LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body / Assessment Unit: Turkey Creek
Water Quality Impairment: Chloride

1. INTRODUCTION AND PROBLEM INDENTIFICATION

Subbasin: Little Arkansas

Counties: McPherson and Harvey

HUC 8: 11030012

Ecoregion: Central Great Plains, Wellington-McPherson Lowland (27d)

Drainage Area: Approximately 279 square miles

Water Quality Limited Segment: 11 & 12

Main Stem Segment with Tributaries by HUC 8 and Watershed/Station Number:

HUC 8	**11030012**		
Watershed:	**Turkey Creek (Alta Mills)**		
Station 533	**Turkey Cr (11)**	Dry Turkey Cr (13)	Bull Cr (24)
	Turkey Cr (12)	Running Turkey Cr (25)	

Designated Uses: **Dry Turkey Cr (13)**: Primary B contact Recreation; Expected Aquatic Life Support, Domestic Water Supply; Food Procurement; Groundwater Recharge, Industrial Water Supply, Irrigation; Livestock Watering. **Bull Cr (24)** same, except Primary C contact Recreation.

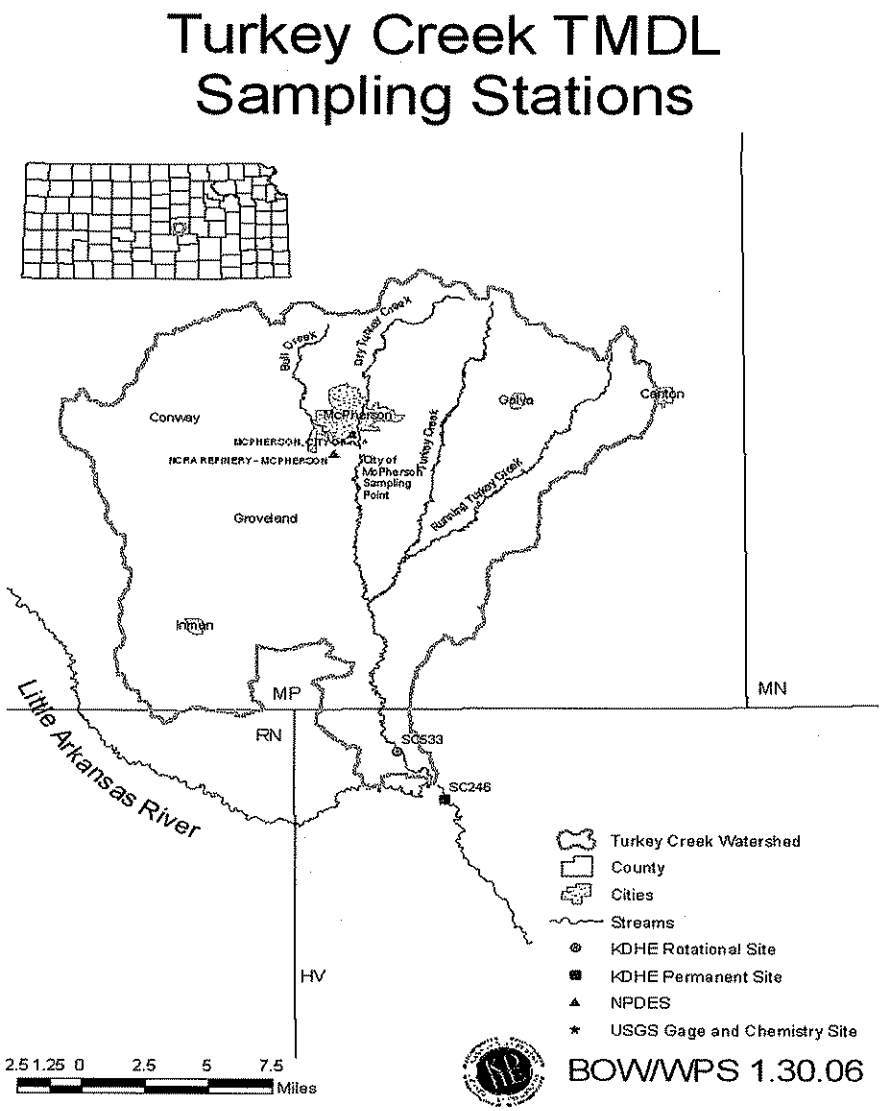
Turkey Cr(11 & 12): Expected Aquatic Life Support; Primary contact C Recreation (segment 11); Secondary contact b Recreation (segment 12); Food Procurement (segment 12). **Running Turkey Cr (25):** Expected Aquatic Life Support; Secondary contact b Recreation.

1998, 2002 & 2004 303(d) Listing: Lower Arkansas Basin Streams: Turkey Creek (Alta Mills) Segments 11 & 12.

Impaired Use: Domestic Water Supply; Acute Aquatic Life Support

Water Quality Standard: Domestic Water Supply: 250 mg/L at any point of domestic water supply diversion (K.A.R. 28e(c) (3) (A)); Acute Aquatic Life Support: 860 mg/L (K.A.R. 28-16-28e(c) (2) (D) (ii)).

Figure 1.



2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2004 303(d): Not Supporting Domestic Water and Partially Supporting Aquatic Life.

Streamflow and Water Quality Monitoring Sites: **Table 1** indicates the USGS Stream Gaging Station and KDHE Ambient Stream Water Quality Monitoring Stations used in this TMDL. Flow estimates for station 533 were made from data from the USGS Scientific Investigations Report 2004-5033, the USGS Water-Resources Investigations

Report 01-4142 (Estimated Flow-Duration Curves for Selected Ungaged Sites in Kansas) and from available data from the flow values at the USGS gaging station (07143665) at Alta Mills on the Little Arkansas River.

Table 1. Stream Gages and Monitoring Stations data utilized for Turkey Cr. TMDL.

Station	Stream	Type	Period of Record Used	Med Q	Avg. Cl (mg/L)	Max Cl (mg/L)	# of samples	# of Samples >250 mg/L
533 Turkey Cr.	Turkey Cr	Rotational WQ	1990-2002	8.16	403	1023	25	17
246 Upper Little Arkansas River	Little Arkansas River	Fixed WQ	1985-2005	21	267	623	144	82
USGS 07143665 Little Arkansas River @ Alta Mills	Little Arkansas River	Q	1973-2006	21	NA	NA	NA	NA
City of McPherson	Dry Turkey Cr	WQ	1998-2005	NA	493	909	93	78

Table 2 indicates the drainage area, mean flows, and estimated flows at selected exceedance percentages as indicated in USGS Scientific Investigations Report 2004-5033 for the upper segment of Turkey Creek and the tributaries covered under this TMDL. The USGS Water-Resources Investigations Report 01-4142 was utilized to estimate the flows for the selected percentiles in **Table 2** along Turkey Creek, segment 11.

Table 2. Selected Hydrology for the Turkey Cr TMDL Area.

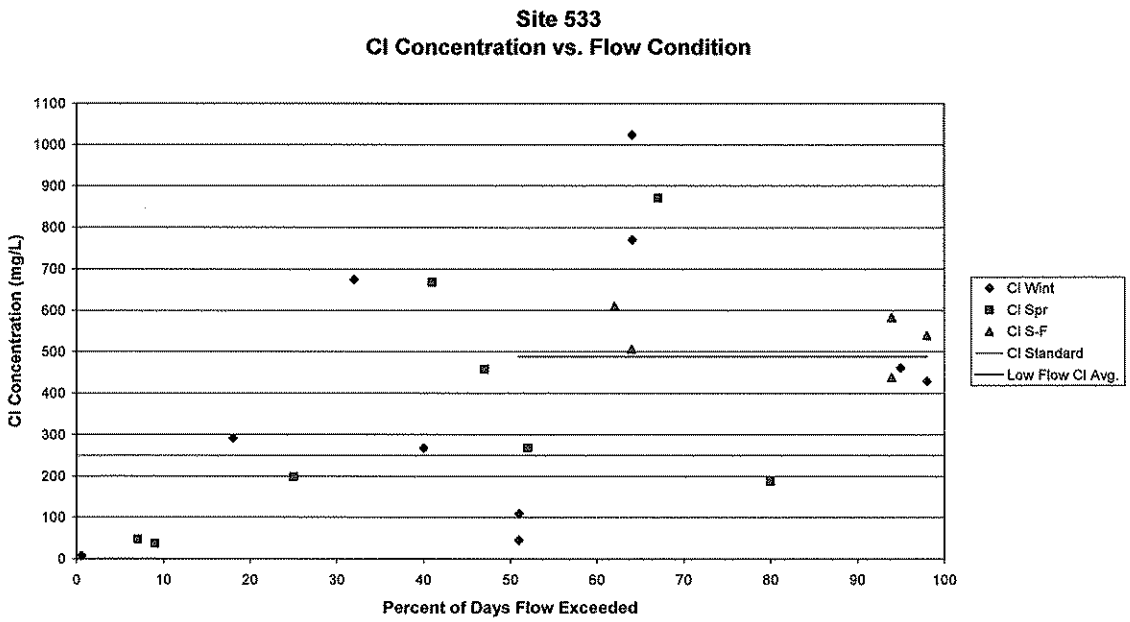
			Percent of Time Flow Exceeded			
Stream & Segment #	Drainage Area	Est. Mean Flow	75%	50%	25%	10%
Turkey Cr (11)	279	62.4	3.81	8.16	21.22	81.6
Turkey Cr (12)	37.9	8.23	0	.39	1.7	6.91
Running Turkey Cr (25)	55.2	12.1	0	.74	2.87	10.9
Dry Turkey Cr (13, below McPherson)	75.7	14.5	0	.79	3.25	13.2
Bull Cr (24)	48.3	8.96	0	.26	1.51	7.08

Long Term Flow Conditions at Station 533: Median Flow 8.16 cfs; 7Q10 = 0.1 cfs; 10% Exceedance Flow = 82 cfs ; 95% Exceedance Flow = 1.5 cfs

Current Conditions: Over the period of record, chloride concentration averages were established for KDHE ambient stream monitoring stations 246 and 533. In addition, data obtained from the City of McPherson, as required by their NPDES permit, was also utilized from a sampling location on Dry Turkey Creek below the confluence with Bull Creek. Data from station 246 was primarily utilized for comparison purposes only in this document, as this station is located along the Little Arkansas River below the

confluence with Turkey Creek (See upper Little Arkansas Chloride TMDL). The chloride averages for the sampling stations are illustrated in **Table 1**. Each site had a number of samples that exceeded the established water quality standards. Station 533 is a KDHE rotational sampling station, which has been sampled five or six times during a one-year period every four years since 1990. There is significant scatter in the sample data along Dry Turkey Creek and at station 533. Chloride exceedances over 250mg/L cease once flows reach the 15% exceedance levels at station 533. Station 533 has only been sampled one time since NCRA ceased discharging. This sample, obtained in February of 2006, resulted in 583 mg/L of chloride.

Figure 2.



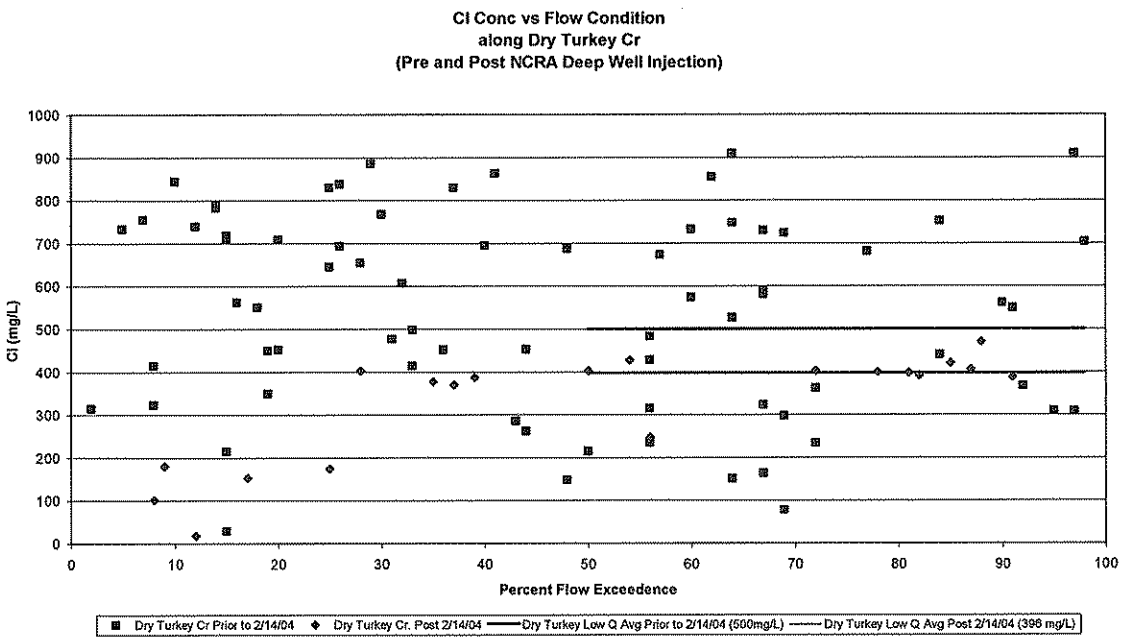
Three principal segments comprise the flow at Alta Mills at station 533; Running Turkey Creek, Turkey Creek (below Running Turkey Creek) and Dry Turkey Creek (downstream of the City of McPherson). During dryer periods, the City of McPherson's wastewater treatment plant discharge forms the majority of the flow in Dry Turkey Creek, and Turkey Creek above Running Creek and Bull Creek often lack observable flow. The minor segments of the Turkey Creek that lack flow during the dryer periods do not contribute to the chloride load downstream during these occurrences. Therefore, chloride loads increase during wetter weather, when these streams contribute to the total load of the watershed.

A holding pond utilized at a golf course adjacent to the treatment facility retains a portion of the discharge originating from the City of McPherson. Once the holding pond is full, the majority of the discharge enters Dry Turkey Creek. In addition, the water in Dry Turkey Creek immediately downstream of the golf course and the wastewater

treatment plant outfall pools naturally due to the general flat topography and wooded debris in the streambed. The City of McPherson and the golf course are authorized to utilize the treated wastewater for irrigation purposes. The sampling point for the City of McPherson is at the outfall of the wastewater treatment plant and directly south of the golf course. These sampling points capture the chloride concentration being discharged to the watershed.

The National Cooperative Refinery Association (NCRA) consistently discharged an average of 1.03 MGD of water into Bull Creek with an average chloride concentration of 1215 mg/L prior to February 14, 2004. NCRA ceased discharging to Bull Creek as of this date and began routing their outfall water to two Class I deep disposal wells. Prior to February 14, 2004, Dry Turkey Creek displayed similar chloride levels under all flow conditions and rarely had any chloride samples below 250 mg/L. After the discharge to Bull Creek was discontinued by NCRA , chloride concentrations in Dry Turkey Creek became diluted under higher flow conditions and Chloride exceedances over 250mg/L were not observed once flows reach the estimated 25% exceedance level.

Figure 3.



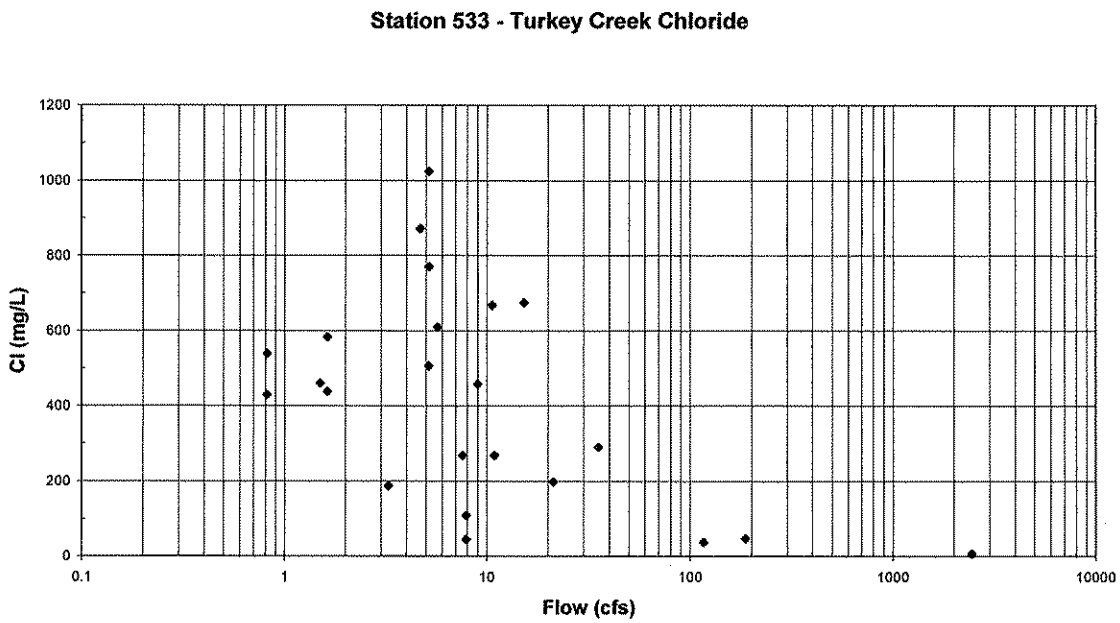
Oil field brine contamination enters the watershed primarily in Running Turkey Creek, and the upper and lower portions of Turkey Creek. During low flow durations in the 75%-99% range, the entire brine load is not expected to reach station 533. As flows increase in the upper portions of Turkey Creek and Running Turkey Creek the brine load substantially increases as the entire load reaches station 533. During higher flow periods

and runoff events, the chloride load expected from natural sources increases as the percentage from oil brine and wastewater decreases.

The only period where near critical low flows were observed at station 533 coincided with the sampling events in September and November of 1994. These two samples averaged 484 mg/L. Actual critical low flows occurred in the fall of 1991, however no samples were obtained during this time period since station 533 is a rotational sampling station.

Based on flow and point source discharge values utilized in the development of this TMDL, it is apparent that the entire chloride load discharged from the NCRA and City of McPherson NPDES facilities are not reaching sampling station 533 under low flow conditions within the 90%-99% flow duration level.

Figure 4. Chloride Concentrations vs. Flow (cfs) at Station 533.



Since loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. Sample data for station 533 were categorized for each of the three defined seasons: Spring (Apr-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Mar). High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range.

Excursions were seen in each of the three defined seasons as indicated in **Table 3** and **Figure 5** at station 533. Samples were over the domestic water supply criterion in 50% of the Spring Samples, 100% of the Summer-Fall samples, and 66% of the Winter

samples. Overall, 68% of the samples were over the criterion. This would represent a baseline condition of non-support of the impaired designated use.

Table 3. Number of Samples Over Chloride Standard of 250mg/L by Flow and Season

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum. Freq.
Turkey Cr (533)	Spring	0	0	2	2	0	0	4/8=50%
	Summer	0	0	0	2	0	3	5/5=100%
	Winter	0	1	2	2	1	2	8/12=66%

Samples obtained from Dry Turkey Creek below McPherson and the confluence with Bull Creek had a chloride concentrations average of 540 mg/L prior to February 14, 2004. Since this time, NCRA has discontinued discharging to Bull Creek and chloride concentrations have significantly decreased to an average of 330 mg/L as seen in **Table 4** and **Figure 6**.

Table 4. Chloride Averages with and without NCRA discharge.

Location	Flow Condition	Cl avg. (mg/L) with NCRA Discharge (Pre 2/04)	Cl avg. (mg/L) without NCRA Discharge (Post 2/04)
Dry Turkey Creek	All Flow	540	330
Dry Turkey Creek	Low Flow 50-99%	500	396
Station 533	All Flow	430	583*
Station 533	Low Flow	488	583*
Station 246	All Flow	275	178
Station 246	Low Flow	342	212

* Only one data set.

Figure 5.

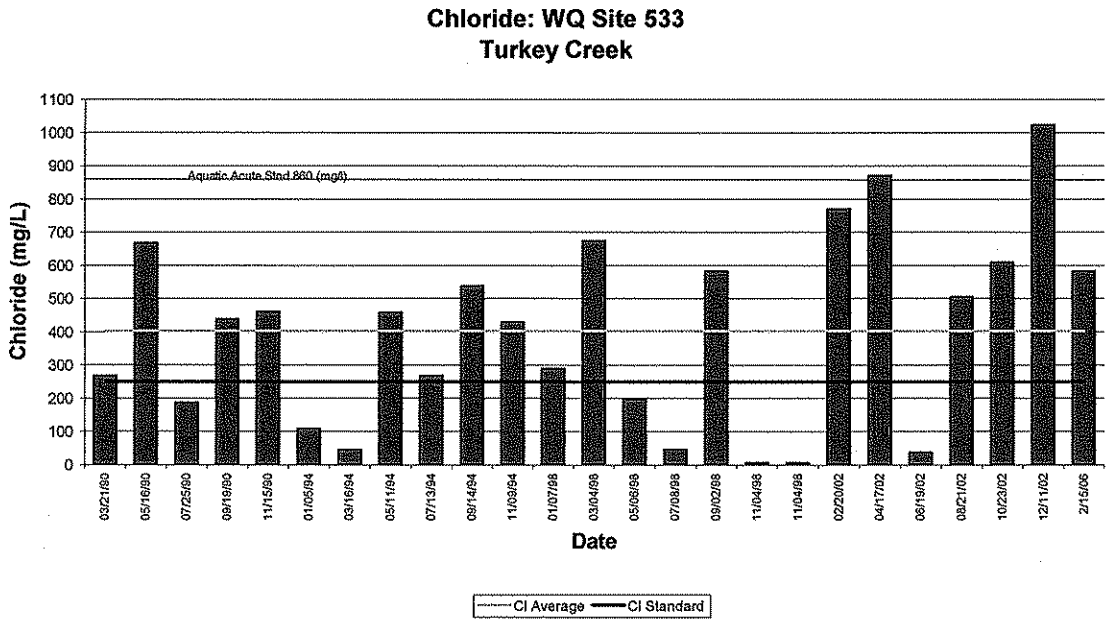
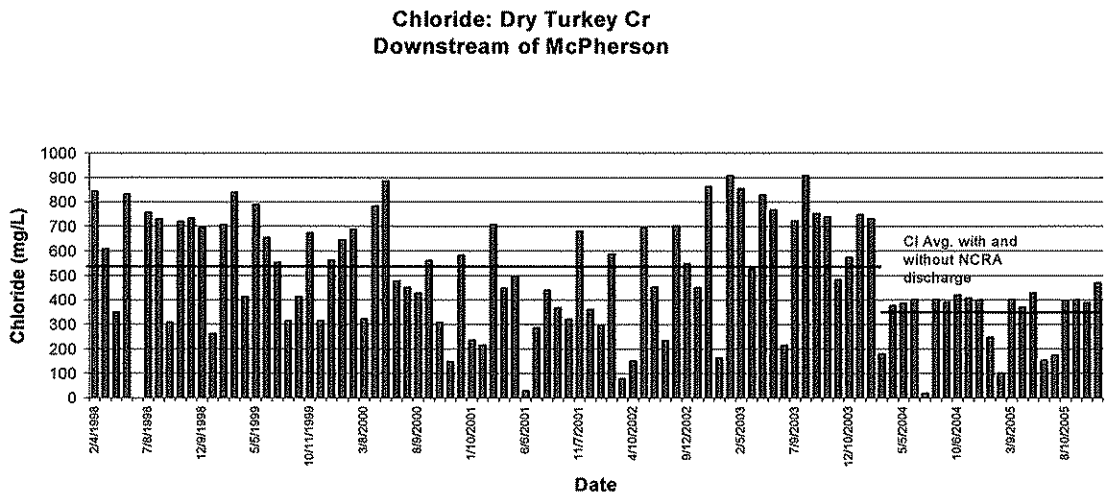


Figure 6.



Interim Endpoints of Water Quality (Implied Load Capacity) at Site 533 over 2010-2015:

The desired endpoint of this TMDL is to protect the domestic water supply by maintaining an average chloride concentration below 250 mg/L in Turkey Creek. The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Drinking Water use. The Turkey Creek watershed portion of the Little Arkansas sub-basin is affected by the discharge of saline groundwater attributed by brine pollution, which increases the chloride concentrations within portions of the sub-basin. This is evident in the data as chloride concentrations are historically greater than 250 mg/L during relatively high flow conditions at station 533. While chloride concentrations have lacked stability at site 533, the concentrations have generally been stable in Dry Turkey Creek over time while NCRA was discharging to the watershed. Since NCRA has ceased discharging, the data from Dry Turkey Creek suggests that the chloride concentrations have even become more stable at a lower magnitude. The primary reason is that the City of McPherson discharge accounts for the majority of the flow to Dry Turkey Creek under low to normal stream flow conditions, after NCRA ceased discharging to Bull Creek. The elevated chloride concentrations resulting from brine pollution, makes the achievement of the Standard unlikely at most flow conditions. The existing criterion is not achievable on Turkey Creek within the short term because it will take several decades for the historic brine pollution to dilute out.

Oil-field brine accounts for a large portion of the chloride load entering the watershed, particularly along Running Turkey Creek and the lower portion of Turkey Creek. The flushing and recharge of groundwater are slowly diluting the saline waters produced from the historical practice of discarding brine pollution on the surface (Whittemore).

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated chloride levels. Achievement of the endpoints indicate loads 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.

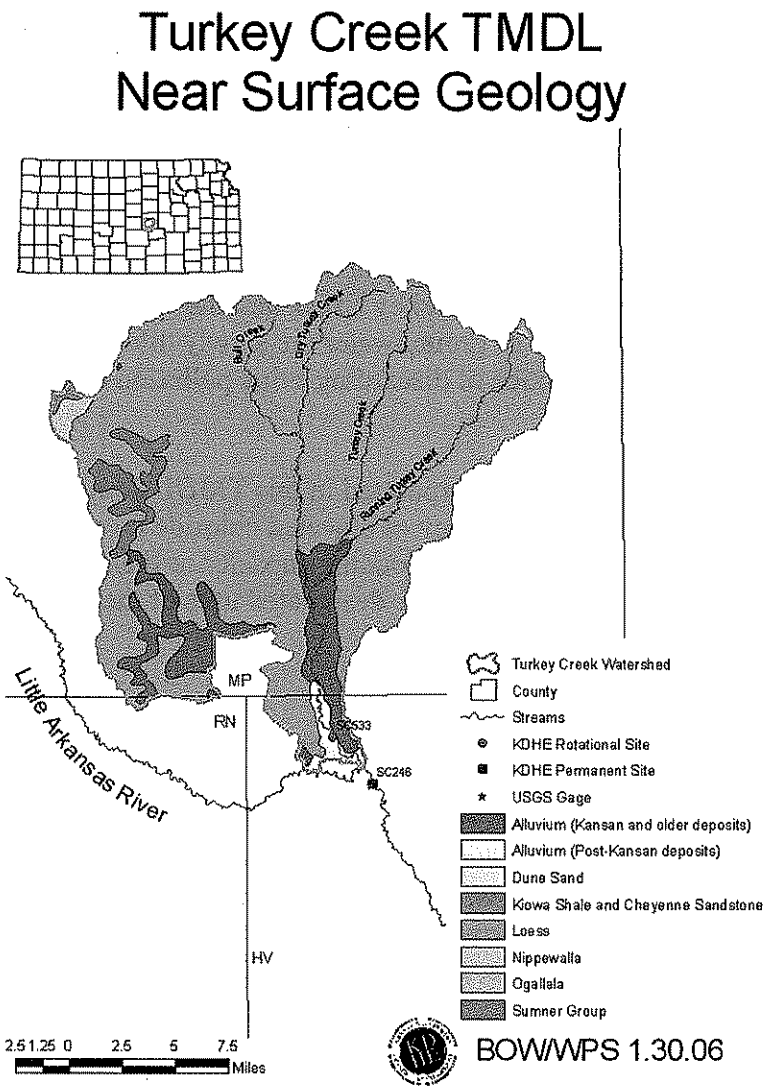
3. SOURCE INVENTORY AND ASSESSMENT

Geology: The primary geologic material underlying the Turkey Creek watershed in McPherson County is the Equus Beds area of the High Plains aquifer and local alluvial aquifers that interact with stream flow. The unconsolidated sediments in the watershed are above the underlying bedrock formed by Permian shales and siltstones. The Permian bedrock also contains limestone beds, gypsum, and rock salt (Whittemore).

The Turkey Creek watershed's average annual rainfall is approximately 28 inches. Flows in the main stream segments during most periods are sustained with adequate rainfall, which recharges the High Plains aquifer enough to provide discharge to

the stream. The water table in the Equus Beds aquifer in parts of the Turkey Creek watershed have experienced slight declines due to water use. Groundwater discharge may not contribute significantly, or at all, to stream flow in areas where declines in the Equus Beds aquifer have occurred. Less permeable silts and clays are a component of the shallow sediments within the Equus Beds aquifer in the McPherson region. Groundwater recharge is confined by the sediments when the groundwater table is lower than the stream bed. This enables runoff from the Equus Beds region to drain faster since the shallow sediments are less permeable (Whittemore).

Figure 7.



Natural Chloride: Natural chloride in the Turkey Creek watershed enters the streams from perched groundwater flowing through soils and shallow sediments above less permeable sediments. Another source of natural chloride is derived from groundwater discharge from the Equus Beds deposits of the High Plains aquifer. Rock salt may be contained in some portions of the Permian bedrock underlying the Equus Beds sediments, however unpolluted groundwater in the Equus Beds aquifer is generally fresh in the watershed of Turkey Creek. The shale in the Permian bedrock may restrict the upward dispersion of saline groundwater. The Permian chloride that does enter the aquifer may be diluted with the natural recharge of freshwater from rainfall. Natural chloride concentrations in the aquifer are typically less than 100 mg/L (Whittemore).

NPDES: There are twelve permitted waste treatment facilities located upstream of station 533, all of which are in McPherson County. The permitted facilities are categorized as follows: three "non-overflowing" ponds or lagoons that are prohibited from discharging, five industrial permitted facilities, one commercial facility, and two municipal facilities. The City of McPherson and the City of Galva are the only two municipal water treatment plants in the Turkey Creek watershed.

Table 5. NPDES discharging Facilities above Station 533.

KS Permit #	Facility	Permit Dates	Design Flow MGD	Type	Receiving Stream
I-LA11-CO03	BPU PP#3	04/01/03-12/31/07	.077	Outfalls 001a & 001	Dry Turkey Cr via Unnamed Trib
I-LA11-PO09	BPU- Plant #1	04/01/03-12/31/07	4.03	Clear Well	Bull Cr via Storm Sewer
I-LA11-PO04	BPU-PP #2	04/01/03-12/31/07	.182 .036	Outfall 001 & 002	Bull Cr
I-LA11-PO11	Abbott Labs	06/01/04-12/31/07	.027	Outfall 001 to Lake	Dry Turkey Cr via Lake
I-LA11-PO02	National Cooperative Refinery Association	02/01/02-01/31/07	.9	*Pond to Oufall 001	Bull Cr
I-LA11-PR02	Mid America Ready Mix East Plant, McPherson	10/01/03-09/30/07		Earth basin	Turkey Cr via ditch
I-LA11-PR01	McPherson Concrete Products West Plant, McPherson	10/01/03-09/30/07		Concrete Basin	Bull Cr via Storm sewer
M-LA11-OO01	City of McPherson, McPherson	09/01/02-08/31/07	2.0 avg.	Mech	Dry Turkey Cr
M-LA03-OO01	City of Galva, McPherson	10/01/02-09/30/07	.058	Five Cell Lagoon	Turkey Cr via Unamed Trib
C-LA03-NO03	Sunflower School, McPherson	10/01/01-09/30/06	Non-overflowing .0029		
I-LA11-NP01	Johns Manville International, Inc., McPherson	07/01/02-06/30/07	Non-overflowing	Pond	
I-LA11-NO06	Krehbiel Specialty Meats, McPherson	06/01/03-12/31/06	Non-overflowing	Lagoon	

The municipal NPDES permit for the City of McPherson requires daily effluent flow measurements, monthly chloride sampling from the effluent discharge, monthly chloride sampling from their designated sampling point on Dry Turkey Creek, monthly

chloride sampling in Bull Creek and monthly flow measurements from Bull Creek. Bull Creek does not support flow during dryer periods and chloride samples where only obtained when flow was present. The industrial permit for NCRA requires weekly chloride sampling and flow measurements. However, other than a few days in July of 2004, this facility has not discharged since February 12, 2004. Of the three Board of Public Utilities (BPU) Power Plant facilities, only two are required to report flow discharges. Of these two, BPU Power Plant #2 has only discharged a few days a year.

Table 6 illustrates the data reported by the City of McPherson as required by their NPDES permit. The data is significantly different from when the NCRA facility did discharge and when their discharging was ceased. More recent chloride concentrations observed when NCRA ceased discharging in Bull Creek are reflective of natural chloride concentrations within this area of the watershed. Chloride concentrations in Dry Turkey Creek during low flow duration periods after NCRA discontinued discharging are correlated with the City of McPherson discharge concentrations. This relationship is also illustrated in **Figure 8**.

Table 6. City of McPherson NPDES data summary.

Facility	Period of Record	Flow Avg.	Cl Avg (mg/L)	Cl Max (mg/L)
Effluent	1998-2005	1.7 MGD	390	849
Dry Turkey Cr All	1998-2005	NA	493	909
Dry Turkey Cr w/NCRA discharging	1998-2/2004	NA	540	909
Dry Turkey Cr w/out NCRA discharging	2/2004-2005	NA	329	470
Bull Creek All	1998-2005	1.39* cfs	823*	1485
Bull Creek w/NCRA discharging	1998-2/2004	1.44* cfs	1148*	1485
Bull Creek w/out NCRA discharging	2/2004-2005	1.24* cfs	12.7*	31

* Average values based on data only recorded when flows present.

Population projections indicate slight increases for the City of Galva and moderate increases for the City of McPherson (Kansas Water Office (KWO)). Projections of future water use and resulting wastewater appear to be within design flows and design population estimates for these current system's treatment capacities. The City of McPherson is in the design phase for upgrading the WWTP. The upgrades will increase the design flow of the system to 2.4 MGD, based on the City of McPherson's population projections for the year 2025. According to the City of McPherson, the improvements planned for the upgrade will primarily involve headworks and solids handling, with only control enhancements to the biological portion of the treatment process.

Figure 8.

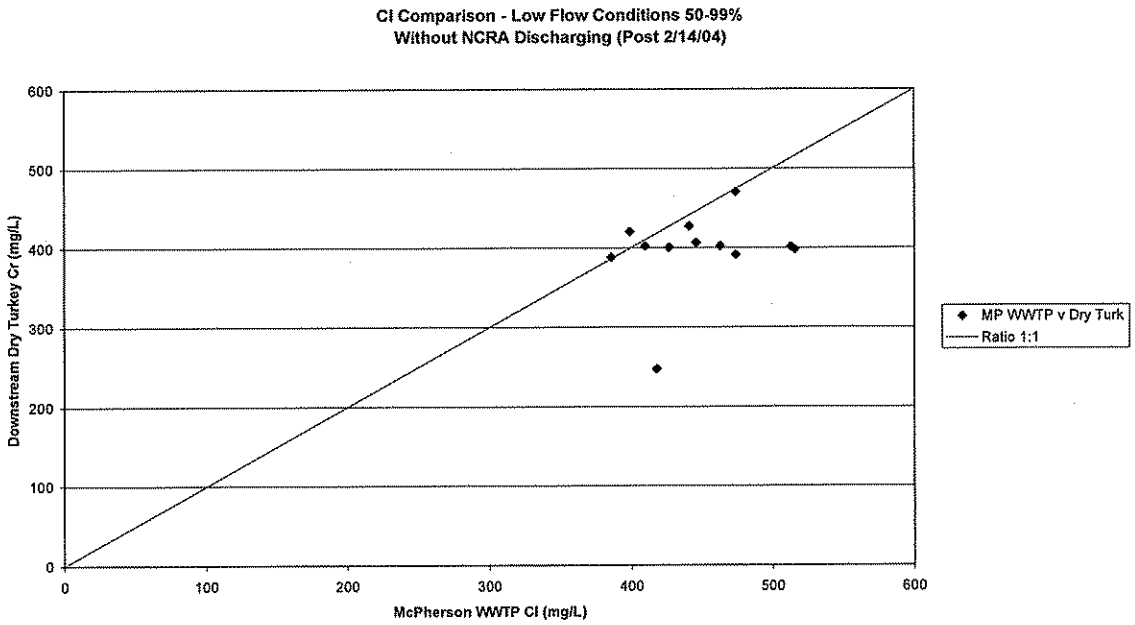
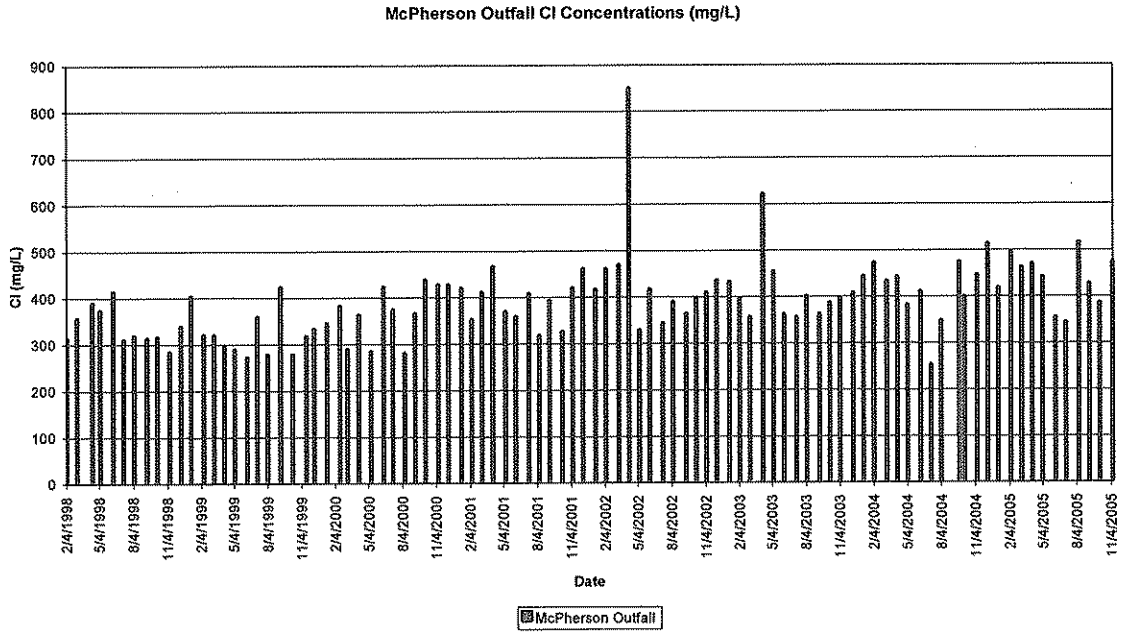


Figure 9.

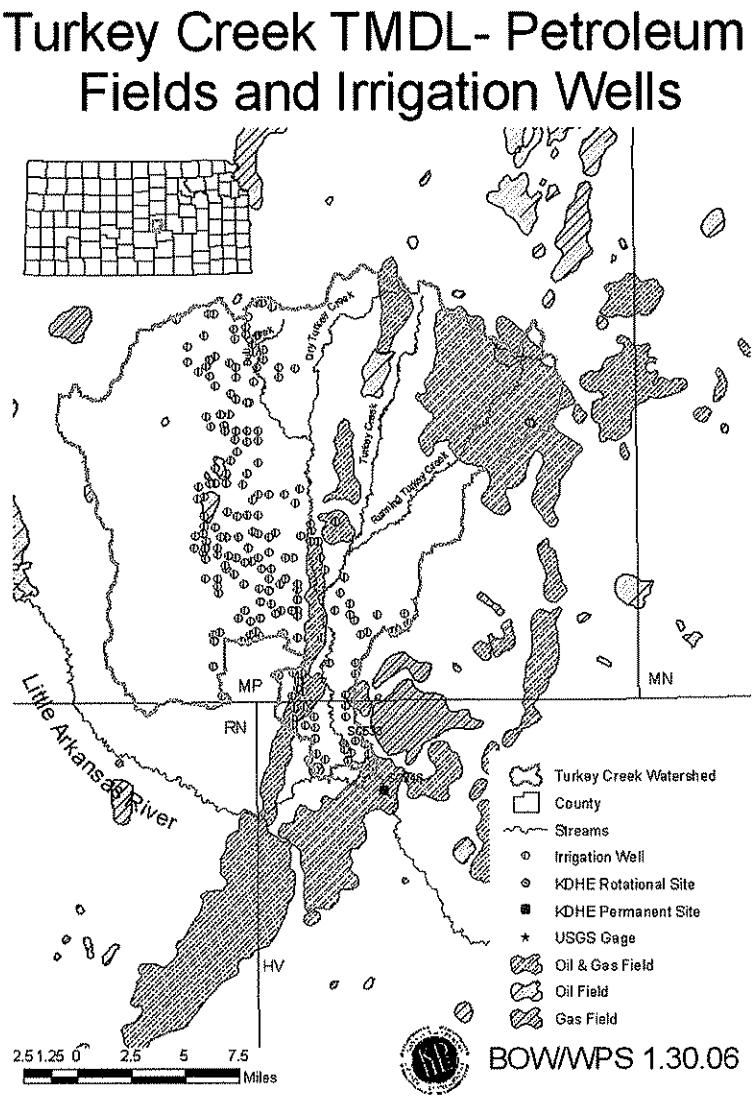


A wastewater holding cell and a retention pond on the golf course adjacent to the treatment facility may at times delay the transport of the full chloride load discharged from the McPherson treatment plant. The load may be reduced as the City and the golf course utilize this discharged water for irrigation. During dryer periods this may significantly reduce the amount of load reaching station 533. The chloride concentration may be diluted within the golf course retention pond(s) as minor rainfall and runoff events may be captured. During wetter periods the pond(s) will most likely discharge the entire chloride load derived from the City of McPherson downstream to station 533 as irrigation would likely discontinue during these periods.

The Kansas Geological Survey (KGS) sampled several locations in the Turkey Creek watershed in 1999 and 2002. Results from three sampling events at a location 0.5 mile downstream of the McPherson WWTP along Dry Turkey Creek averaged 545 mg/L of chloride, which is similar to the average reported by the City of McPherson at their sampling point along Dry Turkey Creek. It is unknown whether these sampling locations were identical, but based on the description of the general location of the sampling points they are assumed to be close in proximity. KGS also sampled Dry Turkey Creek one mile upstream of the confluence with Turkey Creek. This location was sampled twice and averaged 519 mg/L of chloride. Based on the KGS interpretation of a Bromide and Chloride ratio analyses, the main source of chloride at these locations is consistent with water softener salt entering from the City of McPherson discharge. In addition, KGS reported that there also appeared to be chloride originating in these samples from an "unknown, oil-brine like affect" (Whittemore). The data suggests the source described by KGS actually originated from the NCRA facility discharge, and not from old brine deposits in this area. The chloride concentrations are attributed to point sources along Dry Turkey Creek and tend to dilute as water flows towards the confluence with Turkey Creek.

The discharge from the City of Galva must travel some distance prior to reaching the upper portions of Turkey Creek. During low flow conditions the discharge originating from Galva is not reaching the main stem segment leading to station 533, as Turkey Creek in this area lacks flow during these conditions. During higher flow periods, the City of Galva's discharge will contribute to the chloride load in the watershed.

Figure 10.



Irrigation: Use of surface and groundwater for irrigation does occur throughout the western portion of the watershed. According to WIMAS Water Right Information, there are approximately 36,700 Acre-Feet authorized for groundwater irrigation and 790 Acre-Feet authorized for surface water irrigation, totaling 37,490 Acre-Feet of irrigation water use. The use of irrigation water will eventually return salts to the water table and increase the salinity of the aquifer over many decades. The use of groundwater irrigation will contribute to declining the water table in parts of the Equus Bed aquifer in the Turkey Creek watershed. Therefore, the streams in these portions of the watershed may recharge the aquifer rather than the groundwater discharging to the creek. In areas of the Turkey Creek watershed where groundwater return flows may contribute discharge, it is not expected to be significant or contribute to a major portion of the chloride concentration of the creek. Return flows may result from runoff in some areas of the

watershed where low permeable shales and silts underlie the soils. The runoff could flush soil salts that have a higher chloride concentration as a result of evapotranspiration from the use of irrigation water. High runoff events may temporarily increase the background chloride concentrations in the streams during higher flow events as these salts are flushed downstream (Whittemore).

Animal Wastes: The eastern and northeastern portion of the watershed has minimal irrigation points due to the higher chloride and nitrate concentrations in the groundwater. Higher nitrate and chloride concentrations in groundwaters are often associated with animal wastes. The background concentration of chloride is presumed to have slightly increased over time in the locally impacted regions of the Equus Beds aquifer as result of this relationship. Chloride contributions from animal wastes are likely to enter the watershed during high runoff events and would contribute to increased chloride concentrations during higher flows. The impact of animal wastes to this portion of the watershed is minimal in comparison to the oil-field brine that enters the watershed in the same vicinity (Whittemore).

Brine: There are a few old oil fields in the Turkey Creek watershed along Running Turkey Creek and the main segments of Turkey Creek (see **Figure 8**). The majority of the oil-brine pollution originated from the Ritz-Canton Field in the drainage area of the upper portions of Running Turkey Creek and Turkey Creek. The historic disposal of waste brine generally occurred by diverting wastes through drainage ditches, which discharged to surface ponds where contamination seeped into the subsurface. Contamination to the aquifer resulting from the historic oil-field brine activities has been documented. As reported by KGS, water in the aquifer in the Galva area contained a chloride concentration exceeding 30,000 mg/L in 1997 and is attributed to oil brine (Whittemore).

The effects of oil-field brine contamination in the Turkey Creek watershed were also documented in the KGS Salt Assessment study in the watershed. Turkey Creek was sampled 1.5 miles upstream of the confluence with Dry Turkey Creek in 1999 and contained 1126mg/L of chloride. Running Turkey Creek was sample 0.3 miles upstream of the Turkey Creek confluence in 1999 and 2002 and contained 1952 mg/L and 1735 mg/L of chloride respectively. There was no observable flow in Turkey Creek above Running Turkey Creek at the time the later was sampled. Oil brine is the primary chloride source identified in these samples by the KGS. Running Turkey Creek is the primary route for the contamination from the Ritz-Canton Field to enter the watershed during low flow conditions based on the observable flow conditions at the time KGS sampled. Oil-field brine also enters the watershed from the Voshell Field in the lower portion of Turkey Creek. The Ritz-Canton Field was discovered in 1929 and accounted for the production of approximately 51 million barrels through 1959 (Albert). The Voshell Oil field produced approximately 30 million barrels of oil from 1929 through 1959 (Albert). "Brines are produced in Kansas at an average rate of about 5 barrels of brine to 1 barrel of oil; however, the ratio depends on area and production period and may vary from 1 to 10 barrels or more of brine to 1 barrel of oil" (Albert). Recharge is flushing the polluted groundwater, which will slowly dilute the chloride concentrations in

the watershed over time (Whittemore). During dry periods and low flow durations the entire brine load does not reach station 533. As flows increase the brine load is flushed from the upper Turkey Creek and Running Turkey Creek.

4. ALLOCATION OF POLLUTANT REDUCTION REPONSIBILITY

Point and Non-Point Sources: The majority of the current impairment is associated with chloride loads that originated from NCRA, the City of McPherson and historic oil-field brine pollution. Station 533 has been sampled once since NCRA ceased discharging, therefore the extent of the impairment must be estimated. KDHE will be sampling station 533 several more times in 2006. Based on future sampling results, this TMDL may have to be revisited if the City of McPherson proves to be a major source to future impairments if they should occur. The City of McPherson is expected to complete WWTP upgrades within the next few years, at this time it is assumed the design flow will be approximately 2.4 MGD. Until the upgrades are completed, the wasteload allocation will be assigned to the City of McPherson based on a maximum discharge of 2.0 MGD and an average chloride concentration of 400 mg/L. By the year 2025, the wasteload allocation for the City of McPherson will be based on an average chloride concentration of 300 mg/L for their 2.4 MGD of discharge. Since brine will eventually dilute out over time, a load allocation was estimated under this TMDL based on the brine concentration diluting at a rate of 1% per year. Should a domestic water supply point of diversion become established within the TMDL area, the current water quality standard of 250 mg/L would be applied to ensure the water supply use was protected. With NCRA no longer discharging, other point sources within the watershed are not expected to significantly contribute loads to the watershed under low flow conditions.

Select data sets from the City of McPherson discharge in 2002 that corresponded with sampling events from station 533 were used to establish a baseline for this TMDL. The chloride average from the City of McPherson discharge during these months was 415 mg/L. The current wasteload allocation being assigned for the City of McPherson under this TMDL is 6,683 lbs/day of chlorides until the upgrades to the WWTP are implemented. The wasteload allocation assigned to the City of McPherson under this TMDL is 6,015 lbs/day under all flow conditions by the year 2025. Under very low flow conditions it is not anticipated that the entire load from McPherson could reach station 533.

Table 7. Wasteload Allocations for the City of McPherson.

Wasteload Allocation	Discharge Flow	Cl Concentration (mg/L)	Cl Load (lbs/Day)
McPherson 2002 Load - baseline	1.62 MGD	415	5,616
McPherson TMDL	2.0 MGD	400	6,683
2025 TMDL WLA	2.4 MGD	300	6,015

The City of McPherson's annual average chloride concentrations for discharge flows are seen in **Table 8**. As the table illustrates, the City of McPherson has operated in accordance with meeting the goals of this TMDL in calendar years 1998, 1999, 2000, and 2001.

Table 8. City of McPherson annual average discharge chloride concentration, flow and daily load averages.

Year	Cl Avg. (mg/L)	Disharge Flow Avg. (MGD)	Daily Load Avg. (lbs/day)
1998	338	1.82	5138
1999	324	1.84	4972
2000	366	1.83	5595
2001	392	1.67	5462
2002	440	1.61	5916
2003	411	1.58	5426
2004	418	1.52	5308
2005	435	1.78	6468

The milestone for this TMDL has been set for the year 2025. By this time the chloride concentration attributed to brine should be reduced by approximately 21% and the City of McPherson should have improved source reduction practices to achieve an effluent chloride concentration average of 300 mg/L. Several scenarios where developed to evaluate the success of this TMDL up to the milestone year.

The first scenario reflects the baseline condition calibrated with chloride concentration averages from selected data sets from station 533 sampled throughout 2002. This scenario reflects the baseline condition where wasteloads reflect the 2002 condition and were derived from average flows and chloride concentrations from the City of McPherson and NCRA during this period in 2002. The natural chloride load and brine load were adjusted to achieve the average chloride concentration of 630 mg/L of chloride at station 533 for this scenario.

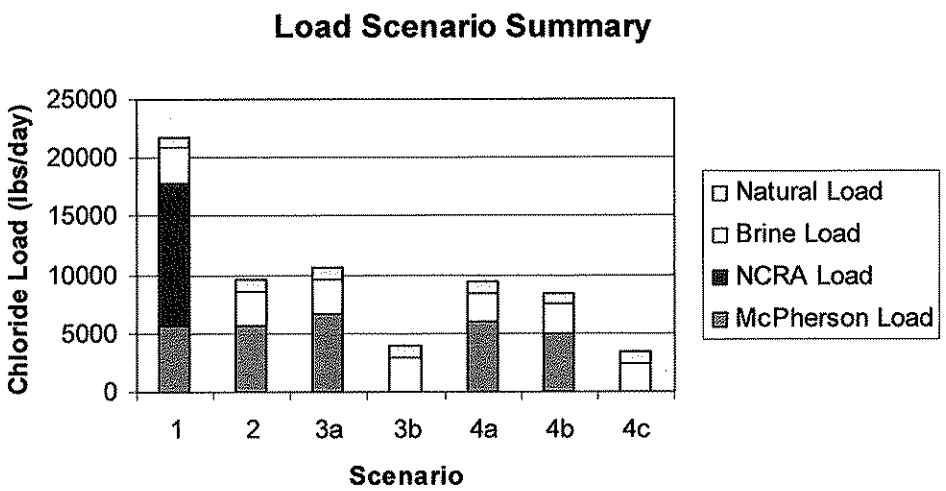
Scenario Two displays the current loads and concentration values at station 533 with the City of McPherson discharging at the design flow of 2.0 MGD with the average chloride concentration utilized in the baseline scenario, NCRA is shutoff, and the brine concentration has diluted out at a concentration of 1% per year from the year 2002.

Scenario Three "A" represents the current TMDL with the City of McPherson discharging at the design flow of 2.0 MGD and the chloride concentration is limited to 400 mg/L. Scenario Three "B" represents the TMDL without the City of McPherson discharge, representing the background condition with brine present.

Table 9. Resulting Chloride Concentrations and Loads (lbs/day) for Turkey Creek.

Scenario	**1**	**2**	**3a**	**3b**	**4a**	**4b**	**4c**
Cl Conc., Loads, and Allocations	2002 Baseline, Flow @ 6.4 CFS	2006 Current, Brine reduction, No NRCA	2006 TMDL, McPherson @ 400 mg/L & 2.0 MGD design Flow	2006 TMDL, No McPherson Discharge	2025 Goal, McPherson @ 300mg/L & 2.4 MGD, Brine Reduction	2025, McPherson at 250, Brine Reduction	2025 McPherson off, Brine Reduction
533 Cl (mg/L)	**630**	**388**	**382**	**354**	**302**	**267**	**307**
533 Load	**21755**	**9505**	**10572**	**3889**	**9385**	**8382**	**3370**
City of McPherson Cl (mg/L)	415	415	400	0	300	250	0
McPherson Load	5616	5616	6683	0	6015	5012	0
NCRA Cl (mg/L)	1210	0	0	0	0	0	0
NCRA Load	12129	0	0	0	0	0	0
Brine Cl (mg/L)	1735	1667	1667	1667	1376	1376	1376
Brine Load	3092	2971	2971	2971	2452	2452	2452
Natural Cl (mg/L)	100	100	100	100	100	100	100
Natural Load	918	918	918	918	918	918	918

Figure 11. Load Summary



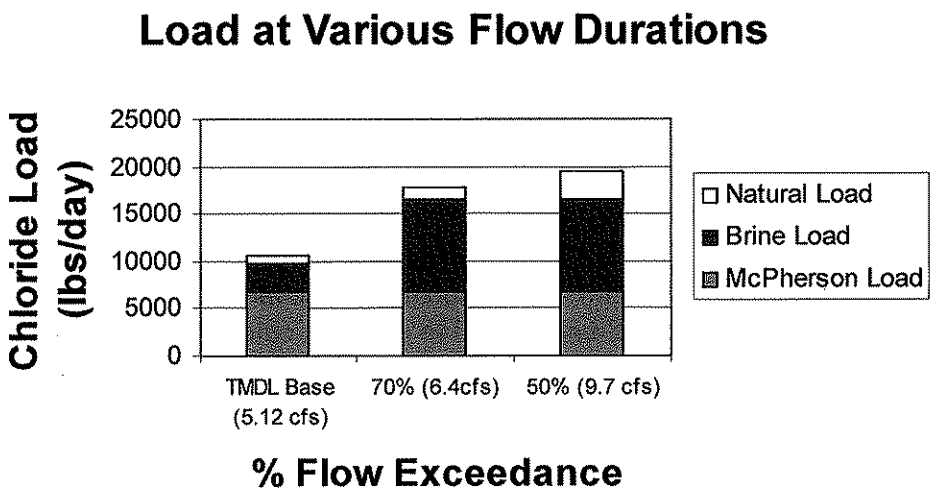
Scenario Four "A" represents the TMDL in the year 2025, where the design capacity for the City of McPherson has increased to 2.4 MGD due to the anticipated completion of plant upgrades, the chloride concentration is limited to 300 mg/L and brine has diluted at the rate of 1% per year since 2002. Scenario Four "B" represents the 2025 TMDL if McPherson is held to discharging at a concentration of 250 mg/L. Scenario 4 "C" illustrates the background condition with brine present in 2025 with the discharge from the City of McPherson turned off

As flows slightly increase, the full brine load will be flushed from the Turkey Creek Watershed. The brine contribution is not expected to surpass a flow rate of 1.1 cfs between the 50-75% flow duration intervals. As seen in **Table 10** and **Figure 11**, the brine load contribution significantly affects the chloride concentration and total load estimates at station 533.

Table 10. Current TMDL Concentrations, Loads and Allocations (lbs/day) for Turkey Creek at specific low flow exceedance frequencies.

Load Description / Flow Duration	50% (9.7 cfs)	50% (9.7 cfs)	70% (6.4 cfs)	70% (6.4 cfs)	TMDL Baseline (5.12 cfs)	TMDL Baseline (5.12 cfs)
Station 533 Cl (mg/L)	**374**		**508**		**382**	
Station 533 Load (lbs/day)		**19555**		**17827**		**10572**
City of McPherson Cl (mg/L)	400		400		400	
City of McPherson Load (lbs/day)		6683		6683		6683
Brine Cl (mg/L)	1667		1667		1667	
Brine Load (lbs/day)		9902		9902		2971
Natural Cl (mg/L)	100		100		100	
Natural Load (lbs/day)		2970		1242		918

Figure 12.



Margin of Safety: The Margin of Safety is implicitly established by conservatively assuming the entire chloride load reaches sampling station 533 under low flow conditions, when in fact the flow does not based on available USGS flow data.

State Water Plan Implementation Priority: Because the chloride impairment along Turkey Creek is primarily due to historical brine pollution, this TMDL will be a Medium Priority for implementation.

Unified Watershed Assessment Priority Ranking: This TMDL addresses streams within the Little Arkansas sub-basin (HUC 8: 11030012) with a priority ranking of 14 (High Priority of restoration).

Priority HUC 11s: Because of the historical oil-field brine pollution contribution of this impairment, no priority sub-watersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor any anthropogenic contributions of chloride loading to the river system.
2. Reduce historic brine pollution concentration through establishing groundwater remediation goals.

Implementation Programs Guidance

NPDES and State Permits- KDHE

a. Municipal and industrial permits for facilities in the watershed will be renewed after 2007 with annual chloride monitoring. The City of McPherson will be required to continue chloride monitoring and will need to address source reduction in their discharge to achieve the endpoint of this TMDL. Any facility with excessive chloride discharge will have appropriate permit limits, which maintain the ambient background levels of chloride. Any new discharger with extremely high chloride will be limited to acute concentrations via permit limits.

Non-Point Source Pollution Technical Assistance – KDHE

a. Evaluate any potential anthropogenic activities, which might contribute chloride to the streams as part of an overall Watershed Restoration and Protection Strategy.

Pollution Prevention Institute – Kansas State University

a. Work with the City of McPherson on process improvements to reduce the waste stream of high chloride water entering the municipal wastewater treatment system to ensure the 2025 TMDL goals are achieved.

Conservation Program – Kansas Corporation Commission (KCC)

a. Initiate remediation of significant brine fields contributing chlorides to the Turkey Creek watershed.

Time Frame for Implementation: The year 2007 marks the renewal period for the NPDES permit at the City of McPherson facility. At this time, the permit will require continued chloride monitoring and will focus on the source reduction of chloride appearing in the wastewater. The NCRA NPDES permit should be modified to reflect the status of a "non-overflowing" permit. If the NCRA facility resumes discharging, significant chloride restrictions will apply.

Targeted Participants: Primary participants for implementation will be KDHE and the City of McPherson.

Future Milestones: The year 2011 marks the midpoint for the ten-year implementation window for the watershed. At that point in time, sampled data from the streams covered by this TMDL should indicate no increase in the average chloride levels in the streams, particularly at lower flows. By 2025, the City of McPherson's treatment plant should have received upgrades and process improvements should be in place to achieve the discharge chloride concentration average of 300 mg/L. Since the upgrade is speculative at this point, the actual discharging flows and chloride concentrations may vary outside of the predictions utilized to establish the future wasteload scenarios. This TMDL will be revisited at this time to ensure the goals of this TMDL are achieved. Should the case of impairment remain, additional source assessment, allocation, and implementation activities will ensue.

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. 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. 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.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control non-point source pollution.

4. 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.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the Kansas Water Plan.

6. The Kansas Water Plan and the Lower Arkansas Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic area of the state for high priority in implementation.

Funding: The State Water Plan 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 to programs supporting water quality protection. The watershed and its TMDL are a Low Priority consideration.

Effectiveness: Minimal control can be exerted on natural contribution to loading. Interception of the saline groundwater and subsequent deep injection may be effective in lowering chloride over the long term.

6. MONITORING

KDHE will continue to collect samples from the rotation station (533) along Turkey Creek. Based on that sampling, the priority status will be evaluated in 2011 and thereafter, including application of numeric criterion based on background concentrations.

Quarterly monitoring of chloride levels in the effluent discharge will be a condition of the NPDES and state permits for facilities above station 533 that actually discharge to the watershed. Current monthly sampling requirements, regarding chlorides, as stated in the McPherson NPDES permit will continue to be required. This monitoring will continually assess the contributions of chloride in the wastewater effluent released to the Turkey Creek watershed.

7. FEEDBACK

Public Meeting: Public meetings to discuss TMDLs in the Lower Arkansas Basin were held on June 7, 2006 in Hutchinson. An active Internet site was established at http:www.kdheks.gov/tmdl/public.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Lower Arkansas Basin.

Public Hearing: A Public Hearing on the TMDLs of the Lower Arkansas Basin was held in Hutchinson on June 7, 2006. The public record was held open until June 20, 2006. No comments were received by KDHE.

Basin Advisory: The Lower Arkansas Basin Advisory Committee met to discuss the TMDLs in the basin on June 7, 2006.

Discussion with Interest Groups: The Kansas Department of Health and Environment met to discuss the implications of this TMDL with the City of McPherson on May 4, 2006.

Milestone Evaluation: In 2011, evaluation will be made to the degree of implementation, which has occurred within the watershed and current condition of the streams of the Turkey Creek watershed. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: Because of the long-term brine loadings, achievement of the Water Quality Standard will extend over fifteen to twenty years. The streams will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2006-2025. Therefore, the decision for delisting will come about in the preparation of the 2026, 303(d) list. Should modifications be made to the applicable water quality criteria during the initial ten-year 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 2007, which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in Kansas Water Plan implementation decisions under the State Water Planning Process for Fiscal Years 2007-2014.

Revised June 28, 2006

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Appendix A. Scenario Calculations.

Baseline – Scenario 1

Baseline	**Baseline 2002**
Low Flow Load	2002 Avg. Cl for MP and NCRA

		Flow Est
Station 533	Turkey Cr. Flow	6.4

Site	Municipal & Industrial Point Source	Flow cfs	Conc*	WLA	LA	*Load %*	TMDL lbs/Day
	McPherson WWTP	2.50614	415	5616.26			
	NCRA	1.8564	1210	12129.72		*81.56915*	
	Brine	*0.33*	1735		3091.77	*14.21128*	
	Natural	*1.7*	100		918	*4.219575*	
	533 Totals	**6.39254**	**630.2412**	**17745.98**	**4009.77**	***100***	**21755.75**

Scenario 3a – 2006 TMDL

Scenario 3a	**2006 TMDL**
Low Flow Load	No NCRA Discharge @ MP at 2MGD and McPherson Cl at 400
	At Baseline CFS

		Flow Est
Station 533	Turkey Cr. Flow	6.4

Site	Municipal & Industrial Point Source	Flow cfs	Conc*	WLA	LA	*Load %*	TMDL lbs/Day
	McPherson WWTP	3.094	400	6683.04			
	NCRA	0	0	0		*63.21672*	
	Brine	*0.33*	1667		2970.594	*28.09967*	
	Natural	*1.7*	100		918	*8.683615*	
	533 Totals	**5.124**	**382.0667**	**6683.04**	**3888.594**	***100***	**10571.63**

Scenario 4a – 2025 TMDL Goal

Scenario 4a **2025 Goal**
Low Flow Load McP at 400 mg/l and 3MGD Reduced Brine from 1300 by 1%/year
23yrs from 2002-2025

	Flow Est
Station 533 Turkey Cr. Flow	7.947

Site	Municipal & Industrial Point Source	Flow cfs	Conc*	WLA	LA	*Load %*	TMDL lbs/Day	Cl Conc Inputs
	McPherson WWTP	3.7128	300	6014.736				
	NCRA	0	0	0		*64.09041*		
	Brine	*0.33*	1376		2452.032	*26.12778*		
	Natural	*1.7*	100		918	*9.781808*		
	533 Totals	**5.7428**	**302.6259**	**6014.736**	**3370.032**	***100***	**9384.768**	

Appendix B. Load Calculations with various flow durations.

~70% Flow Duration

70% **2006 TMDL**
Low Flow Load No NCRA Discharge @ MP at 2MGD and McPherson Cl at 400

		Flow Est	
Station 533	Turkey Cr. Flow	6.4	70%

Site	Municipal & Industrial Point Source	Flow cfs	Conc*	WLA	LA	*Load %*	TMDL lbs/Day
	McPherson WWTP	3.094	400	6683.04			
	NCRA	0	0	0		*37.48826*	
	Brine	*1.1*	1667		9901.98	*55.54479*	
	Natural	*2.3*	100		1242	*6.966952*	
	533 Totals	**6.494**	**508.3616**	**6683.04**	**11143.98**	***100***	**17827.02**

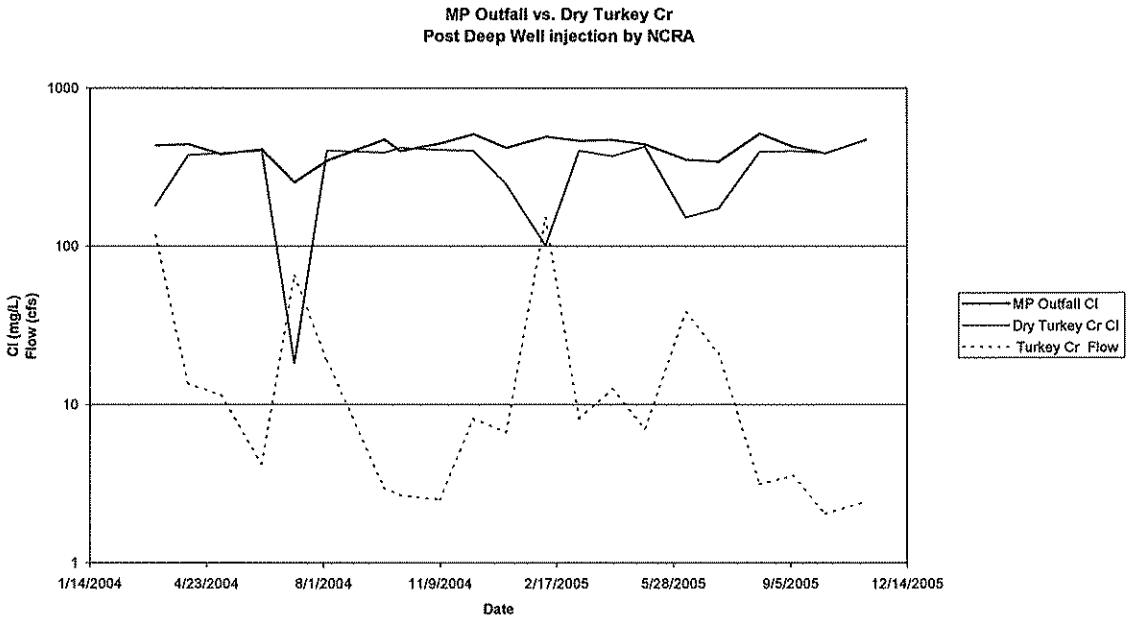
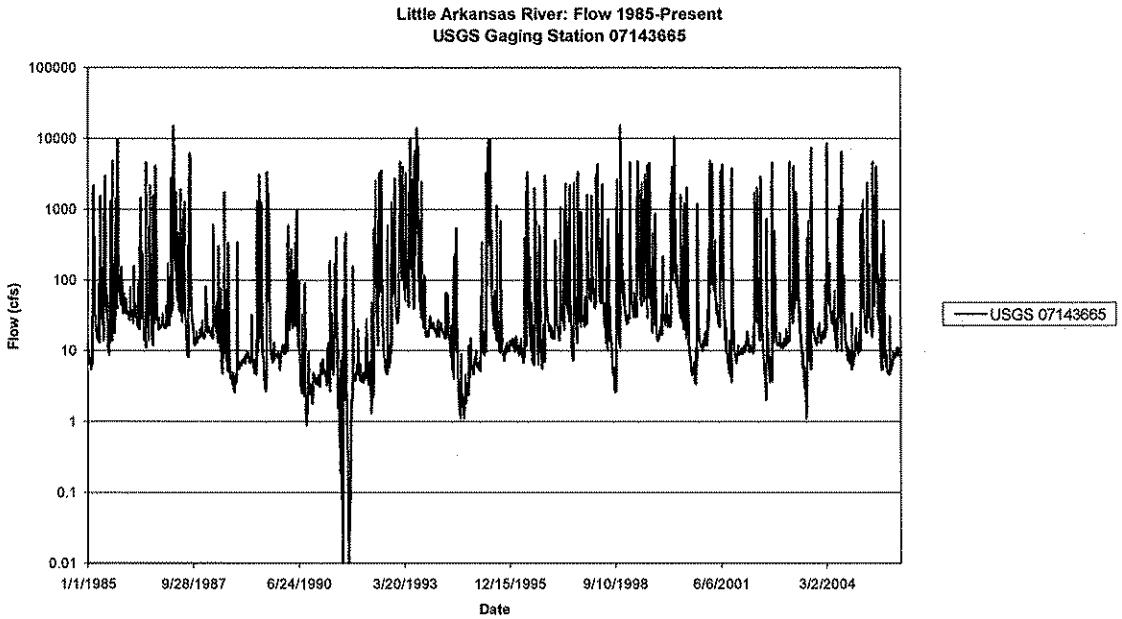
~50% Flow Duration

50% **2006 TMDL**
Low Flow Load No NCRA Discharge @ MP at 2MGD and McPherson Cl at 400

		Flow Est	
Station 533	Turkey Cr. Flow	9.7	50%

Site	Municipal & Industrial Point Source	Flow cfs	Conc*	WLA	LA	*Load %*	TMDL lbs/Day
	McPherson WWTP	3.094	400	6683.04			
	NCRA	0	0	0		*34.17557*	
	Brine	*1.1*	1667		9901.98	*50.63651*	
	Natural	*5.5*	100		2970	*15.18792*	
	533 Totals	**9.694**	**373.561**	**6683.04**	**12871.98**	***100***	**19555.02**

Appendix C. McPherson Outfall vs. Dry Turkey Creek Cl Concentration along with estimated stream flow (when NCRA is no longer discharging)



Appendix D. Little Arkansas River Stream Flow.