LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Water Body: **Arkansas River between Maize and Derby**
Water Quality Impairment: Sulfate

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Middle Arkansas–Slate **Counties:** Sumner and Sedgwick

HUC 8: 11030013

HUC 11 (HUC 14s)**:** **010** (060); **030** (010, 020, 030, and 040)

Drainage Area: 1720 square miles between Maize and Derby

Main Stem Segments: WQLS: 3, 9, 18; starting at the confluence with Ninnescah River and ending at the confluence with the Little Arkansas River.

Designated Uses: Special Aquatic Life Support; Primary & Secondary Contact Recreation; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Main Stem Segments

1998 303d Listing: Table 1 - Predominant Point Source and Nonpoint Source Impacts

Impaired Use: Domestic Water Supply

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); Livestock Watering: 1000 mg/l (Table 1a of K.A.R. 28-16-28e(d));

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the water quality criteria listed in Table 1a of KAR 28-16-28e(d), at ambient flow, the existing water quality shall be maintained, and the newly established numeric criteria shall be the background concentration, as defined in KAR 28-16-28b(e). Background concentrations shall be established using the methods outlined in the "Kansas implementation procedures: surface water," dated June 1, 1999... (KAR 28-16-28e(b)(9)).

In surface waters designated for the groundwater recharge use, water quality shall be such that, at a minimum, degradation of ground water

quality does not occur. Degradation shall include any statistically significant increase in the concentration of any chemical contaminant in ground water resulting from surface water infiltration or injection. (K.A.R. 28-16-28e(c) (5)).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 1998 303d: Not Supporting Domestic Water Supply

Monitoring Sites: Station 281 at Derby, 536 at Maize and 282 at Valley Center

Period of Record Used: 1990 to 2000 at Derby

Flow Record: Arkansas River at Derby (USGS Station 07144550); 1970 to 2000

Long Term Flow Conditions: Median Flow = 528 cfs; 7Q10 = 100 cfs**;** Estimated 7Q10 at Maize = 20 cfs; Estimated 7Q10 at Wichita = 44 cfs.

Current Conditions: Sulfate concentrations averaged191 mg/l at Derby over 1985-1999, below the sulfate criterion of 250 mg/l. Upstream concentrations at Maize averaged higher (280 mg/l). There is considerable linkage in sulfate concentrations at Maize effecting concentrations seen at Derby. When sulfate levels at Maize are low (158 mg/l on average), sulfate levels at Derby average 134 mg/l. However, when sulfates are elevated at Maize (averaging 500 mg/l), the average at Derby rises to 350 mg/l. There is a significant difference in average concentrations between the two sites in either situation, probably reflecting dilution from the Little Arkansas River.

Both sites are influenced by immigration of sulfate-laden water from the Garden City area moving past Dodge City and arriving in the Wichita area. Sulfate levels over 250 mg/l at Derby seen in 1987-1988 and 1996-2000 coincide with movement of flow down the Arkansas River past Dodge City. Arkansas River water entering Kansas from Colorado has extreme concentrations of sulfate (>2000 mg/l). The river undergoes dilution as it flows downstream. Frequently, regional conditions in the river and surrounding aquifers causes flow to cease between Dodge City and Garden City, as was the case between 1990 and mid-1996. Under those conditions, sulfate levels seen at Maize and Derby fall below the water quality standard.

Monitoring Site	Average Sulfate Concentration and Range, 1990 - 1996	Average Sulfate Concentration and Range, 1996 - 2000
Derby	134 mg/L (12-229 mg/l)	348 mg/L (8 - 732 mg/l)
Maize	158 mg/l (26-427 mg/l)	497 mg/l (42-861 mg/l)

Plotting sulfate loads exceeding the standard over the cumulative frequencies of flows seen at Derby reveals the excursions occur at flows near median flow or higher. No violations occur at the extreme low flow condition, where point source impact dominate. Concentrations at higher flows sporadically exceed the standard. Therefore, sulfate concentrations seen at Derby reflect two factors: movement of high sulfate water from western Kansas into the Wichita area and dilution of that water by the fresh water of the Little Arkansas River.

Of the 107 samples taken at Derby over 1985-1999, 22 or 21% of the samples exceeded 250 mg/l. Eight of those occurred in 1987-1988 and 14 occurred since late 1996. In all cases, flows in the Arkansas River's western reaches were moving eastward past the historic no flow zone near Dodge City. Of the 22 excursions, all but 2 occurred at flows which were at median flow or greater.

NUMBER OF SAMPLES OVER SULFATE STANDARD OF 250 MG/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.
Derby	Spring	0	4	6	1	0	0	11/46=24%
	Summer	0	1	1	1	0	0	3/26=12%
	Winter	0	3	5	0	0	0	8/35=23%

Desired Endpoint Condition of Water Quality at Station 281 over 2005 -2010

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Drinking Water Use. The current standard of 250 mg/L of sulfate was used to establish a load duration TMDL curve and represents this endpoint. At 7Q10 flow conditions, the resulting total load would be 85.4 tons per day.

The load will increase during periods when the Arkansas River is flowing from the Colorado stateline to the Oklahoma stateline when there will be continued excursions of the sulfate criterion at flows near or above median flow. Establishing a second endpoint reflecting these elevated background conditions would use a suggested value of 350 mg/l, which is the average concentration of sulfate during recent high flows. At the median flow, the resulting load would be 436 tons per day.

Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal consistency of elevated sulfate levels. Achievement of the endpoints indicates 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

NPDES: There are multiple NPDES permitted facilities discharging to impacted segment, but one NPDES permitted wastewater facility likely contributes sulfate to these stream reaches. The facility, Boeing, is permitted to discharge a maximum of 1,644 mg/L of sulfate per day and has a design flow of 2.15 MGD, although effluent monitoring data indicates typical sulfate levels an order of magnitude lower than permitted limits. There are several groundwater remediation projects in the region, which utilize air stripper technology to remove organics. The effluent discharged from these projects contains varying concentrations of sulfate. For example, the Gilbert & Mosley Site in Wichita discharges a maximum of 1.66 MGD with average sulfate of 205 mg/l. Seventy-three percent of samples were at or below 250 mg/l over 1992, 1995 and 1998.

Irrigation Return Flow: Surface water irrigation is nonexistent along the Arkansas River (segments 3, 9, and 18). Groundwater irrigation is minimal. Irrigation Return Flows do not appear to significantly increase the sulfate load to the Arkansas River in the Middle Arkansas-Slate Subbasin.

Background: The primary geologic material at the flood plain of the Arkansas River is unconsolidated Quaternary sediment comprising the broad alluvial aquifer of the Arkansas River valley. The alluvial aquifer interacts well with the river where it underlies and is adjacent to the river. Permian bedrock underlies the Arkansas River alluvium. Most of this bedrock is the Wellington Formation that includes limestone beds, gypsum ($CaSO_4 \cdot H_2O$), anhydrite ($CaSO_4$), and rock salt (halite, NaCl). The evaporite deposits (halite, gypsum, and anhydrite) are important to the water quality in the subbasin because they contribute varied amounts of chloride and sulfate to groundwater discharging from the Permian rocks to the streams and alluvial aquifers in the subbasin.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The nature of sulfate loading along the Arkansas River reflects decades of natural contributions aggravated by patterns of irrigation water use and reuse along the upstream reaches near the Colorado state line. Resumption of flow in the river past Dodge City has brought about a significant increase in sulfate seen at Derby. Therefore, short term reduction in sulfate loads in this reach of the river at higher flows will be negligible. Improvement in sulfate levels above Garden City should result in gradual lowering of ambient concentrations of sulfate seen at higher flows. However, at lower flows, particularly when the Arkansas River does not flow past Dodge City, sulfate levels in the river at Wichita remain below the 250 mg/l criterion. Therefore, points sources will be subject to expectations that their discharges would not cause excursion from the standard.

Point Sources: Multiple point sources discharge into Segment 3, although few point sources likely contribute significant portions of sulfate to the river. Based on an estimated discharge volume from all point sources of 60 MGD (93 cfs) a Wasteload Allocation of 56.5 tons per day at 7Q10 flow conditions will be established by this TMDL, after accounting for the Margin of Safety. Calculations used to estimate wasteload allocations are given in the attached appendix. Since most sources have modest (<200 mg/l sulfate) levels, this allocation may be used to manage the major industrial discharger loads as well as the ground water remediation projects along the river.

Non-Point Sources: For the purposes of deriving a TMDL for these river segments, a background flow and sulfate level were estimated for Segment 3, where the majority of point sources discharge. The assumptions and calculations for the Load Allocation are given in the attached appendix. An assumed 7Q10 flow entering the segment was estimated to be 49 cfs based on the Wichita gage station. The estimated sulfate concentration attributed to background was calculated to be 171 mg/l based on potential upstream loadings above Maize and historic median concentrations and low flows seen at Maize and the Little Arkansas River. Given these assumed background conditions, the Load Allocation is 22.6 tons per day.

Under conditions when Arkansas River water from western Kansas arrives at Wichita, thereby elevating sulfate levels at Maize and Derby, the Load Allocation increase in response to greater flows and sulfate concentrations. At median flow conditions (528 cfs), the Load Allocation is calculated to be 436 tons per day, reflecting an average sulfate concentration of 350 mg/l, consistent with levels seen from 1996-1999. Most of this Load Allocation originates upstream of Maize with average concentrations of 500 mg/l. Given the dilution impact of the drainage between Maize and Derby, there is an average 30% reduction in sulfate concentration between Maize and Derby. Calculations are provided in the Appendix.

Defined Margin of Safety:. The Margin of Safety will be used to protect the low flow regime of these segments against future loadings of sulfate causing violation of the 250 mg/l water quality standard and to not unduly raise downstream ambient concentrations nor overload the surrounding aquifer where the river loses flow. Therefore, the Margin of Safety will withhold 10% of the available wasteload allocation from future point sources (6.3 tons per day), until further source assessment and monitoring confirms the lack of significant impact to the river from existing permitted discharges. Furthermore, the Margin of Safety is conservative because of the presumption of existing facilities discharging 250 mg/l sulfate at their design flows, exceeding estimated actual loads assumed from ambient data.

At higher flows which coincide with the incidence of elevated sulfate, any point source impacts will be masked by upstream nonpoint and natural contributions. Nonetheless, the Margin of Safety of 10% of future Wasteload Allocation will be maintained. Additionally, given the dilution impact of the drainage between Maize and Derby, the objective of the Margin of Safety would be to attempt to maintain an average 30% reduction in sulfate concentration between Maize and Derby.

State Water Plan Implementation Priority: This TMDL will be a Low Priority for implementation because of the influence of upstream sulfate loading entering these stream reaches, the time needed to establish any sulfate improvements in the upstream reaches, and the need to monitor the impact of any sources along these reaches and within the immediate watershed which might contribute sulfate under conditions seen on the river prior to 1996.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Middle Arkansas - Slate Subbasin (HUC 8: 11030013) with a priority ranking of 6 (High Priority for restoration work).

Priority HUC 11s and Stream Segments: Because the sulfate impairment is confined to the mainstem of the Arkansas River, priority will be given to Segment 3 which receives a majority of the present and potential point source discharges as well reflecting upstream contributions.

5. IMPLEMENTATION

Desired Implementation Activities

1. Evaluate any potential sources between Maize and Derby which possibly raise sulfate levels in the river above pre-1996 levels
2. Establish alternative background criterion
3. Assess likelihood of river being used for domestic uses.

Implementation Programs Guidance

NPDES and State Permits - KDHE

a. Evaluate any point sources releasing wastewater in and around these impacted reaches as to potential to contribute sulfate and degrading water quality above Derby.

Non-Point Source Pollution Technical Assistance - KDHE

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

Water Quality Standards and Assessment - KDHE

a. Establish background levels of sulfate for the river and recommend an alternative water quality criterion for high flows.

Use Attainability Analysis - KDHE

a. Consult with Division of Water Resources on locating existing or future domestic points of diversion on the Arkansas River for drinking water purposes.

Time Frame for Implementation: Work on the upstream management of sulfate levels, including that crossing the state line will commence over 2000-2005. Evaluation of impact of any sulfate control on downstream reaches should occur after 2005. Development of a background level-based water quality standard should be accomplished with the 2002 water quality standards revision.

Targeted Participants: Primary participants for implementation will be KDHE. Otherwise, activity is deferred to that which has to occur along the river above Garden City.

Milestone for 2006: The year 2006 marks the midpoint of the ten-year implementation window for the stream segments. At that point in time, some consideration of upstream water quality improvement on downstream reaches should be evaluated. Additionally, sampled data from Station 281 should indicate evidence of reduced sulfate levels at flow conditions relative to the conditions seen over 1990-1999.

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 along the river 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.A.R. 28-16-69 to -71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.

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. 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 areas of the state for high priority in implementation.

Funding: Other protection or planning activities are incorporated within the Lower Arkansas Basin Plan of 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 a portion of the $16-18 million available annually from the State Water Plan Fund to water quality and water conservation projects and programs. This watershed and its TMDL are a Low Priority consideration and should not receive funding.

Effectiveness: Irrigation return flow controls are difficult to implement, although tailwater management has been practiced in Kansas for decades. The influence of upstream sulfate levels complicates the ability of the state to implement this TMDL. As such, the priority for this TMDL will remain low, as the state evaluates downstream benefits from irrigation return flow management in western Kansas and Colorado.

6. MONITORING

KDHE should collect bimonthly samples at Station 281 over 2001-2010 in order to assess progress in implementing this TMDL over each of the three defined seasons during the initial implementation period. Based on that sampling, the status of 303(d) listing will be evaluated in 2010 including application of numeric criterion based on background concentrations at high flows. Should impaired status remain, the desired endpoints under this TMDL will be refined. Use of the real time flow data available at the Derby stream gaging station can direct sampling efforts.

Monitoring of sulfate levels in effluent will be a condition of NPDES and state permits for facilities discharging to the Arkansas River or tributaries leading to the mainstem of the river.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Lower Arkansas River Basin were held March 9, 2000 and April 26-27, in Hutchinson, Wichita, Arkansas City and Medicine Lodge. 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 River Basin. A draft of this TMDL has been maintained on the website since June 1, 2000 and modifications to the original draft have been available to the public for viewing and review up to the date of submitting this TMDL to EPA.

Public Hearing: A Public Hearing on the original draft of these TMDLs of the Lower Arkansas River Basin was held in Wichita on June 1, 2000.

Basin Advisory Committee: The Lower Arkansas River Basin Advisory Committee met to discuss the TMDLs in the basin on September 27, and November 8, 1999; January 13 and March

9, 2000. The Committee recommended approval of the Basin Plan which set high priority TMDLs in the basin, thereby, delegating medium and low priority status to this and subsequent TMDLs for the basin. The Kansas Water Authority approved the Basin Plan on July 11, 2000.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:

Agriculture: January 12, February 2 and 29, 2000
Environmental: March 9, 2000
Conservation Districts: November 22, 1999
Industry: December 15, 1999, January 13, February 9 and 22, 2000
Local Environmental Protection Groups: September 30, November 2, December 16, 1999

Milestone Evaluation: In 2006, evaluation will be made as to the degree of improvement in water quality in downstream reaches from activities occurring above Garden City. Subsequent decisions will be made on further implementation after 2006.

Consideration for 303d Delisting: The river will be evaluated for delisting under Section 303d, based on the monitoring data over the period 2005-2009. Therefore, the decision for delisting will come about in the preparation of the 2010 303d 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 may 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 2002 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations under this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process after Fiscal Year 2005.

APPENDIX
COMPUTATION OF LOADS AND ALLOCATIONS

1. Estimated historic low flows and median sulfate concentrations

Site	7Q10	Median [SO4]	Remarks
Maize	Est.7Q10=20 cfs;	median [SO4]=170 mg/l	Segment 9 Entry
Valley Center	Est.7Q10=6 cfs;	median [SO4]=60 mg/l	Little Ark Contribution
Wichita	Est 7Q10=44 cfs;	median [SO4]=114 mg/l	Segment 3 Entry
Derby	Est 7Q10=110 cfs;	median [SO4]=150 mg/l	Segment 3 Terminus

2. Computation of Intervening Flow

Wichita - Maize - Valley Center: 44 cfs - 20 cfs - 6 cfs = 18 cfs for upper Wichita
Derby - Wichita: 110 cfs - 44 cfs = 66 cfs for lower Wichita (assumed to be Wichita wastewater discharge[43 MGD])

3. Computation of Sulfate Concentration of Intervening Flow

Assume sulfate concentration of wastewater discharge = 150 mg/l

Intervening Flow C. =

[(Derby Q * Derby C)- (Maize Q * Maize C)+ (Valley Cntr Q * Valley Cntr C) - (Pt.Src Q * Pt.Src C)] / Intrv. Flow Q

Intv. Flow C = [(110*150)-(20*170)-(6*60)-(66*150)] / 18 cfs = 158 mg/l

4. Future Loadings

Maize Flow increases to 25 cfs; Sulfate increases to 207 mg/l (based on Hutch TMDL)
Point Source Discharge increases to 60 MGD (93 cfs)
Background Levels at Wichita: Flow increases to 49 cfs, Sulfate increases to :
[(25*207) + (6*60) + (18*158)] / 49 cfs = 171 mg/l

5. **Load Allocation = 49 cfs * 171 mg/l * 5.4 / 2000 = 22.6 T/D**

6. Wasteload Allocation = 93 cfs * 250 mg/l * 5.4 / 2000 = 62.8 T/D

7. **Total Maximum Daily Load at Derby = 22.6 T/D + 62.8 T/D = 85.4 T/D**

8 Resulting Ambient Concentration below Derby = 85.4 T/D* 2000 /5.4/142 cfs = 223 mg/l

9. Final TMDL Values Incorporating Impact of **Margin of Safety (10% of WLA= 6.3 T/D)**

New WLA = 62.8 * 0.9 = 56.5 T/D
New Load = 79.1 T/D
New Ambient Concentration Downstream of Derby = 206 mg/l

10. High Flow TMDL

Median Flow of 528 cfs * Background Concentration of 350 mg/l * 5.4 / 2000 = 499 T/D

Wasteload Allocation (same as low flow) = 56.5 T/D
Margin of Safety = 6.3 T/D

Resulting Load Allocation = 436 T/D

Approved July 27, 2001.