LOWER ARKANSAS RIVER BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: **Arkansas River Between Nickerson and Maize**
Water Quality Impairment: pH

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Gar-Peace **Counties:** Harvey, Reno, Rice, Stafford and Sedgwick

HUC 8: 11030010

HUC 11s (HUC 14s)**:** **010** (010, 020, 030, 040, 050, 060, 070, and 080)
020 (010, 020, 030, 040, 050, 060, 070, and 080)

Drainage Area: 3095 mi^2 between Maize and Nickerson

Main Stem Segments: WQLS: 1, 3, 4, and 5; starting at the confluence with Little Arkansas River and extending upstream to confluence with Rattlesnake Creek.

Tributary Segments: WQLS: Salt Creek (7)
Peace Creek (6)
Non-WQLS: Big Slough (upper portion) (11)
S.F. Big Slough (35)
Gar Creek (8)

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

Special Aquatic Life on Peace Creek. Expected Aquatic Life on S.F. Big Slough, Big Slough, Gar Creek and Salt Creek. Food Procurement on Big Slough, Peace Creek and Salt Creek. Primary Contact Recreation on Peace and Salt Creek.

1998 303(d) Listing: Table 1 - Predominantly Non-point Source and Point Source Impacts
Table 3 - Predominantly Natural Condition Impacts

Impaired Use: Aquatic Life Support

Water Quality Standard: Artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (KAR 28-16-28e(c)(2)(C))

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 1998 303(d): Partially Supporting Aquatic Life

Monitoring Sites: (Arkansas River) Station 523 above Hutchinson; Station 524 near Yoder; Station 536 near Maize and Peace Creek (Station 658) and Salt Creek (Station 659).

Period of Record Used: 1990 to 2000 for Stations 523, 524 and 536; 1992, 1996 and 2000 for Stations 658 and 659.

Flow Record: Arkansas River near Maize (USGS Station 07143375); 1987 to 2000. Arkansas River near Hutchinson (USGS Station 07143330) 1970 to 2000.

Long Term Flow Conditions: Median flow at Hutchinson = 265 cfs; Hutchinson 7Q10 = 46 cfs; Maize 7Q10 = 19 cfs

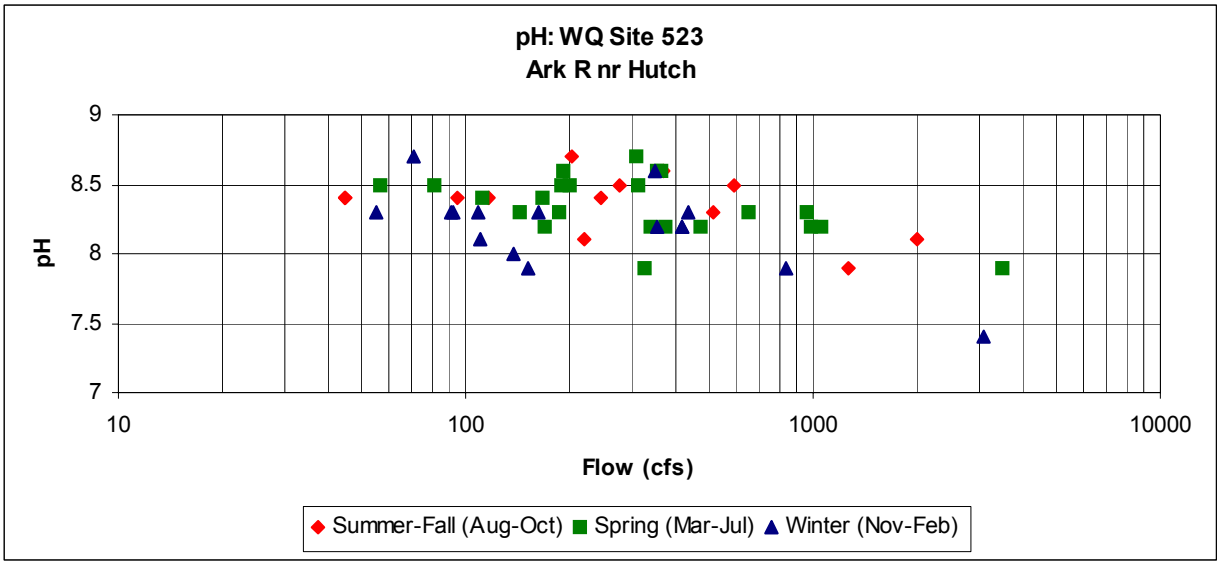
Current Conditions: Excursions above pH of 8.5 were noted in all seasons at Sites 523 and 524, but only in spring for Site 536. There was no significant difference in average pH above or below Hutchinson, but there was a significant difference (*) between Yoder and Maize. Typically, Yoder differed in nitrate and total phosphorus from either upstream or downstream sites. Generally, conditions for samples exceeding 8.5 pH show higher water temperatures, BOD and dissolved oxygen and lower turbidity. Lower nutrient levels were seen during the elevated pH conditions, hinting at assimilation by stream algae. These data indicate that available nutrients and the stream morphology encourage algae photosynthesis and growth demonstrated by the elevated pH, BOD and DO during warmer stream temperatures.

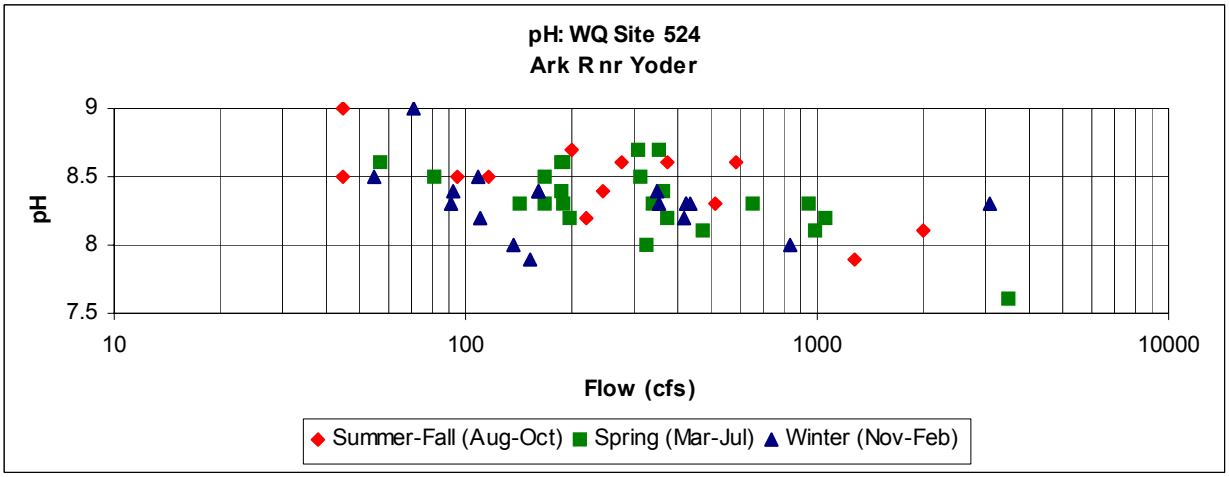
Average Conditions along Arkansas River Between Nickerson and Maize; 1990-2000

Site No.	Site Name	Avg. pH	Pct Samples	Support	Avg BOD	Avg NO3	Avg TP	Avg TSS
523	Abv Hutch	8.32	17%	Partial	3.8	1.75	0.32	86
524	Yoder	8.37	19%	Partial	4.2	2.32*	0.48*	90
536	Maize	8.20*	4%	Full	4.3	1.27*	0.40*	114

Average Characteristics at Arkansas River Stations during Normal and Elevated pH Conditions

Site Name	Avg pH	Avg Temp	Avg BOD	Avg DO	Avg NO3	Avg NH3	Avg TP	Avg TSS	Avg Turb
Abv Hutch	8.25	14	3.3	10.4	1.73	0.04	0.38	92	54
Abv Hutch	8.63*	19	6.2*	11.8	1.01*	0.04	0.22*	82	20*
Yoder	8.28	14	3.6	10.3	2.17	0.09	0.48	94	54
Yoder	8.72*	24*	6.5*	12.3*	1.92	0.03*	0.46	63	16*
Maize	8.17	14	4.3	9.3	1.28	0.07	0.41	122	57
Maize	8.6	18	4.5	10.9	0.88	0.08	0.35	30	8


pH: WQ Site 523
Ark R nr Hutch
9
8.5
8
7.5
7
pH
10
100
1000
10000
Flow (cfs)
Summer-Fall (Aug-Oct)
Spring (Mar-Jul)
Winter (Nov-Feb)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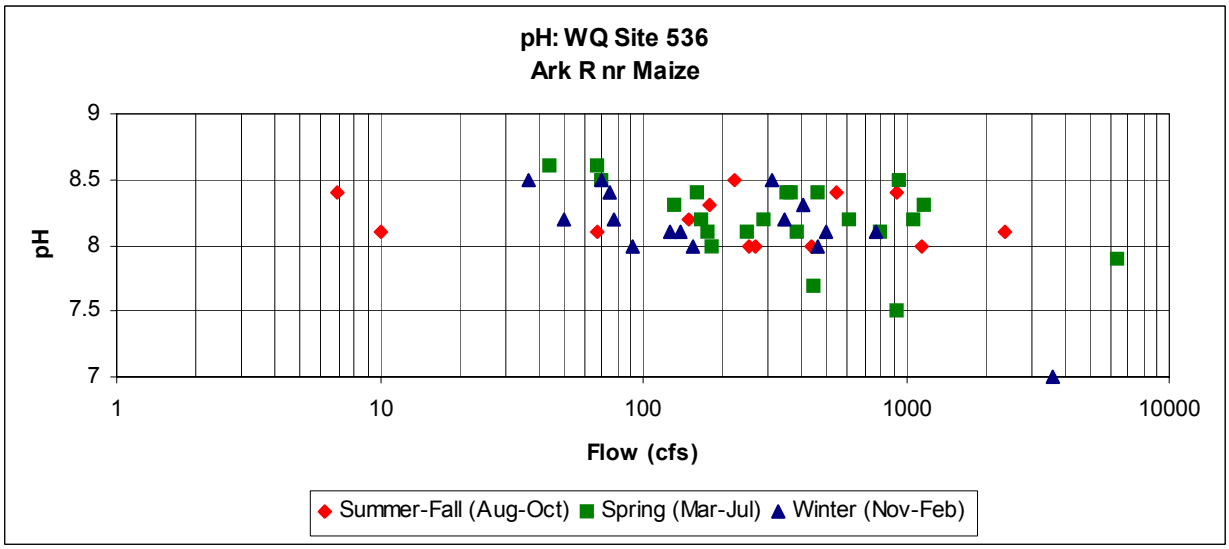
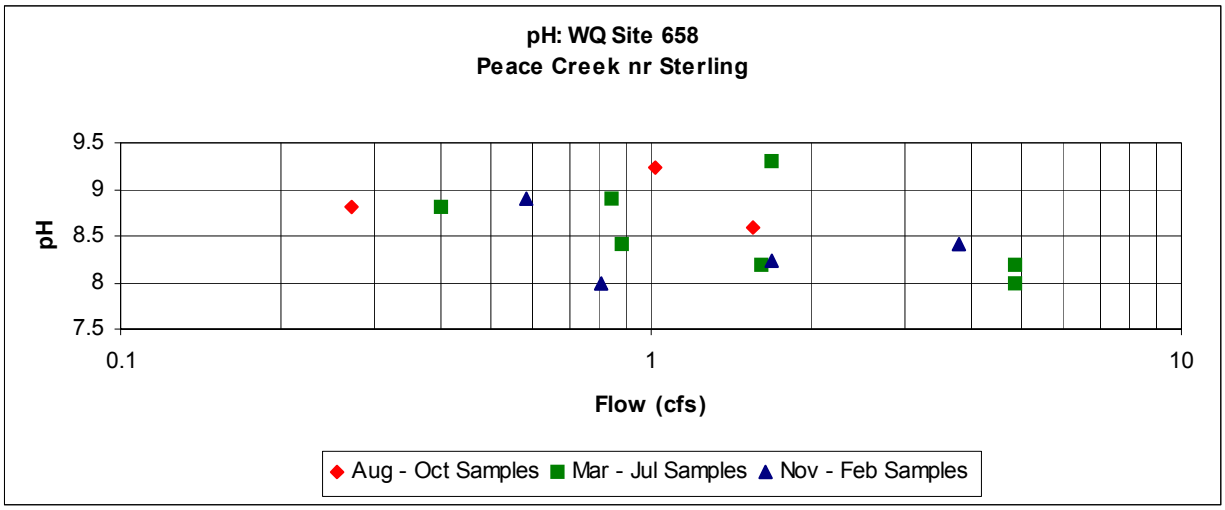
Ark R nr Yoder
9
8.5
8
7.5
pH
10
100
1000
10000
Flow (cfs)
Summer-Fall (Aug-Oct)
Spring (Mar-Jul)
Winter (Nov-Feb)


pH: WQ Site 536
Ark R nr Maize
pH
9
8.5
8
7.5
7
1
10
100
1000
10000
Flow (cfs)
Summer-Fall (Aug-Oct)
Spring (Mar-Jul)
Winter (Nov-Feb)


pH: WQ Site 658
Peace Creek nr Sterling
pH
9.5
9
8.5
8
7.5
0.1
1
10
Flow (cfs)
Aug - Oct Samples
Mar - Jul Samples
Nov - Feb Samples

Average Characteristics at Tributary Stations during Normal and Elevated pH Conditions

Site Name	Avg pH	Avg Temp	Avg BOD	Avg DO	Avg NO3	Avg NH3	Avg TP	Avg TSS	Avg Turb
Peace	8.23	12	3.8	12.3	1.58	0.26	0.185	63	17
Peace	8.87	19	5.0	14.1	0.69	0.06	0.204	51	9
Salt	8.26	14	3.7	12.1	0.28	0.08	0.097	28	11
Salt	8.73	19	5.0	14.1	0.10	0.04	0.179	69	21

Similar relations were seen on Peace and Salt Creeks, where pH excursions occurred in 54% and 36% of their respective samples. Phosphorus levels tended to be higher during the elevated pH condition. Streams in this region tend to run clear and shallow with a sandy substrate, conducive to algal growth and production, particularly during warm, low flow periods.

Samples for each of the three defined seasons, Spring (Mar-Jul), Summer-Fall (Aug-Oct) and Winter (Nov-Feb), are plotted for each of the three Stations on the Arkansas River (523, 524 and 536).Excursions usually occurred under flow conditions of less than 400 cfs at the Hutchinson Gaging Station. High flows and runoff equate to lower flow durations, baseflow and point source influences generally occur in the 75-99% range. pH/flow exceedence curves were established for the criterion by plotting pH samples on flow exceedence for the flow on the sample date. The water quality standard(s) on the pH/flow exceedence curves represent the TMDL, since the standard is dimensionless and no load can be calculated. Historic excursions from WQS are seen as plotted points outside the acceptable pH range. Water quality standards are met for those points plotting within the acceptable range.

NUMBER OF SAMPLES OUTSIDE OF pH STANDARD (6.5 - 8.5) 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.
Ark R. nr Hutch (523)	Spring	0	0	2	2	0	0	4/23 = 17%
	Summer	0	1	1	1	0	0	3/13 = 23%
	Winter	0	1	0	0	0	1	2/16 = 13%

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Ark R. nr Yoder (524)	Spring	0	0	1	2	0	1	4/23 = 17%
	Summer	0	0	4	0	0	1	5/13 = 38%
	Winter	0	0	0	0	0	1	1/16 = 6%

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Ark R. nr Maize (536)	Spring	0	0	0	0	0	2	2/22 = 9%
	Summer	0	0	0	0	0	0	0/13 = 0%
	Winter	0	0	0	0	0	0	0/17 = 0%

Station	Season	0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	Cum Freq.
Peace Cr nr Sterling (658)	Annual	0	0	0	3	2	2	7/13 = 54%

Of the 10 excursions seen at Site 524, 4 occurred while upstream Site 523 saw no excursions and 6 occurred coincidentally with excursions at Site 523.

Desired Endpoints of Water Quality (Implied Load Capacity) at Sites 523, 524, 536, 658 and 659 over 2005 - 2009:

The ultimate endpoint for this TMDL will be to Achieve the Kansas Water Quality Standards fully supporting Aquatic Life. The current standard of a pH of not less than 6.5 and not greater than 8.5 was used to establish the pH/flow exceedence TMDL curves. It must be noted that the stream morphology around Hutchinson, in concert with low turbid conditions with adequate nutrient levels, lends itself to facilitate algal photosynthesis, leading to elevated pH levels seen in the river. Lower nutrients and higher turbidity downstream at Maize results in fewer pH rises over 8.5.

Achievement of the endpoints indicate loads are within the loading capacity of the stream, water quality standards are attained and full support of the designated uses of the stream has been restored.

3. SOURCE INVENTORY AND ASSESSMENT

NPDES: There are four NPDES permitted municipal wastewater dischargers within the watershed. The City of Haven discharges to the Arkansas River downstream of water quality monitoring site 524.

MUNICIPALITY	STREAM REACH	SEGMENT	DESIGN FLOW
Nickerson	Arkansas R	4	0.155 mgd
S. Hutchinson	Arkansas R	3	Combined w/Hutch
Hutchinson	Arkansas R	3	9.27 mgd
Haven	Gar Cr	8	0.25 mgd

Population projections for all municipalities to the year 2020 indicate slight to moderate growth (9 - 16% increase from 1990). Projections of future water use and resulting wastewater appear to be within design flows for all current system's treatment capacity. Three excursions from the water quality standards do appear to occur under lower flow conditions, when point sources may have an impact .

Livestock Waste Management Systems: Eighty one operations are registered, certified or permitted within the watershed. Thirteen facilities are located within a mile of the main stem. The upper portion of the watershed is primarily beef and swine facilities and the lower portion is mainly dairy. Potential animal units for facilities within one mile of the main stem total 6,290. Potential animal units for all facilities in the watershed total 30,610. The actual number of animal units on site is variable, but typically less than potential numbers.

Land Use: Most of the watershed is cropland (82% of the area), grassland (15% of the area) or urban land use (1.5%). The off-season grazing density of livestock is about average when compared to the rest of the Upper and Lower Arkansas River Basin. About half of the watershed's growing season grazing density is average (16 - 30 animal units/mi^2) for those HUC14s primarily along impaired stream segments, while the other half is comparably low. The grassland is mainly located near the main stem of the Arkansas River and in the upper portion of the watershed. Based on 1997 water use reports, approximately 11% of the cropland in the watershed is irrigated. Most irrigation occurs in the lower portion of the watershed.

On-Site Waste Systems: The upper half of the watershed's population density is very low, 1 - 13 persons/mi^2 and the lower half of the watershed's population density is average to high (up to 1,050 persons/mi^2) especially for areas associated with towns/cities. The rural population projection for Reno County through 2020 shows moderate decline. While failing on-site waste

systems can contribute nutrient loadings, their impact on the impaired segments is fairly limited, given the population distribution within the watershed as it relates to impaired segments and given the magnitude of other sources in the watershed.

Background Levels: The primary mechanism of the pH impairment is based on the relatively unique morphology of the stream in the watershed. The Arkansas River between Great Bend and Hutchinson is a clear, shallow, wide stream with a sandy substrate. As a result, sunlight easily penetrates the river's entire water column. As temperatures increase and flows decline in the warmer months (spring and summer) the algae population within the stream can grow rapidly.

During photosynthesis, the phytoplankton up take carbon dioxide and give off oxygen. In this reaction, water molecules are cleaved. The organism takes up the hydrogen cation, and the remaining hydroxyl anion remains in solution. The pH value increases with the decrease in available hydrogen cations.

Peaks in pH occur in the afternoon, when the greatest amount of radiant energy reaches the river. Because the algae are only active during the growing season, the pH excursions are generally a seasonal impairment.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

It is believed that warmer water temperatures and adequate nutrient availability, coupled with the natural morphology of the Arkansas River (consistent base flow conditions, low turbidity, sandy substrate and shallow depth) are conducive to growth in algae population within the stream and the corresponding photosynthesis activity, causes pH to rise above the water quality standard of 8.5. There is often coincidental occurrences of elevated pH levels above and below Hutchinson, indicating that the watershed as a whole, creates a conducive environment for biological activity. This TMDL represents the "Best Professional Judgment" as to the indeterminant relationship between physical/biologic factors, stream morphology and pH.

Point Sources: The major facility discharging to the Arkansas River is Hutchinson. At a cumulative design flow approaching 15 cfs, point sources comprise over 10% of the flow which was exceeded at least 75% of the time. Historic monitoring data indicates that while pH levels are similar above and below Hutchinson, nutrient levels are elevated below the city. Average phosphorus and nitrogen concentrations at flows exceeded at least 75% of the time are 60 ppb and 3.7 mg/l, respectively, at Yoder. This is an increase from the overall average of 48 ppb and 2.3 mg/l and the low flow concentrations seen above Hutchinson (13 ppb, 2.5 mg/l). Availability of nutrients for algal assimilation may be caused by Hutchinson, since the plant has undergone nitrification for some time. A few pH excursions occur at low flows, but there are a number of samplings within the low flow regime with higher levels of nutrients, yet pH remains below 8.5. Further analysis needs to be done, in the face of pending nutrient criteria and monitoring of nutrients in waste water to indicate the level of contribution provided by point sources in the watershed under low flow conditions which cause rises in the pH. In the interim, a reduction in

average low flow concentrations in the river to 48 ppb of phosphorus and 2.3 mg/l of nitrogen should be attempted for flows between 45 and 145 cfs at Yoder. This results in an in-stream Wasteload Allocation of 117 - 376 pounds per day of phosphorus and 560 - 1800 pounds per day of nitrogen at Site 524.

Nonpoint Sources: A majority of the pH excursions occur at flows exceeded 35-65% of the time at both sites. Average concentrations for phosphorus and nitrogen in that flow range at Site 524 is 40 ppb and 2 mg/l, respectively. Reducing the average concentrations to 35 ppb of phosphorus and 1.6 mg/l of nitrogen results in a load allocation at median flow of 265 cfs of 2290 pounds per day of nitrogen and 500 pounds per day of phosphorus

Defined Margin of Safety: The Margin of Safety will be implicit based on the assumption that some reduction in nitrogen and phosphorus will reduce the frequency of pH excursions brought about by biological activity. The assumption is conservative because of the numerous samplings of nitrogen and phosphorus levels during the flow conditions of concern which are associated with normal pH levels yet are higher than the desired levels sought by this TMDL. As a further check that future loads do not impart further impairment, conditions at Maize will be monitored and the frequency of pH excursions at Site 536 will not rise above the current condition of 5% of samples.

State Water Plan Implementation Priority: Because the pH issue in the Gar-Peace watershed centers on nutrient management and will rely on future establishment of numeric nutrient criteria and further source assessment this TMDL will be a Medium Priority for implementation

Unified Watershed Assessment Priority Ranking: This watershed lies within the Gar-Peace Subbasin (HUC 8: 11030010) with a priority ranking of 19 (High Priority for restoration work).

Priority HUC 11s: Both HUC 11s (010 and 020) are of equal importance in this TMDL.

5. IMPLEMENTATION

Desired Implementation Activities

1. Evaluate and minimize artificial influences on stream pH.
2. Evaluate future trends in stream pH and nutrient levels.

Implementation Programs Guidance

NPDES - KDHE

a. Condition future permits of new facilities to maintain pH below 8.5 for the watershed.
b. Incorporate nutrient limits on permitted facilities in future after development of nutrient criteria
c. Monitor nutrient content of wastewater effluent from permitted facilities

Non-Point Source Pollution - KDHE

a. Monitor changes in land use activities in the watershed for potential impacts to stream water quality.

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

Water Quality Monitoring - KDHE

a. Monitor future levels of pH and in-stream nutrients and evaluate for trends.

Time Frame for Implementation: Evaluation of trends and activities should be accomplished over 2001-2005.

Targeted Participants: Primary participants for implementation will be KDHE.

Milestone for 2006: The year 2006 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, additional monitoring data from the Arkansas River will be reexamined to confirm the condition of the river relative to the current condition documented by this TMDL. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

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

Reasonable Assurances

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

1. K.S.A. 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 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: The State Water Plan Fund annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Medium Priority consideration and should not receive funding.

Effectiveness: Minimal control can be exerted on natural contributions to loading. Nutrient control of effluent levels can be accomplished through treatment plant technology and upgrades.

6. MONITORING

KDHE will continue to collect bimonthly samples at Stations 523, 524 and 536, including pH and nutrients over each of the three defined seasons over 2001-2010. Routine sampling will continue at the rotational sites 658 and 659 in 2004 and 2008. Based on that sampling, trends will be evaluated in 2006. If impairments remain, the desired endpoints under this TMDL will be refined and more intensive sampling of the river and sources will be necessary over 2006-2009. The status of 303(d) listing will be evaluated in 2010.

Monitoring of nutrient levels in effluent will be a condition of NPDES and state permits for facilities discharging to the 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 impairment which has occurred within the drainage and current condition of Arkansas River. Subsequent decisions will be made regarding implementation approach and follow up of additional implementation.

Consideration for 303(d) Delisting: Arkansas River will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2005-2009. Therefore, the decision for delisting will come about in the preparation of the 2010 303(d) list. Should modifications be made to the applicable criterion 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 of this TMDL will be considered in Kansas Water Plan implementation decisions under the State Water Planning Process after Fiscal Year 2005.

Approved July 27, 2001.