LOWER ARKANSAS BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit (AU): Lower Arkansas River – Hutchinson to Maize
Water Quality Impairment: Chloride

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Portion of Gar-Peace; Lower Portion of Cow (Hutchinson)

Counties: Reno and Sedgwick

HUC 8: 11030010, 11030011

HUC 11 11030010020, 11030011030

Ecoregion: Central Great Plains, Great Bend Sand Prairie (27c) and Wellington-McPherson Lowland (27d)

Drainage Area: 200 square miles between Maize and Hutchinson; 2900 square miles between Hutchinson and Nickerson, chiefly from Cow Creek drainage

Impaired Main Stem Segments:
11030010 (AU Station 536):part of Arkansas River (1)
11030010 (AU Stations 523 & 524):Arkansas River (3 & 4)

Tributaries:
11030010 (AU Station 659): Salt Creek (1) - impaired
11030010 (Unmonitored): Gar Creek (8)
11030011 (AU Station 522 & 287): Cow Creek (1755) - impaired

Designated Uses: Special Aquatic Life, Primary B Contact Recreation, Domestic Water Supply, Food Procurement, Ground Water Recharge, Irrigation, Livestock Watering, Industrial Water Supply for the Arkansas River; same for Cow Creek, except Expected Aquatic Life. Salt Creek designated for Expected Aquatic Life, Primary C Contact Recreation and Food Procurement

303(d) Listings:
2004 Lower Arkansas River Basin Streams
2002 Lower Arkansas River Basin Streams
1998 Table 1: Impaired streams impacted by non-point and point sources

Impaired Uses: Domestic Water Supply, Aquatic Life Support and Ground Water Recharge

Water Quality Standard: Domestic Water Supply: 250 mg/L at any point of domestic water supply diversion (K.A.R.28-16-28e(c)(3)(A))

Aquatic Life Support [Acute criterion]: 860 mg/l for (KAR 28-16-28e(c)(2)(D)(ii))

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the domestic water supply criteria listed in table 1a in subsection (d), at ambient flow, due to intrusion of mineralized groundwater, the existing water quality shall be maintained, and the newly established numeric criteria for domestic water supply shall be the background concentration, as defined in K.A.R. 28-16-28b(e). Background concentrations shall be established using the methods outlined in the ''Kansas implementation procedures: surface water quality standards,'' as defined in K.A.R. 28-16-28b(gg), available upon request from the department. (K.A.R. 28-16-28e(c)(3)(B) and (b)(9))

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of groundwater quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical or radiological contaminant or infectious microorganism in groundwater resulting from surface water infiltration or injection. (KAR 28-16-28e(c)(5)).

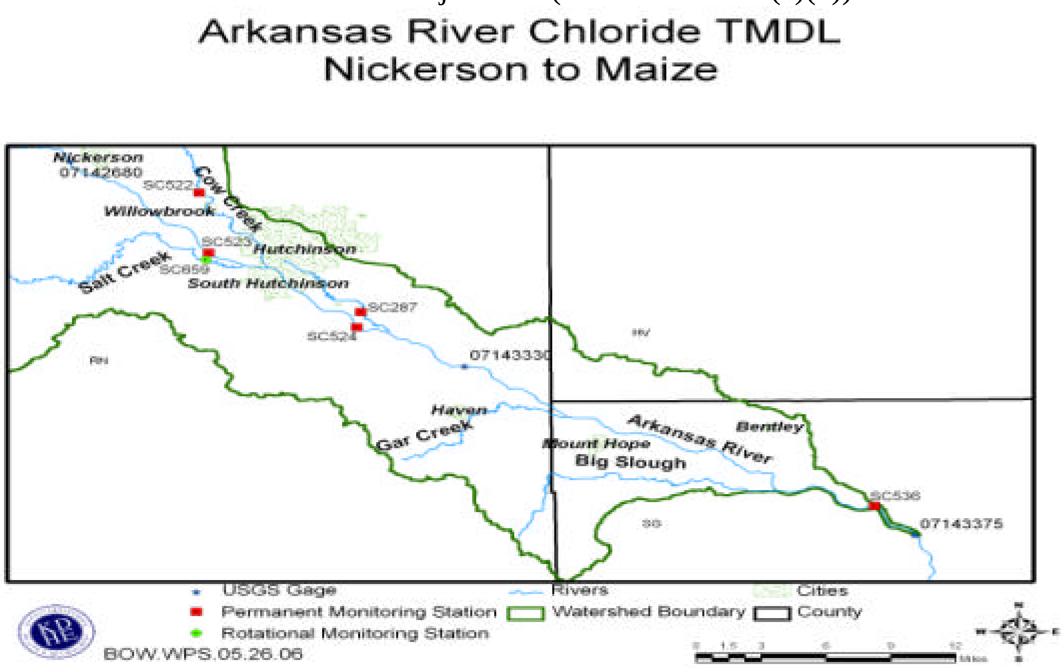

Figure 1. Map of Study Area

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

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

Table 1: Stream Flow and Water Quality Monitoring Sites in Hutchinson Vicinity

Station	Stream	Flow or Water Quality	Period of Record	Mean Flow for POR	Median Flow 1997-2006	Upper Decile Flow (90%)	Average Cl	Maximum Cl	# of Samples / # > 250 mg/l / # > 860 mg/l
07142680	Ark R – Nickerson	Flow	1997-2006	280 cfs	130 cfs	50 cfs	NA	NA	NA
SC 523	Ark R abv Hutchinson	Water Quality	1990-2006	NA	NA	NA	558 mg/l	1365 mg/l	95/86/10
SC 524	Ark R blw Hutchinson	Water Quality	1990-2006	NA	NA	NA	522 mg/l	1190 mg/l	96/84/5
07143330	Ark R - Hutchinson	Flow	1960-2006	520 cfs	250 cfs	110 cfs	NA	NA	NA
SC 536	Ark R near Maize	Water Quality	1990-2006	NA	NA	NA	476 mg/l	950 mg/l	95/82/2
07143375	Ark R near Maize	Flow	1987-2006	700 cfs	290 cfs	110 cfs	NA	NA	NA
SC 522	Cow Creek nr Willowbrook	Water Quality	1990-2006	NA	NA	NA	244 mg/l	470 mg/l	96/52/0
SC 287	Cow Creek blw Hutchinson	Water Quality	1985-2006	NA	NA	NA	402 mg/l	705 mg/l	144/131/0
SC 659	Salt Creek nr Hutchinson	Water Quality	1992,1996, 2000,2004	NA	NA	NA	1250 mg/l	1670 mg/l	22/21/20

Current Hydrology: The USGS flow data are summarized in Table1. The Arkansas River gains flow between Nickerson and Hutchinson, especially due to the inflow from Cow Creek above Hutchinson (Figure 2). The Arkansas River gains little flow between Hutchinson and Maize (Figure 2). During extended dry times and drought, there is a loss of water between Hutchinson and Maize, because of the regional ground water withdrawals in the Equus Beds Aquifer. The resulting cone of depression induces water from the river to be recharge the aquifer on its southern boundary. Figure 3 illustrates the most dramatic loss of water seen along the river, during the 1991-1992 drought. Because of the high chloride content of the river water, deterioration of the fresh water aquifer is a concern.

The closest gaging station on Cow Creek is at Lyons, considerably upstream of the TMDL area. Cow Creek is diverted directly to the Arkansas River immediately west of Hutchinson by a levee system. A small portion of flow goes through the gates of the flood control levee and flows along the original channel, through downtown (often underground) and re-emerges east of Hutchinson. The channel picks up flows from the

GVI ditch, running north and south and enters the Arkansas River prior to the Hutchinson gaging station.

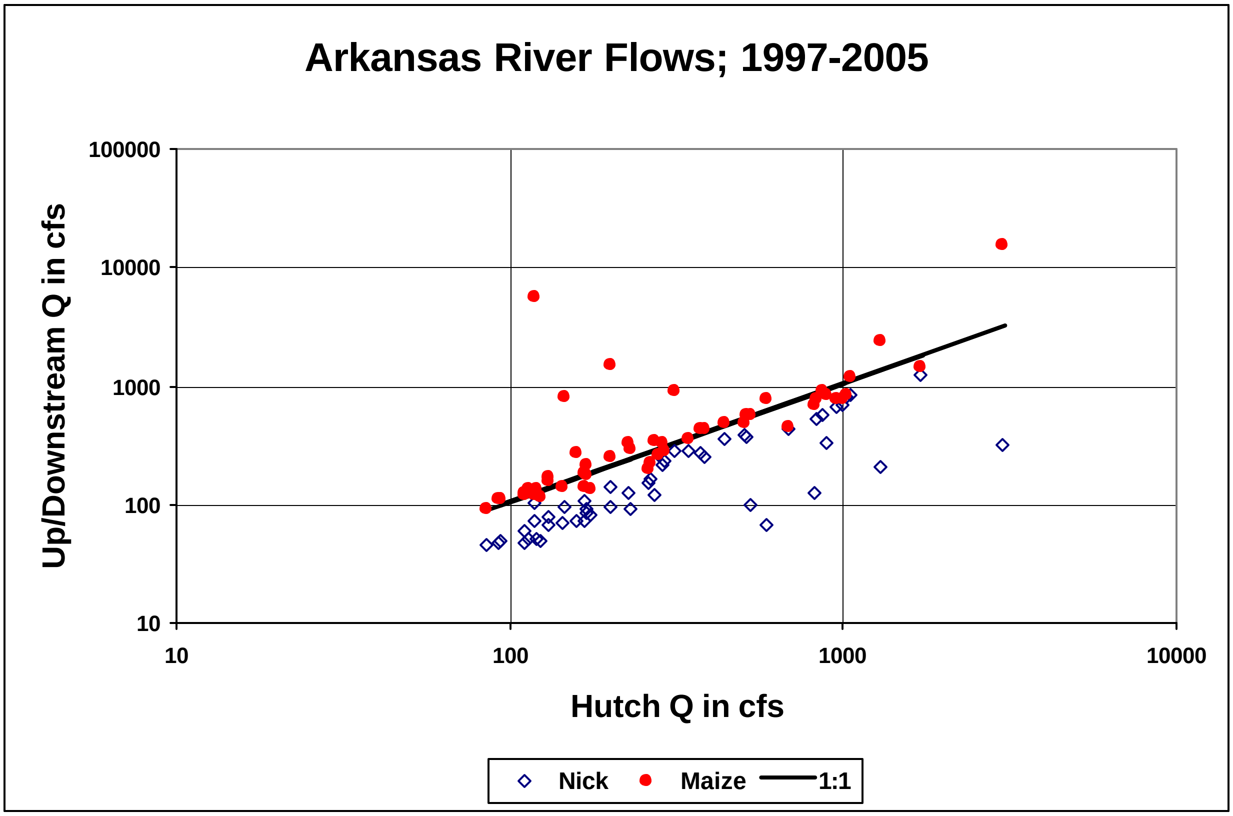

Figure 2. Flows along Arkansas River during samplings from 1997-2006

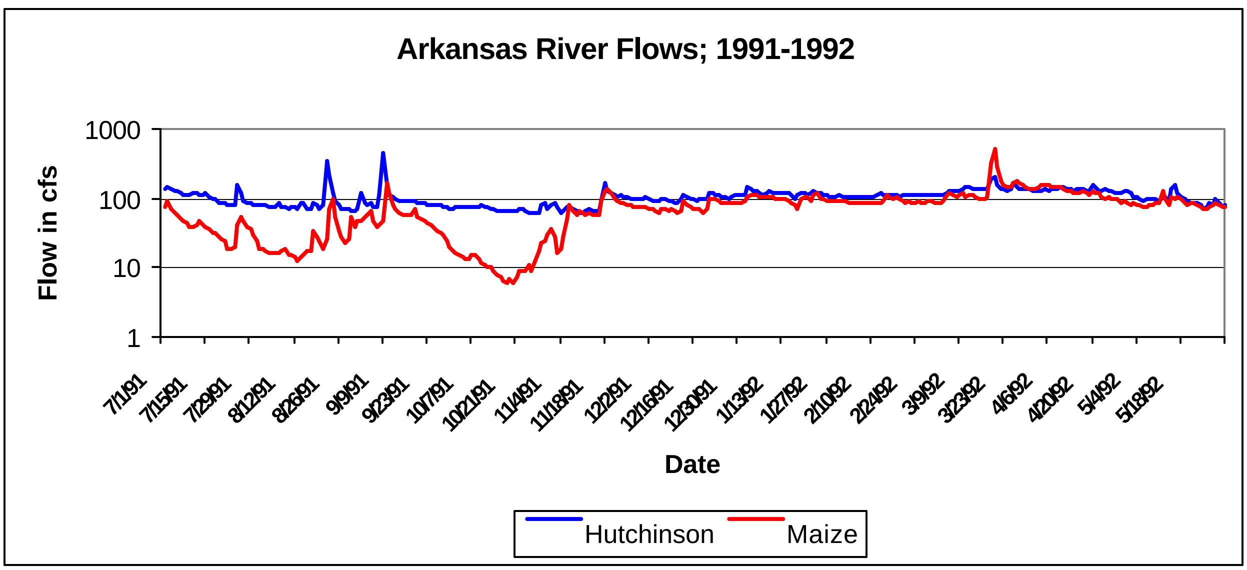

Figure 3. Flows along Arkansas River below Hutchinson during 1991-1992.

Current Water Quality: The KDHE monitoring station chloride data are summarized in Table 1. Chlorides in the Hutchinson vicinity remain high across the hydrologic spectrum, except at the highest flows resulting from overland runoff (Figure 4). Figure 4 also indicates that chloride conditions entering the Hutchinson area are often higher than those seen downstream from the city. Sample data for each sampling site were categorized into three seasons: Spring (April-July), Summer-Fall (August-October), and Winter (November-March). Table 2 shows the seasonal variability above and below Hutchinson. Miscellaneous samples taken in the past by the USGS at gaging stations on area streams are consistent with the values taken by KDHE sampling.

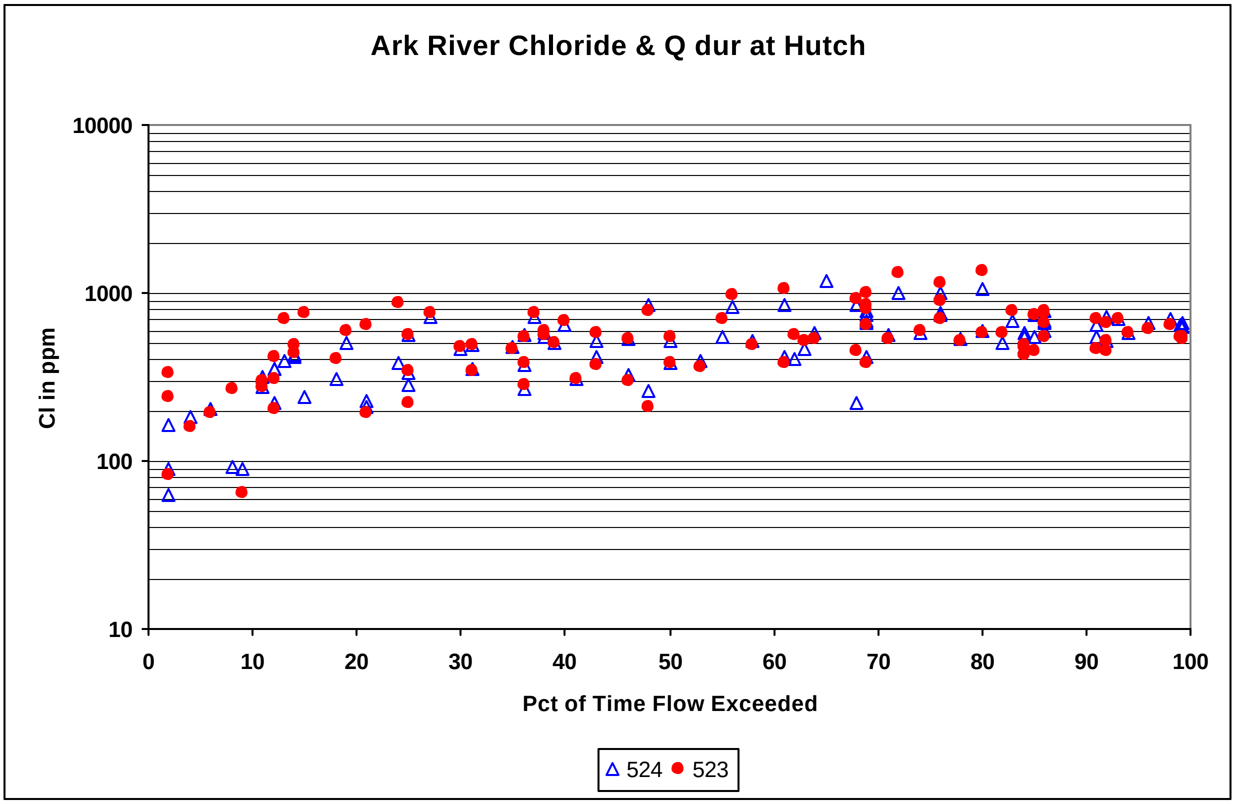

Figure 4. Arkansas River Chloride Concentrations at various flow duration at Hutchinson

Table 2. Seasonal Chloride Concentration on Arkansas River and Cow Creek

KDHE Sites	Winter	Spring	Summer
SC523 (Ark R near Nickerson)	632 mg/l	530 mg/l	440 mg/l
SC524 (Ark R below Hutchinson)	600 mg/l	490 mg/l	410 mg/l
SC536 (Ark R. at Maize)	530 mg/l	450 mg/l	400 mg/l
SC522 (Cow Crk at Willowbrook)	280 mg/l	220 mg/l	210 mg/l
SC287 (Cow Crk nr Hutchinson	440 mg/l	360 mg/l	390 mg/l

Winter tends to have the higher chloride levels because that period is dominated by ground water, much of which is high in chloride because of the underlying Permian deposits in the area. Spring and Summer have episodes of runoff in the region and streamflow generated from upstream areas.

Salt Creek is an outlet of the upwelling saltwater from the Permian deposits south of the Arkansas River. The high chloride levels seen on Salt Creek are consistent over the four years of sampling. There is a strong seasonal pattern of chloride on Salt Creek, averaging 1365 mg/l in Spring and 1280 mg/l in Winter, but rise to 1700 mg/l in Summer. It is probable that regional irrigation depletes any flow of freshwater from Salt Creek, causing the increase in chlorides. Winter probably represents the condition that minimizes the anthropogenic influence of irrigation depletion. Hence, winter averages will be used to establish background concentrations.

Stations 523 and 522 will establish the background levels desired to be maintained below Hutchinson after the input of point source. There is no significant difference among the three stations along the Arkansas River (Figure 5). The only conditions that consistently had an increase in chloride in the downstream direction were extreme drought such as seen in 1991-1992. All other flow conditions had equivalent or greater chloride at Station 523 than Station 524. There were comparable concentrations at Station 536 and 524, despite the loss of flow below Hutchinson. The lack of increase in chloride concentration in the depleted flows at 536 indicates that the loss of water is infiltration to the surrounding aquifer, rather than evaporation.

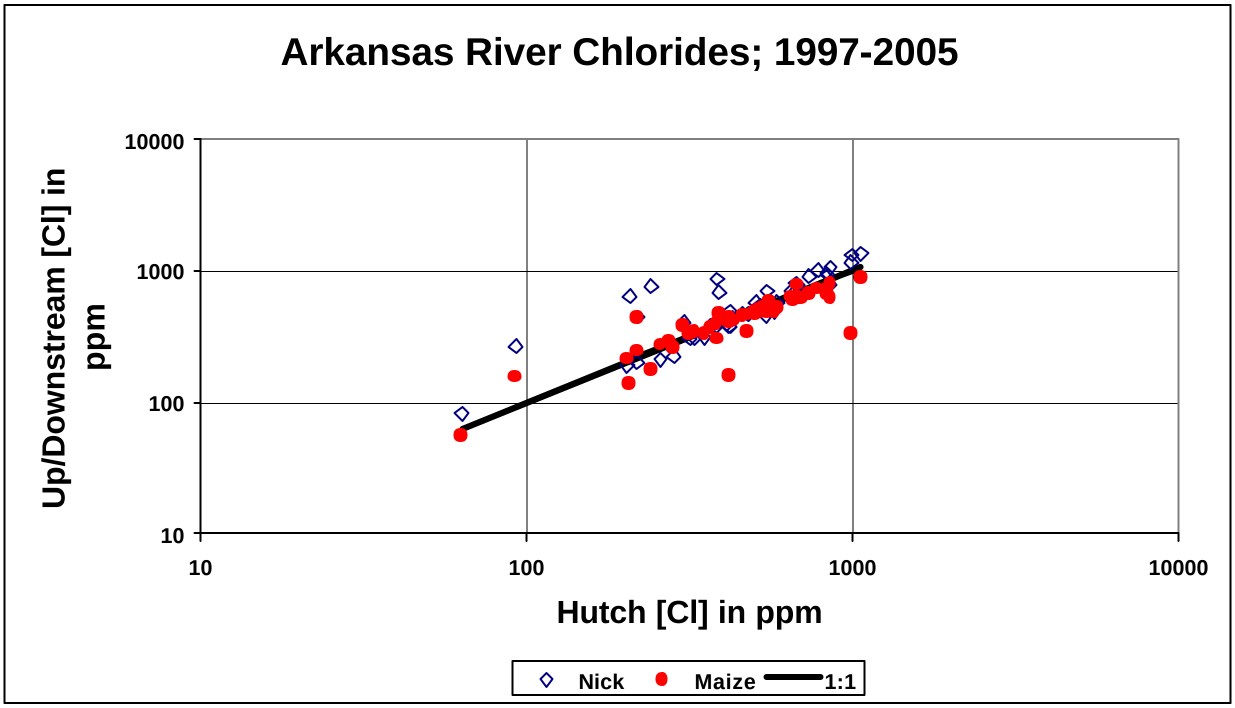

Figure 5. Chloride concentrations on Arkansas River at the three stations near Hutchinson.

While the concentrations between Stations 523, 524 and 536 are not significantly different, the associated in-stream loads of chloride are different between 523 and 524 (Figure 6). This is chiefly because of the inflow of water to the river from ground water, tributaries such as Salt Creek and Cow Creek and discharges by point sources. Generally contributions from the southern alluvium are high in chloride, while the northern contributions are less saline. However, the lack of any substantial increase or decrease in chloride between the two stations indicates that the cumulative impact of these contributions is to mirror the background concentrations of the river above Hutchinson. Therefore, the load increase below Hutchinson is reflective of increased flows (Figure 2), as opposed to cumulative increased chloride. Loads at Maize are similar to those below Hutchinson, indicating the typical lack of additional flow or chloride occurring along the lower reach of the river.

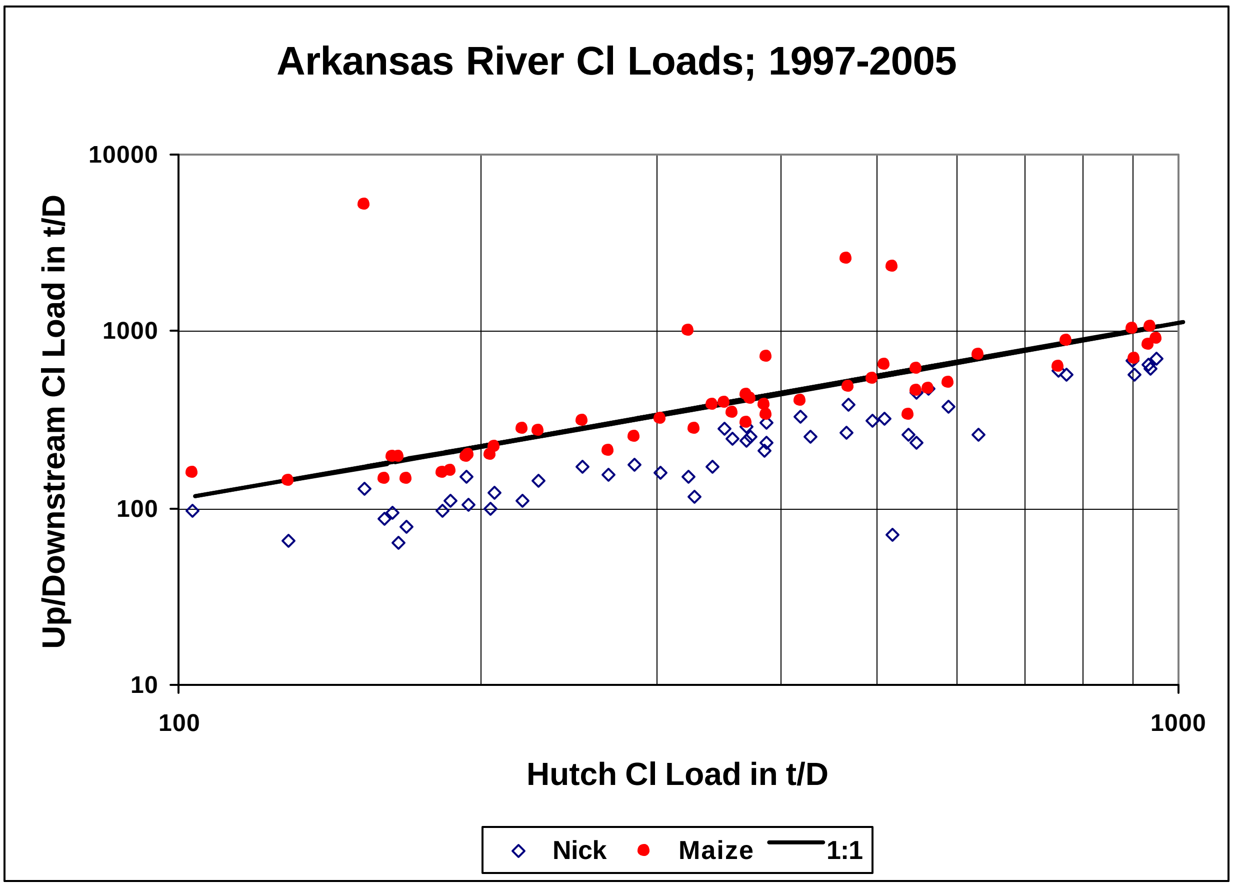

Figure 6. Chloride loads along Arkansas River, 1997-2005.

Because of the similar chloride concentrations among the Arkansas River stations, the increase in loading on the river above and below Hutchinson is a function of the increase in flow between the two stations. This would seem to indicate that the loadings entering the river are consistent with the background levels seen above Hutchinson. Therefore, the background concentration established at Station 523 will serve as the expected average concentration at Station 524 after the cumulative point and non-point source loadings enter the river.

Conversely, there is a consistent and significant increase in chloride on Cow Creek below Hutchinson (Figure 7). The influence of point source discharges into Cow Creek or the GVI ditch intersecting lower Cow Creek is the likely source of the increase. Chlorides on Cow Creek are substantially lower than those seen on the Arkansas River. Background levels will be defined by the typical chloride concentrations seen on the upstream reach of Cow Creek at Station 522.

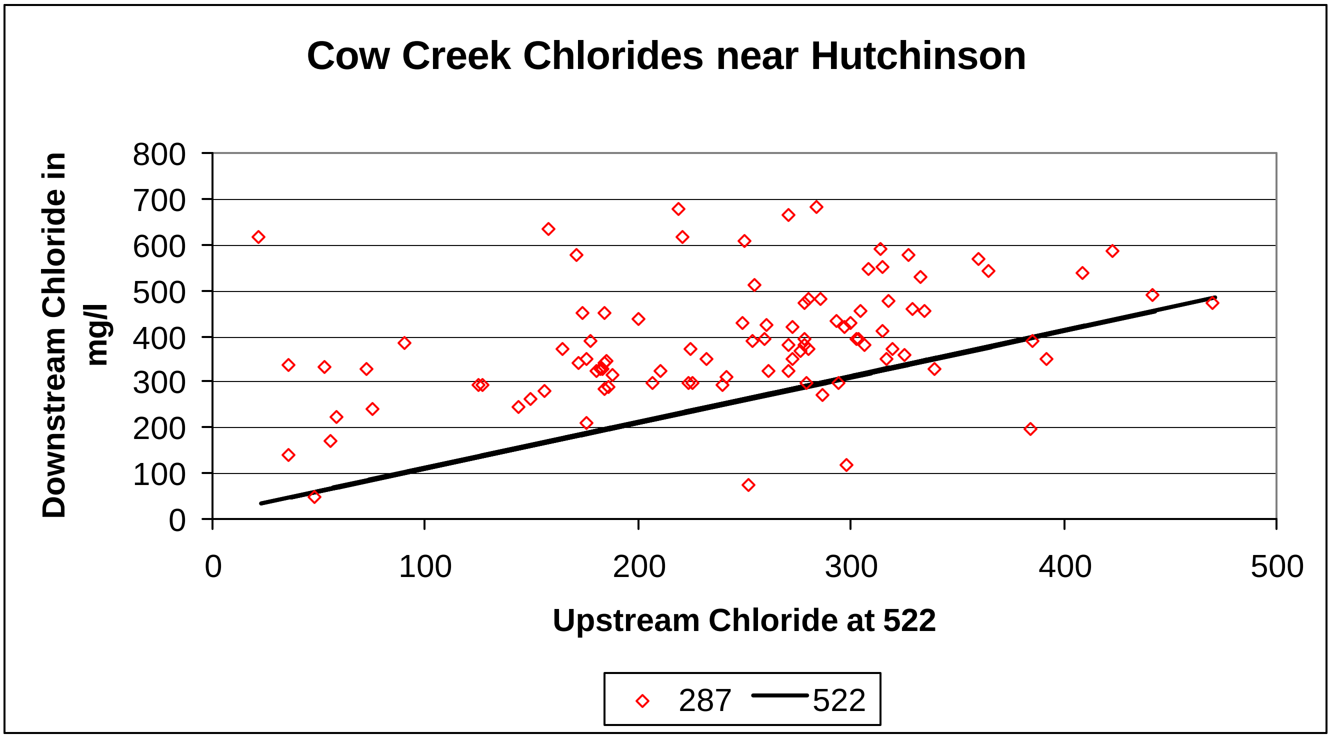

Figure 7. Chloride concentrations on Cow Creek above and below Hutchinson.

Desired Endpoints of Water Quality (Implied Load Capacity) at Sites 523, 524 & 536 on the Arkansas River, Sites 522 and 287 on Cow Creek and Site 659 on Salt Creek, over 2006 – 2016

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Drinking Water Use. This TMDL will, however, be staged. The current criterion of 250 mg/L of chloride is used to establish the initial TMDL. Since this criterion is not attainable due to the relatively high natural contributions of chloride from the surrounding geology, an alternative endpoint is needed at these sites. Kansas Water Quality Standards and their Implementation Procedures for Surface Water allow for a numerical criterion based on natural background concentrations to be established, particularly from ambient samples taken at flows less than median flows. Stage II end points have been set at the background concentrations at Sites 522 and 536 by chloride TMDLs pertaining to those reaches of Cow Creek and the Arkansas River, respectively. These endpoints are 300 mg/l at Site 522 and 620 mg/l at Site 536.

Stage II endpoints at Sites 523 and 524 are based on the winter samples. While the other endpoints use the winter low flow averages for chloride, the background concentration for the Arkansas River will use all the winter samples. This is because the winter average of 650 mg/l at Site 523 is consistent with the Stage II endpoint of 620 mg/l at Site 536, whereas, the winter low flow average of 750 mg/l at Site 523 might allow excessive loading to the river, reducing the probability of attainment for lower reaches of the river. Furthermore, the average flow duration percentage for the winter samples was 61%, compared to 41% for spring and 55% for summer. Hence, the winter samples were collected during relatively low flow conditions on the river and their use is consistent with the Implementation Procedures.

The Stage II endpoint for Site 287 near the mouth of Cow Creek will be 300 mg/l, reflecting the background concentration recommended for Cow Creek at Willowbrook. The Stage II endpoint for Salt Creek will be 1300 mg/l, reflecting the winter concentrations of chloride on the creek, when there is maximum opportunity for pockets of freshwater to discharge to the creek. The freshwater is typically diverted during irrigation season for small scale irrigation and the creek chloride levels rise during the summer. Specific stream background concentrations to supplant the existing criterion will be established through the procedures for revising the State Water Quality Standards on a triennial basis.

Seasonal variation has been incorporated in this TMDL through the documentation of seasonal patterns of elevated chloride levels, especially during periods of low flows, extended drought and wintertime conditions. 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 achieved.

3. SOURCE INVENTORY AND ASSESSMENT

Geology: The Arkansas River valley in the vicinity of Hutchinson is underlain by geologic formations from the Permian Era, including the Hutchinson Salt Member (Figure 8). Hydraulic head differentials between the Permian formations and the overlying Great Bend Prairie Aquifer upwells high chloride water into the fresher waters of the unconsolidated deposits at the surface. The resulting saltwater discharges to streams, predominantly south of the Arkansas River from the confluence of Rattlesnake Creek to Wichita. Rattlesnake Creek, Peace Creek, Salt Creek and the mainstem of the Arkansas River have high levels of chlorides. The Arkansas River chloride concentrations are diluted, in part by freshwater discharges, principally from the northern drainages to the river. As those drainages go dry, chloride levels measured at Station 523 rise considerably, sometimes matching levels seen in the southern tributaries.

Chloride along Cow Creek is chiefly generated in upstream reaches at and above Lyons. These chlorides are the subject of a separate TMDL examining the chloride loading upstream of Site 522. Substantial freshwater inflows from the western fringe of the Equus Beds Aquifer dilutes chloride levels in transit from Lyons to Willowbrook and Site 522. Flows on Cow Creek downstream of Willowbrook are split three ways before entering the Arkansas River: immediately flowing down the diversion works west of Hutchinson; through the Harsha canal in the west end of Hutchinson; and through downtown along the original channel east of the city. The latter reach is the sampled waters of Site 287 and the subject of this TMDL. Geologic interaction with Cow Creek is modest because of the shallow depth of penetration into the surrounding alluvial aquifer by the creek. The highest chlorides reside with the deepest ground waters on either side of the Arkansas River. Hence, Cow Creek flows lightly through Hutchinson and maintains chloride levels reflective of those seen at Willowbrook.

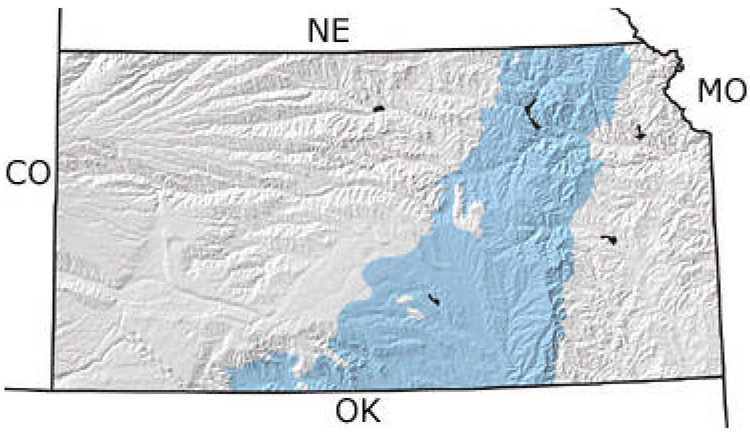

Figure 8. The Permian Formation in Kansas

Oil and Gas Field Brines

Analysis by KGS indicates little influence by oil-field brines along the Arkansas River. Mixing curves of chloride and bromide/chloride and sulfate/chloride ratios indicate the river water represents a mix of freshwater with the Permian ground water and its high chloride content. The exception to this is at Station 522 on Cow Creek where there is a signal of oil-field brines, attributed to historic upstream energy extraction activities on either side of Lyons. These brines are expected to flush out of the system at a slow rate, assumed by the Cow Creek Chloride TMDL to be about 1% per year.

Maps of historic oil and gas fields (Figure 9) show little area of concern along the stream reaches covered by this TMDL. There have been pan brines associated with legacy evaporation of salt water for salt extraction in the Hutchinson area. Brines leaving these areas do so at a slow rate of discharge that may have some influence on local reaches of the stream, but are generally masked by the overall contributions of the regional ground water to the river.

Irrigation

Irrigation is almost exclusively from ground water because of the improved reliability and slightly better quality. Irrigation typically comes from shallow wells diverting freshwater lens off the tops of underlying saline water. There are a number of irrigation wells along the Arkansas River valley (Figure 10), but they are confined to the alluvial deposits or the Equus Beds Aquifer. The northern areas tend to support more irrigation than those south of the river. The influence of the freshwater supplies of the Equus Beds Aquifer can be seen on the eastern edge of Reno County and Harvey and Sedgwick Counties. Figure 11 shows a schematic of the 2004 irrigation water use in the townships and ranges intersected by the Arkansas River. Small values in the vicinity of Hutchinson probably reflect land use more than water quality. Irrigation return flows are not likely to occur nor contribute chloride to the streams. Depletion by irrigation consumptive use, however, may cause a general rise in chlorides because of the reduction of freshwater discharged to the streams.

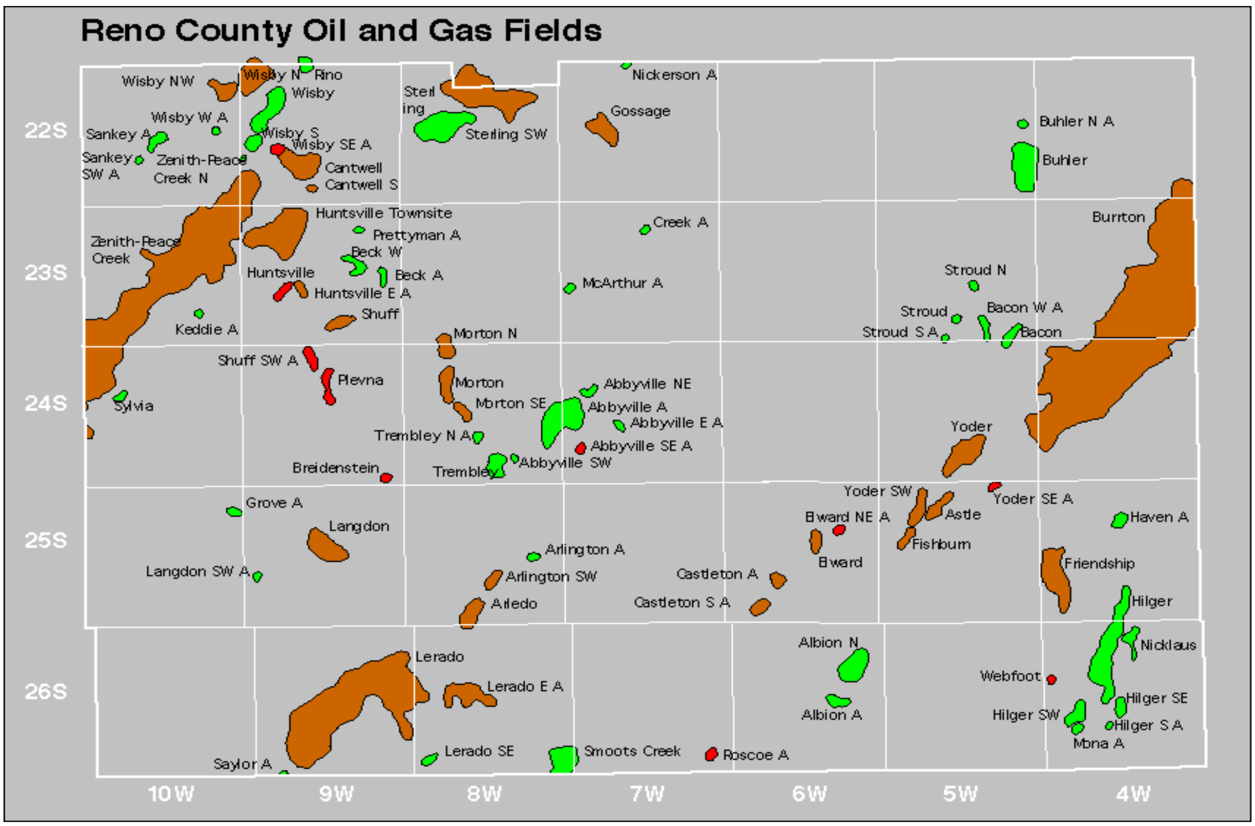

Figure 9. Historic Oil and Gas Fields in Reno County and Arkansas River Valley.
The river runs from the Nickerson area (T22S;R7W) to the Haven area (T25S; R4W).

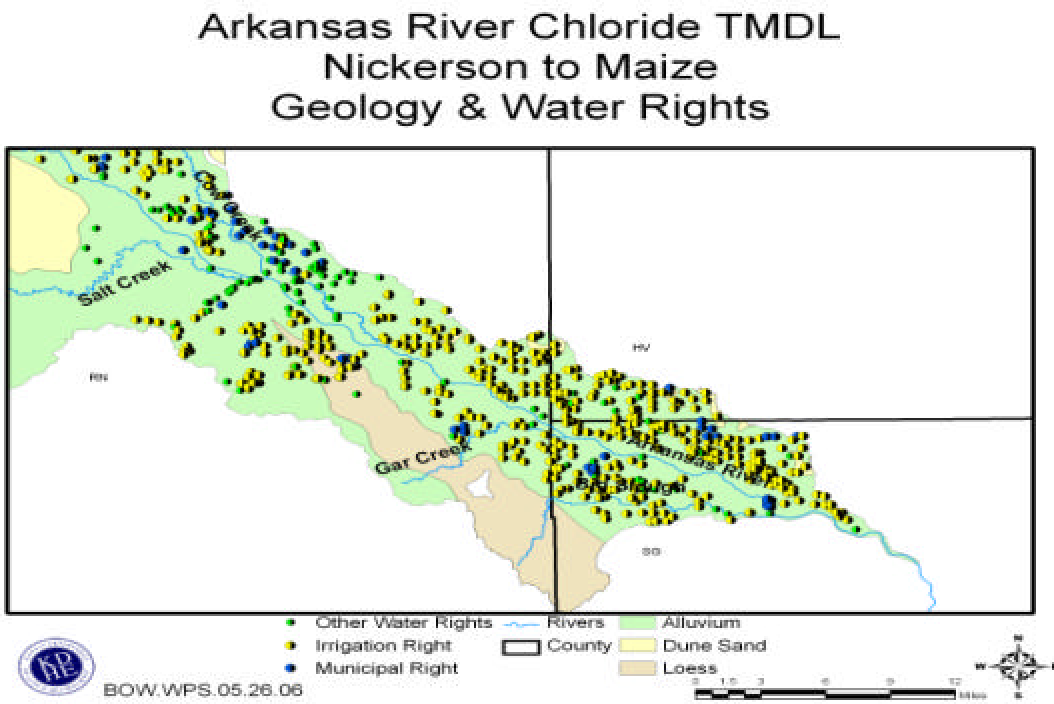

Figure 10. Irrigation, Municipal and Other Wells within TMDL area.

Ranges → / Townships ↓	8	7	6	5	4	3
22	410 af	2715 af	1464 af	182 af	2820 af	
23	0 af	131 af	489 af	677 af	825 af	
24			2657 af	3741 af	7650 af	9100 af
25					1870 af	8200 af

Arkansas R.

Salt C.

Cow C.

Figure 11. 2004 Irrigation Water Use along Arkansas River near Hutchinson

NPDES:
There are three wastewater treatment facilities that discharge flow and chloride into the Arkansas River and two facilities principally discharging to Cow Creek below Hutchinson (Figure 12). There also are a number of small dischargers to the streams that are unlikely to cause any influence on stream water quality. The main dischargers are listed in Table 3 and the small dischargers are in Table 4. The main discharger permits expire in 2007 or 2008.

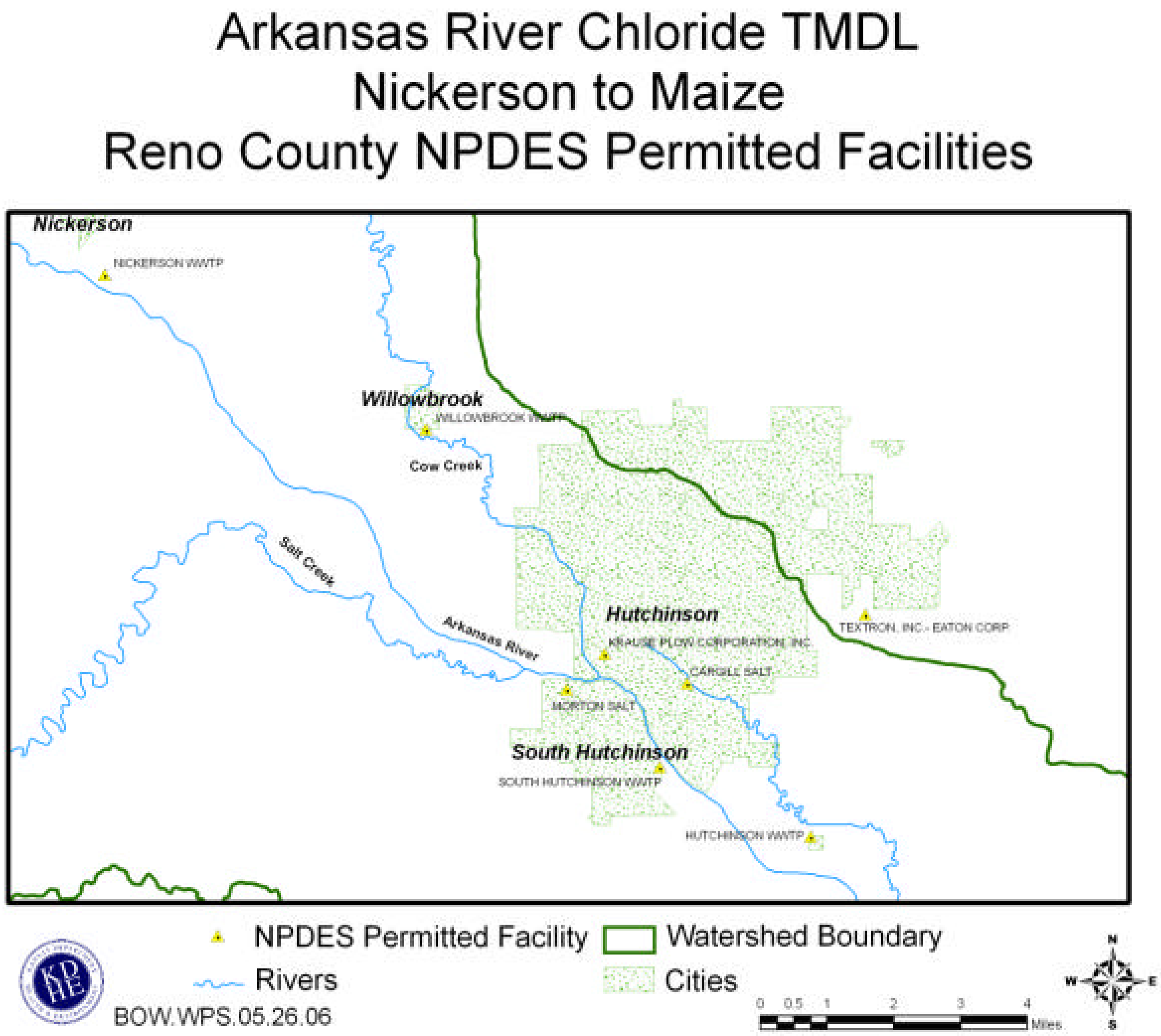

Figure 12. NPDES Facilities discharging to the Arkansas River or Cow Creek

Table 3. High-Impact Wastewater Treatment Facilities

KS #	NPDES #	Facility Name	Receiving Stream (main stem)	Design Flow (MGD)	Ave Flow (MGD)	Ave Cl (mg/L)	Current Load (T/d)	WLA (T/d)
M-AR49-IO01	KS0036188	City of Hutchinson	Arkansas River	8.3	4.7	375	7.4	13
M-AR82-OO02	KS0095711	City of South Hutchinson	Arkansas River	2.0	0.65	740	2.0	6.3
I-AR82-PO01	KS0000345	Morton Salt	Arkansas River	5.55	4.6	1050	20	23
I-AR49-PO08	KS0119733	Cargill Salt	Cow Creek	5.0	3.9	510	8.3	6.3
I-AR49-PO09	KS0088412	Textron	Cow Creek via GVI ditch	2.9	1.4	575	3.4	3.6

Table 4. Low-Impact Wastewater Treatment Facilities

KS #	NPDES #	Facility Name	Receiving Stream (main stem)	Design Flow (MGD)	Actual Flow (MGD)	Ave Cl (mg/L)	WLA (T/d)
I-AR49-CO10	KS0089320	Krause Plow	Cow Creek via GVI ditch.	0.034	0.034	410	0.06
I-AR94-CO04	KS0033294	Sonoco Products	Cow Creek via GVI ditch	0.475	0.4	105	0.21
I-AR49-CO78	KS0091065	Trinity Methodist Church	Cow Creek	0.028	0.02	220	0.03
I-AR49-CO21	KS0095575	Trinity High School	Arkansas River	0.23	0.230	50	0.05
M-AR95-OO02	KS0093050	City of Willowbrook	Cow Creek	0.012	0	610	0.03
M-AR66-OO01	KS0031097	City of Nickerson	Arkansas River	0.155	0.115	440	0.28
M-AR02-OO01	KS0051641	City of Alden	Arkansas River	0.0286	NA	NA	0.05
M-AR41-OO01	KS0116815	City of Haven	Gar Creek	0.1854	NA	NA	0.31
I-AR49-PR01	KSG460038	Concrete Enterprises	Arkansas River	0	0	NA	0.0
I-AR82-PR01	KSG460043	Mid-America Redi-Mix	Arkansas River	0.00002	0	NA	0.0

NA – data not availble

Muncipalities: Chlorides in municipal effluent typically arises from two sources: the source water supply and discharges from residential water softeners. Source water in the TMDL area ranges widely, with Hutchinson finding 100-260 mg/l chloride in their well water. South Hutchinson recorded 70-420 mg/l in 2006, Nickerson: 240-350 mg/l and Haven: 50-310 mg/l. Water softeners exchange sodium for calcium and magnesium in raw water, liberating chloride which is discharged to the city sewer system. Effluent receiving a substantial amount of water softener discharge typically approaches 400 mg/l in chloride in South-Central Kansas.

Among the municipalities, only Hutchinson has a substantial discharge to the Arkansas River, and its effluent is consistently below the ambient concentration of chloride seen in the river, creating a dilution effect. South Hutchinson, has a meat processing plant that discharges into the city system and raises the chloride content substantially (624-850 mg/l over 2004-2006). The volume of effluent entering the river, however, has been quite low. At current conditions, South Hutchinson could potentially raise the chloride in the Arkansas River 2 mg/l at flows of 50 cfs and background concentrations. At design flow, the increase would be potentially 6 mg/l. These increases are not distinguishable against the daily variability of chloride levels in the Arkansas River.

Morton Salt: Wastewater from Morton consists of non-contact cooling water with a small amount of dilute condensate water. The source of the cooling water is deep ground water to take advantage of its cool temperature, but those formations also have the typically high chloride levels. This ground water flows to the southeast toward the river and would eventually discharge to the river at some location downstream of Hutchinson. The effect of Morton's operation is to shortcut the water's transit through the alluvium and deliver the water to the surface quicker and farther upstream than the natural discharge. Figure 13 indicates the similar nature between Morton's effluent chloride content with the supply source from the ground water. Morton monitors above and below its outfall to provide data on the impact of its discharge. Figure 14 displays the relationship between effluent chloride concentration and stream chloride levels. A relationship appears to be lacking and more notable is the lack of separation between the upstream and downstream sampling data.

Figure 15 examines the upstream/downstream relationship and indicates the downstream conditions are not significantly different from those seen upstream. In fact, the downstream conditions are nominally lower than those seen upstream. For upstream concentrations below 650 mg/l, some increase has been noted at the downstream site, although, the loadings from Morton corresponding to these periods is only 3-6%, suggesting other factors create the downstream increase. The stream chloride levels appear to be lower than that of the ground water in the vicinity (Figure 16). Finally, the change in river load at the downstream site is only partially attributed to Morton loadings (Figure 17). Roughly 20% or less of the additional load is tied to Morton, suggesting that most of the load arrives through the contributions of ground water flow and chloride along the river.

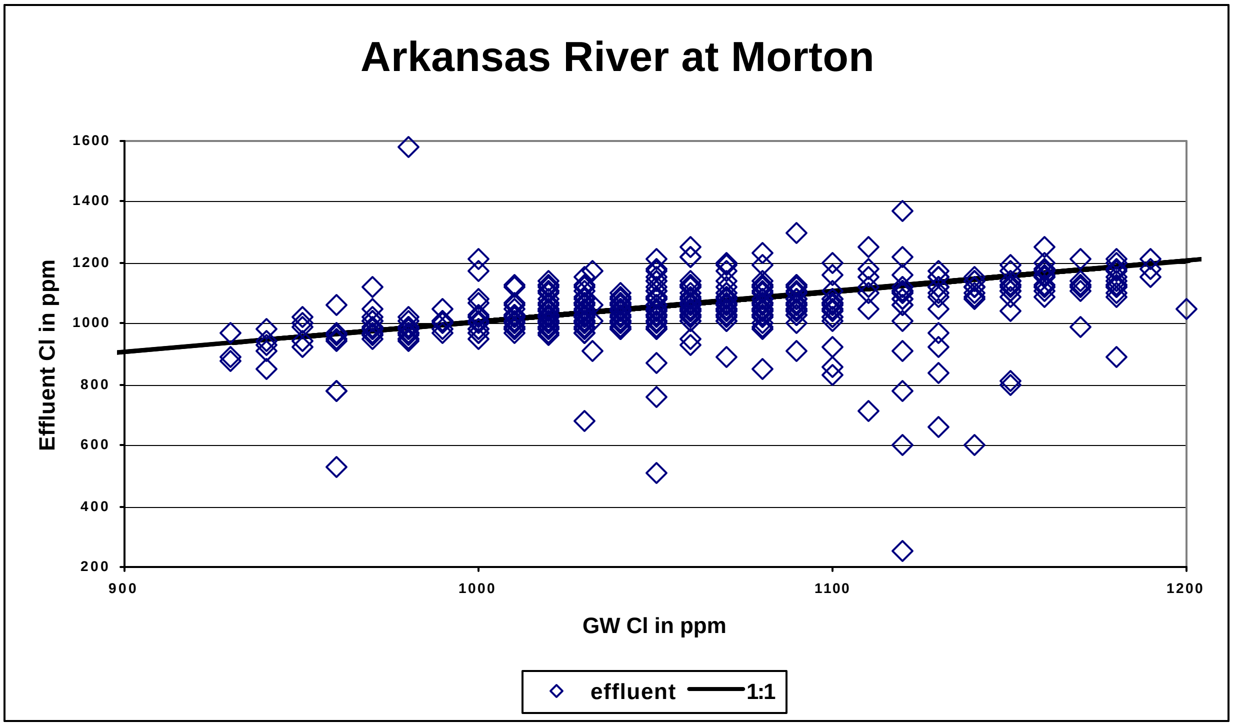

Figure 13. Relationship between Chlorides in Morton's Effluent and its Ground Water Supply.

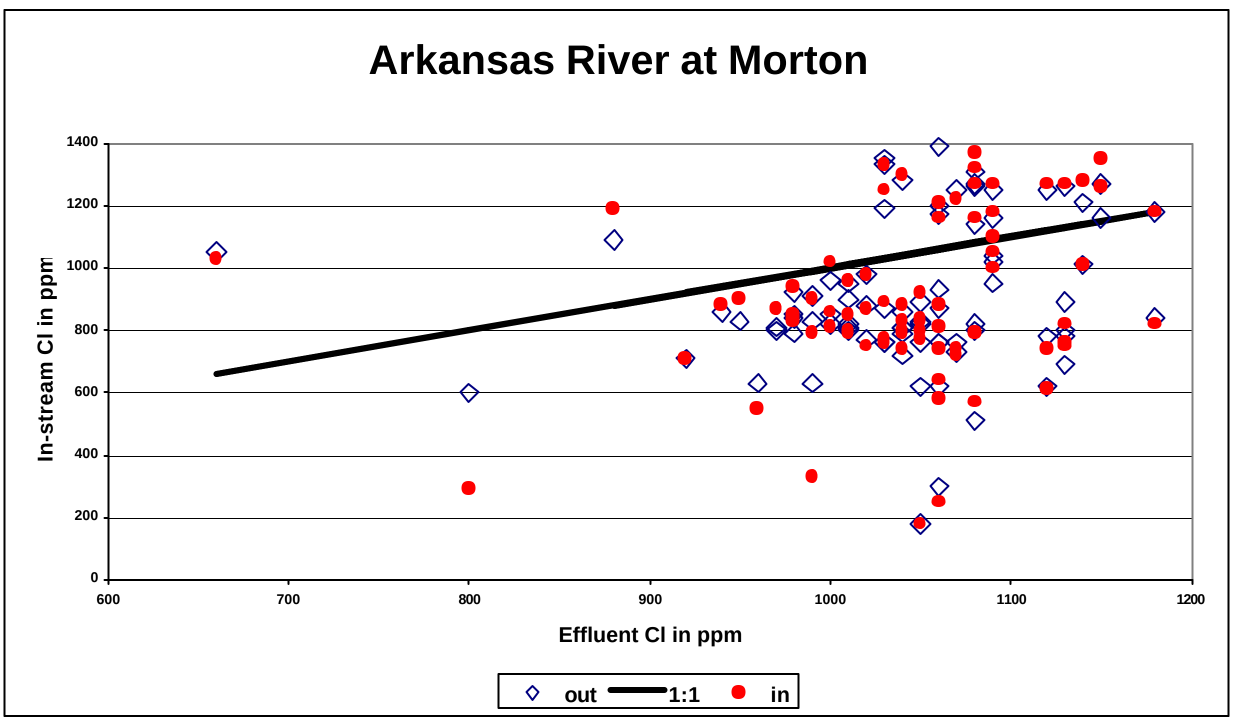

Figure 14. Morton Effluent Impact on Arkansas River Chlorides (out=downstream; in=upstream of outfall)

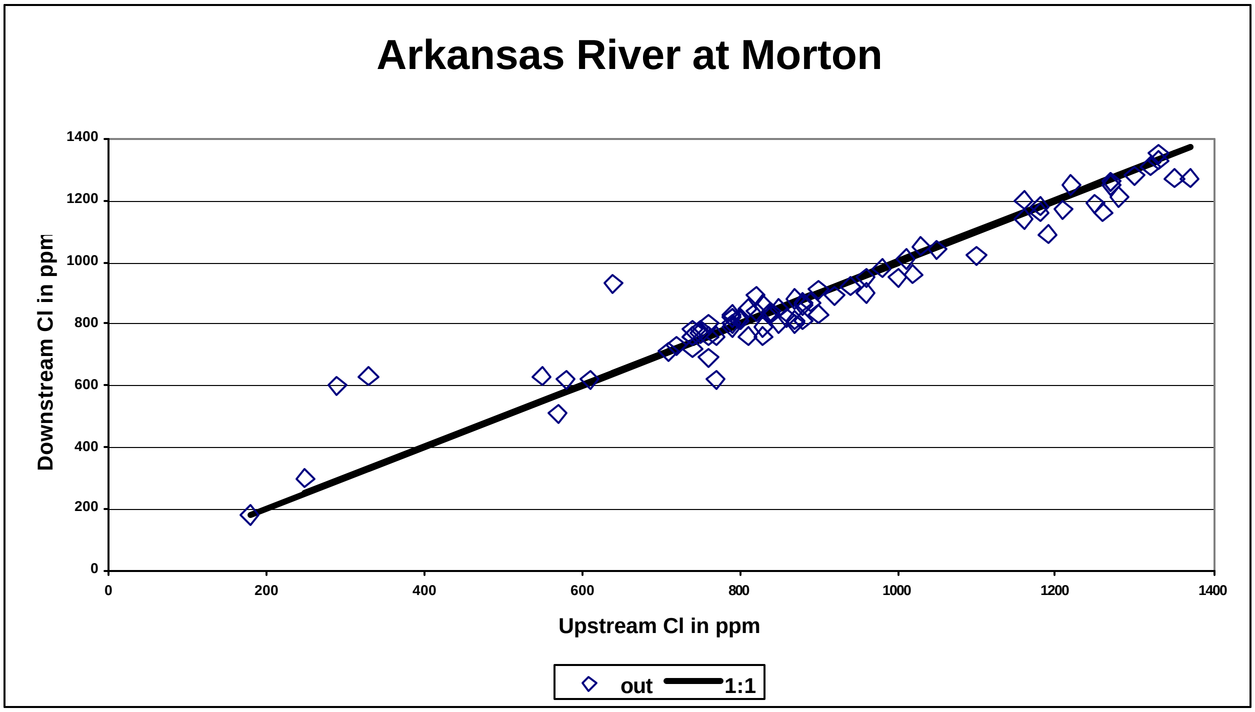

Figure 15. Arkansas River Chlorides Above and Below the Morton Outfall

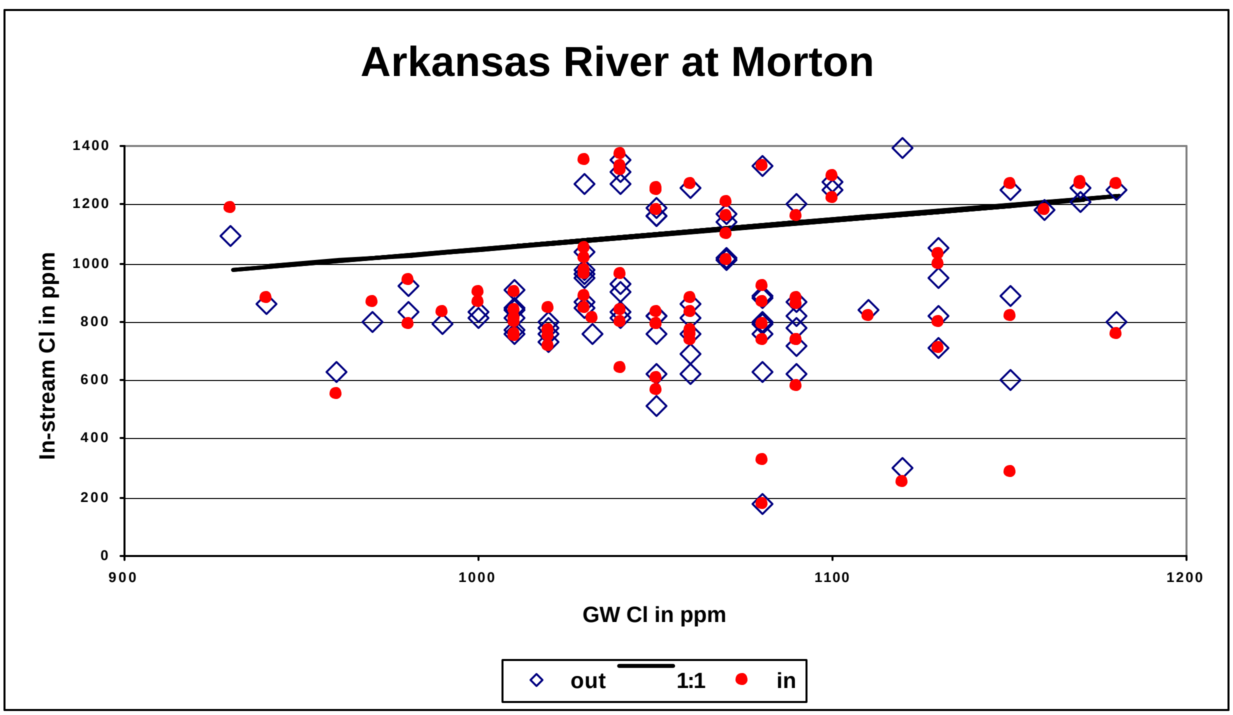

Figure 16. Comparison of Arkansas River Chloride to Surrounding Ground Water Chlorides

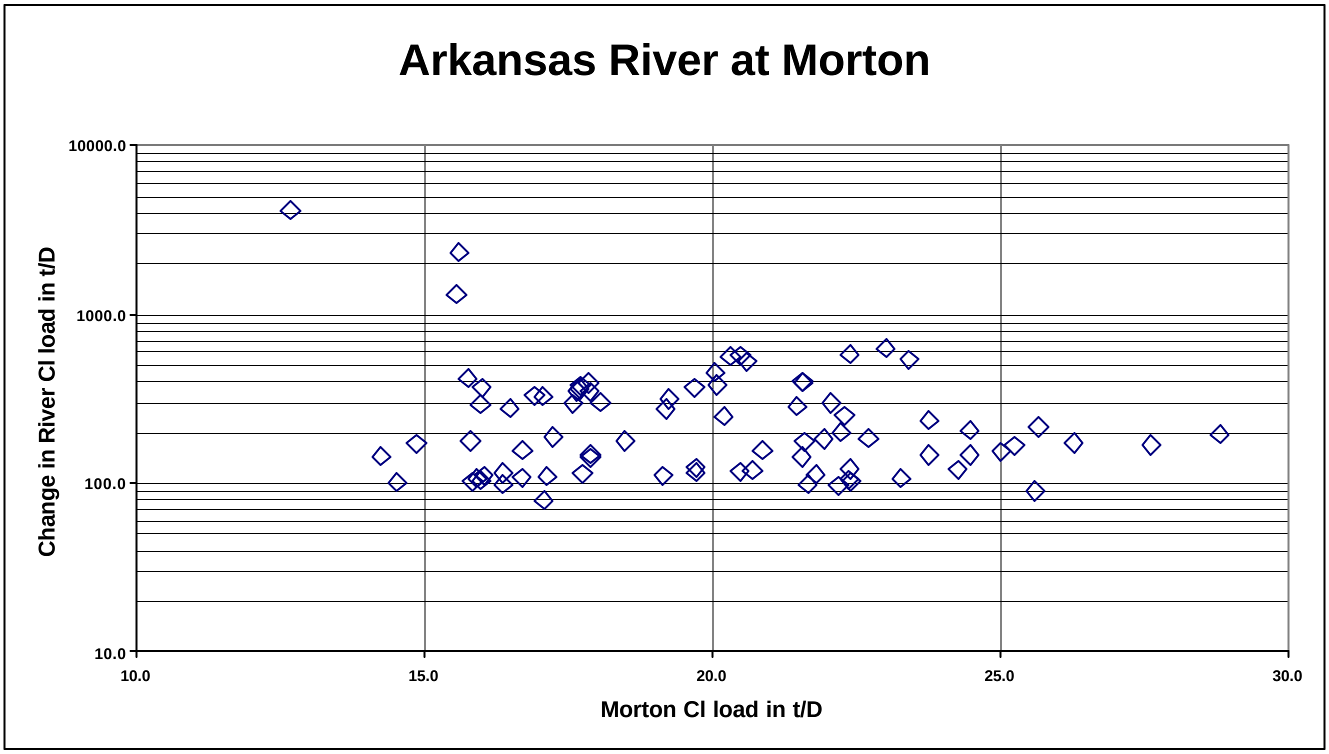

Figure 17. Gain in Chloride Load on the Arkansas River below the Morton Outfall

In 2002, KGS sampled chlorides along the longitudinal profile of the Arkansas River around Hutchinson (Figures 18-19). In both cases, there was a definite increase in chloride along the south bank where Morton discharges, along with the more saline ground water. However, within a short distance, there was no distinction in chloride levels from those seen above Hutchinson. Mixing of the relative fresh northern sources with the more saline south sources obscures the net impact of individual discharges. These data tend to corroborate the persistent lack of significant difference between Stations 523 and 524 and support the notion that the predominant source of chlorides is the natural contribution from the underlying ground water.

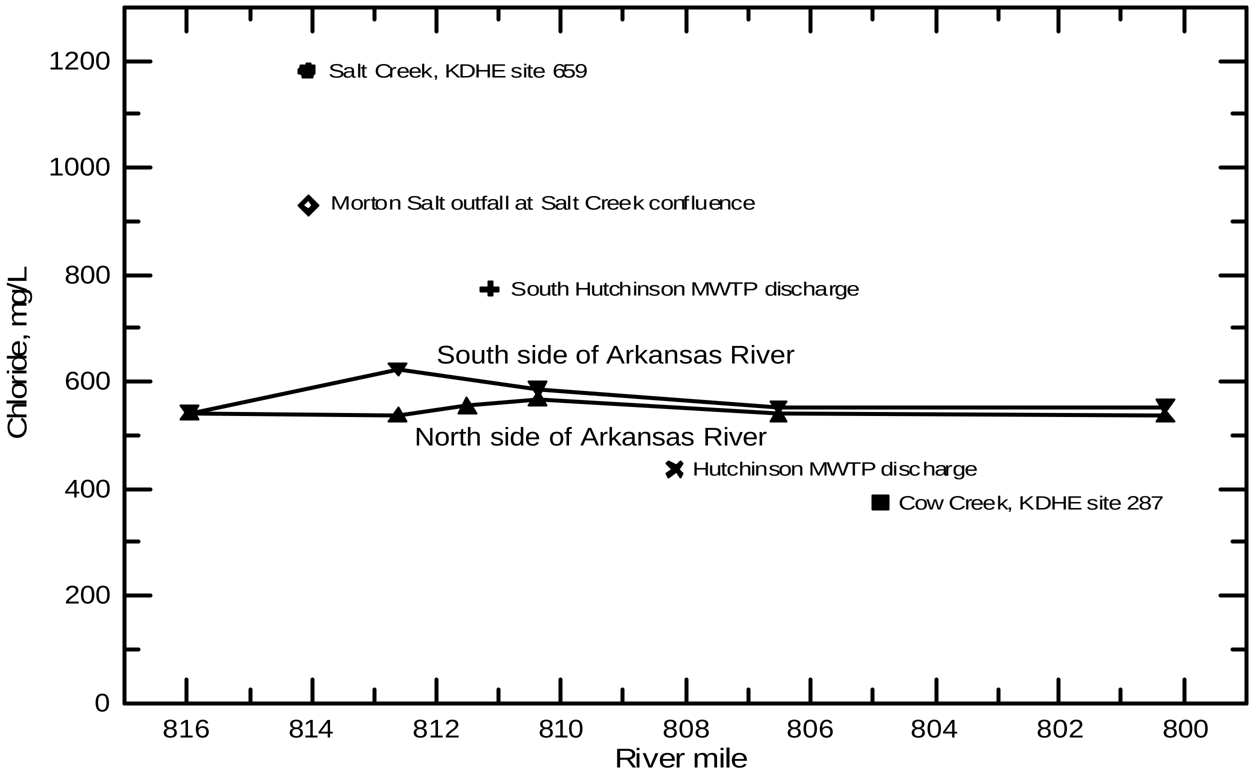

Figure 18. Chloride Profile Along Arkansas River near Hutchinson on March 12, 2002

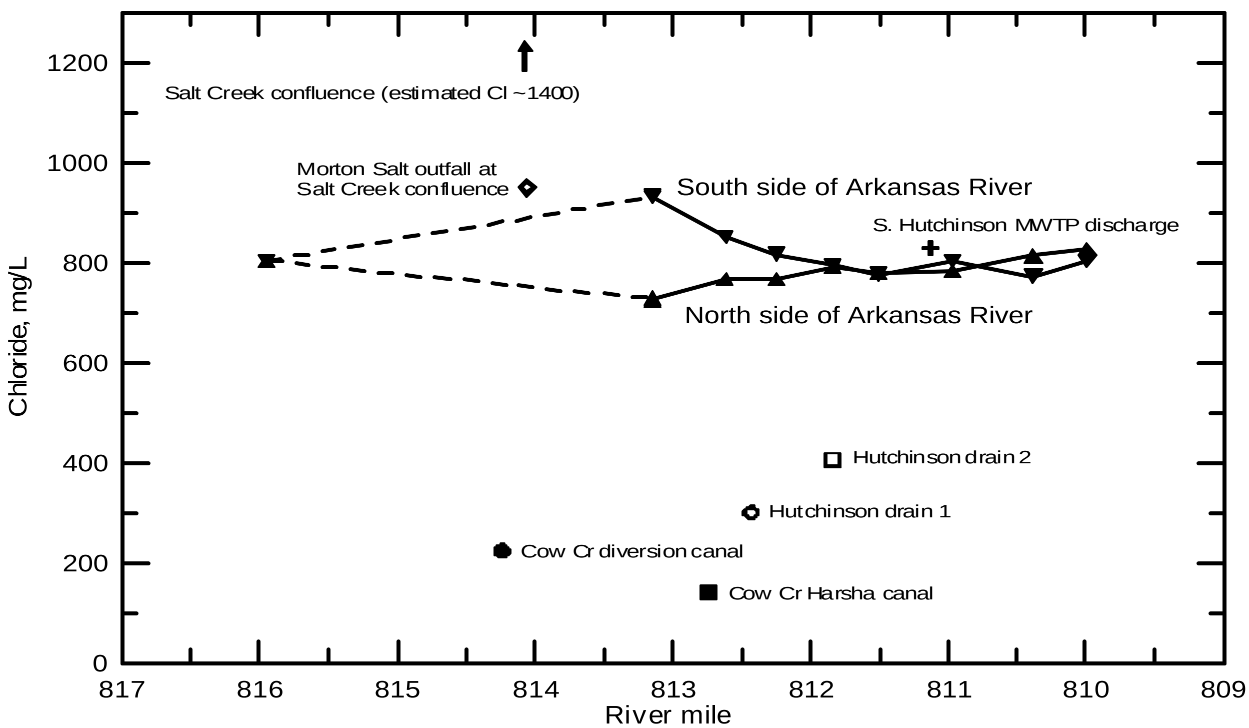

Figure 19. Chloride Profiles along Arkansas River near Hutchinson on July 15, 2002

Cargill and Textron: Cow Creek has lower chlorides than the Arkansas River, but much less assimilative capacity because most of its flow is shunted to the Arkansas River west of Hutchinson. The discharges of Textron and Cargill comprise a majority of the flow seen on the lower reach of Cow Creek before it enters the Arkansas River east of Hutchinson. Textron has discharged consistently 1-2 MGD over 2004-2006, averaging 1.4 MGD (2.15 cfs), with chlorides ranging from 300-1100 mg/l. Cargill averaged about 6 cfs of discharge over 2004-2005 with its chlorides ranging from 160-840 mg/l. Similar to Morton, Cargill's effluent is largely cooling water drawn from deep ground water with some condensate mixed in, thus its effluent typically is the result of slight dilution of the ground water passing through its condensers acting as a heat exchange (Figure 20).

Generally, the ambient stream chlorides are below the levels seen in the Cargill effluent (Figure 21), but in contrast to the Morton situation on the Arkansas River, there are large increases in chlorides at the site downstream of the Cargill outfall. Furthermore, at higher effluent chloride concentrations, the difference in downstream chloride concentrations appears to increase. This suggests Cow Creek lack much assimilative capacity for Cargill effluent and the downstream conditions are dictated by the chloride levels discharged by Cargill. The comparison of chlorides between the upstream and downstream stations confirms this assertion and is comparable to the relationship seen between Station 522 and 287 (Figure 22). Although there is considerable scatter in plotting the change in stream chloride against Cargill's chloride load, there is a notable direct relationship between the two (Figure 23).

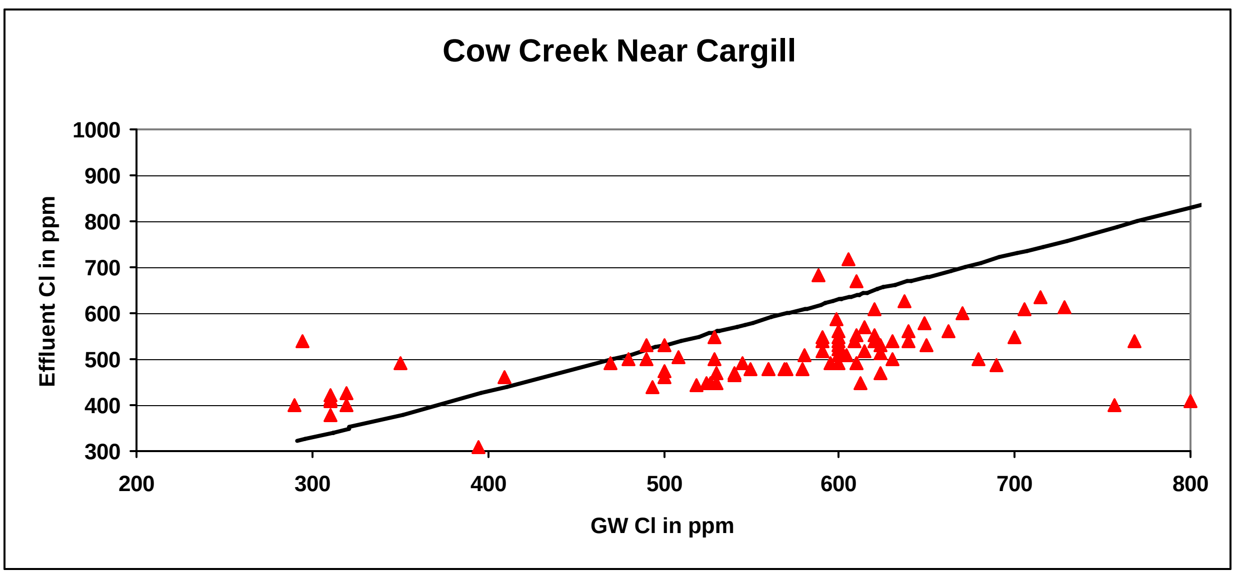

Figure 20. Cargill Salt Chloride Content of its Effluent and Ground Water Supply

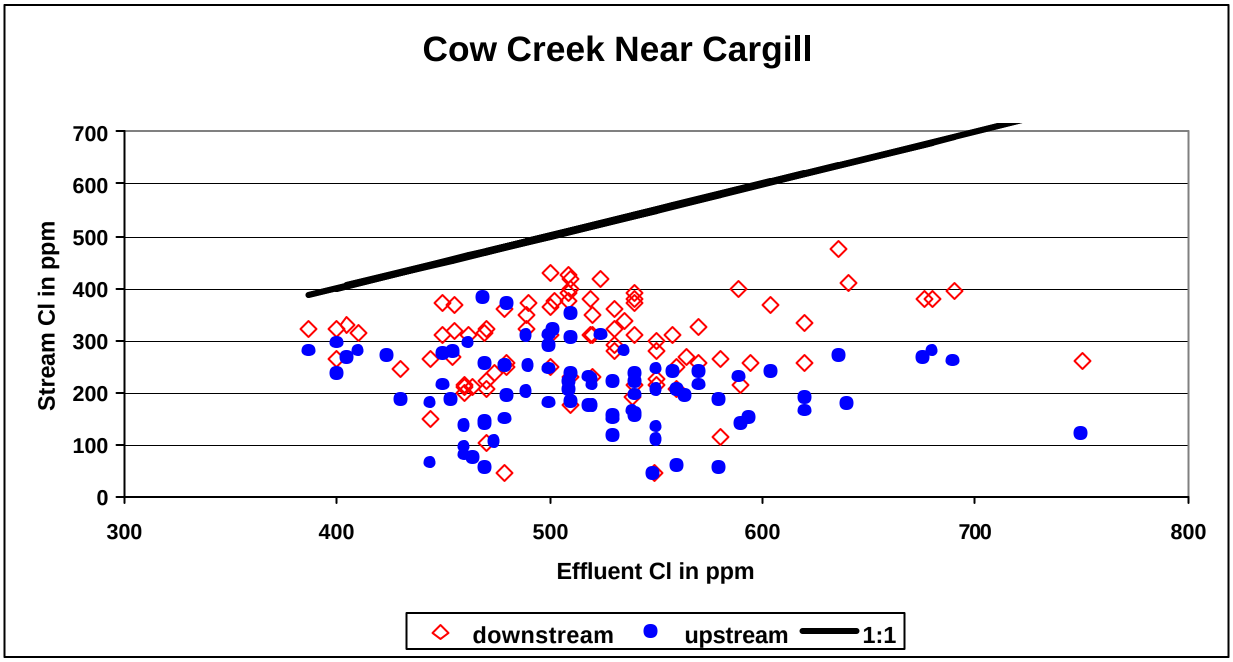

Figure 21. Cargill Effluent Chloride relationship with Cow Creek Chlorides

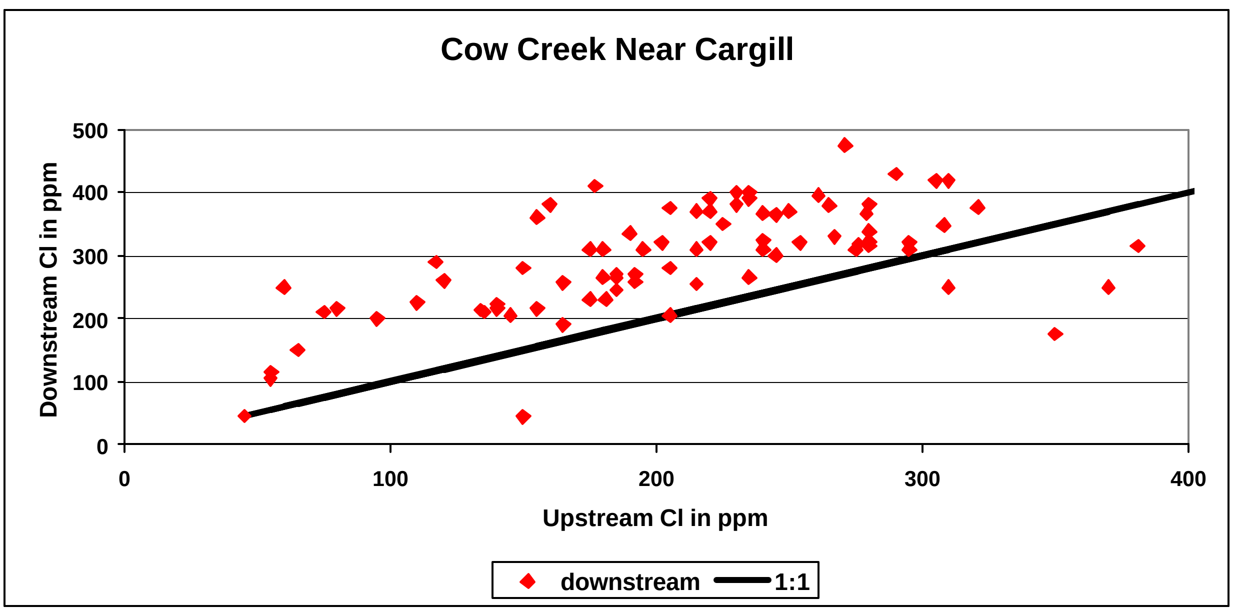

Figure 22. Cow Creek Chloride Levels Above and Below Cargill

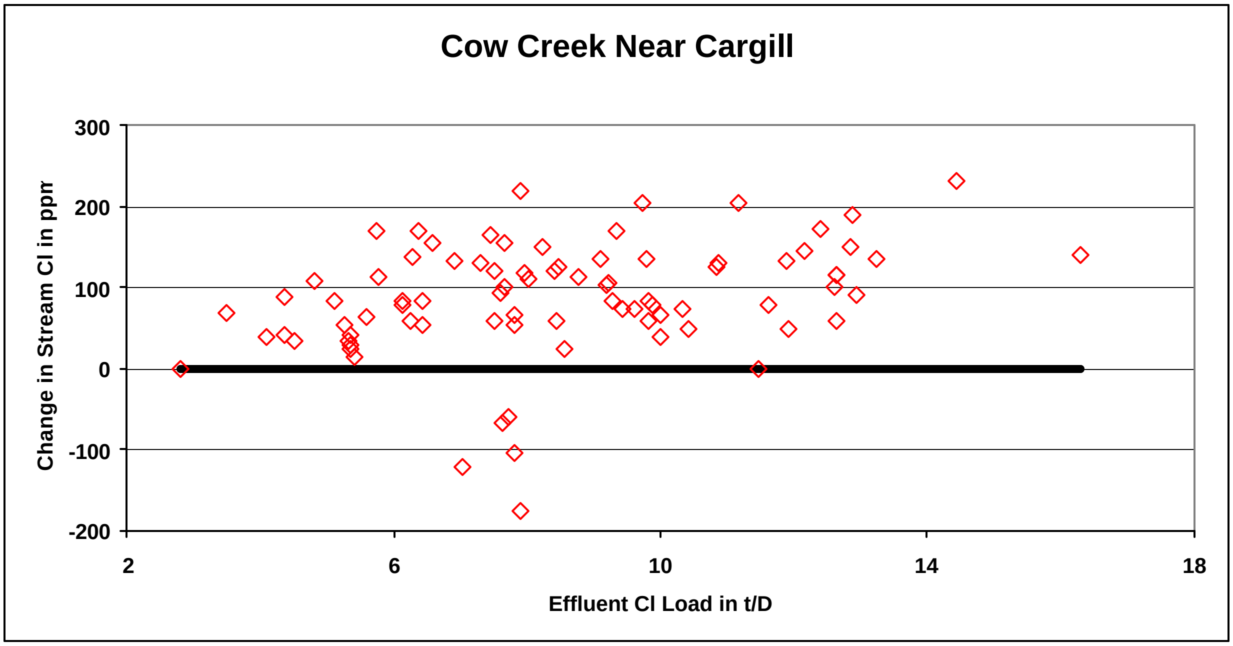

Figure 23. Change in Cow Creek Chloride at Various Cargill Chloride Loadings.

Textron is a remediation project located north of Cow Creek near the Hutchinson Industrial Airport. In the course of remediating ground water contaminants through air stripping, high chloride water is brought to the surface and discharged down the GVI ditch which enters Cow Creek below the Cargill facility, east of Hutchinson. The operation discharged an average of 1.4 MGD over 2004-2006 and contributed an average 3.3 tons per day in chloride loading to Cow Creek.

Current plans for many of the ground water remediation projects in the Hutchinson area are for the water produced by those operations to be directed toward the reverse osmosis facility under construction for the city of Hutchinson. These wastewaters will serve as a supply source for the city with the reject water generated by the RO process disposed through deep well injection. This would effectively remove those loadings from area streams, in particular, Cow Creek.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Point and Non-point Sources: Mass balance analysis and suggested background levels were used to allocate the chloride loading among the sources. Table 5 lists the Wasteload Allocations for the three principal dischargers to the Arkansas River, the Load Allocation within the river itself from ground water contributions and the estimated downstream concentration of chloride. The Wasteload Allocations hold the three dischargers to close to their current average chloride concentration in their effluent at design flow. Total Wasteload Allocation is 42.3 tons per day. Load Allocations are set by the anticipated low flow seen on the Arkansas River and the background concentration.

While the net impact to the river is a slight dilution from the background levels, there may be some localized impacts of higher chloride along the south bank of the Arkansas River because of the discharges from South Hutchinson and Morton Salt. Therefore, South Hutchinson should work with the meat processing plant discharging to their sewer system to reduce the chloride content of that waste stream, thereby lowering the city's effluent chlorides. Morton Salt should examine options for source water control, including blending of well waters of differing chloride content and use of more shallow, less saline ground water for its cooling water supply. These efforts will result in Morton's effluent reflecting more closely the chloride levels in the Arkansas River and provide an enhanced dilution base to work with the Hutchinson effluent to decrease background chlorides in the Arkansas River when they increase above Hutchinson.

Table 5. Wasteload Allocations, Load Allocations and Downstream Chloride Concentrations on the Arkansas River near Hutchinson

Source	S. Hutch	Hutchinson	Morton	Ark R 30	Ark R 40	Ark R 50
Cl Conc.	750 mg/l	375 mg/l	1000 mg/l	650 mg/l	650 mg/l	650 mg/l
Flows	2 MGD	8.3 MGD	5.55 MGD	30 cfs	40 cfs	50 cfs
WLA	**6.3 T/d**	**13 T/d**	**23 T/d**	**42.3 T/d**	**42.3 T/d**	**42.3 T/d**
LA	------	-----	-----	**52 T/d**	**70 T/d**	**88 T/d**
TMDL				94 T/d	112 T/d	130 T/d
d/s [Cl]				646 mg/l	647 mg/l	647 mg/l

On Cow Creek, it is apparent that reductions in current chloride wasteloads will be necessary in order to attain the background concentration on the lower reach of the creek. Table 6 examines scenarios involving the effluent from Cargill and Textron and their impact on Cow Creek concentrations. Cow Creek is presumed to maintain 300 mg/l above the Cargill outfall. Scenarios 1-3 show the effect of increased flow on Cow Creek and current loadings from Cargill and Textron. The impact of the loadings decreases with increased flow in Cow Creek, but chlorides still increase substantially over background levels. Scenario 4 displays the impact if Cargill and Textron discharged at design rates. Scenario 5 shows the impact of bringing Textron alone down to background levels; downstream levels remain elevated because of Cargill loadings. Scenario 6 presents the converse case, where Cargill alone discharges 300 mg/l. The resulting downstream concentration is reduced below 400 mg/l. Scenario 7 reduces the Textron contribution to current average flow rates. Scenario 8 eliminates the Textron discharge altogether, but holds Cargill at full current loadings. The final scenario #9 indicates the Wasteload Allocations assigned to Cargill and Textron based on design flows and background concentrations, resulting in 300 mg/l of chloride on the lower creek reach.

Table 6 Scenarios of Chloride Wasteload Allocations, Load Allocations and Downstream Chloride Concentrations on Lower Cow Creek

Scenario	Creek	Cargill [Cl]	Cargill Flow	Textron [Cl]	Textron Flow	Cargill WLA	Textron WLA	Cow Crk LA	d/s [Cl]
1	1 cfs	513 mg/l	3.9 MGD	576 mg/l	1.4 MGD	8.4 T/d	3.4 T/d	**0.8 T/d**	505 mg/l
2	2 cfs	513 mg/l	3.9 MGD	576 mg/l	1.4 MGD	8.4 T/d	3.4 T/d	**1.6 T/d**	503 mg/l
3	5 cfs	513 mg/l	3.9 MGD	576 mg/l	1.4 MGD	8.4 T/d	3.4 T/d	**4.1 T/d**	468 mg/l
4	1 cfs	513 mg/l	5 MGD	576 mg/l	2.9 MGD	10.7 T/d	7.0 T/d	0.8 T/d	518 mg/l
5	1 cfs	513 mg/l	5 MGD	300 mg/l	2.9 MGD	10.7 T/d	3.6 T/d	0.8 T/d	425 mg/l
6	1 cfs	300 mg/l	5 MGD	576 mg/l	2.9 MGD	6.3 T/d	7.0 T/d	0.8 T/d	394 mg/l
7	1 cfs	300 mg/l	5 MGD	576 mg/l	1.4 MGD	6.3 T/d	3.4 T/d	0.8 T/d	355 mg/l
8	1 cfs	513 mg/l	5 MGD	0 mg/l	0 MGD	10.7 T/d	0.0 T/d	0.8 T/d	489 mg/l
9	1 cfs	300 mg/l	5 MGD	300 mg/l	2.9 MGD	**6.3 T/d**	**3.6 T/d**	0.8 T/d	300 mg/l

From these scenarios, it is clear that reduction or removal of current loadings will be necessary to achieve the endpoint for Cow Creek. Options include treatment of the effluent to reduce chlorides, discharging to the Arkansas River, which could assimilate these wasteloads easily, alternative disposal methods, such as deep well injection or delivering the waste water to the Hutchinson reverse osmosis plant.

On Salt Creek, the Wasteload Allocation is zero because of the lack of point source discharges to the stream. The Load Allocation is set at the ambient stream flow and the background concentration of 1300 mg/l. At one cfs, the Load Allocation is 3.5 tons per day, at median flow of 5 cfs, it is 17.6 tons per day and at mean flow of 20 cfs it is 70 tons per day.

Defined Margin of Safety: The Margin of Safety is implicitly set because the geology and ground water are the main contributors for the chloride impairment and the endpoints are established from the Winter data when man-made influences are minimal. Furthermore, loadings from the point sources typically act as a dilution base for natural chloride contributions, particularly during periods when the ambient levels are above the recommended background concentrations from this TMDL.

State Water Plan Implementation Priority: Because the chloride impairment is due to upstream loading and geologic sources, this TMDL will be a Low Priority for implementation, except regarding point source discharge to Cow Creek, which should be addressed over the next permit cycle.

Unified Watershed Assessment Priority Ranking: The watersheds lie within the Gar-Peace (11030010) and Cow (11030011) with priority rankings of 19 and 27, respectively.

Priority HUC 11s and Stream Segments: Because of the natural geologic contribution of this impairment, the only priority stream segments will be Cow Creek below Hutchinson.

5. IMPLEMENTATION

Desired Implementation Activities

1. Monitor and limit any anthropogenic contributions of chloride loading to Cow Creek.
2. Establish alternative background concentrations for Arkansas River and Cow Creek
3. Invoke source water control and pollutant reduction techniques to contributions on south side of Arkansas River.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. NPDES and state permits for facilities in the watershed will be renewed in 2007 or 2008 with continued chloride monitoring and any appropriate permit conditions that work to reduce chloride loading to the Arkansas River or Cow Creek. Dischargers to Cow Creek should initiate plans for load reduction or elimination. Dischargers to the Arkansas River should initiate source control planning to reduce long term chloride levels within their effluent. These plans should be fully implemented by 2012-2013.

Ground Water Remediation – BER - KDHE

a. Coordinate with Bureau of Water on any existing or new remediation projects, to plans for alternative disposal of remediation water to reduce or eliminate chloride loadings to area streams.

Water Quality Standards and Assessment - KDHE

a. Establish background levels of chloride for the Arkansas River and Cow Creek.

Timeframe for Implementation: Development of a background level-based water quality standard should be accomplished with the water quality standards revision after 2007.

Targeted Participants: Primary participant for implementation will be KDHE.

Milestone for 2011: The year 2011 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from the watersheds should indicate no evidence of increasing chloride levels relative to the conditions seen in 1990-2005. Should stream conditions worsen, source assessment, allocation and implementation activities will be revisited and revised.

Delivery Agents: The primary delivery agent for program participation will be KDHE.

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. 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 nonpoint 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 Ark Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund, annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration for chloride control.

Effectiveness: Minimal control can be exerted on natural contributions to loading.

6. MONITORING

KDHE will continue to collect bimonthly samples at Stations 287, 522, 523, 524, and 536, including chloride samples, in each of the three defined seasons over 2006-2011. Based on that sampling, the priority status will be evaluated in 2012 including application of numeric criterion based on background concentrations. Should impaired status remain, the desired endpoints under this TMDL will be refined and more intensive sampling will be needed under specified seasonal flow conditions after 2012.

Monitoring of chloride levels in effluent will be a condition of NPDES and state permits for facilities. This monitoring will continually assess the contributions of chloride in the wastewater effluent released to the stream. Monitoring of upstream and downstream reaches relative to the facility outfall will be required so more accurate assessment of the impact of effluent chloride on streams may be determined.

7. FEEDBACK

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

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

Discussion with Interest Groups: The Kansas Department of Health and Environment met with representatives of Morton Salt, Cargill Salt, Textron, Hutchinson and South Hutchinson numerous times over 2000-2006. These discussions centered on operational issues of chloride reduction, ambient chloride levels in Cow Creek and the Arkansas River and the proposed Reverse Osmosis water plant in Hutchinson.

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

Milestone Evaluation: In 2011, an evaluation will be made as to the degree of planning and implementation for chloride load reduction and removal through alternative disposal, waste stream management and source water management, that has occurred along the Arkansas River and Cow Creek. Subsequent decisions will be made regarding the implementation approach at that time.

Consideration for 303(d) Delisting: The stream will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2006-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the 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 will come in 2006 which will emphasize implementation of TMDLs. 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 2007-2011

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