Walnut Creek, where higher temperatures along with the low flow condition are common with DO violations. As seen in Table 6, the DO compliant samples have lower average TSS, BOD, TSS, and Bacteria concentrations than those DO samples that are noncompliant.

Table 6. Average Concentrations for Compliant and Noncompliant DO samples.

SC596 Samples	TOC Avg (mg/L)	BOD Avg (mg/L)	TSS Avg (mg/L)	E.Coli Avg. (cfus/100ml)	FCB (cfus/100ml)
DO< 5 Noncompliant	10.3	5.03	127	745	1183
DO $\geq$ 5 Compliant	7.7	4.02	91	348	542

SC597 Samples	TOC Avg (mg/L)	BOD Avg (mg/L)	TSS Avg (mg/L)	E.Coli Avg. (cfus/100ml)	FCB (cfus/100ml)
DO< 5 Noncompliant	25.25	5.80	140	210	1143
DO $\geq$ 5 Compliant	8.81	4.64	127	342	634

Figure 10. Walnut Creek Dissolved Oxygen concentrations relative to stream temperature.

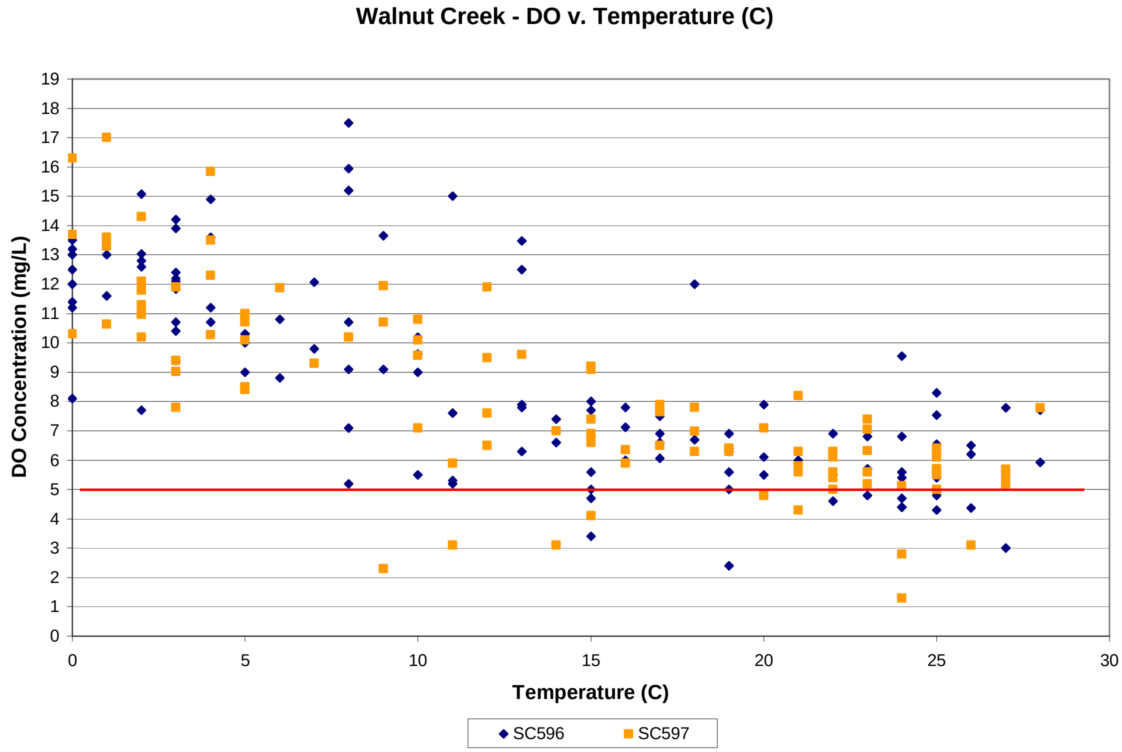


Table 7a. Number of DO violations relative to Stream Temperature.

Station	Temperature Range (Degrees C)				
	0-5 º	6-10º	11-15º	16-20º	> 20º
SC596	0	0	2	1	10
SC597	0	1	3	1	4

The DO violations predominately occur when stream temperatures are greater than 20ºC at SC596 as seen in Tables 7a and 7b. There is more variation in the temperatures of the noncompliant samples at SC597 since some of these violations are more influenced by unstable flow conditions rather than temperature. The relationship between DO concentrations and stream temperature are illustrated in Figure 10. Table 7b, illustrates the relationship between the stream temperature and flow condition for the DO violations in Walnut Creek. All violations in the 0-50% flow exceedance range at both stations occurred when stream temperatures were greater than 20º C.

Table 7b. Number of DO violations relative to stream temperature and % of Flow Exceedance.

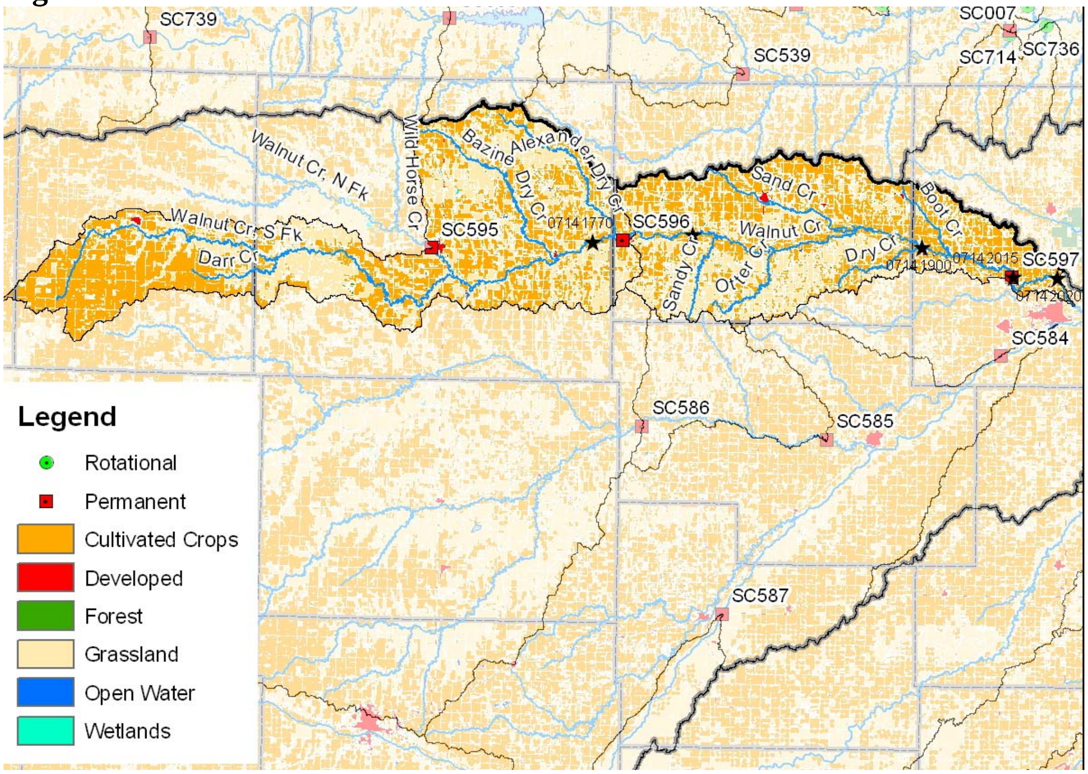
Temperature Range	Percent of Flow Exceedance		
SC596	0-50%	51-75%	76-100%
0-5º C	0	0	0
6-10º C	0	0	0
11-15º C	0	1	1
16-20º C	0	0	1
>20º C	5	2	3
SC597	Flow 0-50%	51-75%	76-100%
0-5º C	0	0	0
6-10º C	0	0	1
11-15º C	0	3	0
16-20º C	0	1	0
>20º C	4	0	0

Desired Endpoint of Water Quality (Implied Load Capacity for Dissolved Oxygen) in Walnut Creek: The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Aquatic Life, indicated by dissolved oxygen concentrations of 5 mg/L or more. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint is sensitive to the low flow and temperature conditions usually occurring in the Summer-Fall season and higher DO levels occur during the winter when flows are typically more stable. Achievement of the endpoint indicates any loads of oxygen demanding substance are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

3.0 SOURCE INVENTORY AND ASSESSMENT

Land Use: The cover in the Walnut Creek watershed includes 60% cropland, 34% grassland, 4% developed, and less than 1% of open water, wetlands, and forest. Landuse for the Walnut Creek watershed is detailed in Figure 11.

Figure 11. Landuse in Walnut Creek Watershed.



Point Sources: There are fifteen NPDES facilities within the Walnut Creek watershed as listed in Table 8. Of these, six of are municipal permitted discharging facilities, two are concrete batch facilities, six are non-overflowing facilities, and one facility discharges to a wastewater treatment plant. The facilities that discharge within the watershed are detailed in Table 9. Based on the available discharging monitoring reports all the facilities are discharging below their design flows and complying with their Biological Oxygen Demand (BOD) discharge limits. The Cities of Dighton has no reported discharges and the Cities of Otis and Ransom do not discharge very often based on their monitoring report submissions. The Cities of Rush Center and Lacrosse are the only two facilities in the watershed that monitor their discharge flow, of which both facilities average well below their design flows and have low BOD concentration averages.

Table 8. NPDES facilities in the Walnut Creek watershed.

Permit #	Federal NPDES #	Facility Name	Permit Expires	Type
M-UA04-OO01	KS0116688	BISON, CITY OF	3/31/2016	2-cell Lagoon
M-UA10-OO01	KS0022527	DIGHTON, CITY OF	9/30/2016	3-cell Lagoon
M-UA31-OO01	KS0091758	OTIS, CITY OF	9/30/2016	3-cell lagoon 120 day detention time
M-UA34-OO01	KS0031453	RANSOM, CITY OF	3/31/2016	3-cell lagoon 120 day detention time
M-UA36-OO01	KS0117102	RUSH CENTER, CITY OF	11/30/2016	Activated Sludge
M-UA23-OO01	KS0024643	LACROSSE, CITY OF	6/30/2016	3-cell Lagoon
I-UA28-PR01	KSG110057	UBC-CONCRETE INDUSTRIES-NESS CITY	9/30/2012	concrete batch plant
I-UA10-PR01	KSG110058	UBC-CONCRETE INDUSTRIES-DIGHTON	9/30/2012	concrete batch plant
M-UA01-NO01	KSJ000288	ALBERT, CITY OF	10/31/2012	Non-Discharging 2-cell Lagoon
M-UA02-NO01	KSJ000289	ALEXANDER, CITY OF	5/31/2017	Non-Discharging 2-cell Lagoon
M-UA03-NO01	KSJ000290	BAZINE, CITY OF	5/31/2017	Non-Discharging 3-cell lagoon
M-UA30-NO01	KSJ000271	OLMITZ, CITY OF	1/31/2017	Non-Dishchargin 3-cell Lagoon
C-UA16-NO01	KSJ000533	ALL SEASONS MOBILE PARK	12/31/2012	Non-Dishcharging 2-cell Lagoon
M-UA28-NO01	KSJ000269	NESS CITY, CITY OF	5/31/2017	Non-Dishcharging 3-cell lagoon
P-UA34-OO01	KS0116688	DEINES CORPORATION	6/30/2015	Discharge to WWTP

Table 9. Disharging Facilities in the Walnut Cr watershed.

Discharging Facility	Design Flow MGD	Receiving Stream	BOD Limit	Avg. BOD mg/L	Avg. Discharge MGD
Bison, City of	0.03	Sand Cr via Unnamed Trib	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	29.1	Not Monitored
Dighton, City of	0.2	S. Fk Walnut Cr	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	No discharges on file	None
Otis, City of	0.044	Boot Cr	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	25.3, rarely discharges	Not Monitored, Rarely Discharges
Ransom, City of	0.038	Bazine Dry Cr	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	28.3, rarely discharges	Not Monitored, Rarely Discharges
Rush Center, City of	0.035	Walnut Cr	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	8.8	0.014
Lacrosse, City of	0.14	Sand Cr	Weekly Avg 45 mg/L; Monthly Avg. 30 mg/L	5.9	0.10

Livestock Waste Management Systems: There are 48 active certified or permitted confined animal feeding operations (CAFOs) within the Walnut Creek watershed (see Appendix C). These facilities are designed to retain a 25-year, 24-hour rainfall/runoff event as well as an anticipated two weeks of normal wastewater from their operations. Typically, this rainfall event coincides with streamflow that occurs less than 1-5% of the time. Though the total potential number of animals is approximately 71,653 head in the watershed, the actual number of animals at the feedlot operations is typically less than the allowable permitted number. It is not anticipated that livestock operations contribute to the impairment in the watershed.

According to the Kansas Agricultural Statistics the estimated number of all cattle and cows for counties that are included within this watershed as of January 1, 2010 are: 118,000 for Barton, 22,000 for Rush, 38, 000 for Ness, and 67,000 for Lane County.

Contributing Runoff: The watershed of Walnut Creek has a mean soil permeability value of 1.03 inches/hour according to the NRCS STATSGO database. According to a USGS open-file report (Juracek, 2000), the threshold soil-permeability values that represents very high, high, moderate, low, very low, and extremely low rainfall intensity, were set at 3.43, 2.86, 2.29, 1.71, 1.14, and 0.57"/hour, respectively. The lower rainfall intensities generally occur more frequently than the higher rainfall intensities. The higher soil-permeability thresholds imply a more intense storm during which areas with higher soil permeability potentially may contribute runoff. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than the soil permeability. As soil profiles become saturated, excess overland flow is produced. For the Walnut Creek watershed, approximately 47% of the watershed will produce runoff with rainfall events that produce 1.14 inches/hour of rain. Over 99% of the entire watershed has a low soil permeability value that will produce runoff with rainfall events that produce 1.29 inches/hour of rain. Runoff contributes to the dissolved oxygen deficiencies within the watershed that are observed above the low flow condition.

Nonpoint Sources: The DO violations that occurred in the watershed above the low flow condition are related to runoff events with unstable flow conditions that deliver high nutrients and organic material that influences the demand on available oxygen.

Background: The natural hydrologic characteristics of the watershed influence DO concentrations during periods of low flow in the watershed. Prolonged periods of lower flow and warmer stream temperatures account for the primary cause of the impairments during the low flow condition. Leaf litter and wastes derived from natural wildlife may add to the nutrient load.

Population: The populations within the watershed is approximately 8,000 people according to the 2000 U.S. Census Block information, which details the populations within the 1,679 census reporting blocks within the watershed. Of the 8,000 people within the watershed, 5,743 of these folks residing in the cities within the watershed as detailed in Table 10. Populations within the watershed indicate populations have slight declines for most cities between the 2000 and 2010 census.

Table 10. Populated Cities within the Walnut Cr Watershed.

City	2000 U.S. Census Population	2010 U.S. Census
La Crosse	1376	1342
Ness City	1534	1449
Dighton	1261	1038
Brownell	48	29
Alexander	75	65
Albert	181	175
Bazine	311	334
Bison	235	255
Olmitz	138	114
Otis	325	282
Rush Center	176	170
Timken	83	76

Relationship with Other Parameters: Based on the assessment it is apparent that DO violations are driven by two main factors. The first factor is driven by low flow conditions and higher stream temperatures. The second scenario that involves DO violations occurs during various unstable flow conditions. These violations are driven by brief runoff periods when the watershed is flushing high levels of organic material during unstable flow conditions.

A comparison of the compliant and non-compliant DO data sets is illustrated in Figures 12, 13, 14, 15, and 16. Based on these comparisons, there are some distinct observations between the two datasets. Temperatures are higher for samples that violated the DO standard at both sampling stations. Total Phosphorus Concentrations are higher at both stations for the non-compliant DO samples. Total Organic Carbon (TOC) and Biological Oxygen Demand (BOD) concentrations are higher for the non-compliant DO samples at both stations. The bacteria counts for the compliant DO samples are lower than the non-compliant samples for each respective station, which is also indicative of organic loading.

Figure 12. Temperature comparisons between compliant and noncompliant DO samples at SC596 and SC597.

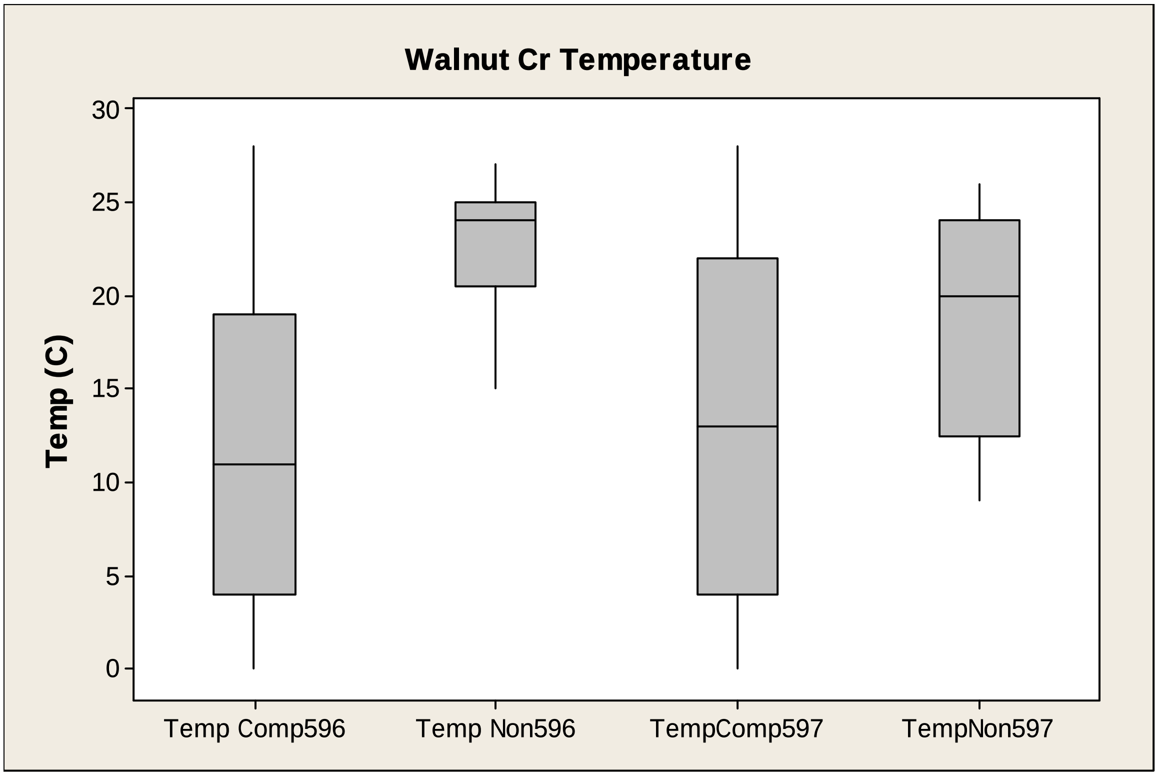


Figure 13. Total Phosphorus concentration comparisons between compliant and noncompliant DO samples at SC596 and SC597.

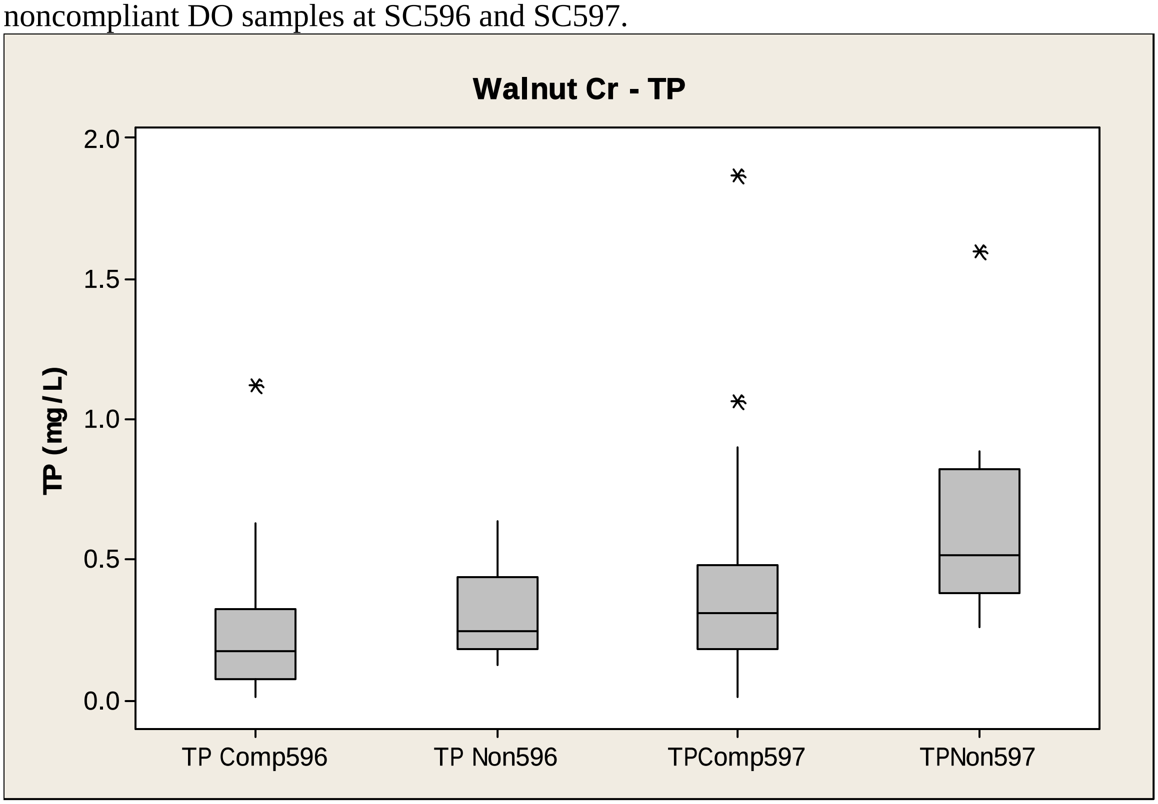


Figure 14. TOC concentration comparisons between compliant and noncompliant DO samples at SC596 and SC597.

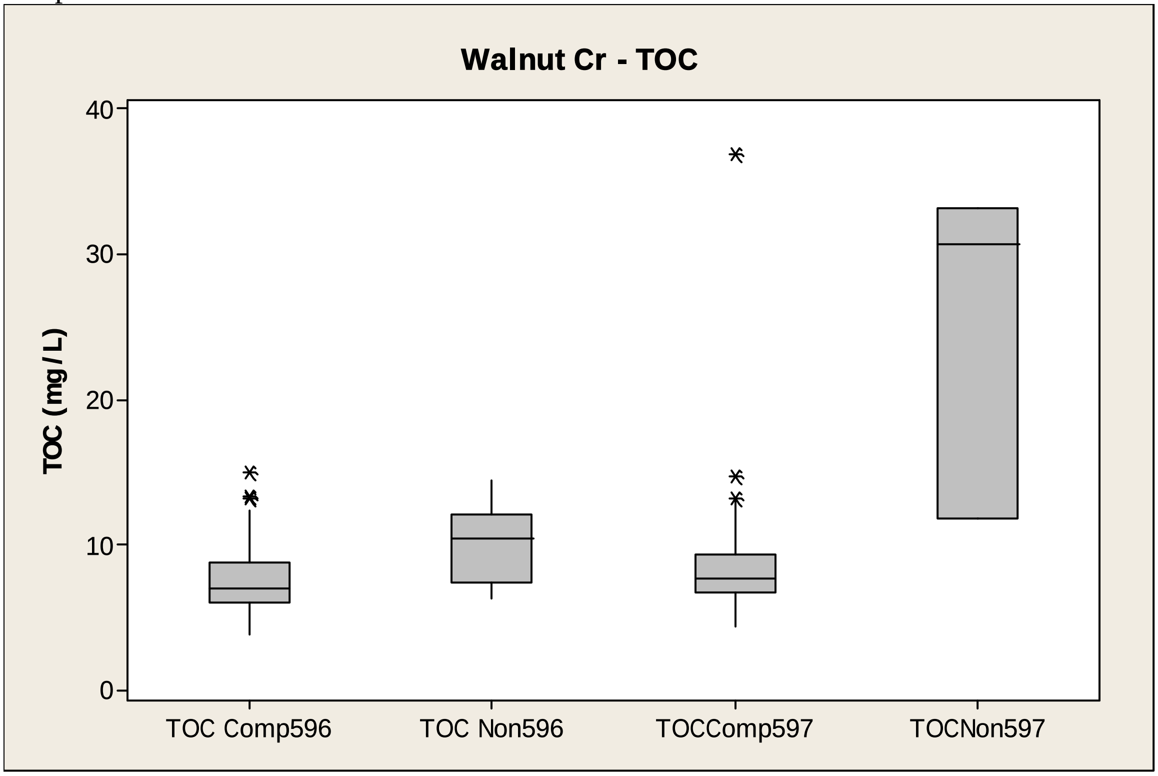


Figure 15. BOD concentrations comparisons between compliant and noncompliant DO samples at SC596 and SC597.

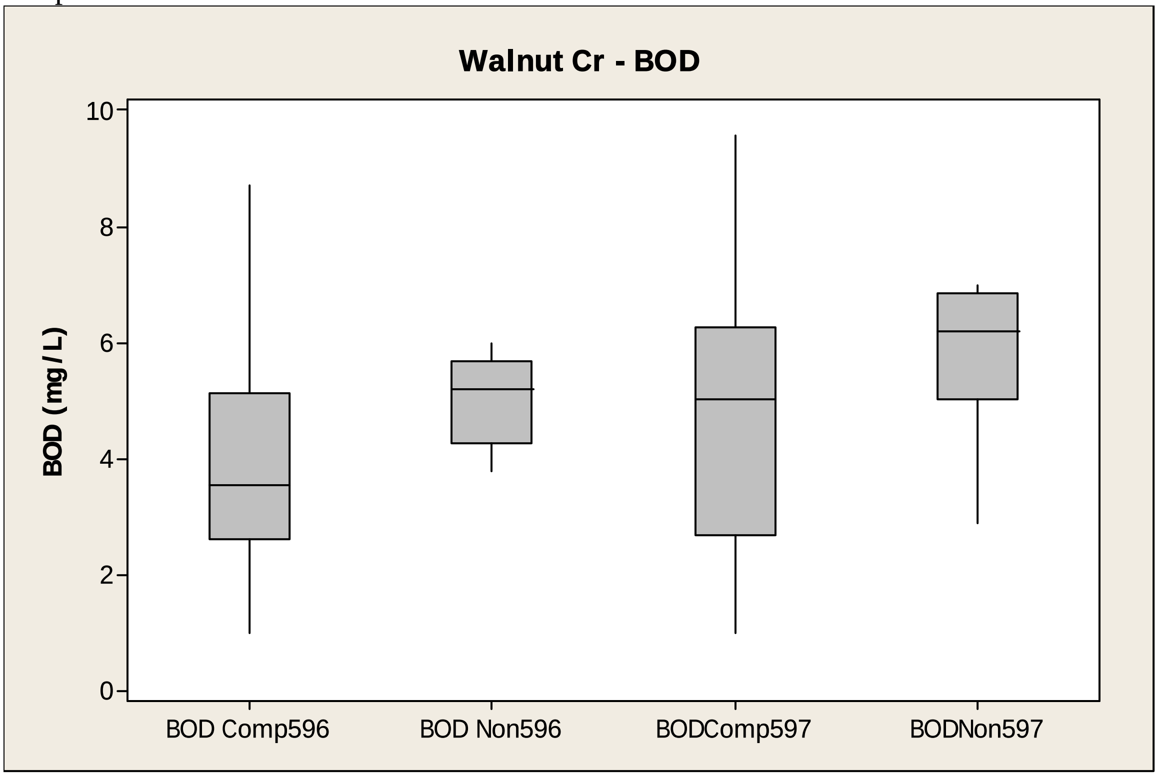
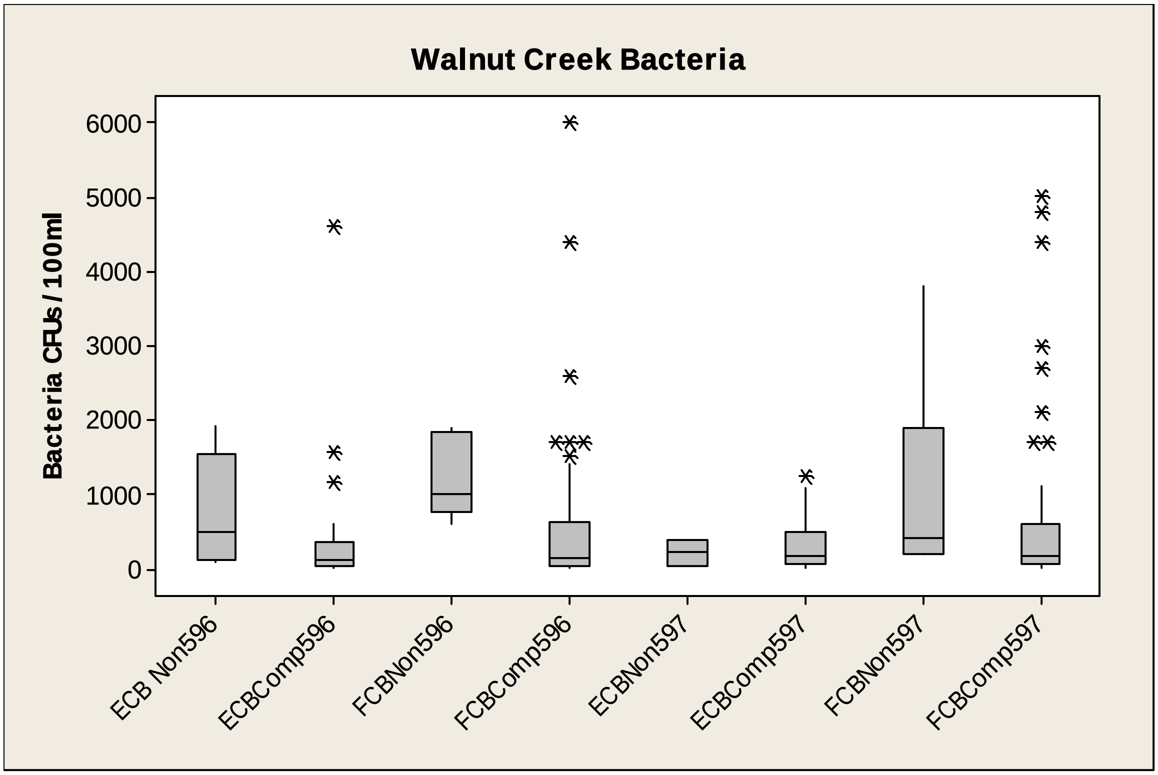


Figure 16. Bacteria concentrations comparisons between compliant and noncompliant DO samples at SC596 and SC597**.**



4.0 ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The TMDL is a concentration based TMDL, where all stream segments within the watershed must maintain a Dissolved Oxygen Concentration of 5 mg/L or more at all times that the stream has sustained flow. There is some degree of uncertainty on establishing allocations under this TMDL. Total Organic Carbon (TOC) will be allocated under this TMDL as the pollutant to meet the DO TMDL, though ultimately success of this TMDL will be measured through in stream DO compliance.

KDHE discontinued sampling for Biological Oxygen Demand (BOD) in 2001 and began utilizing Total Organic Carbon (TOC) analyses in late 2000 in lieu of BOD. KDHE conducted analyses in 2000 to determine if TOC concentrations could be utilized as a surrogate for BOD and whether a statistical translation could be made for this expression. KDHE utilized 675-paired sets of data in the analyses and concluded that there are relationships in the stream data. "The data suggest that, for effluent and point source related waters, the BOD/TOC ratio is almost one-to-one. Ambient waters have much lower ratios, suggesting that a portion of the TOC is in more refractory substances (i.e., cell walls, lignin, cellulose, etc.)" (Carney, 2000). The analysis of the paired ambient stream data was utilized for this report. The regression analyses for this group is summarized as follows:

R square = 0.34
P Value = <0.0001
For a TOC value of 10mg/L the most likely BOD concentration = 4.31 mg/L
Lower 95% BOD = 3.34 mg/L
Upper 95% BOD = 5.29 mg/L

BOD/TOC Ratio:
Arithmetic Mean = 0.44
Geometric Mean = 0.35
Median = 0.37

Generally higher BOD and TOC concentrations indicate that more oxygen will be consumed by an ecosystem, which may result in an oxygen deficient stream as the population increases among microorganism communities.

TOC will be allocated based on the data set of compliant ambient samples at SC596, with a mean TOC concentration of 7.7 mg/L of TOC being allocated under all flow conditions. The compliant samples at SC596 had an average Biological Oxygen Demand (BOD) concentrations of 4.0 mg/l. There are five compliant samples that have both TOC and BOD analysis, and have an average BOD and TOC ratio of 0.42. Based on the BOD and TOC ratio of 0.42, the resulting ambient BOD concentration is 3.23 mg/L for the compliant data set. Since the translating BOD concentration based on the BOD:TOC ratio is lower that the average BOD concentrations for the compliant samples, the lower BOD concentration will be utilized for establishing the load allocations as a conservative measure. Stream BOD will be allocated for the wasteload allocation based on respective NPDES permit BOD limits at the present time. The ambient BOD can be converted by the site specific ratio of 0.42 to ambient TOC.

Point Sources: Since the DO violations are generally associated with unstable flow conditions associated with brief runoff events and low flow events it is conceivable that point sources are not contributing to the DO impairment. Wasteload Allocations (WLA) will be assigned to all discharging facilities based on 30 mg/L monthly averages. The WLA at SC596 (Walnut Creek Segment 6) is 59.5 lbs/day of BOD and the WLA at SC597 (Walnut Creek Segment 2) is 62.3 lbs/day. The established WLA is based on the design flow for these facilities. Based on the discharge monitoring reports most of the facilities do not continuously discharge or have an average flow value well below the design flow. Therefore it is anticipated that these facilities will be well under the assigned WLA throughout the year. The established WLA in the watershed is detailed in Table 11. The equivalent TOC WLA for SC596 and SC597 is 140.9 lbs/day and 147.4 lbs/day respectively as seen in Table 12. Wasteloads at SC596 are not accounted for at SC597 since the BOD and TOC associated with point sources will be consumed well before reaching station SC597. All non-discharging facilities and CAFOs within the watershed have been assigned a WLA of zero lbs/day.

Table 11. WLA for Discharging Municipal NPDES Facilities in the Walnut Creek Watershed.

Facility	WLA – BOD (lbs/day)	WLA – TOC (lbs/day)	Contributing Station / Segment
Rush Center, City of	8.77	20.8	SC597 – Walnut Cr Seg 2
Dighton, City of	50.1	118.6	SC596 – Walnut Cr Seg 6
Bison, City of	7.52	17.8	SC597 Walnut Cr Seg 2
La Crosse	35.1	83.0	SC597 Walnut Cr Seg 2
Otis, City of	10.92	25.8	SC597 Walnut Cr Seg 2
Ransom, City of	9.4	22.3	SC596 Walnut Cr Seg 6

Nonpoint Sources: The TMDL and allocations are expressed incrementally within the watershed, to differentiate the loads associated with those entering the watershed from upstream and those loads associated with the streams within the watershed. The TMDL and allocations assigned to the Walnut Creek watershed are illustrated in Table 12. The Load Allocations under average flow conditions are 349.7 lbs/day of TOC at station SC596 and 1233.1 lbs/day of TOC at SC597. Incremental TOC loading within the watershed is detailed in Table 13, which details the TOC loads associated with waters entering the watershed covered under this TMDL and the total load capacity at SC597. The TMDL at SC596 and SC597, detailing incremental loads is illustrated in Figure 17.

Defined Margin of Safety: The margin of safety provides some hedge against the uncertainty of daily loading that contributes to the impairment of dissolved oxygen deficiencies. This TMDL uses an implicit margin of safety, relying on conservative assumptions since the wasteload allocations are assumed to be reaching the stream based on the facilities design flows, when the discharge from these facilities is actually much less. Additionally, the allocations are conservatively set for all flow conditions when the vast majority of the impairment occurs during unstable flow conditions or during the low flow condition with higher stream temperatures.

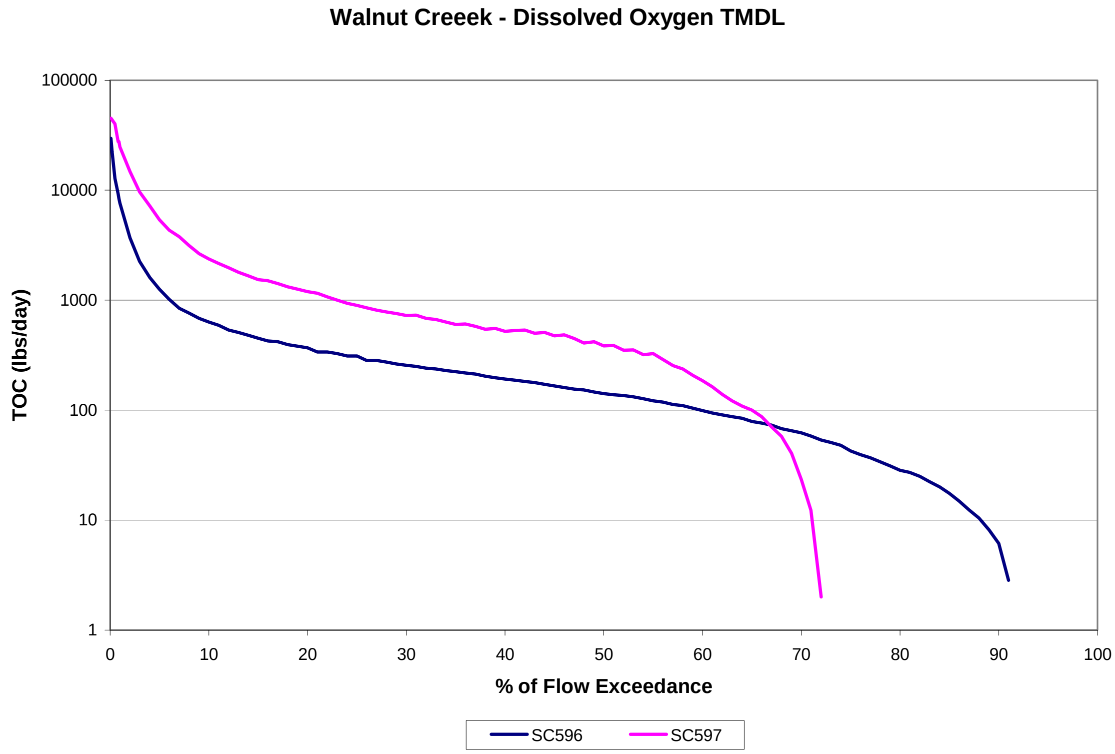
Table 12. Walnut Creek Incremental DO TMDL, TOC allocations.

Station SC596 % Flow Exceedance	Flow (cfs)	SC596 WLA (lbs/day)	SC596 LA (lbs/day)	SC596 / Walnut Cr Segment 6 TMDL (lbs/day)
Average Flow	18.6	140.9	349.7	490.6
50%	5.3	140.9	0.3	141.2
25%	11.8	140.9	169.7	310.6
10%	23.9	140.9	491.1	632.0
5%	47.7	140.9	1118.8	1259.7
Station SC597 Flow Condition	Flow (cfs)	SC597 WLA (lbs/day)	SC597 LA (lbs/day)	SC597 / Walnut Cr Segment 2 TMDL (lbs/day)
Average Flow	51.8	147.4	1233.1	1380.5
50%	14.56	147.4	235.7	383.1
25%	33.29	147.4	747.4	894.8
10%	81.1	147.4	2230.7	2378.1
5%	177.77	147.4	5260.0	5407.4

Table 13. Incremental TOC Load Capacity in the Walnut Creek Watershed

Location	50% Flow Exceedance	25% Flow Exceedance	10% Flow Exceedance	5% Flow Exceedance
Upstream Load at SC595 (lbs/day)	81.2	178.6	363.5	724.5
Incremental Load Capacity at SC596 / Walnut Cr Segment 6 (lbs/day)	141.2	310.6	632.0	1259.7
Incremental Load Capacity at SC597 / Walnut Cr Segment 2 (lbs/day)	383.1	894.8	2378.1	5407.4
Total Load Capacity at SC597 /Walnut Cr Segment 2 (lbs/day)	605.5	1384.0	3373.6	7391.6

Figure 17. Walnut Creek Dissolved Oxygen TMDL.



State Water Plan Implementation Priority: Because of the uncertainty of the pollutant sources causing the dissolved oxygen deficiencies in the arid Walnut Creek watershed, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: A portion of this watershed lies within the Upper Walnut Creek Subbasin (11030007) with a priority ranking of 46 (Medium Priority for restoration work) and a portion lies in the Lower Walnut Creek Subbasin (11030008) which is classified as catgory II, a watershed meetin gth egoals needed to sustain water quality.

Priority HUC 12s and Stream Segments: Because of the lack of certainty regarding potential sources and naturally occurring background concentration in the watershed, no priority subwatershed or stream segment will be identified.

5.0 IMPLEMENTATION

Desired Implementation Activities

1. Install grass buffer strips where needed along streams.
2. Maintain adequate streamflow by ensuring streamflow is not artificially reduced or impeded, particularly during low flow durations.

3. Ensure that labeled application rates of chemical fertilizers are being followed and implement runoff control measures.
4. Implement nutrient management plans to manage manure land applications and runoff potential.
5. Ensure appropriate treatment of wastewater through compliance of NPDES limits.

Implementation Programs Guidance

Nonpoint Source Pollution Technical Assistance-KDHE

a. Support Section 319 demonstration projects for reduction from streambank erosion, sediment runoff, and livestock operations.
b. Provide technical assistance on practices geared to the establishment of vegetative buffer strips.

NPDES and State Permits – KDHE

a. Livestock permitted facilities will be inspected for integrity of applied pollution prevention technologies.
b. Registered livestock facilities with less than 300 animal units will apply pollution prevention technologies.
c. Manure management plans will be implemented.
d. Municipal wastewater BOD concentration is below permit limits.

Riparian Protection Program – SCC

a. Establish or re-establish natural riparian systems, including vegetative filter strips along small tributaries.

Buffer Initiative Program – SCC

a. Install buffer strips near streams.
b. Work in conjunction with Federal Conservation Reserve Enhancement Program and Conservation Security Program to hold marginal riparian land out of production.

Timeframe for Implementation: Continued monitoring over the years from 2012 to 2021, particularly when Dodge City begins discharging to the watershed.

Milestone for 2016: In accordance with the TMDL development schedule for the State of Kansas, the year 2016 marks the next cycle of 303(d) activities in the Upper Arkansas Basin to review data from the Walnut Creek watershed to assess continued incidence of dissolved oxygen deficiencies.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment.

Reasonable Assurances:
Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution.

1. 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.

2. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage 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 Watershed Restoration and Protection Strategies.

9. The *Kansas Water Plan* and the Upper Arkansas Basin Plan provide 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 Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant 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 watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund programs supporting water quality protection through the WRAPS program. This watershed and its TMDL are a Low Priority consideration.

Effectiveness: Buffer strips are publicized as a means to filter sediment before it reaches a stream and riparian restoration project have been acclaimed as a significant means of stream bank stabilization. The key to effectiveness is participation within a targeted area to direct resources to the activities influencing water quality. Secondary wastewater treatment is very effective at reducing BOD in effluent.

6.0 MONTITORING

KDHE will continue to collect samples through 2021 at the permanent stations SC596 and SC597 on the Walnut Creek on a quarterly basis every year. Point Source facilities will continue to monitor BOD in their wastewater.

7.0 FEEDBACK

Public Notice: An active internet website was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Kansas Lower Republican Basin.

Public Hearing: A Public Hearing was held on September 20, 2012 in Garden City to receive comments on this TMDL.

Basin Advisory Committee: The Upper Arkansas River Basin Advisory Committee met to discuss these TMDLs on April 4, 2012 in Jetmore and September 20, 2012 in Garden City.

Milestone Evaluation: In 2016, evaluation will be made as to the degree of impairment continuing to occur within the watershed. Subsequent decisions will be made regarding the implementation approach, priority of allotting resources for implementation and the need for additional or follow up implementation in this watershed at the next TMDL cycle for this basin in 2016 with consultation from local stakeholders and the BAC.

Consideration for 303(d) Delisting: Walnut Creek River will be evaluated for delisting under section 303(d), based on the monitoring data over 2012-2021. Therefore, the decision for delisting will come about in the preparation of the 2022-303(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 might be adjusted accordingly.

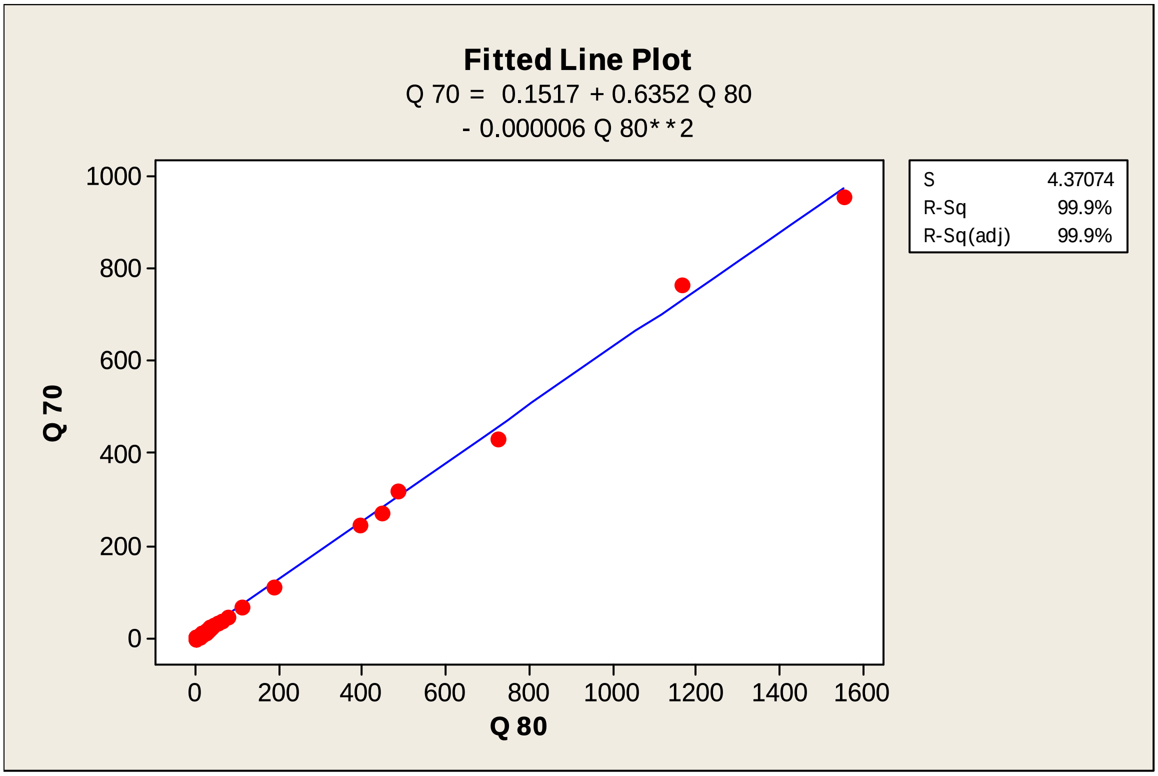
Incorporation into Continuing Planning Process, Water Quality, Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision would come in 2012, which will emphasize implementation of WRAPS activities. At that time, incorporation of this TMDL will be made into the WRAPS. Recommendation of this TMDL will be considered in the Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2012-2021.

Rev 12/19/2012

Carney, E.C., May 4, 2000. Kansas Department of Health and Environment Memorandum regarding: Comparison of historic BOD and TOC data in Kansas.

Perry, C.A., D.M. Wolock and J.C. Artman, 2004. Estimates of Low Duration, Mean Flow, andPeak-Discharge Frequency Values for Kansas Stream Locations, USGS Scientific Investigations Report 2004-5033.

Appendix A. Regression calculating flow at USGS Gage 07141770 based on flow from USGS Gage 07141780, utilized to estimate flow for the sampling dates from 1990 through 1994.



Appendix B. Flow Conditions preceding DO violation in Walnut Creek.

SC596 Sampling Date	Flow (CFS) on Date of Sample	Flow (CFS) for 5 Days Prior to Sampling Date					Flow Condition
		1 Day Prior	2 Days Prior	3 Days Prior	4 Days Prior	5 Days Prior	
6/27/90	11.03	19.9	36.9	70.1	134.7	138.1	Declining, Unstable
8/29/90	4.04	3.42	3.63	4.58	6	9.68	Decline then Rise, Unstable
5/21/91	0.00	0	0	0	0.28	0.43	Low Flow
7/27/93	609.11	740	963	1830	3488	3845	Declining, Unstable
7/22/97	21.39	31	3.6	1.6	0.64	0.55	Rise then Decline, Unstable
7/11/00	10.38	11.8	13.9	20.3	36.4	138	Declining, Unstable
8/11/03	0.17	0.21	0.31	0.24	0.31	0.33	Low Flow
10/13/03	0.44	0.39	0.27	0.34	0.22	0.19	Low Flow
5/10/04	1.60	1.6	1.28	0.86	1.93	2.35	Low Flow
9/13/04	0.67	0.64	0.57	0.55	0.53	0.52	Low Flow
7/10/06	98.41	98	48	0.07	0	0	Rising, Unstable
11/6/06	2.03	2.25	2.25	2.35	2.46	2.67	Low Flow
7/12/11	0.73	0.79	0.82	0.69	0.73	0.71	Low Flow

SC597 Sampling Date	Flow (CFS) on Date of Sample	Flow (CFS) for 5 Days Prior to Sampling Date					Flow Condition
		1 Day Prior	2 Days Prior	3 Days Prior	4 Days Prior	5 Days Prior	
4/25/90	5.83	0	0	0	0	0	Rising, Unstable
7/28/93	2590.07	2954	3078	3099	2871	2184	Rise then Decline, Unstable
6/29/94	17.68	21.8	24.9	26	18.7	16.6	Rise then Decline, Unstable
8/24/94	1.56	2.49	4.57	8.74	13.5	0.66	Unstable
10/19/94	5.83	6.14	5.2	4.16	3.43	2.81	Rise then Decline, Unstable
7/11/00	35.37	43.7	60	110	307	31	Rise then Decline, Unstable
11/4/02	0.50	0.47	0.61	0.7	0.79	0.73	Low Flow
7/10/06	87.38	0.17	0.37	0.94	1.77	2.81	Rising, Unstable
11/6/06	1.66	1.66	1.77	1.66	1.66	1.77	Low Flow

Appendix C. Permitted and Registered CAFOs.

Permit	County	Animal Totals	Type	WLA
A-UANS-BA02	Ness	600	Beef	0
A-UANS-BA03	Ness	200	Beef	0
A-UABT-BA04	Barton	250	Beef	0
A-UARH-BA09	Rush	150	Beef	0
A-UARH-BA21	Rush	150	Beef	0
A-UARH-BA22	Rush	200	Beef	0
A-UARH-BA14	Rush	220	Beef	0
A-UARH-BA12	Rush	500	Beef	0
A-UARH-BA18	Rush	300	Beef	0
A-UARH-BA06	Rush	400	Beef	0
A-UARH-BA11	Rush	100	Beef	0
A-UANS-BA04	Ness	210	Beef	0
A-UABT-BA08	Barton	120	Beef,Swine	0
A-UARH-BA20	Rush	310	Beef	0
A-UARH-BA13	Rush	850	Beef	0
A-UARH-BA01	Rush	40	Beef	0
A-UARH-BA07	Rush	500	Beef	0
A-UARH-BA10	Rush	600	Beef	0
A-UARH-BA08	Rush	250	Beef	0
A-UARH-BA19	Rush	500	Beef	0
A-UARH-BA03	Rush	250	Beef	0
239	Rush	40	Beef	0
A-UARH-BA04	Rush	700	Beef	0
A-UANS-BA06	Ness	999	Beef	0
A-UABT-SA04	Barton	175	Swine,Beef,Sheep	0
A-UARH-BA16	Rush	500	Beef	0
A-UANS-BA07	Ness	800	Beef	0
A-UARH-C004	Rush	1200	Beef	0
A-UARH-B010	Rush	131	Beef	0
A-UABT-B004	Barton	999	Beef	0
A-UABT-B003	Barton	999	Beef	0
A-UARH-B012	Rush	800	Beef	0
A-UARH-B014	Rush	350	Beef	0
A-UARH-C005	Rush	1950	Beef	0
A-UARH-B015	Rush	200	Beef	0
A-UARH-B006	Rush	150	Beef	0
A-UARH-B013	Rush	800	Beef	0
A-UARH-B001	Rush	800	Beef	0
A-UARH-B002	Rush	950	Beef	0
A-UALE-C002	Lane	12000	Beef	0
A-UALE-B001	Lane	750	Beef	0
A-UABT-C002	Barton	35000	Beef	0
A-SHRH-BA04	Rush	140	Beef	0
1087	Rush	800	Beef	0
A-UARH-BA15	Rush	70	Beef	0
A-UARH-C001	Rush	2000	Beef	0
A-UABT-C005	Barton	1350	Beef	0
A-UARH-B011	Rush	300	Beef	0