UPPER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody/Assessment Unit: Beaver Creek
Water Quality Impairment: Fluoride

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Beaver, Little Beaver, & South Fork Beaver

Counties: Decatur, Rawlins, Cheyenne & Sherman

HUC 8: 10250014, 10250013, & 10250012

HUC 11 : 10250014 (010, 031); 10250013 (010, 020); 10250012 (015, 020)

Drainage Area: 1,618 square miles above stateline gage and sampling station; 1,411 square miles above Ludell

Main Stem Segment: WQLS: 2 (Beaver Creek) starting at the Kansas-Nebraska state line and traveling upstream southwesterly through Decatur and Rawlins counties with North Fork Beaver Creek (Segment 2) and Little Beaver Creek (Segments 1,3 & 4) branching off above Atwood and with headwaters extending into Cheyenne and Sherman counties and Colorado (**Figure 1**).

Tributaries: Most tributaries are located near the Colorado border and are not likely to contribute flow except in the most extreme conditions.

Designated Uses: Expected Aquatic Life Support, Secondary Contact Recreation (b), Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Beaver Creek in Rawlins and Decatur counties.

Impaired Use: Irrigation

Water Quality Standard: 1 mg/liter for Irrigation (KAR 28-16-28e(c)(1))

In stream segments where background concentrations of naturally occurring substances, including chlorides and sulfates, exceed the water quality criteria listed in Table 1a of the "Kansas surface water quality standards: tables of numeric criteria," as adopted by reference in subsection (d) of this regulation, 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 quality standards," as defined in K.A.R. 28-16-28b(gg), and available upon request from the department. (KAR 28-16-28e(b)(9)).

Beaver Creek Watershed

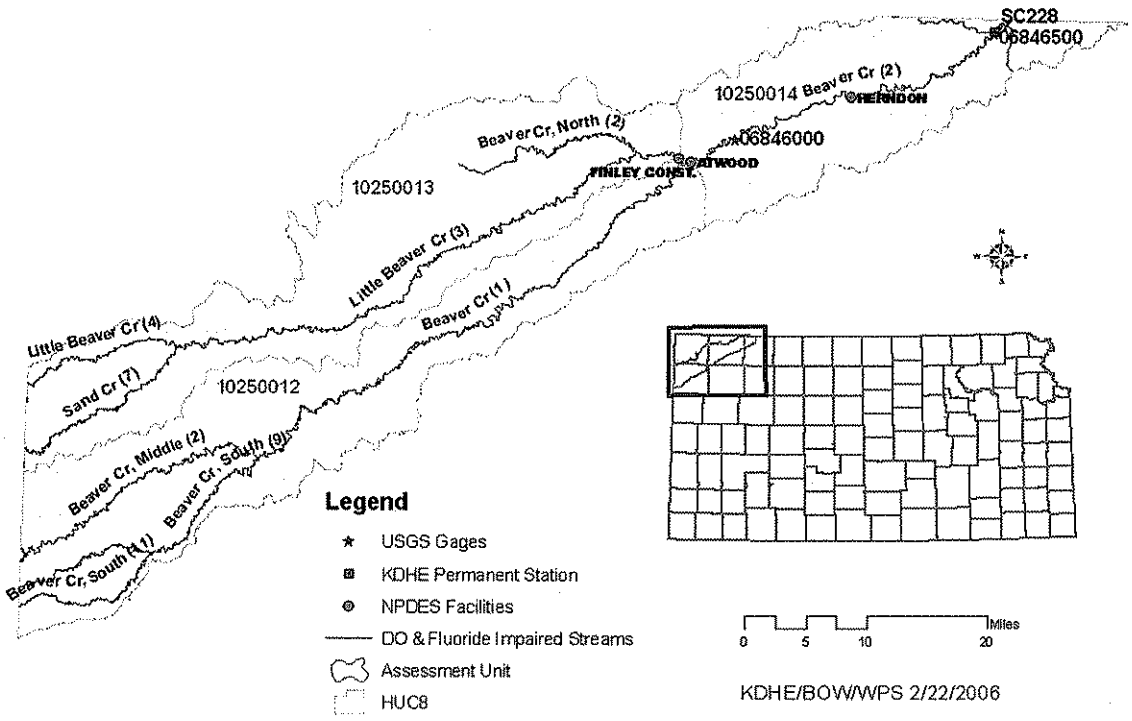

Figure 1- Base Map of Beaver Creek Watershed, along with monitoring sites and NPDES facilities.

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Level of Support for Designated Use under 2004 303(d): Not Supporting Irrigation

Monitoring Sites: Station 228 at Cedar Bluffs.

Period of Record Used: 1993-2005 for Station 228 (**Figure 2**)

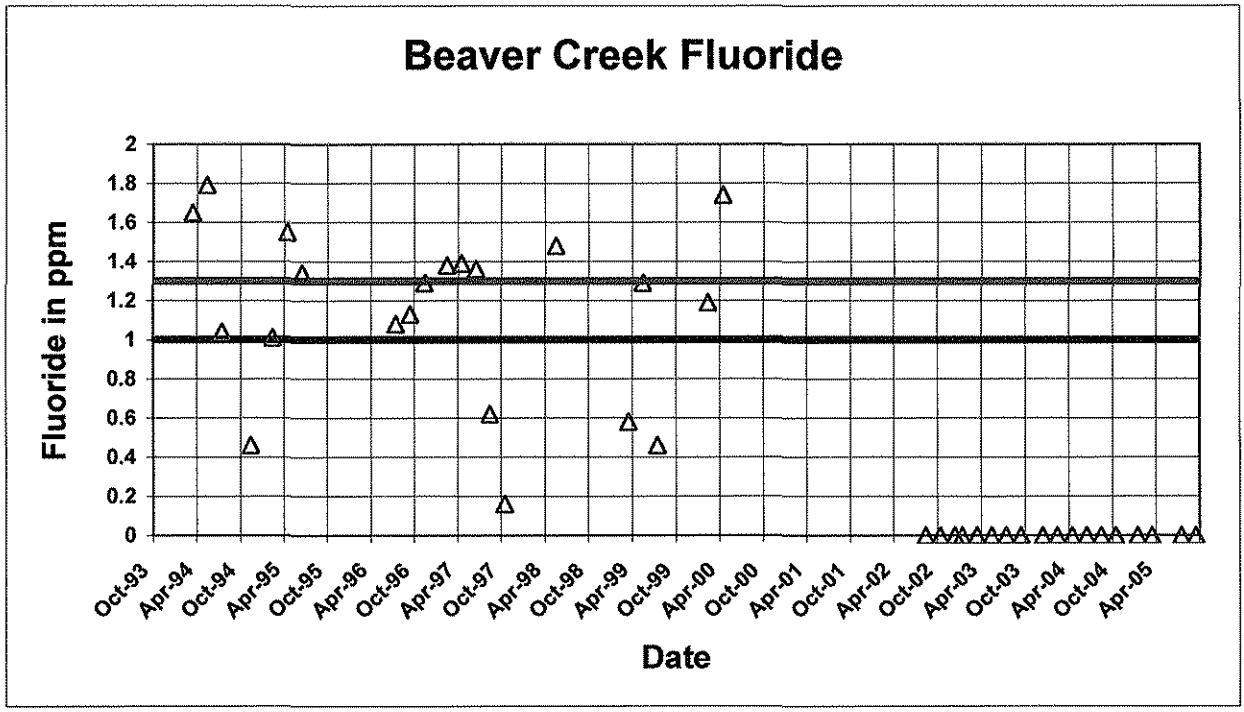

Figure 2. Fluoride concentrations seen on Beaver Creek. Blue line indicates irrigation criterion. Red line indicates proposed background concentration. Dates without data correspond to no-flow events when KDHE personnel visited the site.

Flow Record: Beaver Creek at Ludell (USGS Station 06846000); 1995-2005 & at Cedar Bluffs (USGS Station 06846500); 1970-2005 (**Figure 3**).

Long Term Flow Conditions: 90% Exceedance = 0 cfs, 75% Exceedance = 0 cfs, 50% Exceedance = 0 cfs, 25% Exceedance = 0.01 at Ludell, 1.8 cfs at Cedar Bluffs, 10% Exceedance Flows = 5.7 cfs at Ludell, 7.1 cfs at Cedar Bluffs. Mean Flow at Cedar Bluffs = 3.4 cfs.

Current Conditions: Since loading capacity varies as a function of the flow present in the stream, this TMDL may be represented as 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. However, Beaver Creek baseflow is depleted to the point where flow is seen less than 25% of the time. Point source effluent likely infiltrates into the stream channel rather than flows downstream to the monitoring station. Load Curves were established for the Irrigation 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 fluoride 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 below the load duration curve (**Figure 4**). Violations of the criteria occur within the flow range of 0.5 – 35 cfs over all three defined seasons, Winter: November-March, Spring: April-July, Summer-Fall: August-October (**Figure 5**). Fluoride concentrations averaged below the 1 mg/l irrigation criterion at flows below mean flow (**Table 1**).

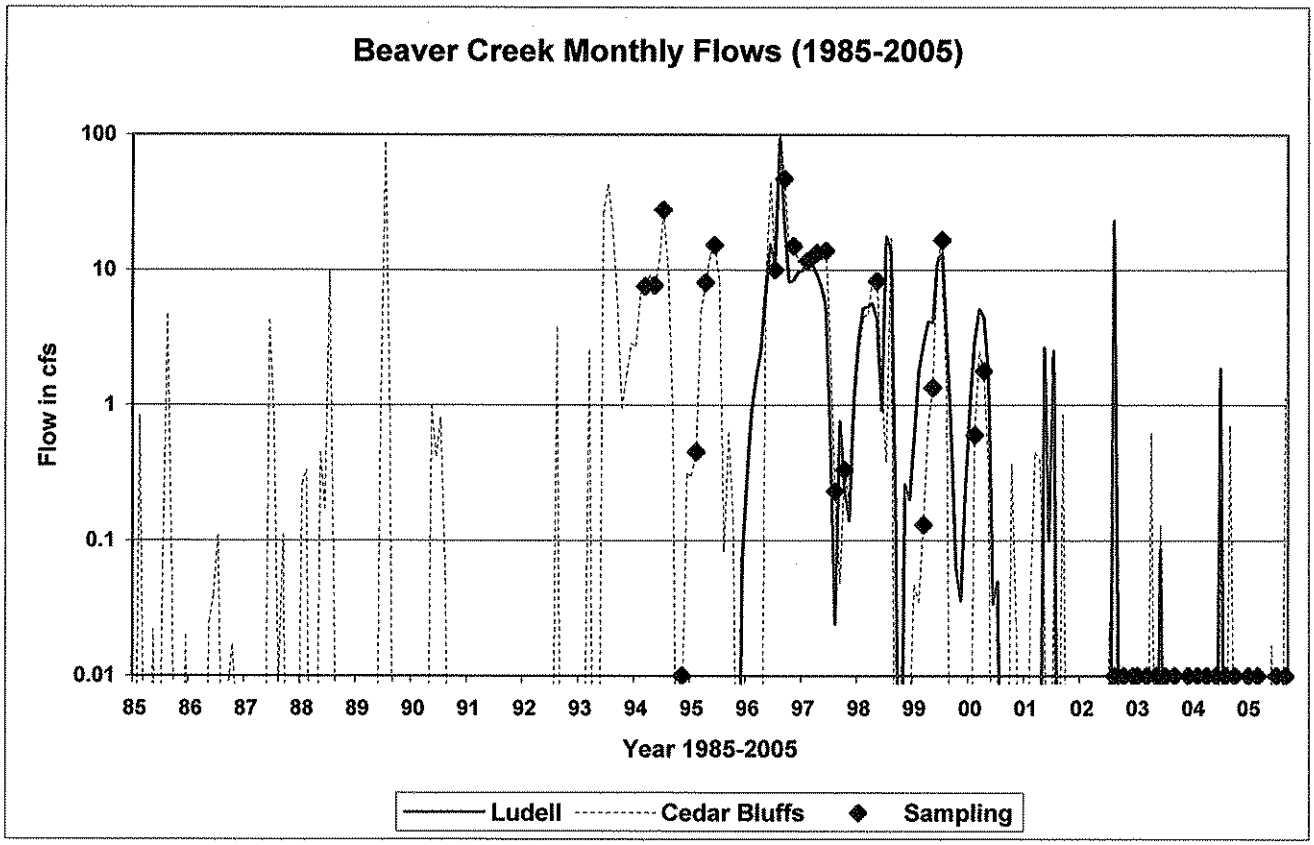

Figure 3. 20-year flow record on Beaver Creek. Blue diamonds indicate sampling dates. Dates with 0.01 cfs were no flow events, and samplings during no flow events indicate that KDHE personnel found insufficient water to conduct routine sampling (all 18 visits since 2000).

Table 1- Average fluoride concentrations (mg/L) on Beaver Creek at Station 228.

Fluoride Average	Overall	Winter	Spring	Summer-Fall
All flows	1.14 ppm	1.07 ppm	1.29 ppm	0.64 ppm
>3.4 cfs	1.30 ppm	1.34 ppm	1.31 ppm	1.13 ppm
<3.4cfs	0.88 ppm	0.89 ppm	1.20 ppm	0.39 ppm

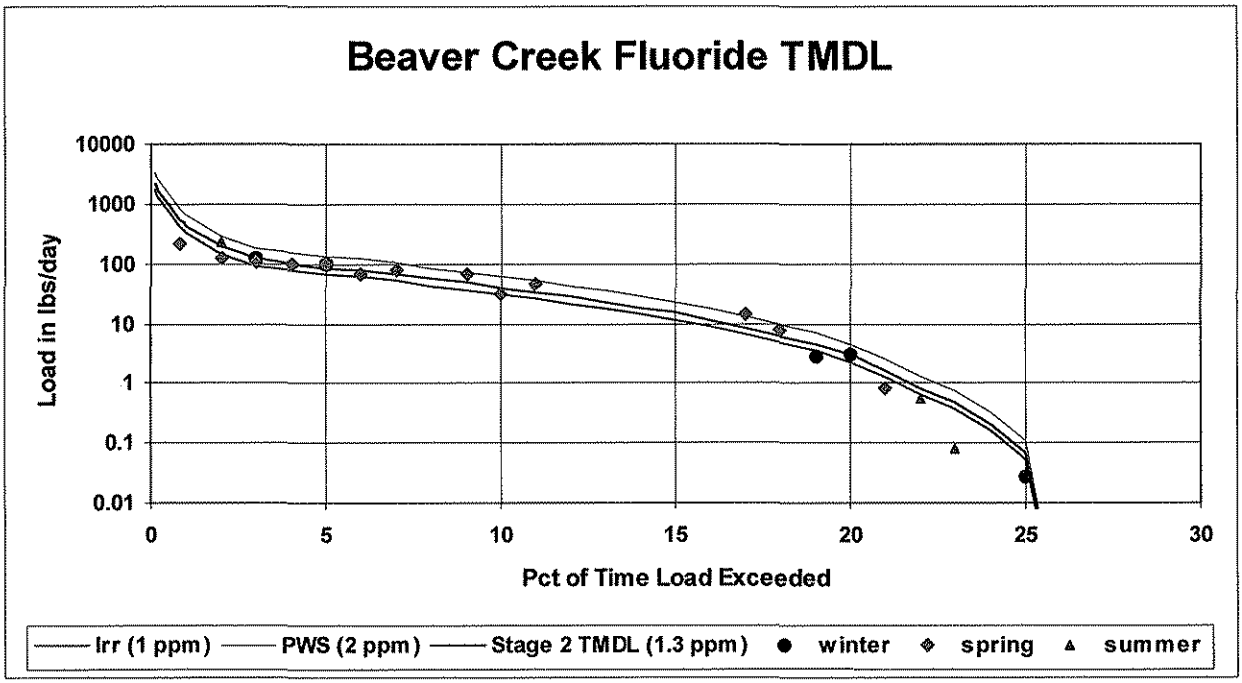

Figure 4. Fluoride loads in pounds per day based on flow duration. No values are presented beyond 25% exceedance, because long-term stream gaging data indicate no flow on Beaver Creek 70-75% of the time.

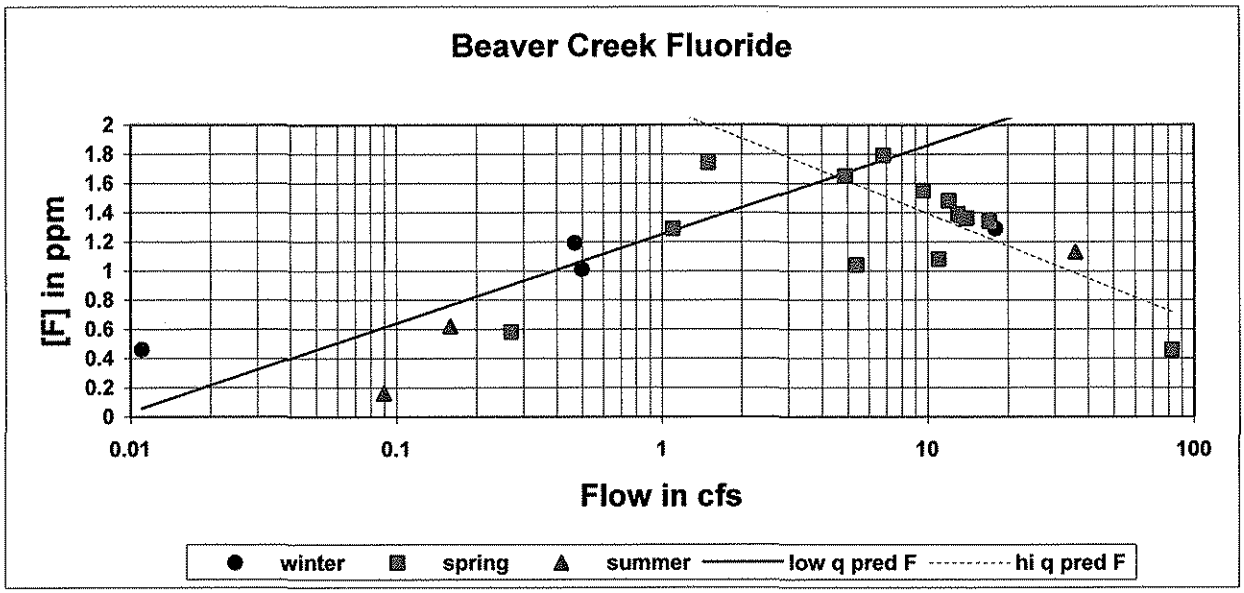

Figure 5. Relationship between flow and fluoride concentration on Beaver Creek. Fluoride tends to rise with flow up to mean flow, then begins to decline with higher flows.

Desired Endpoints of Water Quality (Implied Load Capacity) at Site 228 over 2008 – 2012

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting Irrigation. The presence of natural sources may elevate concentrations above the criteria during mean flow and suggests this TMDL should be staged. The current criterion of 1 mg/L of fluoride was used to establish a load duration curve (**Figure 4)** for the monitoring site.

Kansas Implementation Procedures for Surface Water allow for a background to be established when the monitoring record indicates that the existing criteria is unachievable due to naturally occurring conditions at higher flows.. The specific stream criteria to supplant the general standard will be developed subsequent to Stage One of this TMDL following the assessment of irrigation return flows. A Stage Two endpoint has been developed for Site 228 based on currently available information and will be 1.3 mg/l (the overall average seen at mean flow or greater). Future TMDL assessment will be based on this proposed background standard applied to flows over the long term average of 3.4 cfs. The Stage One (current) criterion will remain in force for low flows below mean flows.

Seasonal variation has been incorporated in this TMDL through the documentation of the elevated fluoride levels during spring when flows are typically the highest. 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

Background Levels:
Based upon observations provided by the Kansas Geological Survey, the source of the dissolved fluoride in the river water is ground-water discharge from the Ogallala-High Plains aquifer to the river. The Ogallala portion of the High Plains aquifer typically has higher fluoride concentrations than in the Quaternary portion of the aquifer in south-central Kansas and the alluvial aquifers in eastern Kansas. The higher fluoride concentration in the High Plains aquifer of Kansas is generally associated with higher silica content in the ground water. The higher silica concentrations are generally derived from dissolution of the ash deposits in the Tertiary Ogallala deposits. The amorphous glass in the ash has a higher solubility than silica in the form of quartz that composes most of the silt, sand, and gravel in the aquifer sediments. Fluoride is commonly associated with volcanic gases, therefore, fluoride could be expected to be associated with volcanic ash. Silica concentrations average 38 mg/l in Beaver Creek water. There is a negative correlation between fluoride and silica, although it is not statistically significant.

Average fluoride concentration of regional streams tends to be greater than the existing criterion of 1 mg/L. Samples collected by the USGS averaged 1.4 mg/L on the North Fork of the Republican River in 1947 and 1.2 mg/L on the Republican River below the confluence of the Arikaree River from 1980-1984. Samples collected by Colorado on the North Fork Republican from 1968-1977 average 1.1 mg/L. Kansas has already established elevated background fluoride criteria on the South Fork of the Republican, ranging from 1.2-1.45 mg/l. The Kansas TMDL for fluoride on the Arikaree River suggests a background level of 1.25 mg/l. Surrounding drainages to Beaver Creek are shown in **Figure 6**.

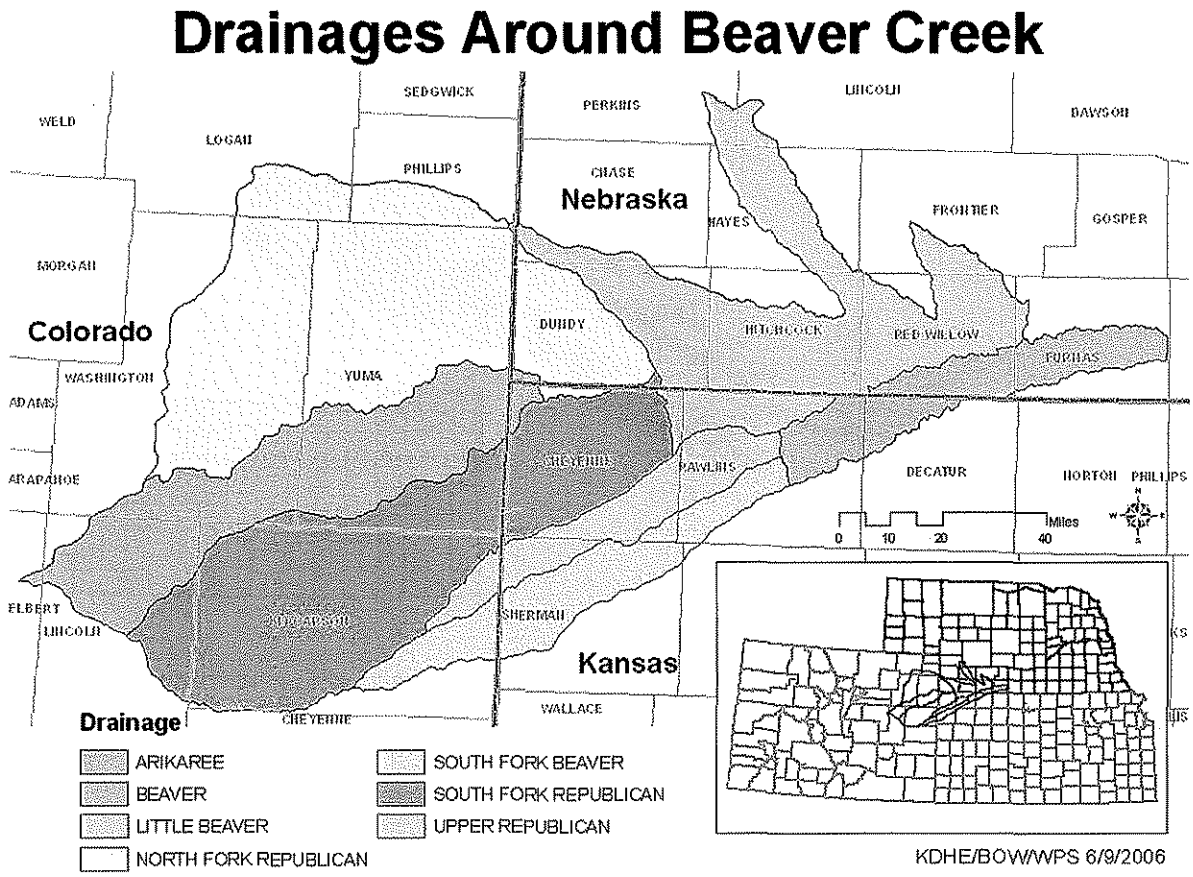

Figure 6. Surrounding Drainages to Beaver Creek

Fluoride on Beaver Creek is significantly correlated with conductivity, total dissolved solids and dissolved oxygen, and negatively correlated with BOD, fecal coliform and strep, total phosphorus and total suspended solids. These correlations suggest ground water is the primary source of fluoride and as runoff ensues, fluoride levels decline. However, **Figure 5** indicates fluoride levels increase as flows increase toward mean flow, then those levels begin to decrease at higher flows ([F] = 1.25+0.609*log Q {[below 3.4 cfs}; [F] = 2.13-0.735*log Q {above 3.4 cfs}. Stronger initial re-connection between the regional Ogallala formation and the stream might be suggested as the mechanism to explain the initial rise in fluoride. The Ogallala outcrops along the stream in Rawlins and Decatur counties (**Figure 7**). Once overland flow becomes the dominant contribution to streamflow, fluoride levels begin to diminish. The marginal hydrology of this stream system makes the fluoride levels very transient.

Beaver Creek Watershed - Geology

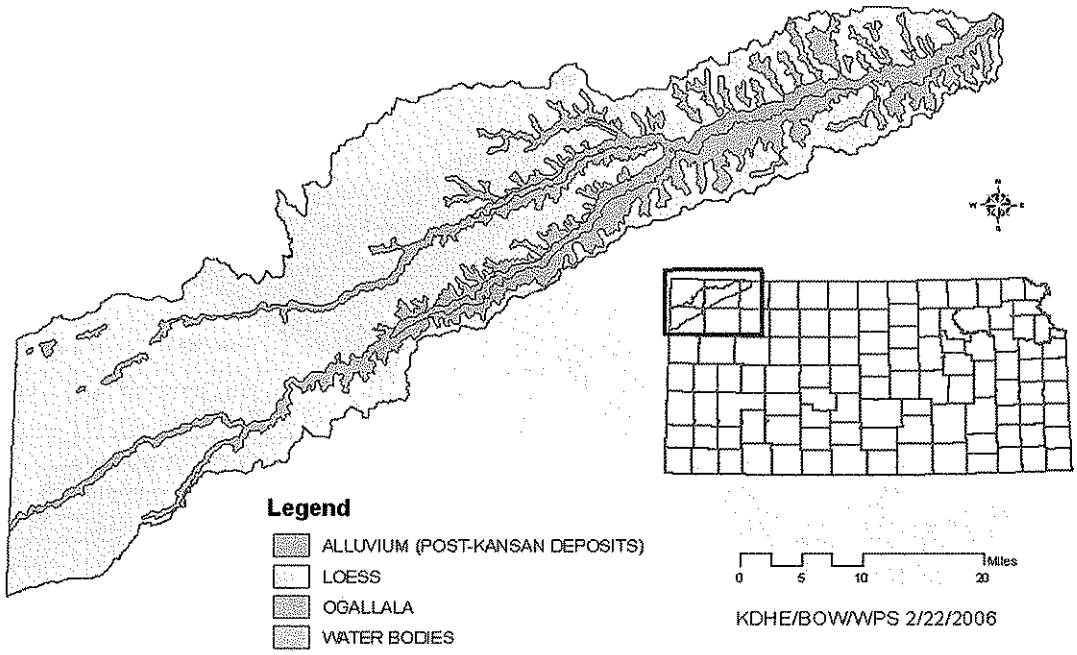

Figure 7. The surficial geology of the Beaver Creek Watershed.

NPDES: There are three NPDES permitted dischargers within the Beaver Creek watershed (**Figure 1**), all of them located in the lower portion of the stream system. None of the facilities contribute enough flow to deliver loads down to the Cedar Bluffs monitoring site (**Table 2**). Though the cities do not monitor for fluoride in their effluent, they do monitor fluoride in their source water. Atwood has averaged 1.12 mg/l F in its ground water supply over 1995-2003; Herndon has averaged 0.79 mg/l F in its ground water supply over 1995-2006. It is likely these levels are passed through the municipal system relatively unchanged.

There are also a number of non-discharging systems located in the watershed in Cheyenne and Sherman counties. None of these are expected to contribute any loadings monitored at station SC228.

Table 2. Discharging Wastewater Systems in the Beaver Creek Watershed

Facility	NPDES#	KS Permit #	Type	Receiving Stream	Design Q	Permit Expires	F Monitored?
Atwood	KS0095265	M-UR02-OO01	3-Cell Lagoon	Beaver Creek	0.20 MGD	06/30/2007	No
Herndon	KS0025551	M-UR10-OO01	3-Cell Lagoon	Beaver Creek	0.035 MGD	09/30/2007	No
Finley Construction	KSG110122	I-UR02-PR01	Concrete Plant	Little Beaver Creek	None from Settling Basin	09/30/2007	No

Livestock Waste Management Systems: **Livestock Waste Management Systems**: There are a number of confined animal feeding operations within the watershed, but only four between Atwood and monitoring station SC228 (**Figure 8**). The other facilities located in the upper portions of the watershed are not likely contributors of any pollutant causing the impairment because they are designed not to discharge and the stream system is depleted sufficiently that any spill would likely infiltrate into the immediate stream channel and not flow down into the lower reaches of Beaver Creek. The four facilities along the lower river are summarized in **Table 3**. Despite their proximity to the creek, they are certified not to cause significant pollution to the stream except in situations of extreme precipitation events (stream flows associated with such events are typically exceeded only 1% of the time). Such events would not occur at a frequency or of a duration that they would constitute a long-term impairment to the designated uses of the river. All four operations maintain relatively small numbers of animals within open lots ranging in area from about 3-10 acres. It is doubtful that any animal feeding operations are contributing fluoride to the stream system.

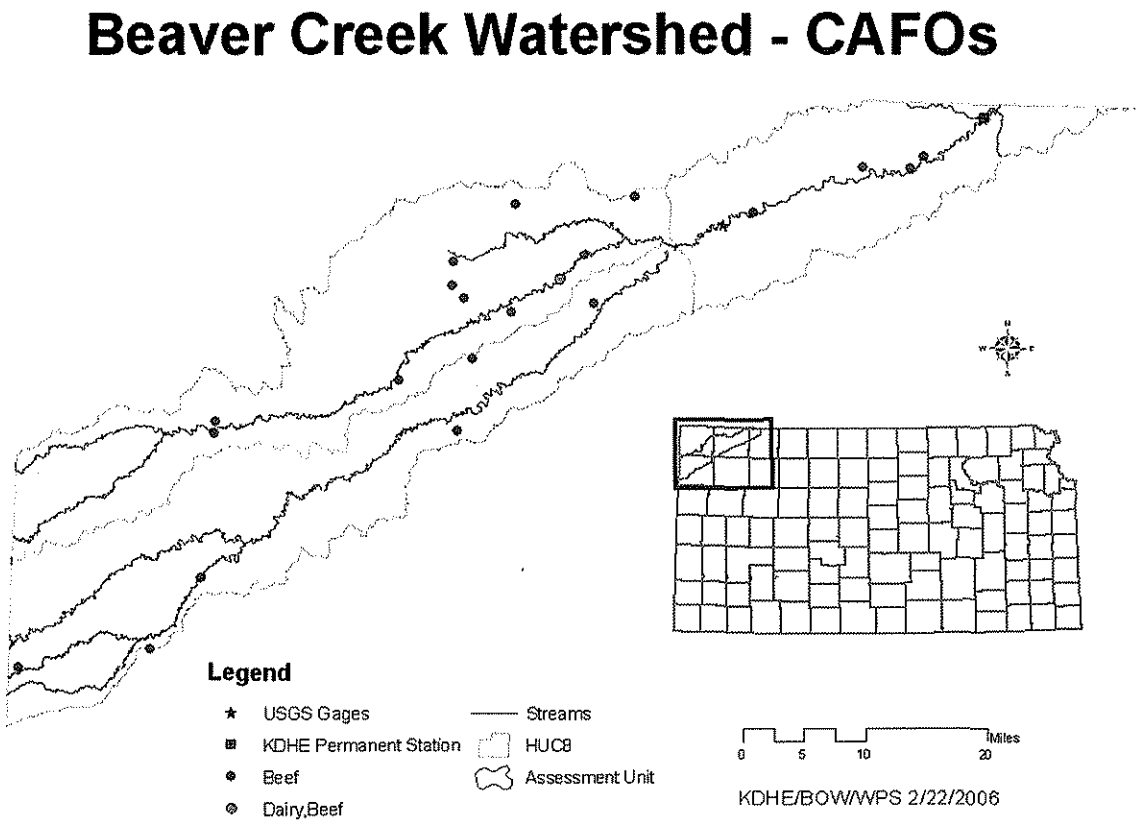

Figure 8. Animal Feeding Operations in the Beaver Creek Watershed.

Table 3. Animal Feeding Operations Along Lower Beaver Creek

Permit #	Type	Number of Animal Units	Remarks	Certificate Date
URRA-BA06	Beef	600 Head	2.75 acre open lot; runoff flows over 700 feet of cropland and 300 feet of grass strips before Beaver Creek	July 1, 2002
URRA-BA05	Beef	150 Head	10 acre open lot; runoff flows over 900 feet of grass areas before small trib of Beaver Creek	March 13, 2001
URDC-BA04	Beef	150 Head	3 acre open lots	July 19, 1977
URDC-BA02	Beef	600 Head	5 acre open lots; runoff flows over 0.5 mile of cropland and 1 mile of grassy draw before Beaver Creek	January 20, 1975

Land Use: National Land Cover Database GIS layers were used to assess land use in the basin. Most of the watershed is grassland (48% of the area) or cropland (47%) (**Figure 9**). Major crops were estimated by county level National Agricultural Statistics records. The majority of crop production is dryland wheat and irrigated corn and sorghum. Irrigation water likely draws on deepwater wells drawing from the High Plains Aquifer, although irrigation along the lower reaches of Beaver Creek probably uses alluvial water as its water supply.

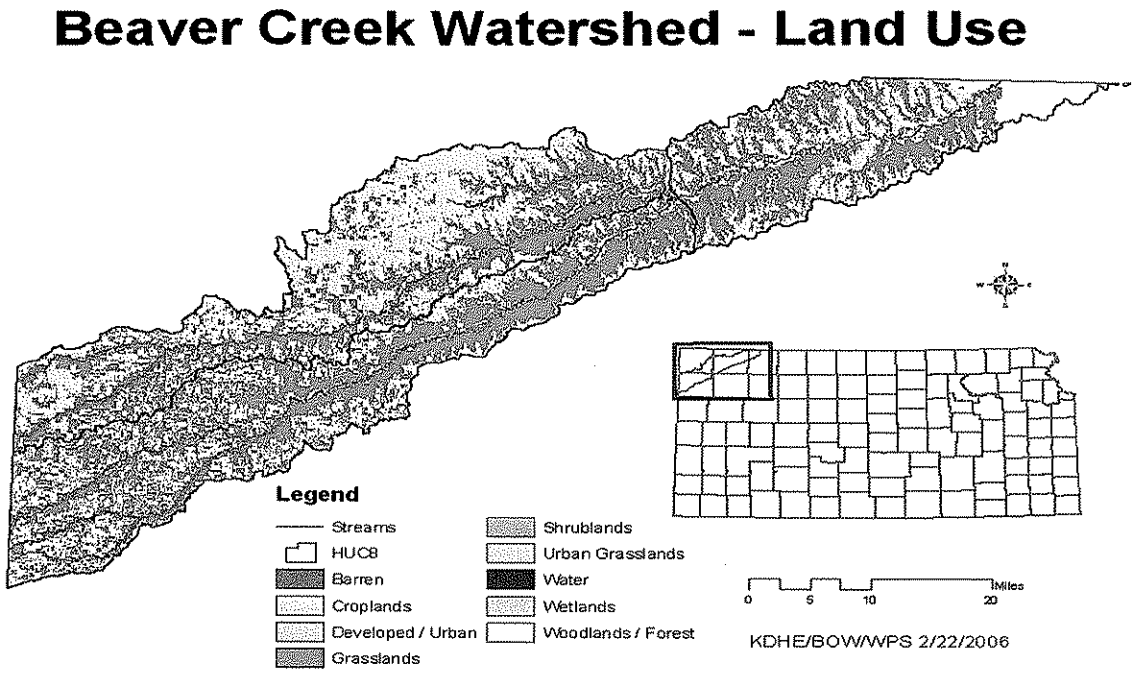

Figure 9. Land Use in the Beaver Creek Watershed

Irrigation: In 2003, over 111,300 acre-feet of water were used for irrigation in the Beaver Creek Watershed. Between 2000-2004, an average of 5075 acre-feet were used in the lower watershed below Atwood. Irrigation between Atwood and Herndon used 2000 acre-feet, and the balance was used between Herndon and the stateline. Much of the irrigation occurs in the western portion of the watershed supported by the High Plains Aquifer (**Figure 10**). This irrigation may not directly divert from Beaver Creek and its alluvium, but the accumulated withdrawal of water from the Ogallala formation and concurrent lowering of ground water levels have rendered Beaver Creek as a perpetual losing stream. There are pockets of perched ground water that intersect the stream channel along portions of the southern branch of Beaver Creek. A surface water diversion for irrigation has consistently been used (approximately 26 acre-feet annually). Field observations made in March 2006 found some flow in Beaver Creek in southwest Rawlins County above Atwood. This flow disappeared within a mile above Atwood. Lake Atwood within the city has been all but dry for two decades.

Beaver Creek water use is governed by the Republican River Compact between Kansas, Nebraska and Colorado. Kansas has an allocation of 6400 acre-feet of consumptive use under the Compact. Ground water modeling done under the administration of a Special Master assigned by the Supreme Court to establish impacts of the three states to the Republican River and its tributaries indicates the average impact to Beaver Creek by Kansas pumping is 5150 acre-feet per year. Most of the recharge to the aquifers in the watershed is from precipitation, followed by return flow from ground water irrigation, but there is no surface water recharge. Hence, the stream suffers depletion of flow since there is generally no baseflow available to discharge from the aquifers to the creek. The lack of surface water irrigation also points out that fluoride levels are not the limiting factor causing impairment to irrigation in the watershed.

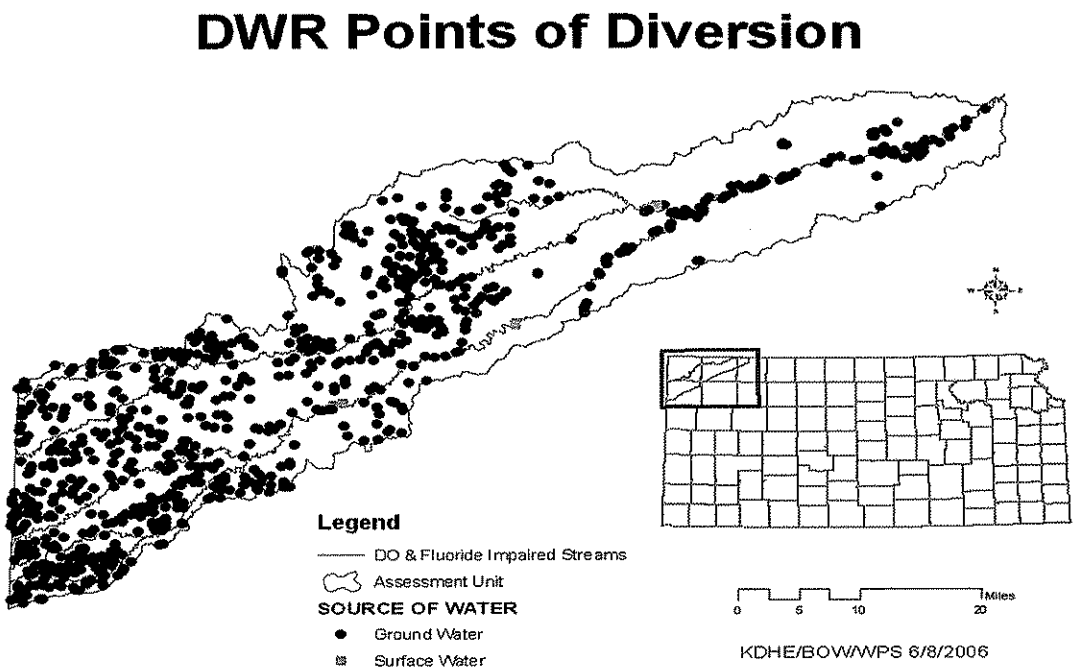

Figure 10. Water Right Points of Diversion (Mostly Irrigation) in the Beaver Creek Watershed

Population Density: Population density is low throughout most of the watershed. Estimates of 2004 population in Cheyenne, Rawlins and Decatur counties show declines over time and a low density of about 3 people per square mile. Estimates by the Kansas Water Office population indicate declining population through 2020, although current Census estimates for 2004 already approach KWO estimates of lower population for 2010-2020.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Fluoride is chiefly contributed by the discharges of High Plains - Ogallala ground water to the Beaver Creek channel under favorable conditions. These elevated fluoride levels tend to be commonly seen through out northwest Kansas, southwest Nebraska and northeast Colorado.

Point Sources:
Above Station 228, current Wasteload Allocations will be set for Herndon and Atwood, based on their average source water content of fluoride and the design flows of their wastewater treatment facilities. Therefore, Herndon will receive a Wasteload Allocation of 0.2 pounds per day of fluoride, while Atwood will receive an allocation of 1.9 pounds per day. Neither point source with active discharge is seen as a main contributor to the elevated fluoride seen at higher flows along Beaver Creek because of their small loadings and the lack of transmission of their effluent through the course of the stream channel to Station 228.

There will be a Wasteload Allocation of zero for Finley Construction and any state or NPDES permitted CAFO's within the drainage because such facilities do not discharge to Beaver Creek, except under extreme conditions and such conditions are not conducive to high fluoride levels in the Beaver Creek.

Non-Point Sources: The majority of the fluoride load in Beaver Creek appears to be background in nature. At site 228, the Load Allocation based on the existing fluoride criteria of 1.0 mg/L across all flow conditions is shown in **Figure 4**, respectively and is 18.4 pounds per day of fluoride at the mean daily flow of 3.4 cfs. The LA at station 228 will increase if the elevated background concentration (1.3 mg/L) becomes the applicable criteria (23.9 lbs/day at mean daily flow of 3.4 cfs). Exceedances were noted at flows in vicinity of the mean flow.

Defined Margin of Safety: The Margin of Safety provides some hedge against the uncertainty of loading and the fluoride endpoints for the Beaver Creek system and is considered implicit in this TMDL. The irrigation water use standard of 1.0 mg/L is extremely conservative considering it was developed for fluoride toxicity in acid soils. The soils in Rawlins and Decatur Counties are neutral to alkali (pH 6.1 – 9.0) and should effectively inactivate fluoride applied in irrigation water at the levels found in the river. There are no violations of the 2 mg/L criteria impacting the two more likely uses of surface water; livestock watering and domestic water supply.

Additionally, exceedances of the 1 mg/l criterion have not precluded surface water irrigation use, provided there is water available for irrigation, as evidenced by the small reach above Atwood where surface irrigation has been ongoing for years. hat would be impacted by the fluoride in the Arikaree River. The lack of consistent flows limits surface water withdrawals for irrigation moreso than ambient chemistry. Fluoride concentrations in effluent from Atwood and Herndon

are less than the background levels contributed by the regional ground water. Thus, the cities could potentially dilute the ambient concentration of fluoride seen in the stream and help achieve the endpoint of this TMDL.

Similar concentrations seen in area streams imply that the underlying groundwater is elevated in fluoride. None of the Kansas irrigation systems using ground water have indicated problems with fluoride. The proposed background concentration applies only to flows over the mean daily flow, which would be generated in this stream by rainfall, thereby removing the need for irrigation during this period. The two municipalities are allocated loads tied to their source water, both allocations are based on concentrations below the background concentration.

State Water Plan Implementation Priority: Because the dominant source for fluoride in the stream is from natural sources, groundwater sources are likely contributors to the fluoride concentrations seen at the monitoring stations and elevated fluoride occurs during higher flows along the main stem. This TMDL will be a **Low Priority** for implementation.

Unified Watershed Assessment Priority Ranking: The lower Beaver Creek watershed (HUC 8: 10250014) is classified as a Category I, priority 54 watershed under the Unified Watershed Assessment, a low priority for restoration.

Priority HUC 11s and Stream Segments: Because of the natural geologic contribution of this impairment, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Desired Implementation Activities

1. Establish alternative background criterion.
2. Restore some level of perennial flow to Beaver Creek

Implementation Programs Guidance

Water Quality Standards and Assessment - KDHE

a. Establish background levels of 1.30 mg/L for fluoride for the river below Atwood.

Republican River Compact Administration – KDA – DWR

a. Work to restore supply and demand balance to the water resources of Beaver Creek, consistent with the provisions of the Republican River Compact between Kansas, Nebraska and Colorado.

Timeframe for Implementation: Development of a background level-based water quality standard should be accomplished with the 2008 water quality standards revision.

Targeted Participants: Primary participants for implementation will be the Technical Services Section of KDHE.

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 Beaver Creek will be reexamined to confirm the impaired status of the river and the suggested background concentration. Additionally, the Division of Water Resources should report on the level of compact compliance in the Beaver Creek watershed since 2005.

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 228, including fluoride samples, in each of the three defined seasons. Based on that sampling, the stream will be evaluated in 2011 with application of numeric criterion based on background concentrations.

7. FEEDBACK

Public Meetings: Public meetings 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: Public Hearings on the TMDLs of the Upper Republican Basin were held in Atwood on March 2, 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 Beaver Creek. Subsequent decisions will be made regarding the need for an implementation approach if fluoride levels in Kansas elevate with improved flows in Beaver Creek.

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 may be adjusted accordingly.

Revised June 26, 2006