UPPER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Arikaree River
Water Quality Impairment: Sulfate

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Arikaree River **County:** Cheyenne

HUC 8: *(In Kansas)* 10250001

HUC 11 (HUC 14s): *(In Kansas)* **080** (030, 040 and 050)

Drainage Area: 37 square miles in Kansas
1725 square miles total above sampling station

Main Stem Segment: WQLS: 1 (Arikaree River) starting at the Kansas-Nebraska state line and traveling upstream through northwest Cheyenne County to the Kansas-Colorado state line (**Figure 1**).

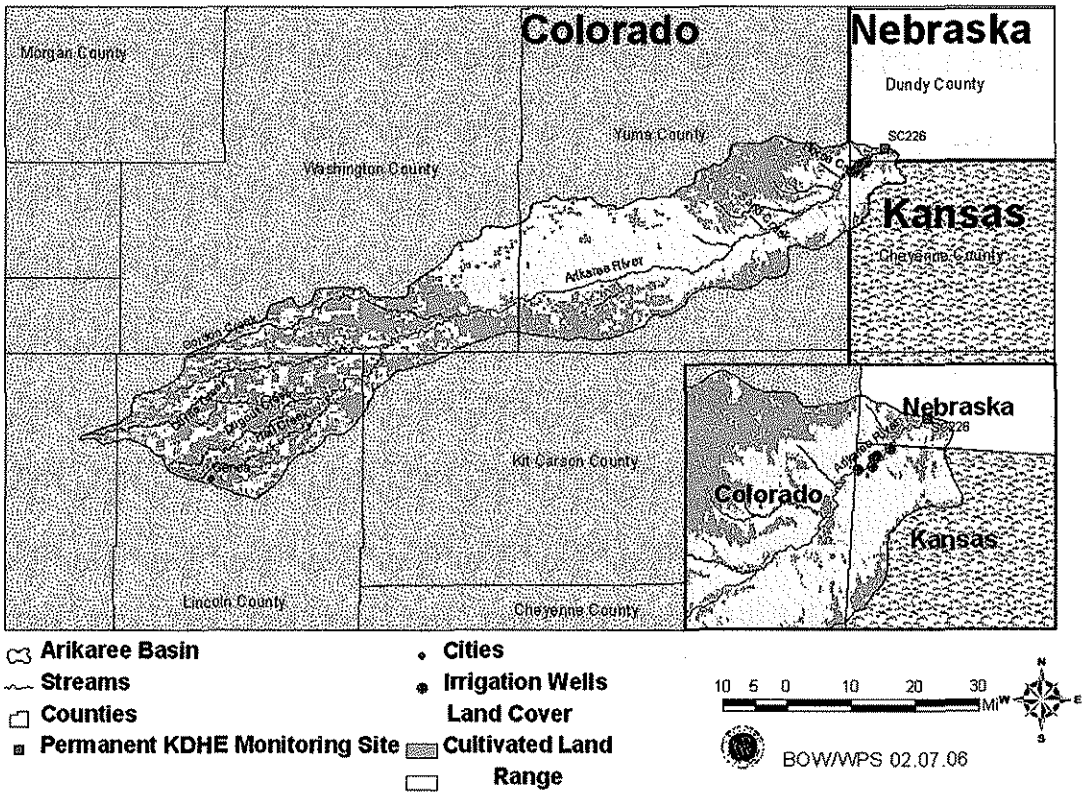
Tributaries: **All tributaries located in Colorado, segment numbers unknown**
Horse Creek
Sand Creek
Gordon Creek
Currie Creek
Dugout Creek
Hell Creek
North Fork Arikaree River

Designated Uses: Special Aquatic Life Support, Primary Contact Recreation (C), Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Kansas Segment.

Impaired Use: Domestic Water Supply

Water Quality Standard: Sulfate: 250 mg/l for Domestic Water Supply (KAR 28-16-28e(c) (3) (A))

Arikaree River Basin TMDL



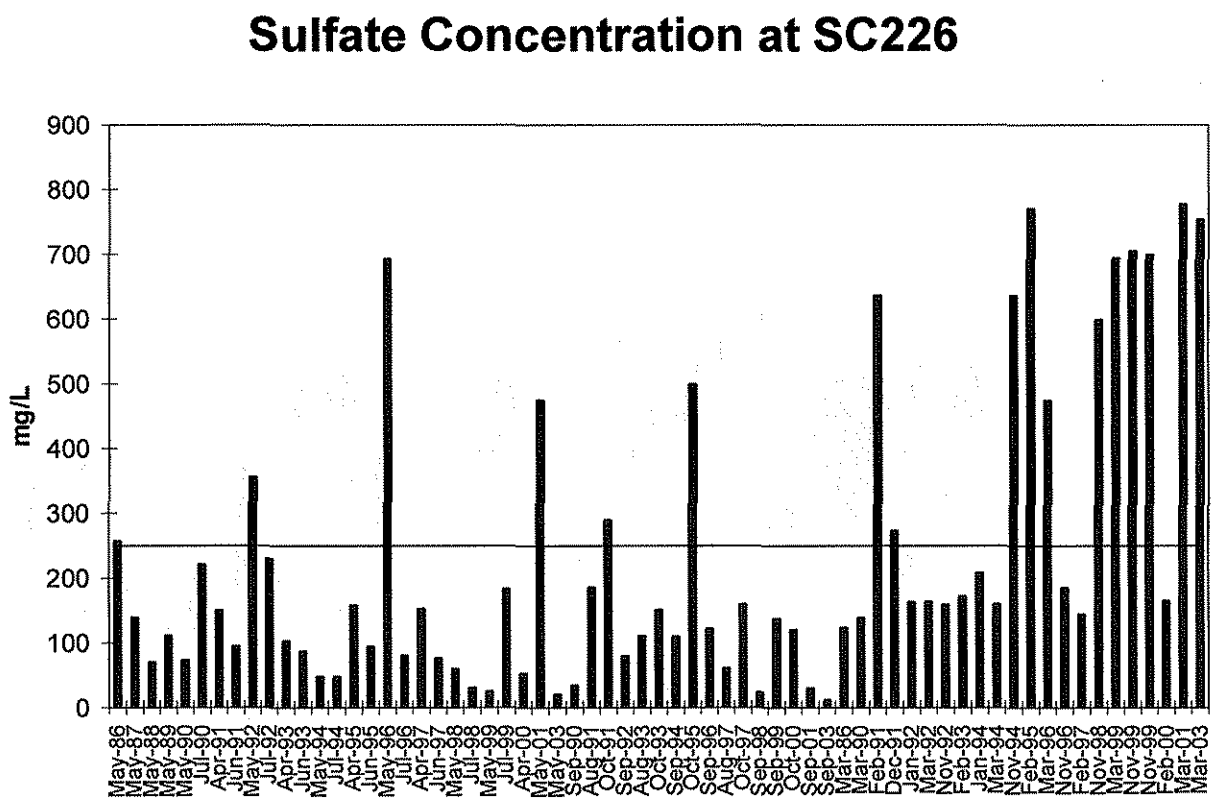
(Figure 1)

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

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

Monitoring Sites: Station 226 at Haigler, NE.

Period of Record Used: 1986-2005 for Station 226 (**Figure 2, Table 1**)



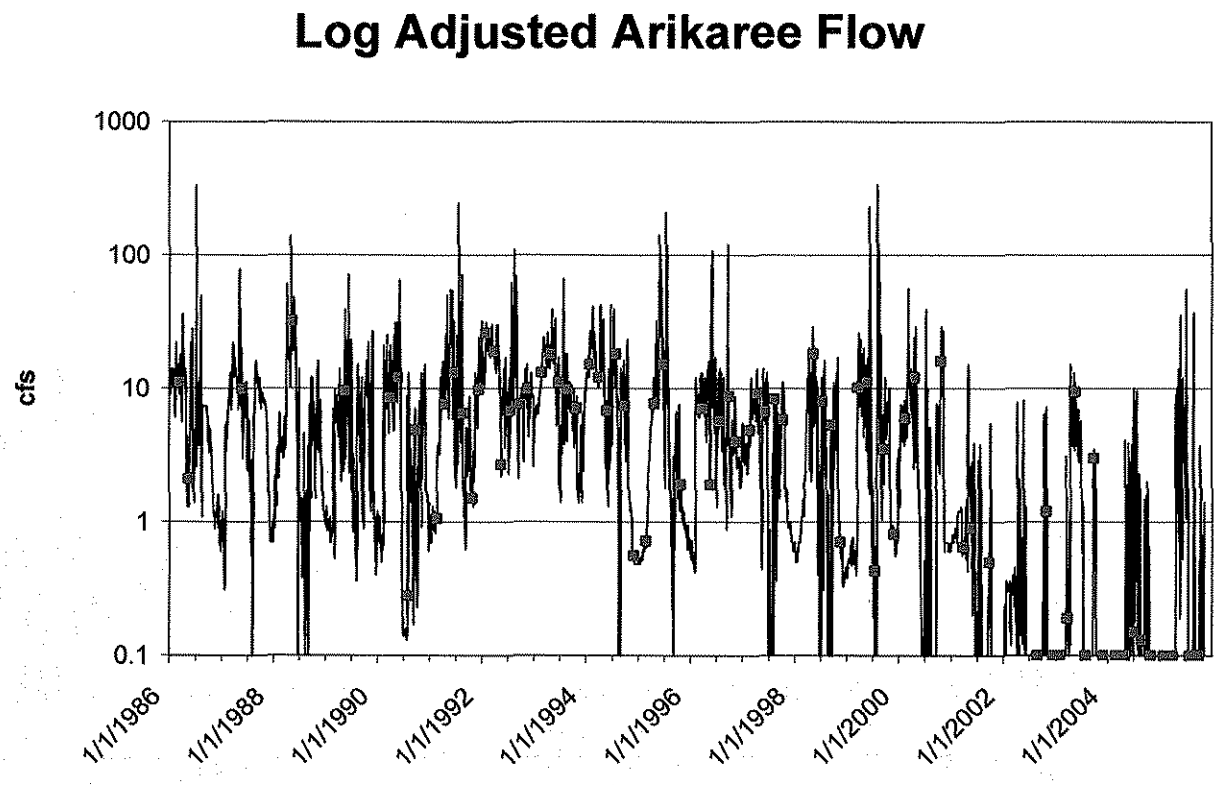
(Figure 2-Line indicates domestic water supply criteria. Since 2003 all visits by KDHE personnel, 10 occurrences have been during no-flow events. 15 of the last 18 visits by KDHE personnel corresponded with no-flow events.)

Flow Record: Arikaree River at Haigler, NE (USGS Station 06821500); 1970-2005 (**Figure 3**).

Long Term Flow Conditions: 90% Exceedance = 0 cfs, 75% Exceedance = 0.86 cfs, 50% Exceedance = 3.7 cfs, 25% Exceedance = 11 cfs, 10% Exceedance Flows = 21 cfs

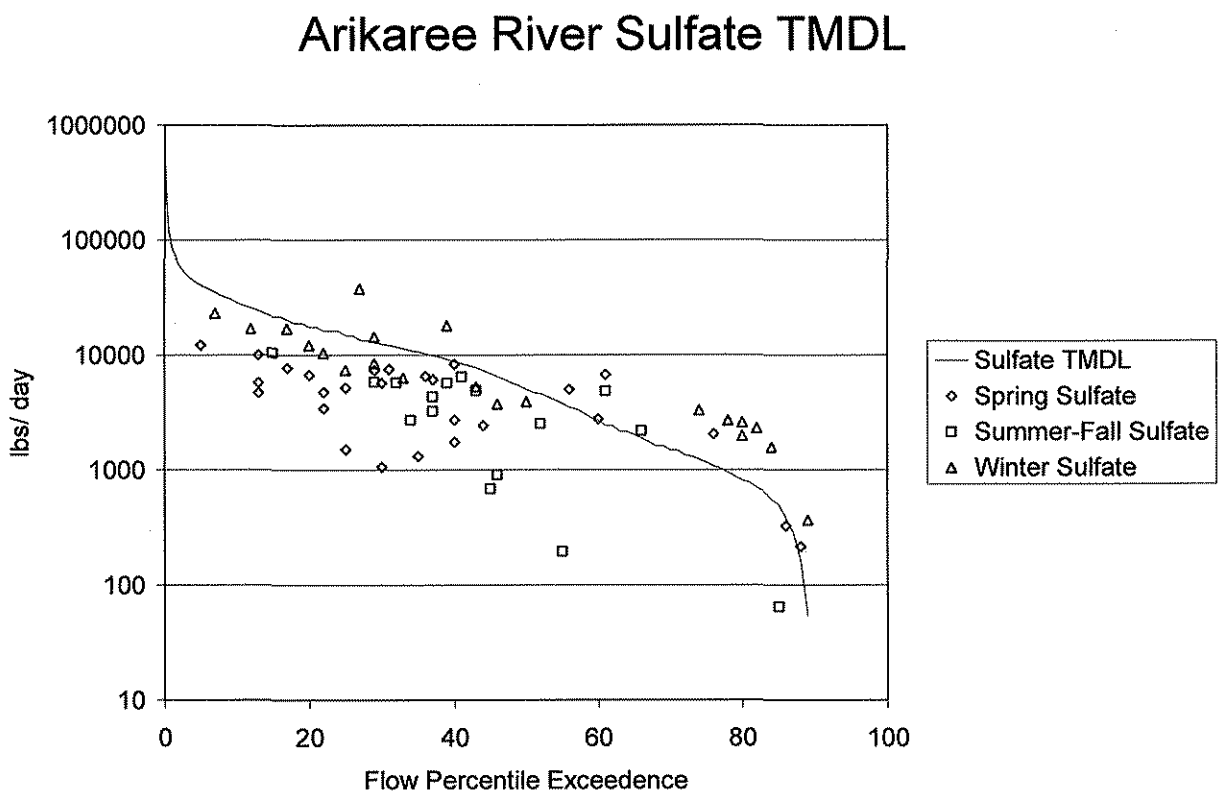
Average	Overall	Winter	Spring	Summer-Fall
>3.7 cfs	137	230	90	194
< 3.7 cfs	460	697	364	106
Overall	231	400	151	133

(Table 1: Sulfate concentrations by seasonal average at SC226. Seasons as defined by KDHE, Winter: November – March, Spring: April – July, Summer/Fall: August – October.)



(Figure 3- 20-year flow record. Red squares indicated sampling dates. Flow adjusted by adding 0.1 cfs to all flow values for log transformation. Dates with 0.1 cfs were no flow events, and red squares during no flow events indicate that KDHE personnel visited the site and found insufficient water to conduct routine sampling.**)**

Current Conditions: 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. High flows and runoff equate to lower flow durations; baseflow and point source influences generally occur in the 75-99% range. A Load Curve was established for the Domestic Water Supply criterion by multiplying the flow values along the curve by the applicable water quality criterion and converting the units to derive a load duration curve of pounds of sulfate per day. This load curve represents the TMDL since any point along the curve denotes water quality for the standard at that flow. Historic excursions from the water quality standard are seen as plotted points above the load curve. Water quality standards are met for those points plotting on or below the load duration curve (**Figure 4**).



(Figure 4 – Sulfate loads in pounds per day based on flow duration curve. No values are projected for 90-100% because long-term gaging data indicate that ten percent of the time the Arikaree River has no flow.**)**

Desired Endpoints of Water Quality (Implied Load Capacity) at Sites 226 over 2008 – 2012

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Domestic Water Supply. The current standard of 250 mg/L of sulfate was used to establish a load duration curve (**Figure 4)** for the monitoring site.

Seasonal variation has been incorporated in this TMDL through the documentation of seasonally elevated loads during winter low flow conditions. Achievement of the loading curve will serve as documentation that water quality standards are attained and full support of the designated uses of the stream has been restored.

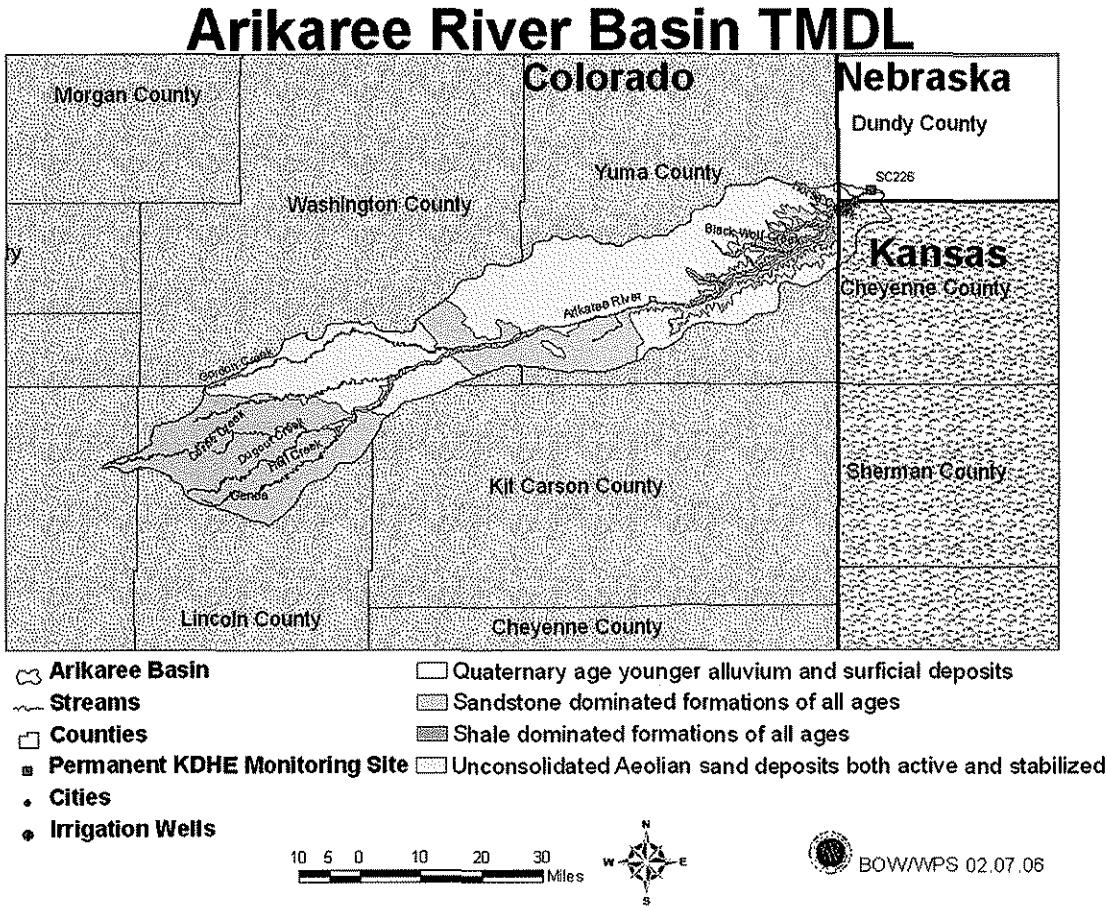
3. SOURCE INVENTORY AND ASSESSMENT

Background Levels: Sulfate naturally occurs in geologic formations present in this drainage basin, particularly in the shale near the Colorado state line (**Figure 5**). However, these formations are likely to contribute sulfate at elevated levels only when provided extended residence time for water in the channel overlying the shale, as indicated by the winter exceedences at lower flows. Conversely there is a near absence of violations during periods of moderate to high flows, especially during non-winter months (**Figure 4**). As discussed below,

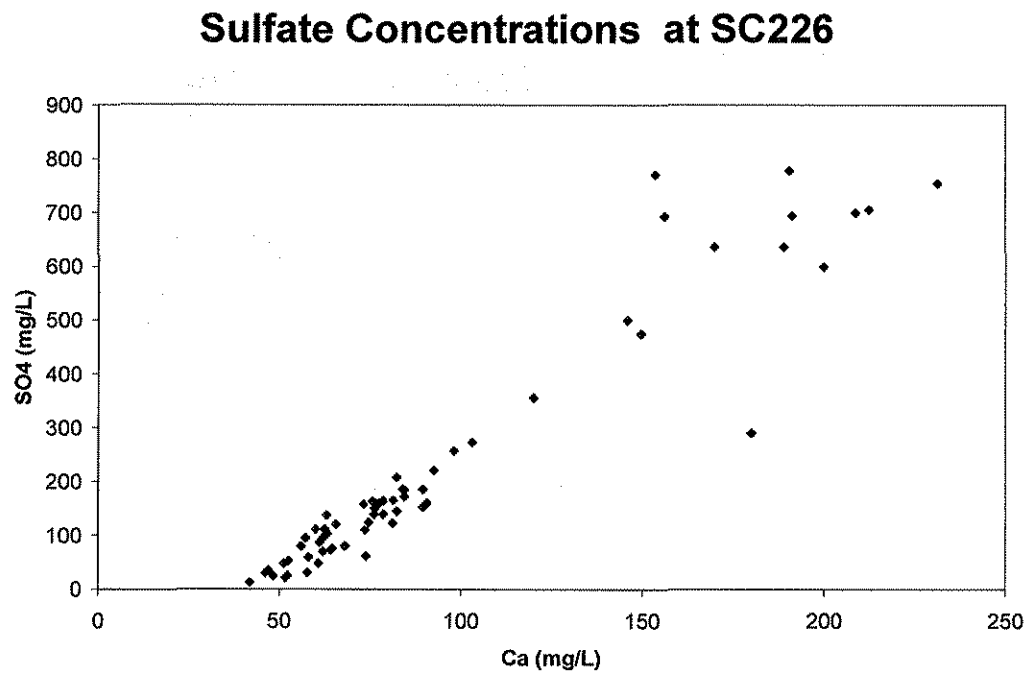
extensive irrigated agricultural activity occurs in the Colorado portion of the basin with some use and reuse of irrigation water. Sulfate concentrations are strongly related to calcium levels (**Figure 6**). $CaSO_4$ accumulates as gypsum in the soil of irrigated agricultural regions when evaporative losses exceed precipitation inputs. During months of seasonally higher flow (**Figure 7**) runoff moves quickly through the basin and apparently does not carry much sulfate to the river. During winter months when flow is generally lower, as is precipitation, and irrigation demand is low, flow will primarily be generated by return flow with longer residence times in the soil with increased leaching and longer contact with shale along the channel. The elevated sulfate concentrations in the Arikaree River may be a long-term impact of irrigated agriculture in an arid region with moderately elevated soil sulfate levels. Absent irrigation return flows the Arikaree River would likely remain below water quality criteria. The question remains where those return flows enter the Arikaree River above the monitoring station.

If elevated sulfate levels in the Arikaree River occur in Kansas, they likely come from baseflow contributions after runoff events, or return flows from irrigated lands, and seasonally elevated alluvial aquifer and soil seepage during winter months, originating in Colorado. Colorado pumping in Yuma, Washington and Lincoln counties over 1981-2000 depleted the Arikaree River streamflows by an average of 1289 acre/feet per year. Over the same period, pumping in Cheyenne County, KS, was responsible for an average depletion of 175 acre/feet per year. Very little surface water irrigation occurs in the watershed, confined to Yuma County. There is no surface water irrigation in the Kansas portion of the drainage and the five active water rights used an average of 153 acre-feet over 2000-2004 along the Arikaree. Any Kansas contribution to sulfate loading in the Arikaree River is minimal.

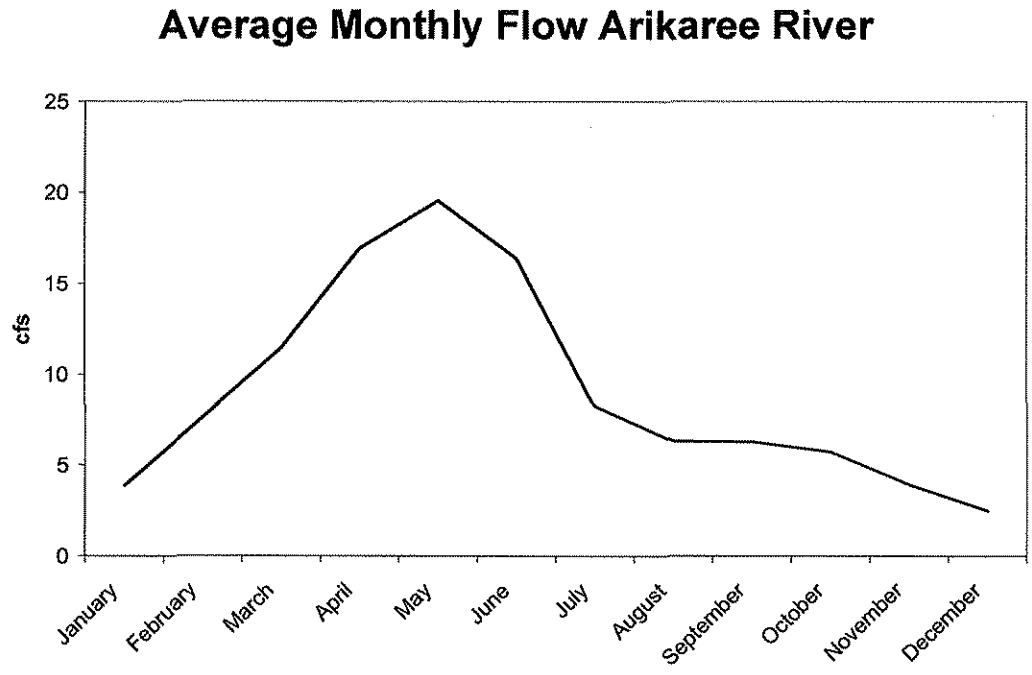
There is an unusual seasonal pattern in sulfate concentration observed at SC226 (**Figure 8**). Sulfate concentrations are lower during the period from Memorial Day until mid October, and then rise dramatically during November to May.



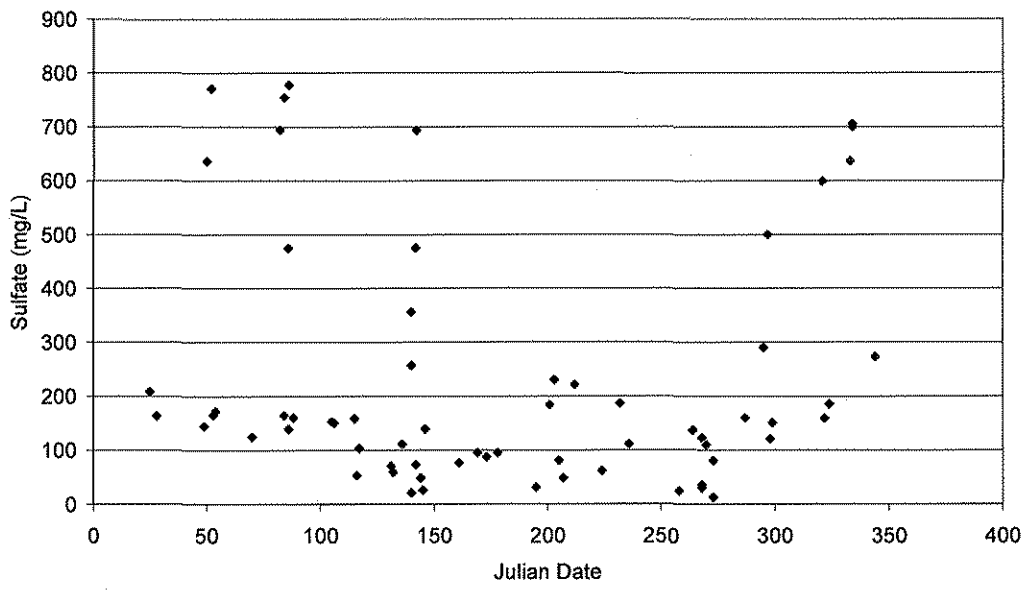
(Figure 5- Near-surface geology in Colorado in the Arikaree basin. Due to variation in classification techniques, Kansas and Nebraska near-surface geology is omitted. The formations are substantially similar across the state border.)



(Figure 6- Sulfate concentrations as related to calcium concentrations at SC226.)

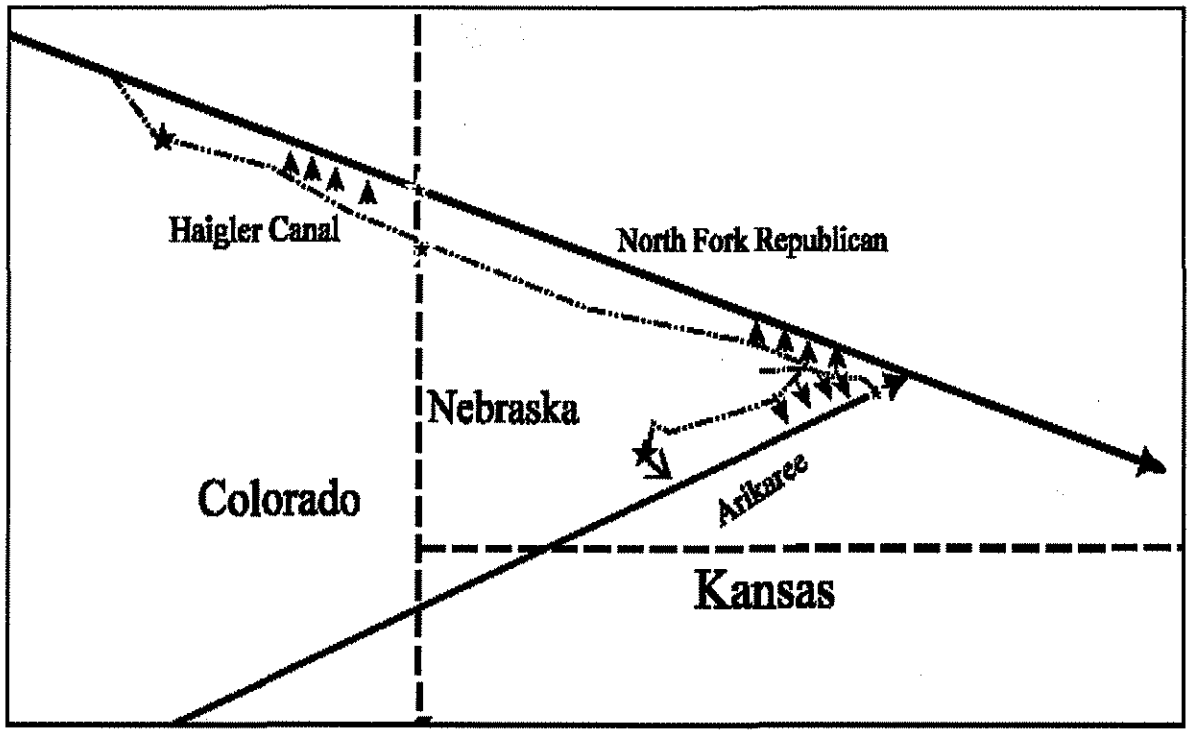


(Figure 7- Average monthly flow at USGS gage 06821500 from 1970-2005.)



(Figure 8- Sulfate concentrations at SC226, which generally show that during periods of low irrigation activity, October through May, concentrations can be elevated over the drinking water criteria.)

Documentation provided by the Kansas Division of Water Resources (DWR) suggests that samples taken by KDHE, especially at lower flows, may not reflect conditions in the Arikaree River in Kansas. Pursuant to the Republican River Compact, DWR obtained maps of the Haigler Irrigation Ditch servicing an irrigation district in eastern Colorado and western Nebraska near the Kansas-Nebraska border (**Figure 9**). As marked in the map, this irrigation ditch diverts water from the North Fork of the Republican River to provide irrigation water to fields in Colorado and Nebraska. The ditch carries wasteway water or return flows from the irrigated lands into the channel of the Arikaree River, which then joins the North Fork to form the Republican River below Haigler. These flows return to the Arikaree River upstream of the KDHE sampling point, which is located at Haigler, the first readily accessible location in the vicinity of the Kansas-Nebraska border. .



(Figure 9- A general schematic of the location of withdrawals and returns associated with the Haigler irrigation ditch. Provided by the Kansas Division of Water Resources as part of supporting documentation related to the Republican River Compact.)

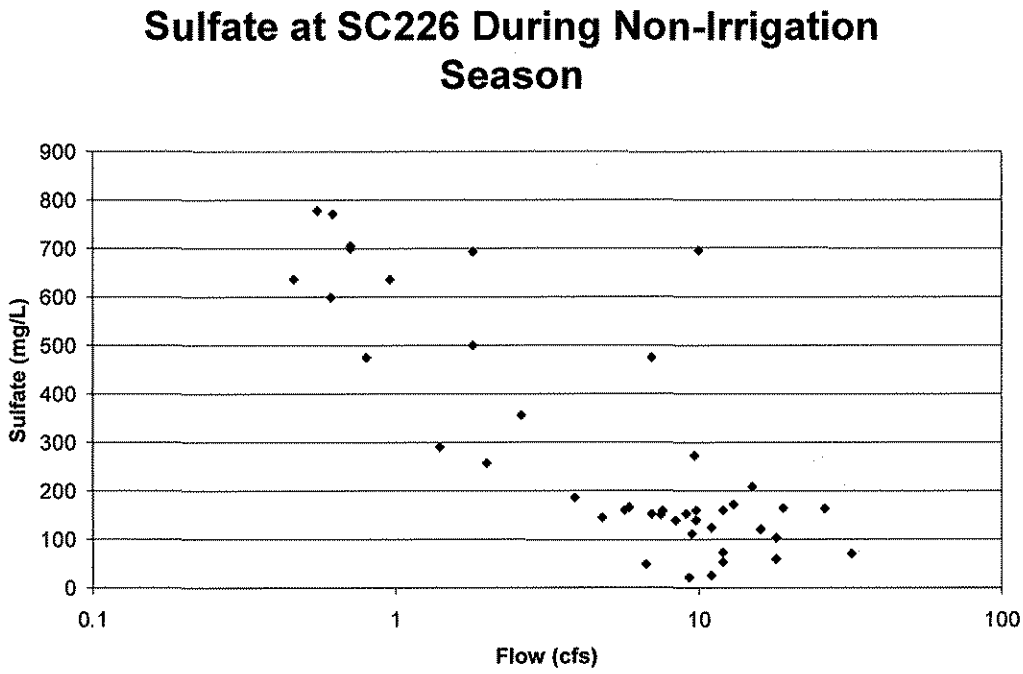
Field investigation by KDHE personnel during the winter of 2006 revealed that flows originating in the Haigler Ditch system contributed all flows at the KDHE monitoring site. The Arikaree River contained no flow in the Kansas segment, but had flow downstream of the Haigler Ditch return, located in Nebraska. While it is possible that the Arikaree River is impaired in Kansas, sampling at Haigler does not necessarily provide direct evidence of that impairment, given the multiple sources of water seen at Haigler that are not related to Kansas. The field investigation indicated that the channel of the Arikaree River in Kansas had not had flow for some time, based on the state of vegetation encroachment in the flow way. Therefore, to the extent that the impairment originates in Colorado and flows directly to Nebraska via the Haigler Ditch, the impairment is a concern for those states, and does not suggest action by Kansas.

Further evidence of the influence of surface water irrigation in Colorado and Nebraska is provided by the tracking the constituent ion levels during the irrigation season and the off-season portion of the year (**Figure 10 and 11**). Conventional wisdom suggests that the concentration of conservative ions, like sulfate, will be lower during high flow events when compared to low flow, or base flow conditions. In the case of data collected by KDHE at SC226, a strong negative relationship exists between flow and concentration of sulfate ions during the non-irrigation months, as expected if mounded ground water from irrigation returns to the Arikaree through the alluvial aquifer with occasional dilution during runoff events. Mounding of groundwater as the result of irrigation activities can provide a source of extended residence groundwater experiencing the conditions described elsewhere in this TMDL. As that water leaves the alluvial aquifer and enters the return ditch, and ultimately the Arikaree River, it will carry with it the ions

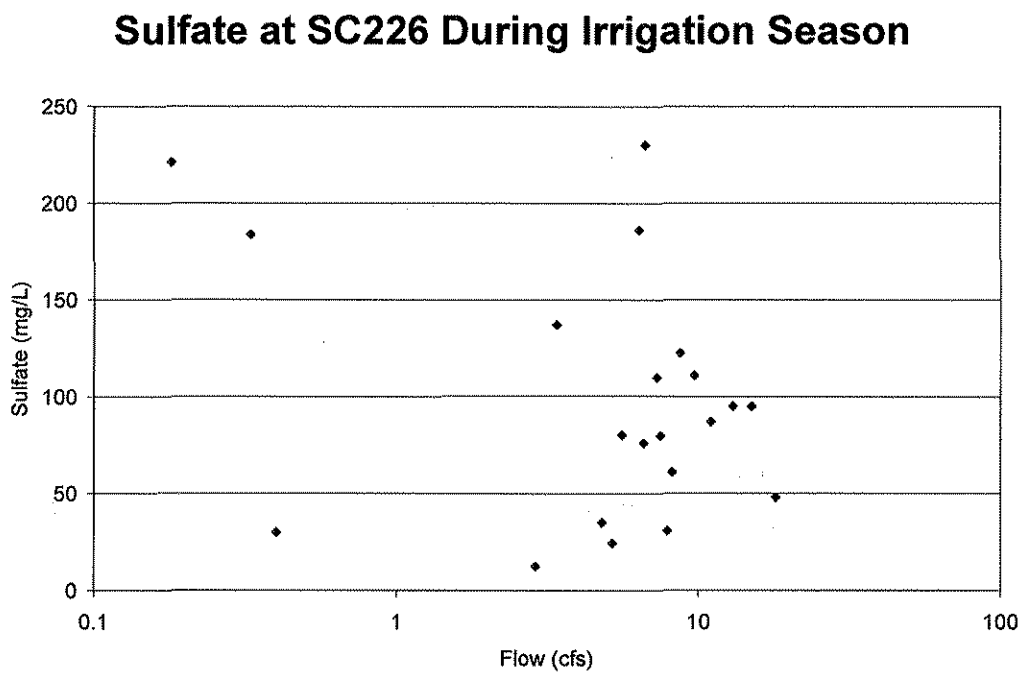
of concern that have accumulated in the soils of the irrigated fields and obtained from near surface geologic formations.

During the irrigation season no pattern is evident at all, though overall levels are generally lower, which is consistent with anecdotal descriptions of the relative quality of the water in the North Fork of the Republican River. The hydraulic function of irrigation ditches requires some wasteway water to exit the ditch into the Arikaree River to facilitate the gravity flow of North Fork Republican water through the irrigation system. Hence the water seen at Haigler during irrigation season is likely predominantly North Fork Republican water and thus, of a better quality than water native to the Arikaree.

Colorado has sampled the Arikaree River during 2002-2005 and shown an average of only 8 mg/L sulfate. Samples taken from the North Fork Republican River over 1968-1992 averaged 37 mg/L of sulfate. USGS samples averaged 30 mg/L in 1947 at the North Fork. USGS samples at the Republican below the Arikaree confluence average 107 mg/L irrigation season and 79 mg/L during off-season over 1980-1989.



(Figure 10- Sulfate concentrations at SC226 as a function of flow during the non-irrigation season. Samples were assigned Julian dates, and sorted. The irrigation season was defined as starting on Julian date 151 (the beginning of June) and ending on Julian date 280 (the end of September). Concentrations displayed in Figure 10 are from samples with Julian dates less than 151, or greater than 280.)



(Figure 11- Sulfate concentrations at SC226 as a function of flow during the irrigation season. Samples were assigned Julian dates, and sorted. The irrigation season was defined as starting on Julian date 151 (the beginning of June) and ending on Julian date 280 (the end of September). Concentrations displayed in Figure 11 are from samples with Julian dates greater than 151, or less than 280.)

NPDES: There are no NPDES permitted dischargers within the Kansas portion of the watershed. There is one city within the watershed; Genoa, CO. US Census figures list 211 people in Genoa in 2000.

Livestock Waste Management Systems: There are no confined animal feeding operations within the Kansas portion of the watershed.

Land Use: National Land Cover Database GIS layers were used to assess land use in the basin. Most of the watershed is grassland (59% of the area) or cropland (41%). Major crops were estimated by county level National Agricultural Statistics records. The majority of crop production is dryland wheat and irrigated corn. Irrigation water likely draws on deepwater wells drawing from the high plains aquifer.

Population Density: Most of the watershed's population density is low throughout the basin. Colorado county level populations statistics for 2000 are, Yuma- 4 person/ sq. mile, Washington- 2 persons/ sq. mile, and Lincoln- 2 person/ sq. mile. The rural population projection for Cheyenne County through 2020 shows slight declines (7% decrease). The small population is not likely to contribute significant sulfate loading from wastewater.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Additional assessment will be necessary to ascertain the natural sulfate loading within the watershed and balance due to anthropogenic contributions. The following can be anticipated:

Point Sources:
Site 226: A current Wasteload Allocation of zero is established by this TMDL because of the lack of point sources located within Kansas upstream of the sampling site. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current wasteload allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers.

There will be a wasteload allocation of zero for state and NPDES permitted CAFO's within the drainage because no such facilities exist in Kansas in this drainage basin.

Non-Point Sources: The majority of the sulfate load in the Arikaree River appears to be irrigation related. At site 226 the Load Allocation based on the existing sulfate standard of 250 mg/L across all flow conditions is shown in **Figure 4**, respectively and is 4995 pounds per day of sulfate at the median flow of 3.7 cfs. Exceedances were noted at flows below the median flow. Additional assessment of the contribution from upstream sources is needed.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the sulfate endpoints for the Arikaree River system, specifically, lack of knowledge between effluent limitations and the river's water quality. Since there are no point sources discharging to the Arikaree River, there are no effluent limitations, there is complete certainty over the impact of this lack of point source loading, and, hence, the Margin of Safety for this TMDL will be set at zero.

State Water Plan Implementation Priority: Because the likely dominant source for sulfate in the stream is from out of state sources, upstream sources are likely contributors to the sulfate problems seen at the monitoring stations. Additional source assessment is necessary to examine contributing activities along the main stem. This TMDL will be a low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the South Fork Republican Basin (HUC 8: 10250001) and is classified as a Category I, priority 55 watershed under the Unified Watershed Assessment, a low priority for restoration.

Priority HUC 11s and Stream Segments: Because of the limited area of this drainage in Kansas, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Assess changes in sulfate and irrigation return flows as irrigation management activities are employed to comply with the Republican River Compact.
2. Monitor winter stream chemistry on the Arikaree River at the Colorado state line.

Implementation Programs Guidance

Water Quality Assessment – KDHE Bureau of Environmental Field Services

a. Continue monitoring sulfate levels annually at SC226.

Division of Water Resources- KDA

a. Report changes in consumptive use along the Arikaree River to KDHE.

Timeframe for Implementation: Ongoing development of irrigation management will proceed through the Republican River Compact after 2006.

Targeted Participants: Primary participants for implementation will be the Division of Water Resources.

Milestone for 2011: The year 2011 marks the mid-point of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from Arikaree River will be reexamined to confirm the impaired status of the river and changes in sulfate concentrations.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Division of Water Resources.

Reasonable Assurances:

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

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.

2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

3. K.S.A. 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.

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

5. The *Kansas Water Plan* and the Upper Republican 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 and should not receive funding.

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

6. MONITORING

KDHE will continue to collect bimonthly samples at Station 226, including sulfate samples, in each of the three defined seasons. Based on that sampling compliance with the 250 mg/l criterion will be evaluated in 2011 including sampling at the upstream Colorado state line during winter baseflow conditions.

7. FEEDBACK

Public Meeting: A Public Meeting to discuss TMDLs in the Upper Republican Basin were held March 2, 2006 in Atwood. An active Internet Web site was established at http://www.kdheks.gov/tmdl/index.htm to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Upper Republican Basin.

Public Hearing: A Public Hearing on the TMDLs of the Upper Republican Basin were held in Atwood on March 2, 2006. The public comment period remained open until April 1, 2006.

Basin Advisory Committee: The Upper Republican Basin Advisory Committee met to discuss the TMDLs in the basin on March 2, 2006.

Milestone Evaluation: In 2011, evaluation will be made to confirm the degree of impairment that has occurred within the watershed of the Arikaree River. Subsequent decisions will be made regarding the need for an implementation approach if water from Kansas is shown to contain elevated sulfate concentrations.

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 intervening implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities might be adjusted accordingly.

6/26/06