KANSAS-LOWER REPUBLICAN BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody: **Tuttle Creek Lake Drainage, including Big Blue River, Little Blue River, Black Vermillion River, Mill Creek and Rose Creek**

Water Quality Impairment: Atrazine

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasins: Lower Big Blue & Lower Little Blue

Counties: Marshall, Nemaha, Washington, and Republic

Ecoregions: Tuttle Creek Lake in Great Plains Grass and Shrublands-Flint Hills (IV-28)
Eastern Drainage in Western CornBelt Plains-Loess and Glacial Drift Hills (VI-47i)
Western Nebraska Drainage in Central Great Plains-Rainwater Basin Plains (V-27f)
Western Kansas Drainage in Central Great Plains-Smoky Hills (V-27a)

HUC 8s: 10270205 & 10270207

Drainage Area: Approximately 9,628 square miles above dam.

Water Quality Limited Segments: Tuttle Creek Lake, Big Blue River (7,17,18,20&21), Black Vermillion River (8,10,11,13&14), Little Blue River (1,2,3&4), Mill Creek (14,16,18,20,22,&31) and Rose Creek (12)

Other Significant Tributaries: Big Blue River – Horseshoe Creek (26)
Tuttle Creek Lake – Fancy Creek (9029)
Little Blue River – Coon Creek (23)
Black Vermillion River – Roubidoux Creek (16)
- NF Black Vermillion River (15)

Water Quality Criteria: Domestic Water Supply - Atrazine: 3 µg/l (ppb)
Aquatic Life Support – Atrazine Chronic: 3 µg/l (ppb)
Aquatic Life Support – Atrazine Acute: 170 µg/l (ppb)
(KAR 28-16-28e(c)(2)(D)(ii) and (3)(A))

Domestic Water Supply is assessed by examining annual averages concentrations, pursuant to Safe Drinking Water Act protocols; Aquatic Life Support is assessed by determining the proportion of samples that are over the chronic criterion; if the proportion is over 10%, the water only partially supports aquatic life; over 25% indicates non-support conditions. These proportions are consistent with the methodology of the 1996 305(b) Report pursuant to K.S.A. 65-1,176.

Designated Uses of Impaired Streams: All Waters are General Purpose Waters with Expected Aquatic Life Support. Tuttle Creek Lake, Big Blue R., Little Blue R. and Black Vermillion R. are designated for Domestic Water Supply.

1998 303d Listing: Tuttle Creek Lake (LM 021001) listed for Atrazine

2004 303d Listing: Big Blue River (233,240), Black Vermillion River (505), Mill Creek (507) & Rose Creek (712) listed for Atrazine

Stream Network of Tuttle Creek Lake Drainage and KDHE Monitoring Stations:
Subbasin Maps of Numbered Stream Segments in Appendix A

The Watershed Hierarchy of the Immediate Tuttle Creek Lake Watershed

HUC8	**10270205**		
Watershed	**Tuttle Creek Lake**		
Station			
021001	Mill Cr (31)		
	Fancy Cr (9029)-part	N. Otter Cr (62)	
	Blue R (7)	Timber Cr (64)	
		Spring Cr (65)	Bluff Cr (573)
			Bucksnort Cr (566)
	Blue R (17)-part	Game Fork (54)	

HUC8	**10270205**		
Watershed	**Fancy Creek**		
Station			
502	Fancy Cr (9029)-part	School Branch (63)	
		Otter Cr (67)	
		N. Fk. Fancy Cr (61)	
		West Fancy Cr (29)	Deadman Cr (60)
			Carter Cr (59)

The Watershed Hierarchy of the Black Vermillion River Watershed

HUC8	**10270205**		
Watershed	**Black Vermillion River**		
Station			
505	Black Vermillion R (8)	Corndodger Cr (52)	
		DeShazer Cr (55)	
		Clear Fk Black Vermillion R (9)	Jim Cr (57)
	Black Vermillion R (10)	Johnson Fork (51)	
		Cedar Cr (56)	
		Robidoux Cr (16)	Dog Walker Cr (53)
			Perkins Cr (47)
	Black Vermillion R (11)	Little Timber Cr (48)	
		S. Fk. Black Vermillion R (12)	Kearney Branch (58)
	Black Vermillion R (13)	Ackerman Cr (49)	
		N. Fk. Black Vermillion R (15)	Weyer Cr (50)
	Black Vermillion R (14)		

The Watershed Hierarchy of the Big Blue River Subbasin

HUC8	10270205		
Watershed	**Lower Big Blue River**		
Station			
240	Big Blue R (17)-part	Elm Cr (46)	
	Big Blue R (18)	Dutch Cr (44)	
		Hop Cr (43)	
		Spring Cr (19)	Schell Cr (45)
			Lily Cr (39)
	Big Blue R (20)		
	Big Blue R (21)	Deer Cr (36)	
		Scotch Cr (38)	

HUC8	10270205	
Watershed	**Horseshoe Creek**	
Station		
717	Horseshoe Cr (26)	Raemer Cr (33)
		Indian Cr (37)
		Meadow Cr (34)
		Little Indian Cr (35)

HUC8	10270205		
Watershed	**Upper Big Blue River**		
Station			
233	Big Blue River (21)	Bommer Cr (40)	
		N. Elm Cr (41)	
		Mission Cr (22)	Murdock Cr (42)

The Watershed Hierarchy of the Little Blue River Subbasin

HUC8	10270207		
Watershed	**Lower Little Blue River**		
Station			
741	Little Blue R (1)	Fawn Cr (45)	
		Coon Cr (23)	Camp Cr (44)
	Little Blue R (2)	Walnut Cr (41)	
		Bolling Cr (42)	
		Mercer Cr (43)	
		Malone Cr (37)	
		Beaver Cr (38)	
		Lane Branch (39)	
		Cedar Cr (40)	
	Little Blue R (3)	Joy Cr (13)	
	Little Blue R (4 - part)		

HUC8	10270207		
Watershed	**Mill Creek (Hanover)**		
Station			
507	Mill Cr (14)	Spring Cr (aka Devils Cr) (15)	Spring Cr (30)
	Mill Cr (16)	Ash Cr (36)	
		Camp Cr (35)	
		Riddle Cr (17)	
	Mill Cr (18)	Buffalo Cr (32)	
		Melvin Cr (33)	
		Salt Cr (19)	
	Mill Cr (20)	Iowa Cr (34)	
		Jones Cr (29)	
		Gray Branch (27)	
		Bowman Cr (21)	
	Mill Cr (22)	Meyer Cr (26)	
		S. Fk. Mill Cr (31)	
		Cherry Cr (25)	

HUC8	10270207	
Watershed	**Little Blue River**	
Station		
232	Little Blue R (4 - part)	School Cr (49)
		Silver Cr (28)
		Humphrey Branch (24)
		10270206 Dry Cr (41)

HUC8	10270207
Watershed	**Rose Creek**
Station	
712	Rose Cr (12)

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

Period of Record Used: **Water Quality Data (Sources):**
Tuttle Creek: 1986-2004 (KDHE, USGS, KC-COE)
Big Blue, Little Blue & Black Vermillion Rivers: 1986-2004 (KDHE, USGS, KC-COE, KSU)
Mill Creek: 1990-2004 (KDHE, KSU)
Fancy Creek: 1990, 1994-1998, 2002 (KDHE)
Horseshoe Creek: 1998 (KDHE)
Rose Creek: 1997, 2001 (KDHE)

Streamflow (USGS): 1984-2004

Lake Elevation and Outlet Flow (KC-COE): 1984-2004

Conservation Pool: Elevation at 1075'; Estimated Volume is 265,000 acre-feet

Current Condition: **Lake Elevations**: Tuttle Creek Lake fluctuates annually as floodwaters enter the reservoir in the spring and the lake is drawn down in the summer and fall for flow augmentation to the Kansas River (Figure 1). Over the period of 1984-2004, the lake reached a maximum elevation of 1137.66 ft during the 1993 flood. Conversely, the lake was dropped to 1068.33 ft in January 2001, on the heels of an autumn drawdown intended to provide water to support navigation service on the Missouri River below Kansas City. Generally, the lake remains within a ten-foot zone bounded five feet on either side of the conservation pool elevation (1075'). There has been a tendency to hold the lake three feet into the flood pool (elevation 1078') to accommodate in-lake recreation, waterfowl and wildlife needs. This interim storage also provides a source of augmentation water for navigation needs if the Corps of Engineers decides to supplement the Missouri River in the autumn.

As shown in Figure 2, the lake has been below the conservation pool level only 40% of the time since 1984. The pool level has been between 1075 ft and 1078 ft 30% of the time, while the pool has been above 1080 ft 15% of the time. This display of elevation frequency signifies the two main objectives of Tuttle Creek operations: evacuate water from the flood pool rapidly and retain as much water in the conservation pool as possible for later use. During the critical months of May and June, higher elevations are the norm. Half of the time pool elevations lie below 1078 ft but 35% of the time the pool is over 1080 ft. These two months are major filling periods for the reservoir, and germane to this TMDL, the primary periods of atrazine loading.

The increase in volume in the first three feet of the flood pool is 43,072 acre-feet, increasing the effective conservation pool by 15%. Another 33,027 acre-feet accrue in the next two feet of storage and storage increases substantially with each additional five-foot increment.

Figure 1. Daily Elevations at Tuttle Creek Lake from 1984-2004 (KC-COE data)

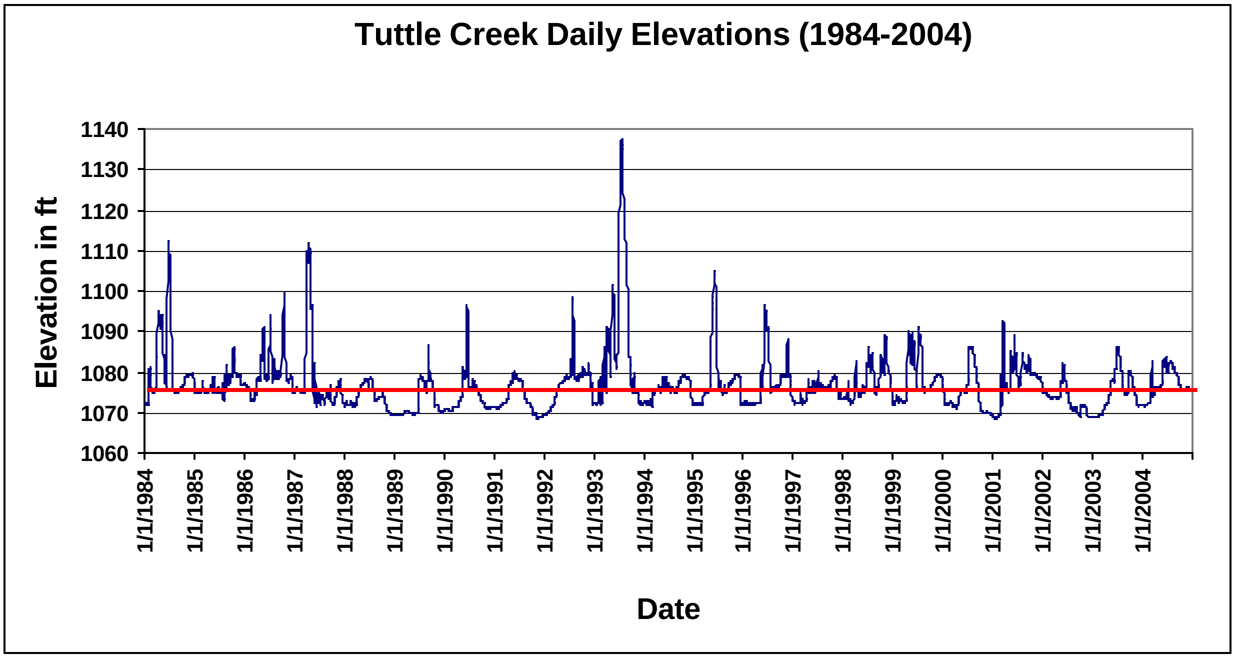
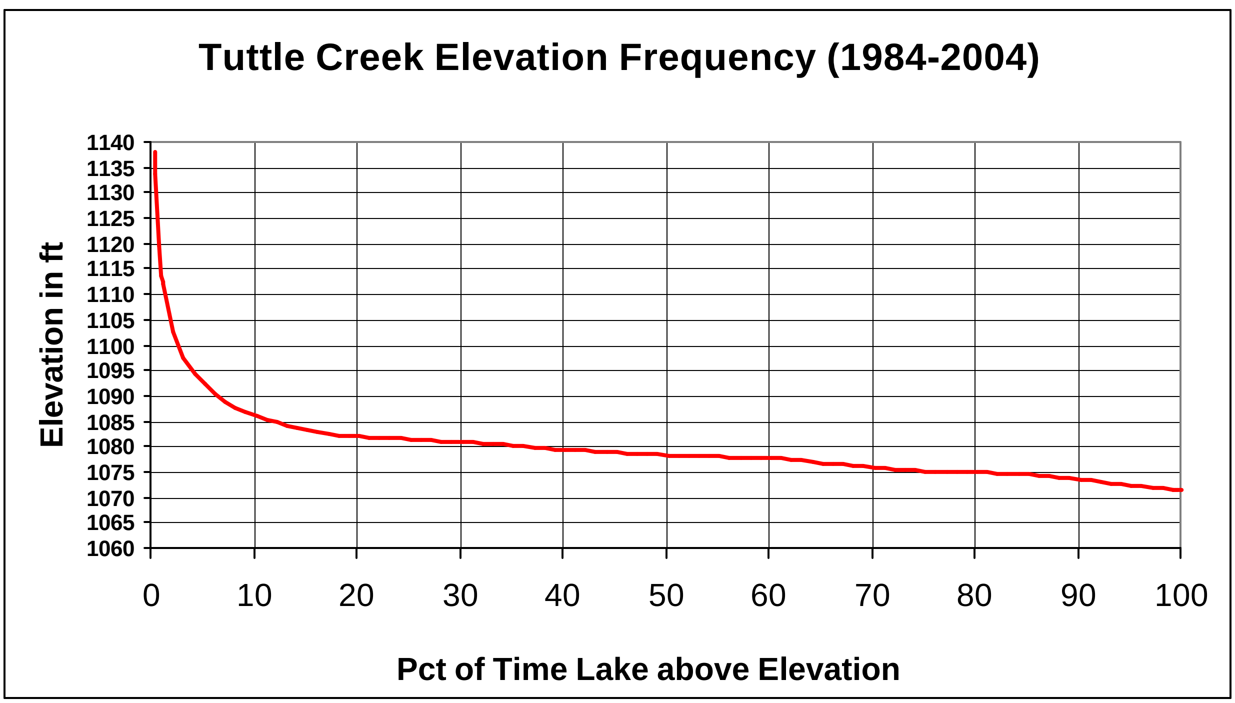


Figure 2. Pool Elevation Frequency at Tuttle Creek based on Daily Data from KC-COE



Reservoir Releases: The primary purpose for Tuttle Creek Lake is to act as a reservoir in detaining flood flows and subsequently releasing the stored volume at substantially lower peak rates. Secondarily, Tuttle Creek is a primary augmentation source to maintain flows (typically 1000 cfs at Kansas City) on the Kansas River during dry, low flow periods. Additionally, Tuttle Creek has been used by the Federal government to supplement Missouri River flows (by up to 2000 cfs) during navigation season below Kansas City.

Since the storage pool is relatively stable, inflows and outflows should be equivalent over the long run. Figure 3 relates monthly outflows to the calculated inflows as measured at the USGS gages on the Little Blue River near Barnes, the Big Blue River at Marysville and the Black Vermillion River near Frankfort. These three stations measure 88% of the drainage flowing into Tuttle Creek. There is variability in inflows at a given outflow rate, which is expected since outflows tend to be lagged over a month to allow the flow detention benefits of the reservoir to be realized.

There appears to be a general pattern of inflows exceeding outflows of 500 cfs or less, and outflows exceeding inflows when outflows increase beyond 500 cfs. At the lower flows, operations are attempting to supplement the Kansas River, typically with releases from conservation storage. Inflows during those drier periods will be retained to replenish vacated storage. At higher release rates, some degree of flood control is in operation. The reservoir typically handles a flood event by restricting outflows as high inflows enter and are stored, then subsequently, as inflows recede, vacate the flood storage with large outflow releases, in anticipation of the next high inflow event.

The relationship between pool level and outflow rate is displayed in Figure 4. Note that in the typical 10-foot operation zone (1070'-1080'), outflows span multiple orders of magnitude, depending upon the driving objective. Once elevation exceeds 1080 feet, flood operations are the rule and releases are rarely below 1000 cfs, reaching up to the desired maximum capacity of 25,000 cfs. During the 1993 flood, conditions dictated increased outflows as elevations rose beyond 1120 feet, peaking at 60,000 cfs as the emergency spillway was used when water rose beyond the top of the flood pool at elevation 1136 feet.

The release patterns demonstrate the low residence time of waters entering the flood pool of Tuttle Creek Lake. Since these flood waters are the typical transport mechanism of atrazine into the lake, there appears to be little time to accumulate the pesticide in the conservation pool.

Streamflow: The Tuttle Creek drainage is dominated by three main streams; the Big Blue River, the Little Blue River and the Black Vermillion. The Big and Little Blue Rivers are shared by Kansas and Nebraska, the Black Vermillion River lies wholly in Kansas. Mill Creek, also substantially in Kansas, is the major tributary to the Little Blue River and the drainage system. Minor tributaries to the rivers and the lake abound. Figure 5 shows the flow duration curves for the gaged streams in the drainage. Barneston and Marysville are located on the Big Blue River and Hollenberg and Barnes are located on the Little Blue River. The Big Blue River is the dominant inflow to the lake, followed by the Little Blue River and the Black Vermillion River.

Figure 3. Average Monthly Inflows and Outflows at Tuttle Creek Lake, 1984-2004.

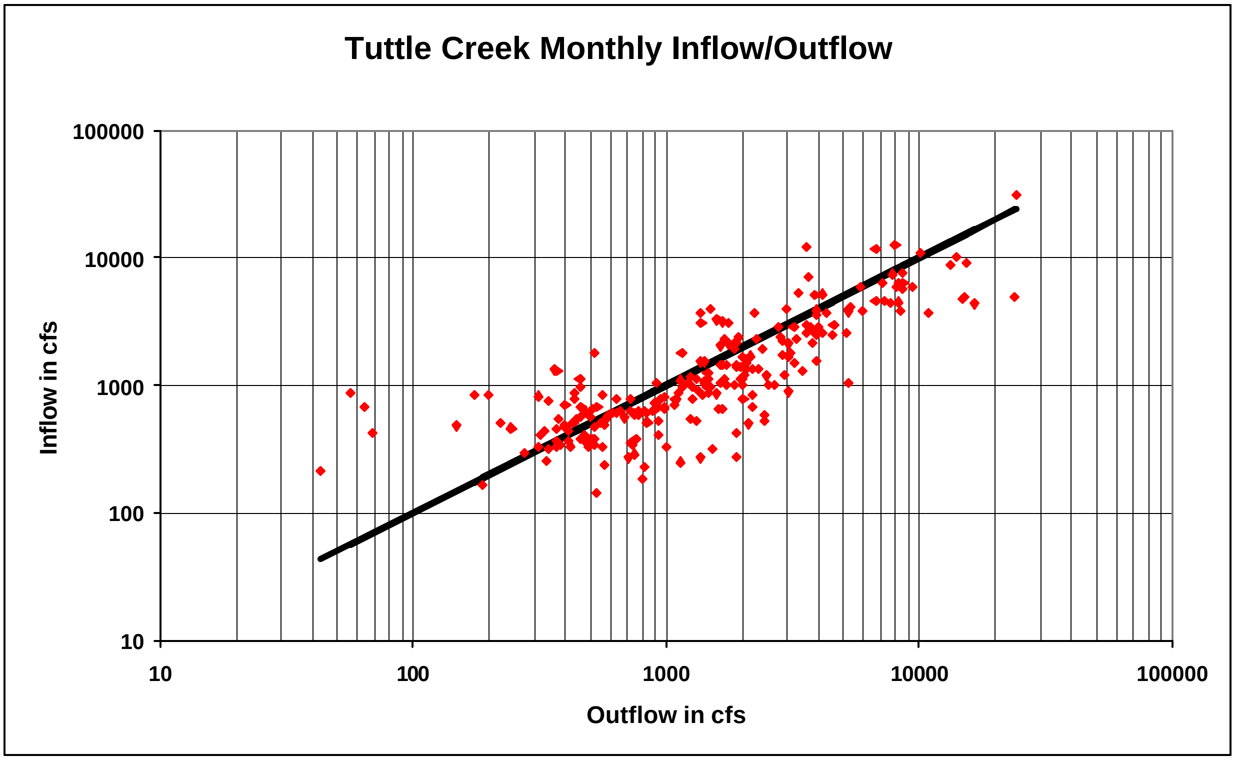


Figure 4. Daily Pool Elevations and Outflows at Tuttle Creek Lake, 1984-2004

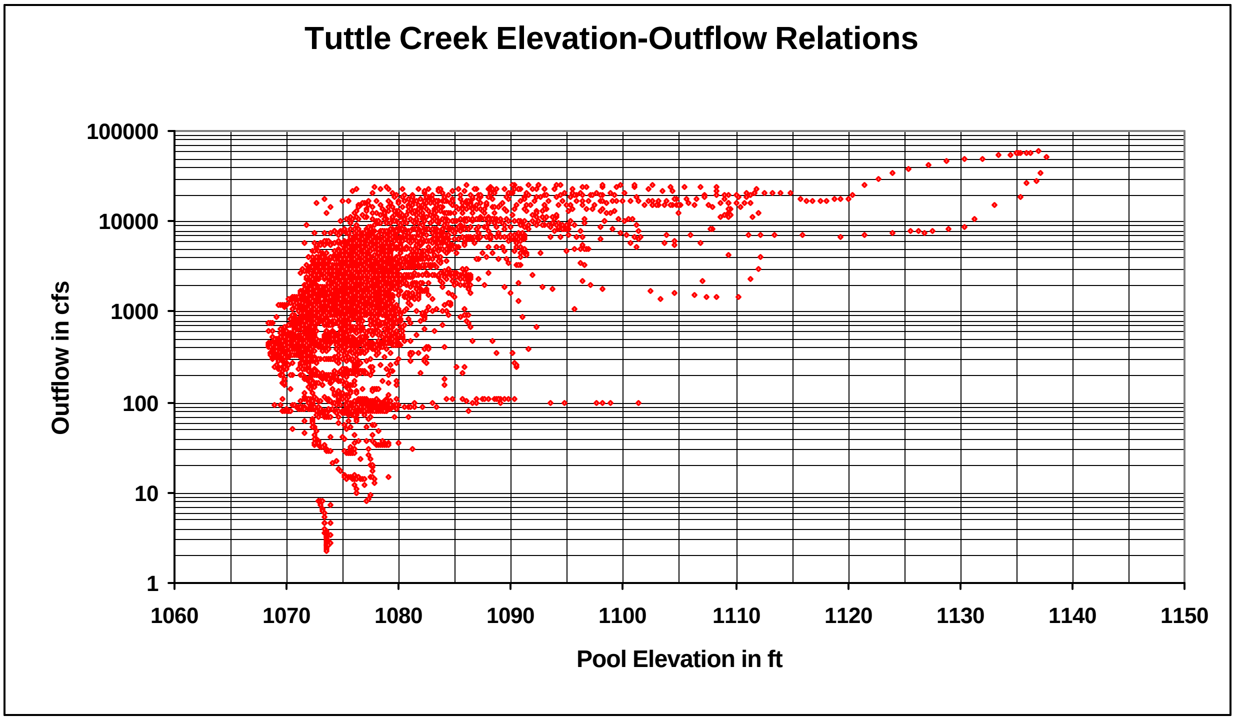


Figure 5. Flow Duration Curves for Streams in the Tuttle Creek Drainage, 1984-2004

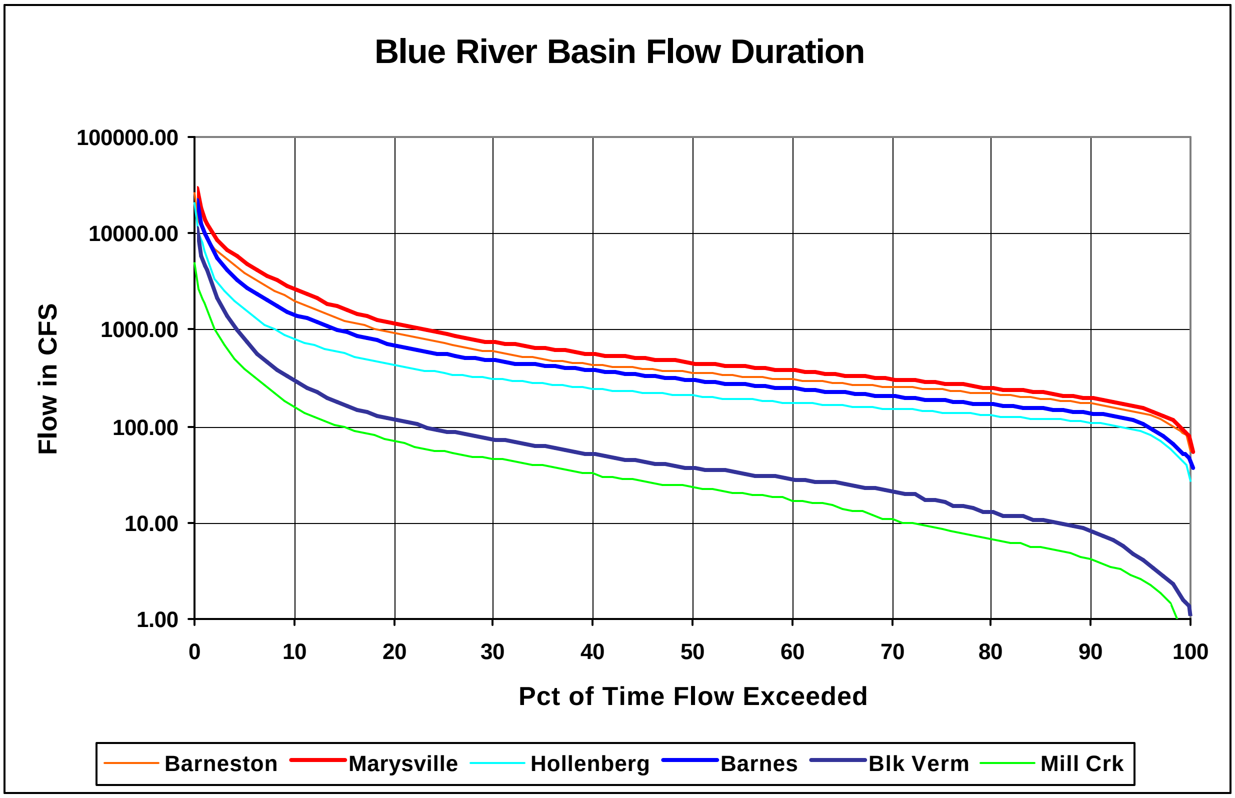


Table 1 indicates the streamflow occurring at certain cumulative frequencies of exceedance. There is a greater increase in flow in Kansas below the stateline on the Little Blue River than the Big Blue River. Most of the gain in drainage area on the Little Blue comes from Mill Creek. Of particular interest are the high flows (25 & 10% exceedance; 2 year flood). These flows will be the most likely to transport atrazine from upland fields to the on-stream monitoring sites and Tuttle Creek Lake. Hydrology will be used to establish geographic targets for Best Management Practices to reduce atrazine loadings to the stream system.

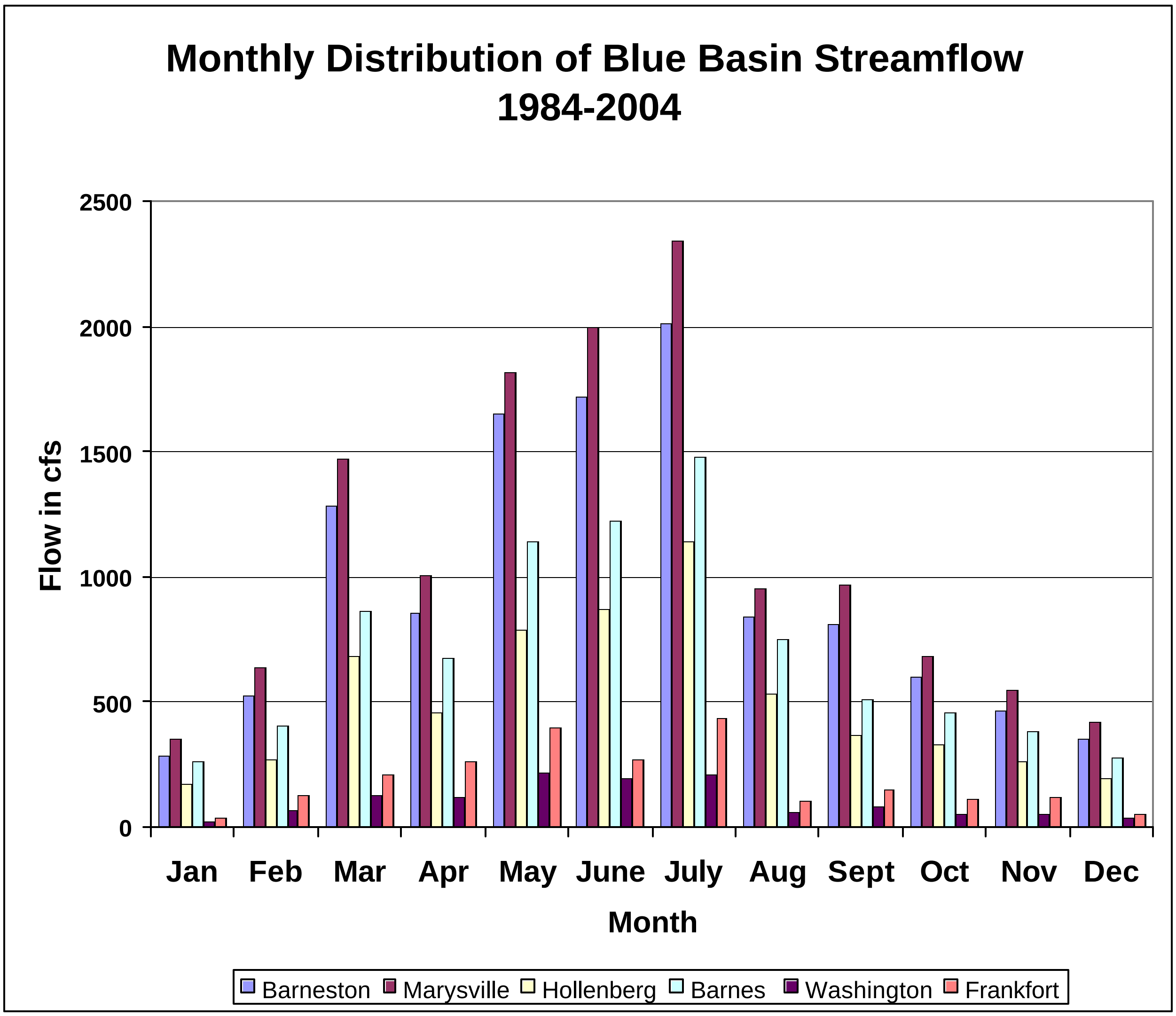
Table 1. Selected Flow Statistics for Stations in the Tuttle Creek Drainage

Flows in cu.ft per sec; Drainage Area in sq. miles; Flow statistics calculated from USGS daily flow records, except two-year floods which are provided by Perry, Wolock and Artman, 2004.

			Percent of Days Flow was Exceeded					
Stream	Station	D.A.	90%	75%	50%	25%	10%	2-yr Flood
Big Blue	Barneston	4447	170	239	363	721	1990	18,300
Big Blue	Marysville	4777	180	260	421	845	2386	19,100
Little Blue	Hollenberg	2752	109	140	206	355	801	11,200
Little Blue	Barnes	3324	127	170	280	515	1310	13,100
Mill Creek	Washington	344	4.1	8.7	23	54	160	4,830
Black Vermillion	Frankfort	410	7.5	15	34	83	267	7,030

May, June and July are the months with the major runoff events as seen in Figure 6. Streamflows enter the Spring period with a slight decrease between March and April. Flows then increase substantially in the three months following April. As Summer conditions begin in August, flows decrease to pre-runoff levels, then continue to decline into Autumn and Winter. The three runoff months of May, June and July demarcate the period of highest risk in applying herbicides on land surfaces.

Figure 6. Monthly Average Streamflows on Streams of the Tuttle Creek Drainage, 1984-2004.



Upstream Atrazine: USGS data from 1986 - 2002 and KDHE data since 1990 from the Big Blue River indicate numerous digressions from the water quality criterion of 3 µg/l (Figure 7). Most of these elevated concentrations occurred under high flow or runoff conditions where flows were exceeded less than half of the time. If the samples are segregated as to month of sampling, the runoff-oriented samples (April through July) represent the excessive levels (Figure 8), whereas there are no digressions during August through March (Figure 9). In fact, there has not been a digression during April and if May was dry, there was not a concentration seen over 3 µg/l. However, once wet conditions develop, concentrations will exceed the criterion. Historically, digressions occurred in July, but more recent samplings have seen generally compliant conditions after June.

There are less frequent and lower in magnitude digressions on the Little Blue River (Figure 10). The same relationship between digressions and season seen on the Big Blue River occurs on the Little Blue River. The Black Vermillion River tends to have frequent digressions across the flow spectrum, but the magnitude of those samples is typically below 10 µg/l unless very high flow conditions are occurring (Figure 11). Samples on Mill Creek mirror those seen on the Little Blue River, there are not many digressions and they tend to be lower in magnitude than those seen on the Big Blue River (Figure 12). There was one digression on Mill Creek during the non-runoff season, occurring in August, 1991 (4.2 µg/l).

Limited data on the minor tributaries (Fancy Creek and Horseshoe Creek) show limited number of digressions. Fancy Creek had three digressions among 26 samples, occurring in May of 1994 and 1996 and July of 1990. Horseshoe Creek did not see a digression among its samples of 1998. Rose Creek in Republic County, however, had a disproportionate number of digressions among its six samples, with three samples over 3 µg/l in June of 1997 and 2001 and October of 2001.

Runoff season atrazine levels have generally not diminished since the original atrazine TMDL was developed for Tuttle Creek in 1999 (Table 2). While magnitudes have not diminished, digressions have typically been confined to May and June since 2000. Concentrations are also down considerably from the mid-1980's when USGS first sampled for atrazine in the watershed. Nonetheless, sampling and estimates of annual average concentrations made by Kansas State University on the main streams entering Tuttle Creek Lake indicate a number of years when those averages exceeded 3 µg/l over 1997-2004 (Big Blue River: 4 years; Little Blue River: 3 years; Black Vermillion River: 1 year). Hence, there is evidence that the domestic water supply use of the surface water in the watershed has been impaired by excessive atrazine.

Table 2. Average April through July Atrazine Concentrations (µg/l) for KDHE Stations Before and After 2000

Stream & Station	Big Blue R-Oketo (SC233)	Big Blue R -Blue Rapids (SC 240)	Little Blue R – Hollenberg (SC 232)	Black Vermillion R – Frankfort (SC 505)	Mill Creek – Hanover (SC 507)	Rose Creek – Narka (SC 712)	Fancy Creek – Randolph (SC 502)	Horseshoe Creek – Marysville (SC 717)
Avg Before 2000	6.30	6.00	3.40	3.91	4.75*	7.7***	2.68	.55***
Avg 2000-2004	8.14	7.51	4.72	3.09	3.54	11.5**	1.5***	----

* Includes August 1991 Sample ** Includes October 2001 Sample *** Single Sample Only

Figure 7. Atrazine Concentrations on Big Blue River at Ambient Flow Condition

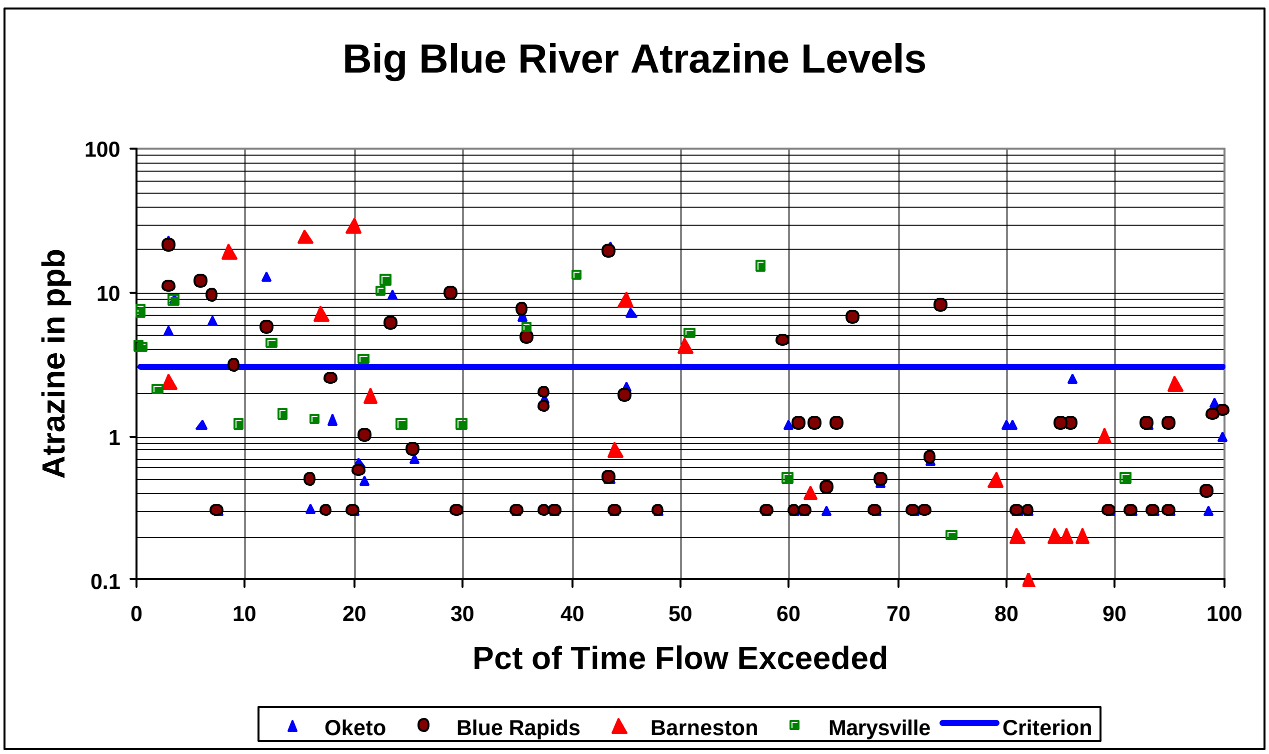


Figure 8. April-July Atrazine Concentrations on Big Blue River at Ambient Flow Condition

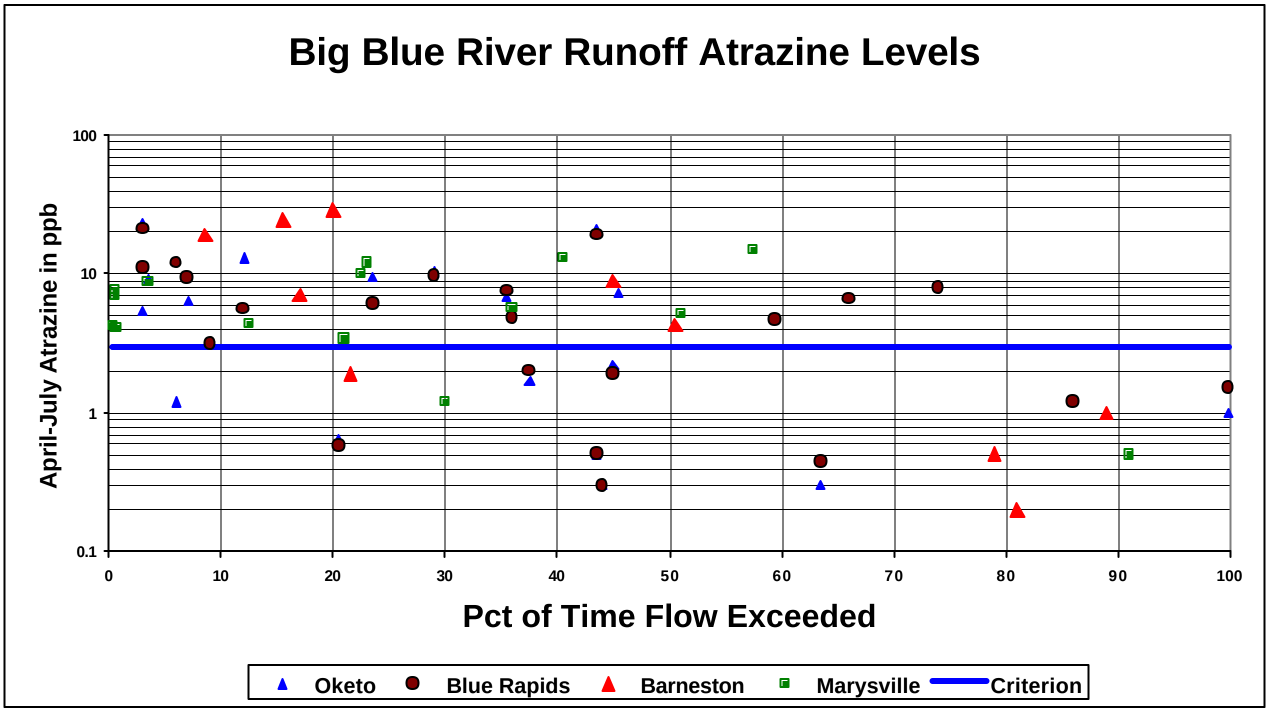


Figure 9. August–March Atrazine Concentrations on Big Blue River at Ambient Flow Condition

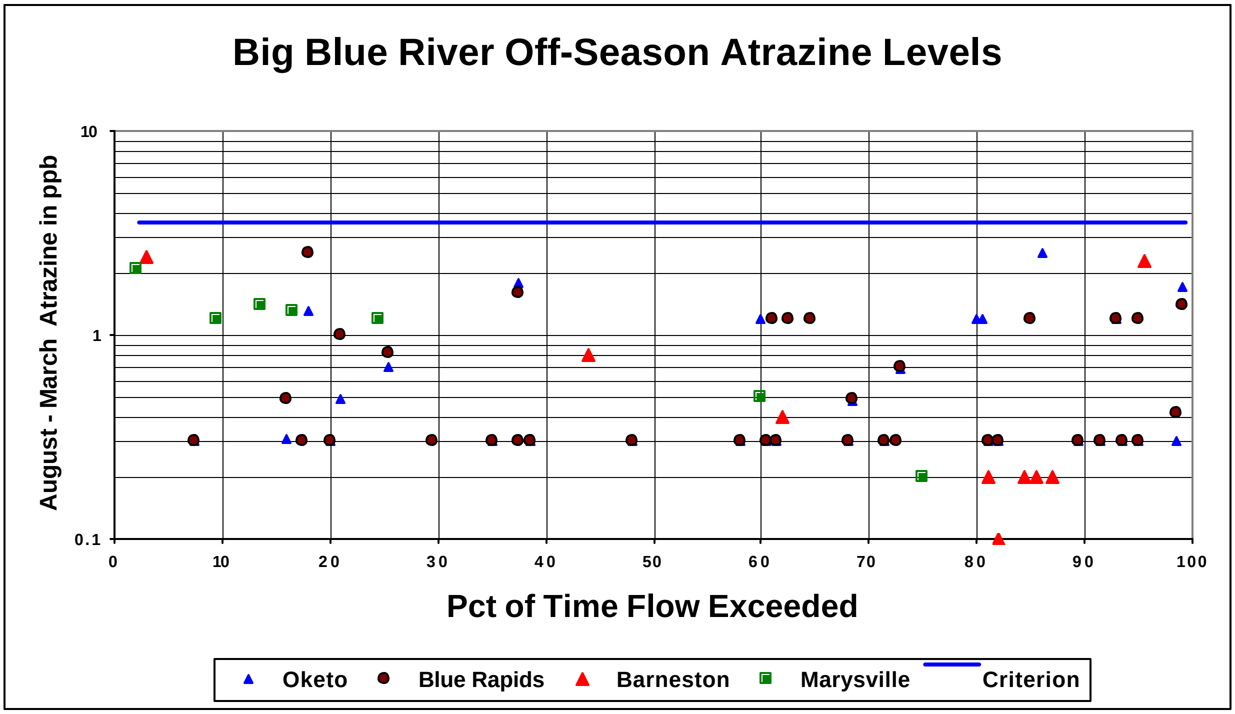


Figure 10. Atrazine Concentrations on Little Blue River at Ambient Flow Condition

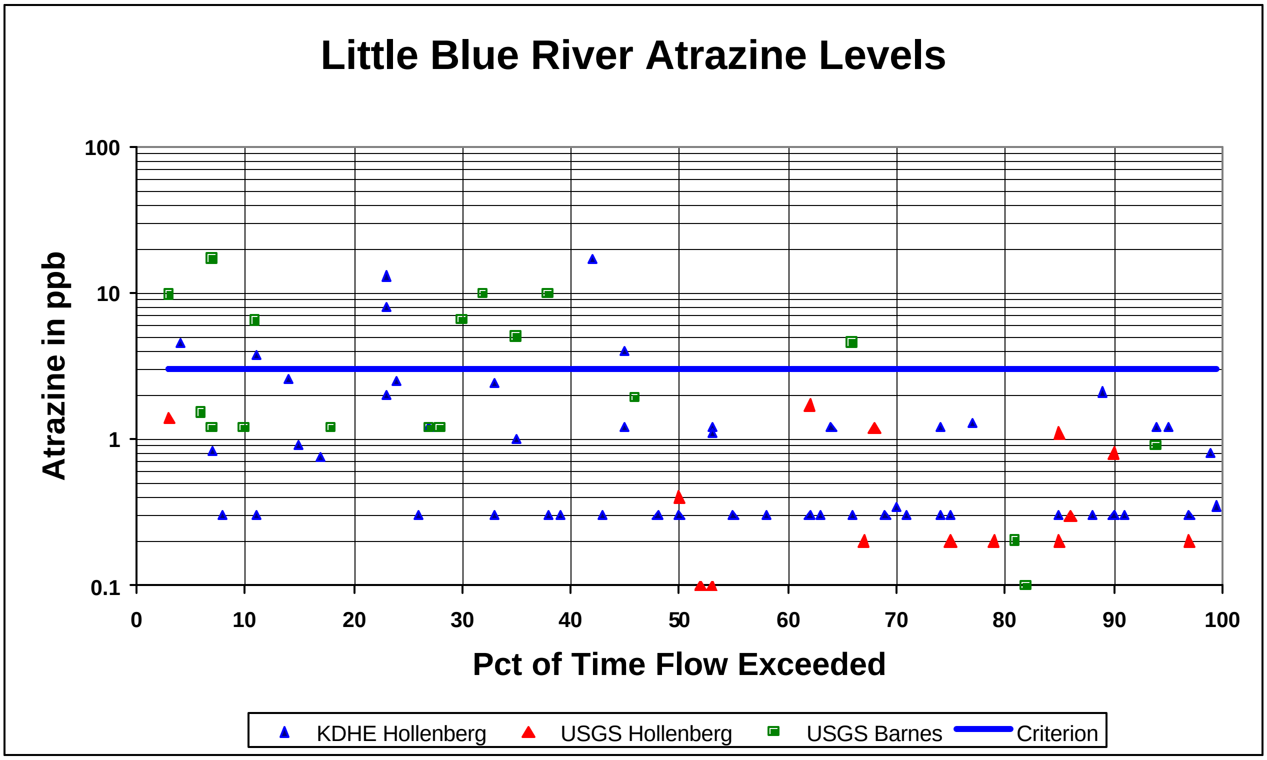


Figure 11. Atrazine Concentrations on Black Vermillion River at Ambient Flow Condition

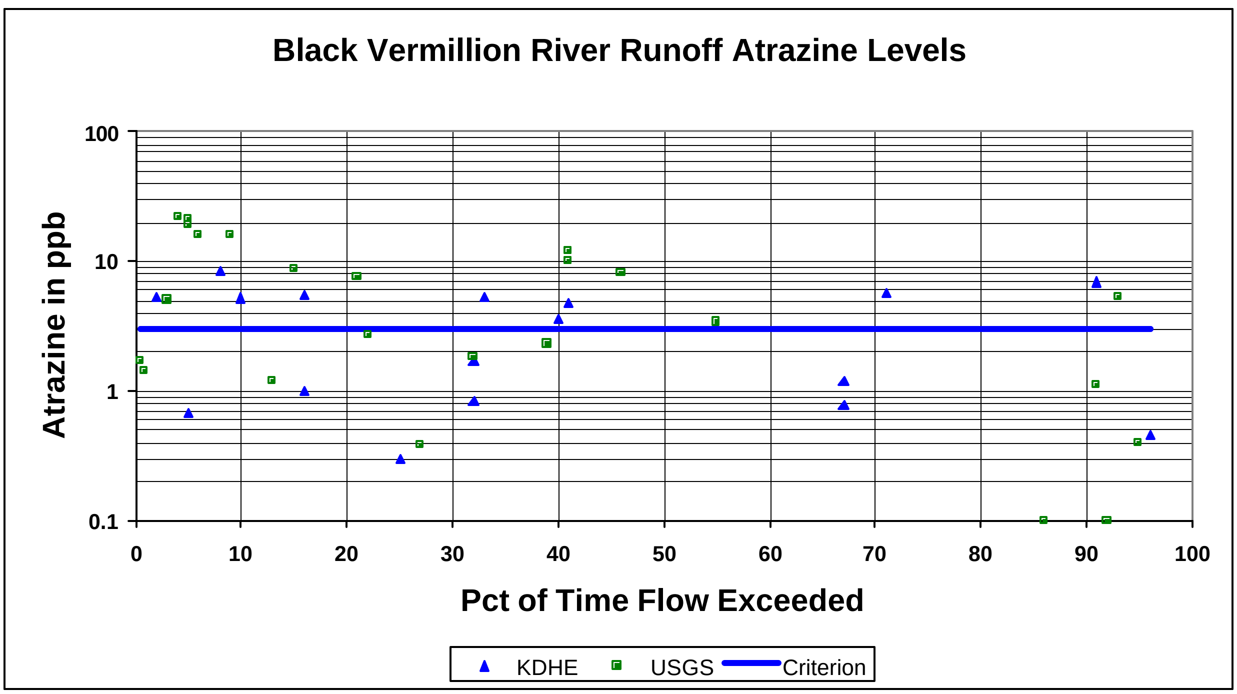
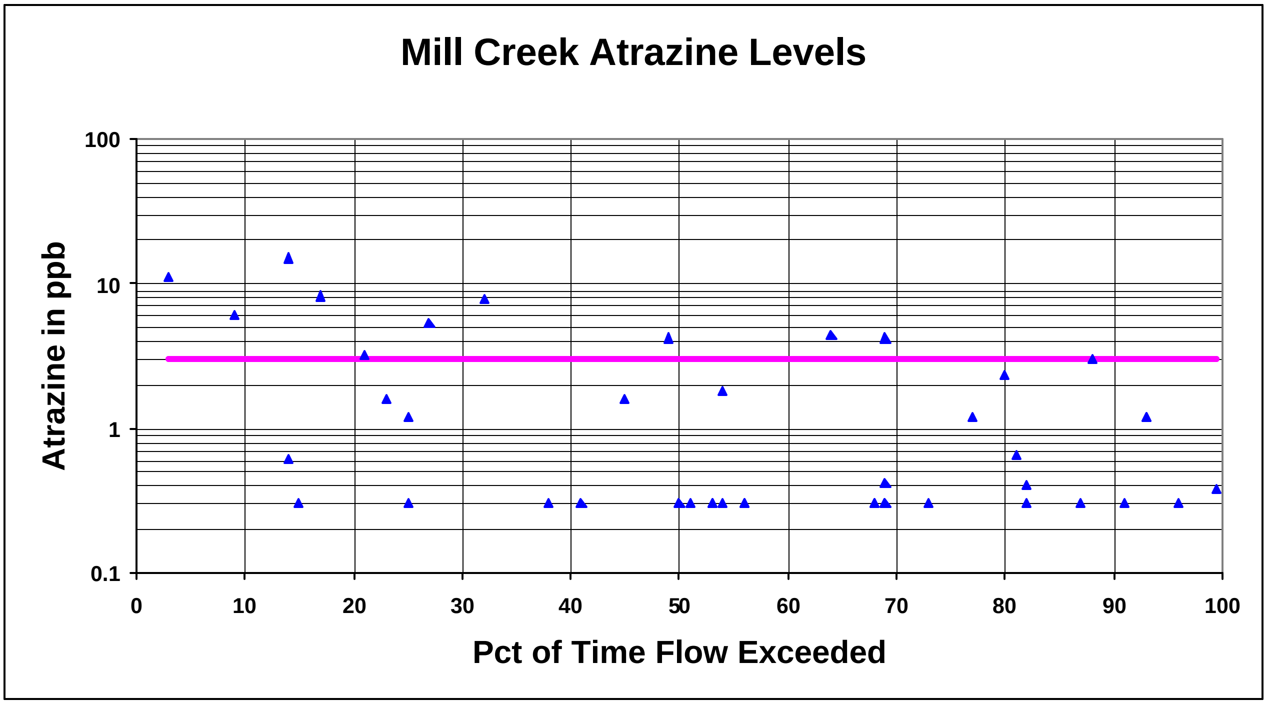


Figure 12. Atrazine Concentrations on Mill Creek at Ambient Flow Condition



Tuttle Creek Atrazine : Tuttle Creek Lake has been sampled extensively by KDHE, the Kansas City District of the Corps of Engineers and the USGS. The USGS samplings were in the mid-1980's. The Corps samples at three locations on the lake from April to October. Typically, the lake does not have digressions above 3 µg/l when the pool level is at or below conservation pool (1075') (Figure 13). Because the lake operations tend to maintain water levels within five feet of the conservation pool, most of the samples exceeding 3 µg/l have been taken been elevations 1075 and 1080 feet. Most of the higher concentrations are seen at the upper portion of the lake where the Big Blue and Black Vermillion Rivers enter Tuttle Creek Lake. Concentrations dilute out as inflows move through the lake and reach the lower sampling stations near the dam.

If the data are segregated by month, we see the seasonal pattern of digression from the water quality criterion develop at various locations on the lake (Figure 14). Throughout the lake, there are no issues in April. In May, the initial digressions appear, typically at the stations located in the upper lake, although a large event could elevate atrazine at mid-lake or in the lower lake. In June, elevated atrazine tends to be present throughout the lake and average levels are generally at the peak concentration. By July, levels begin to decline and some reversal in the longitudinal profile develops. Concentrations at the lower end of the lake begin to exceed the upper end, as atrazine moves down lake and inflows into Tuttle Creek carry smaller pesticide loads. The overall concentration in the lake tends to increase, although it is predominantly below 3 µg/l. By August, atrazine levels are further declining, such that digressions are very infrequent. Overall concentrations continue to build over 1 µg/l as the lake mixes and dilutes the initial high-end loads. This pattern continues into September and October.

Figure 13. Atrazine Concentrations at Various Locations and Elevations on Tuttle Creek Lake

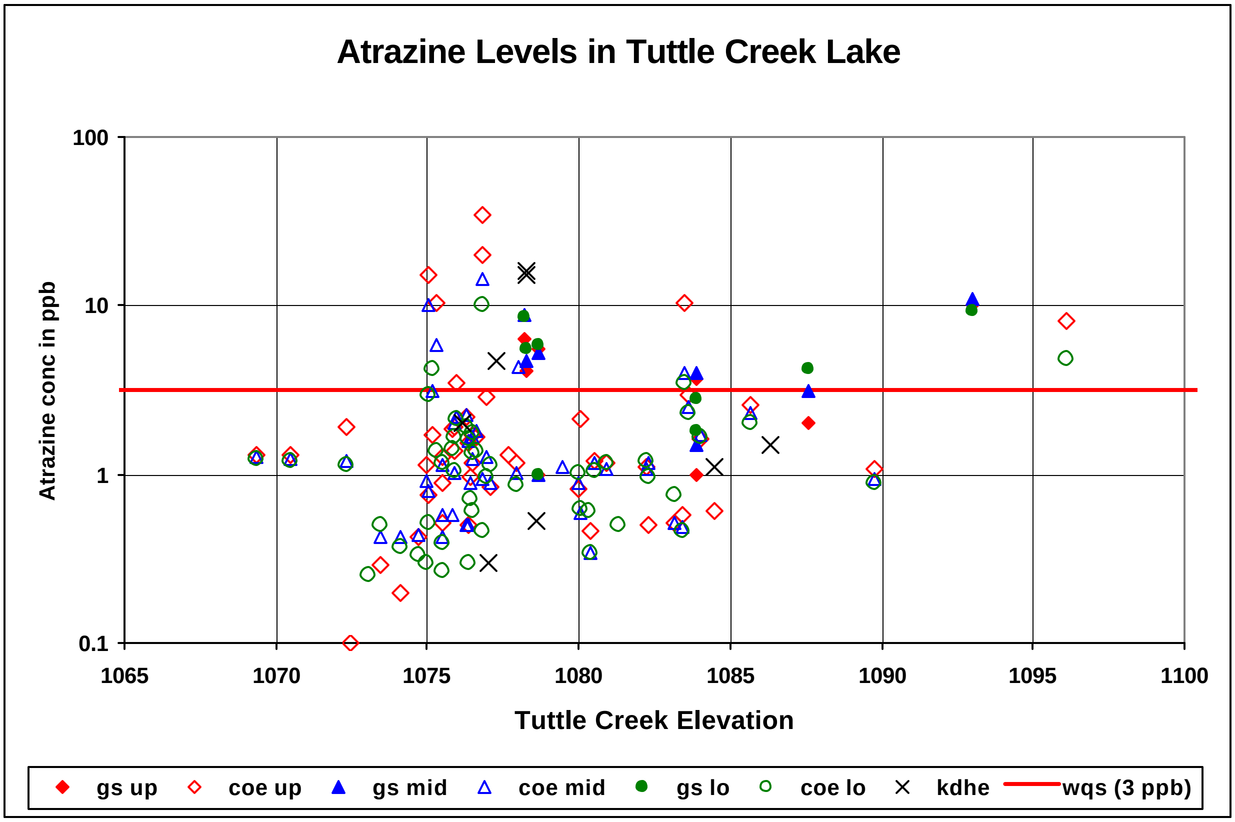
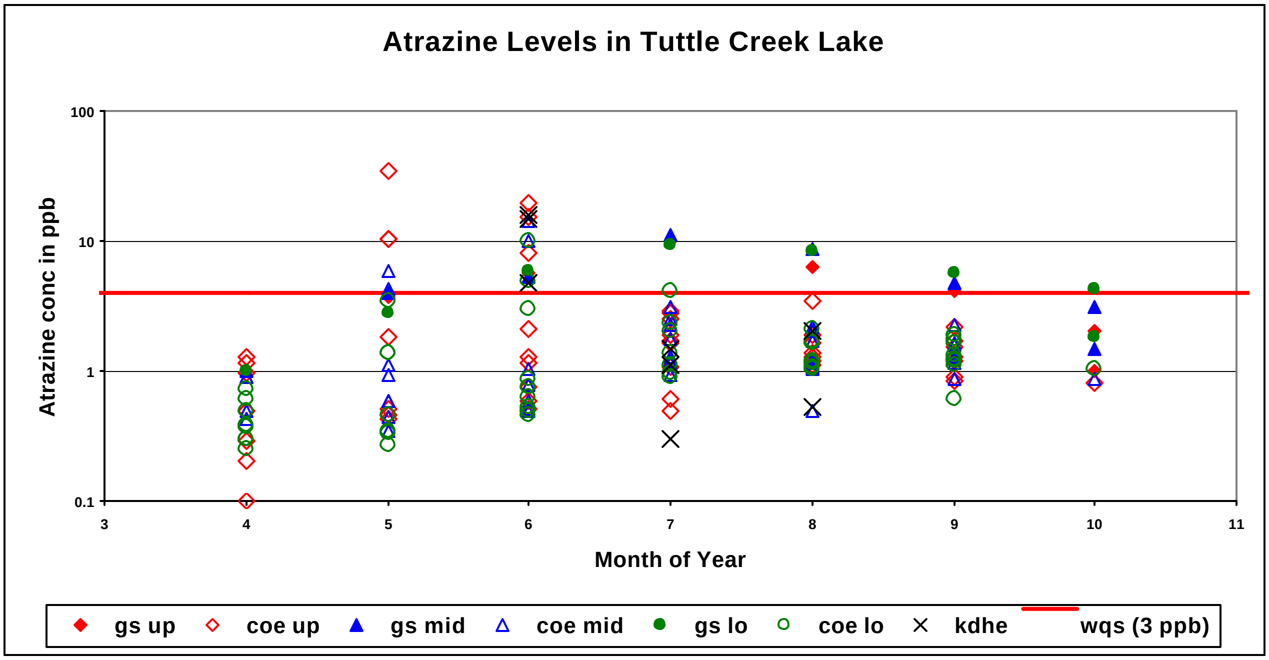


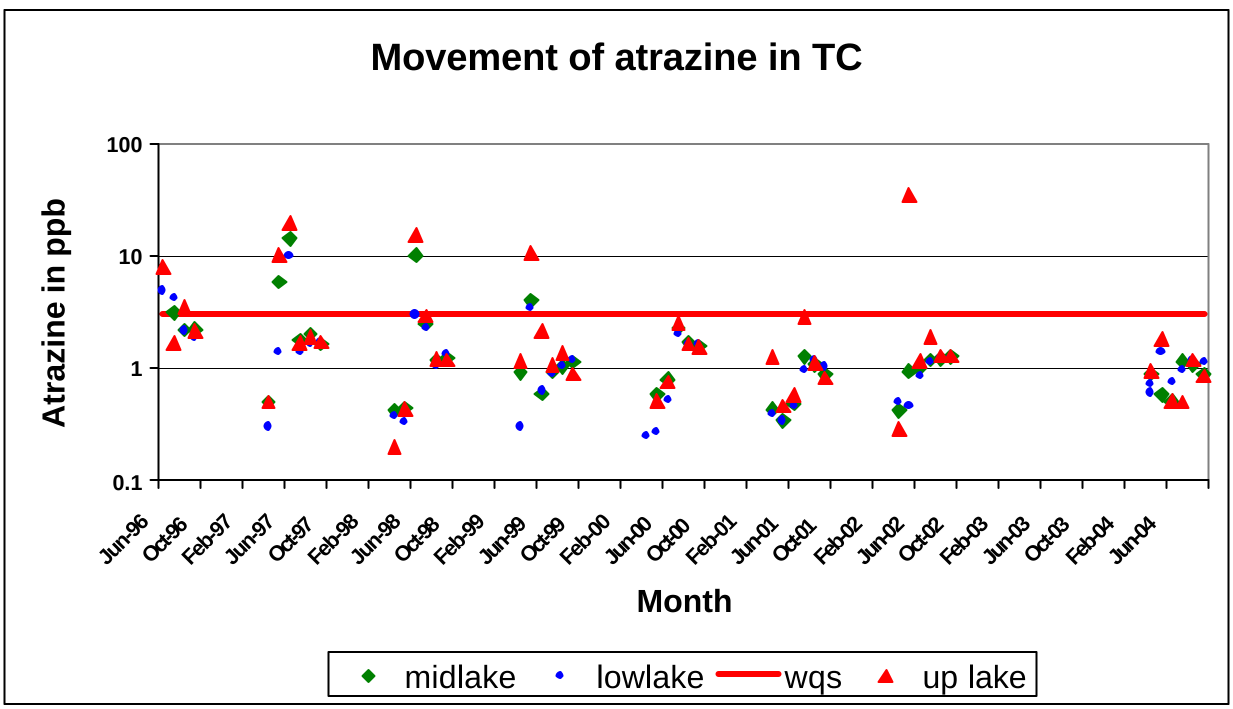
Figure 14. Monthly Distribution of Atrazine in Tuttle Creek Lake



There are three things to note from the monthly distribution of atrazine in Tuttle Creek Lake. First, there is a definite seasonality to atrazine in the lake with the maximum concentrations occurring in May and June, mirroring in-stream concentrations occurring with runoff events in the drainage. Second, atrazine travels down the lake over time, degrading and becoming dilute as the initial slug flows toward the dam, much like a plug flow loading event. High concentrations at the upper lake decline with time at lower lake stations. Furthermore, initial low concentrations at the lower lake increase through the summer, albeit, remaining below the criterion. Later in summer, concentrations at the lower lake exceed those found in the upper lake. Finally, the earliest data were collected in the mid-1980's by USGS. Subsequent sampling by KDHE and KC-COE have shown reduced levels of atrazine later in the summer than those recorded by USGS. The months of digression are restricted to May and June, an improvement over USGS samples over 3 µg/l collected in July through October. This third observation is indicative of improved pesticide management in the drainage, with further application restrictions on atrazine labels since 1993.

Examination of Corps data from the various lake locations confirms the positional differences in atrazine levels, with greatest concentrations in the upper portions of the lake (Figure 15). Those Corps data also indicate that atrazine is becoming less of a problem within the lake since 2000. The solitary digression occurred in June 2002 in the upper lake, there were no digressions elsewhere in the lake.

Figure 15. Monthly Samples from Three Locations in Tuttle Creek Lake (Corps Data).



Tuttle Creek Outlet Atrazine: Concentrations from the outlet of Tuttle Creek Lake may represent integrated samples from the lake, incorporating changes in longitudinal and temporal degradation of atrazine, as well as depth integration. By the time, atrazine reaches near the dam face and exits through the outlet, it tends to be uniform throughout the water column but at much lower concentrations than initially seen upstream (Figure 16).

Early intensive sampling by KDHE in the late 1990's at the outlet hinted at some reduction of atrazine inputs to the lake reaching the outlet in 1998(Figure 17). The atrazine levels recorded at the Corps since 1996 show the same pattern and suggest the same conclusion, that atrazine levels in the lake have declined below 3 µg/l for some time now (Figure 18). Data collected by Kansas State University also indicate lower atrazine levels at the outlet since 2000 (Figure 19). Taken in total, the data support the conclusion that Tuttle Creek Lake only suffers digressions from the atrazine criterion during typical Spring runoff and any high concentrations seen at the upper lake are dissipitated by the time the atrazine plug reaches the main waterbody at the lower lake.

Figure 16. Atrazine Concentrations at Lower Tuttle Creek (TC27=Outlet; TC3=Near Dam, Surface; TC3D=Near Dam, Deep

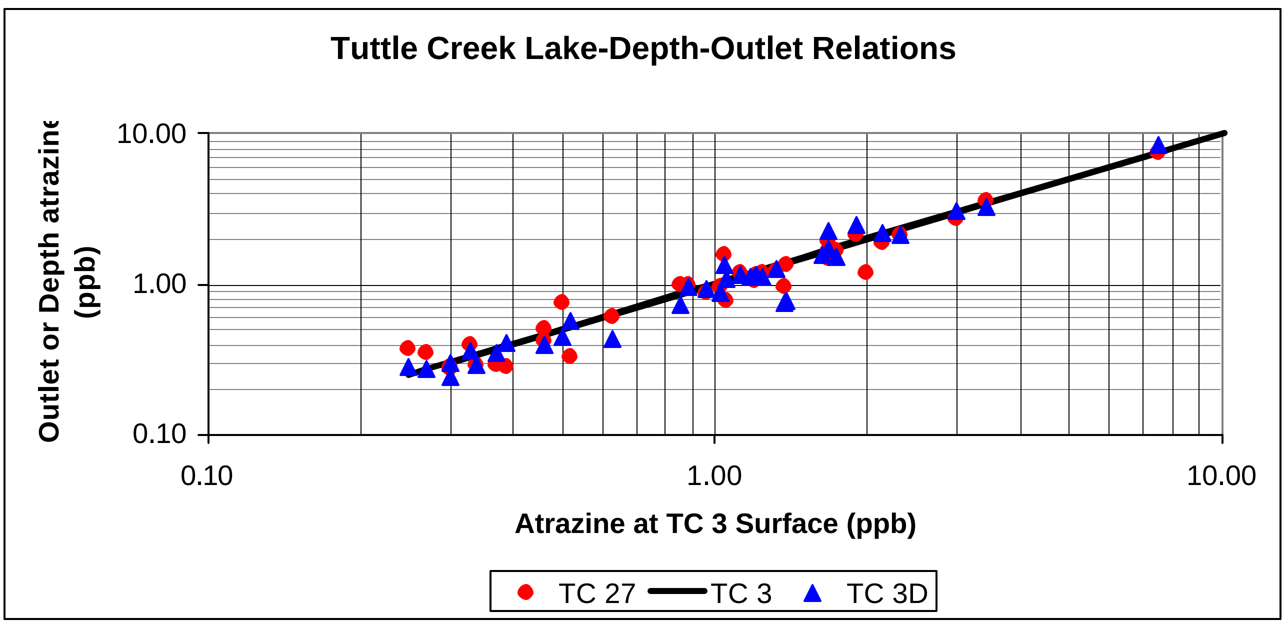


Figure 17. KDHE Atrazine Data from Tuttle Creek Lake Outlet

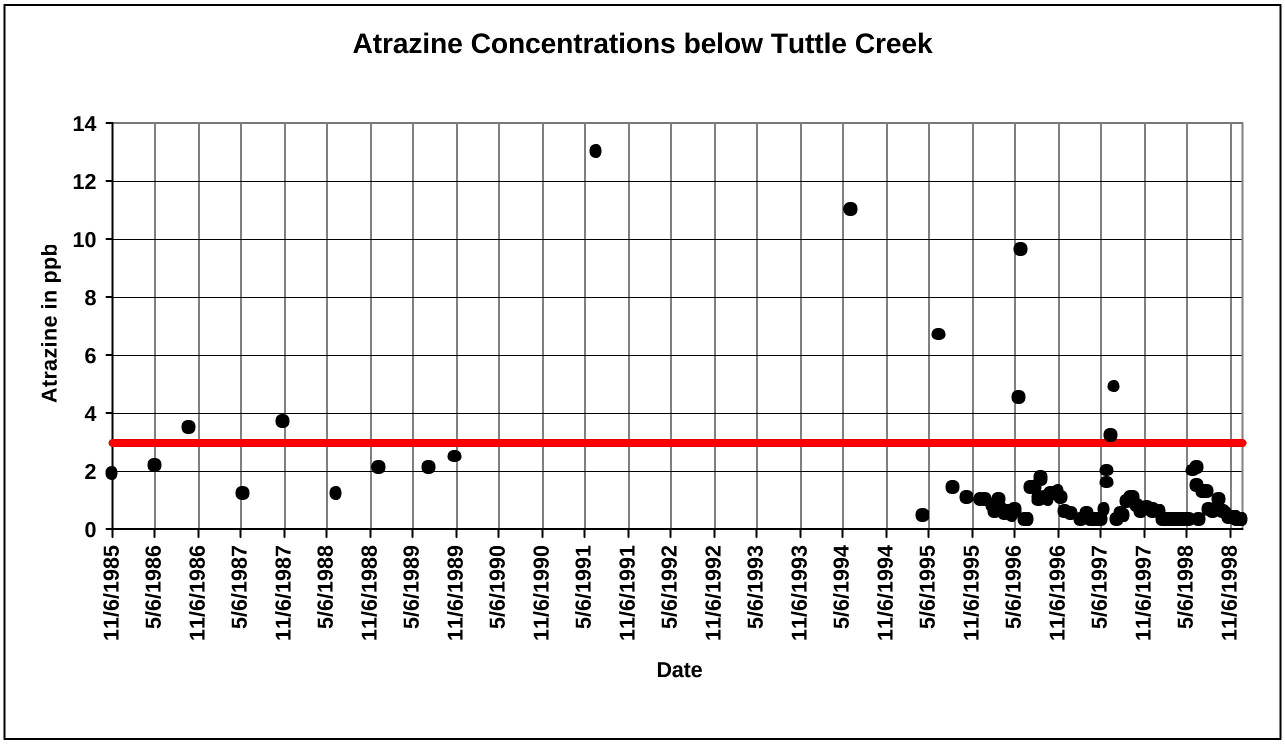


Figure 18. KC Corps Atrazine Data from Tuttle Creek Lake Outlet

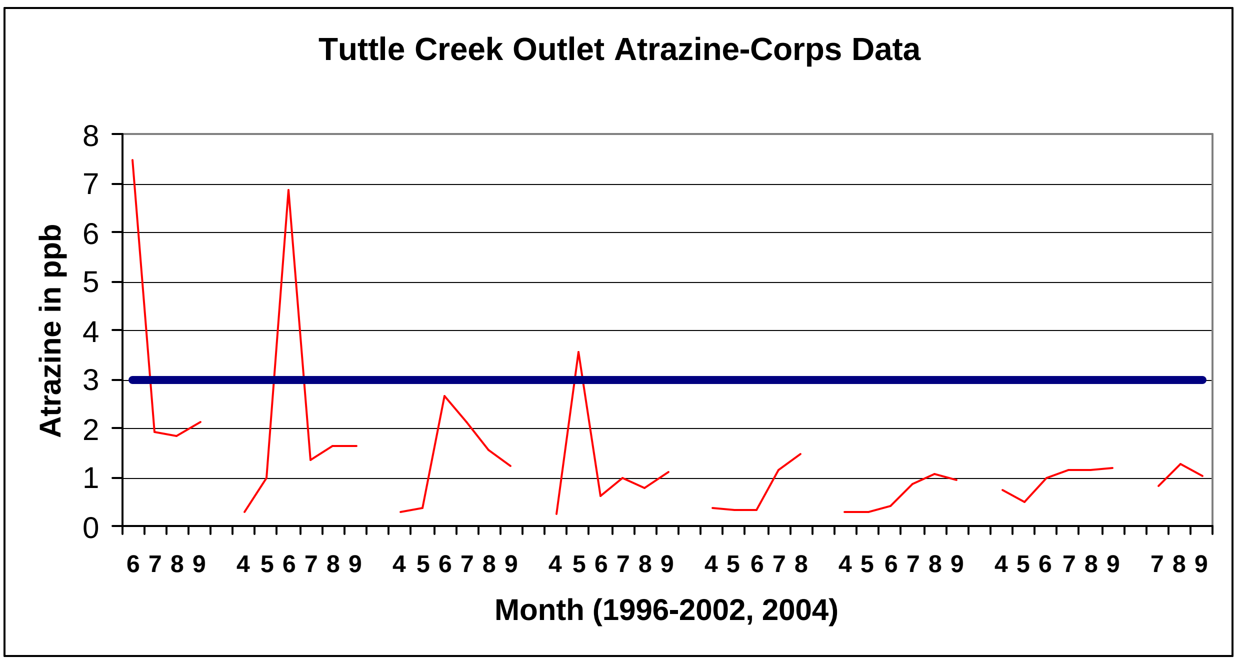
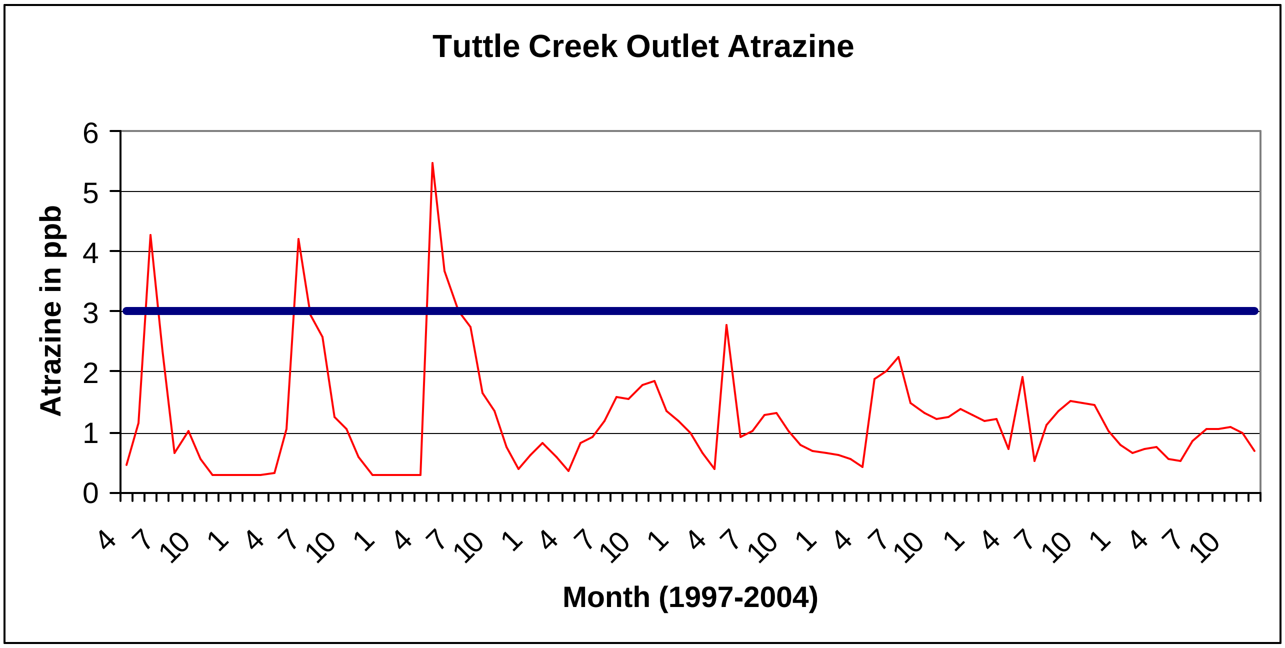


Figure 19. Kansas State University Data from Tuttle Creek Lake Outlet



Desired Endpoints and Interim Milestones of Water Quality (Implied Load Capacity for Atrazine) at Tuttle Creek Lake and its Drainage (Stations 232, 233, 240, 505, 507, & 712) over 2005-2010.

The ultimate endpoint for this TMDL will be to achieve the Kansas Water Quality Standards fully supporting chronic aquatic life support and domestic water supply. The current standard of (3 µg/l) for atrazine was used to establish the TMDL. Seasonal variation has been incorporated in this TMDL through the documentation of the seasonal (May-June) occurrence of elevated atrazine levels.

The following endpoints will define achievement of the water quality standards.

1. Average monthly atrazine exceedances over 3 ppb will not occur more frequently than once every three years in Tuttle Creek Lake or the streams within its watershed.
2. Average annual concentrations of atrazine will be below 3 ppb in Tuttle Creek Lake, its outlet and the streams comprising its watershed.
3. No individual sample of atrazine will exceed 170 ppb.

The following milestones will establish the baseline of current water quality conditions in order to judge progress in the interim.

1. There will be no atrazine digressions over 3 ppb in Tuttle Creek Lake nor the streams of the Blue River Drainage in any month other than May or June.

2. There will be no digressions of atrazine over 3 ppb in Tuttle Creek Lake at pool elevations of 1078' or lower, regardless of month.
3. There will be no digressions of atrazine over 3 ppb in Tuttle Creek Lake in the main pool at the water control tower near the dam.
4. There will be no digressions of atrazine over 3 ppb in the outlet flow from Tuttle Creek Lake.
5. Digressions over 3 ppb are restricted to the May-June runoff season at the upper lake below the Randolph causeway.
6. There will be no digressions of atrazine over 3 ppb in streamflow throughout the Tuttle Creek basin during flows less than the long term mean daily flow of the Big Blue, Little Blue and Black Vermillion Rivers and Mill and Rose Creeks.

These milestones reflect the current level of progress that restricts digressions of excessive atrazine to the runoff season of May and June, to conditions of seasonal runoff, including high flows and water in the permanent flood pool (above 1078') in Tuttle Creek Lake, and to the upper reaches of the lake where the emerging wetland features in the silted floodplain will reduce atrazine levels before each slug reaches the main water body of the lake. Over the next four years, 2007-2010, ideally, there should be one episode of seasonal digression of atrazine over 3 µg/l.

Aquatic life criteria are under review by EPA currently. EPA provided an October, 2003 revised draft regarding Ambient Aquatic Life Water Quality Criteria for Atrazine that suggested values similar to the Kansas water quality criteria are likely more stringent than necessary to protect aquatic life. However, numerous values are recommended for various durations of time and it is unclear what is the specific recommendation EPA is making for continuous concentration criterion. Furthermore, EPA has yet to finalize its finding in the three years since publishing its draft document. Once EPA finalizes its recommendations for criteria, KDHE will initiate revision to the state surface water quality standards for atrazine.

Achievement of the endpoints indicates atrazine loads are within the loading capacity of the streams and lake, water quality standards are attained and full support of the designated uses of the waters has been restored. Maintenance of the milestones indicates the progress made to date in abating atrazine loads is continuing in the future.

These endpoints can be reached through implementation of Best Management Practices for Atrazine as outlined by Kansas State University. The permanent flood pool is occupied sufficiently infrequent (less than 30% of the time), that digressions will not have an impact on the resources supported by the permanent and interim conservation pool. Full support of the domestic water supply use is affirmed when samples do not lead to an annual average over 3 µg/l and no drinking water use restrictions apply to Tuttle Creek Lake.

3. SOURCE INVENTORY AND ASSESSMENT

The primary source of atrazine entering Tuttle Creek Lake is springtime runoff off of croplands in the Big Blue, Little Blue and Black Vermillion River watersheds. Atrazine has been widely used since the 1960's for selective control of broadleaf and grass weeds in corn and grain sorghum. Because of its high solubility in water, atrazine is susceptible to removal from cropland during overland runoff events. Within Marshall and Nemaha counties, a majority of the cropland is planted with grain sorghum with substantially smaller acreage in corn.

KDHE data indicate that the Big Blue River tends to be the driver in the atrazine delivered to Tuttle Creek Lake (Figure 20). Same-day atrazine along the Little Blue River tends to be lower than that measured at Blue Rapids after the confluence of the Big and Little Blue Rivers. These relationships may be tempered by lags in delivery from upstream reaches to Blue Rapids. However, it is clear that once digressions are detected at the upper stations, atrazine at Blue Rapids will be over 3 µg/l.

Being an interstate river system, atrazine in the Blue River system originates in both Nebraska and Kansas. Intensive monitoring by Kansas State University throughout the Blue River Subbasin indicates some measure of the relative contributions by both states to the atrazine load arriving to Tuttle Creek Lake. Samples taken on the Big Blue River at the stateline near Barneston, Nebraska and downstream at Marysville, Kansas show marked increases in atrazine concentrations at the lower station (Figure 21). Monthly contributions by Nebraska were modest, below 10 µg/l, until 2003 and 2004. Those two years also showed the gap between Barneston and Marysville closed somewhat. Digressions start appearing when average flows exceed 700 cfs (Figure 22)

The figures suggest tremendous loading occurring in Kansas below the stateline. In fact, given the relatively small increase in drainage area between the two stations (330 sq.mi), the concentration of atrazine coming off the intervening drainage has to be large in order to boost Maryville atrazine concentrations so much greater than Barneston. Loads with concentrations greater than the acute criterion of 170 µg/l would be necessary. As a point of reference, if atrazine were applied to an acre at the label rate of 2 pounds per acre and a one inch rain immediately followed, placing all the atrazine into solution, the concentration of atrazine coming off that acre would be 8830 µg/l. Thus, additional practices (incorporation, buffers) have to be applied in conjunction with the label application rate to reduce atrazine runoff to streams.

Conversely, atrazine on the Little Blue River looks to be directly tied to the levels seen at the stateline station at Hollenberg (Figure 23). There is actually little gain in atrazine seen at the downstream Barnes station throughout the sampling period. When average monthly flows exceed 300 cfs on the Little Blue River, average monthly atrazine concentrations will exceed 3 µg/l (Figure 24).

The Black Vermillion River shows the same seasonal distribution of atrazine as the other streams of the Sub-basin (Figure 25). Digressions appear at flows as low as 20 cfs

(Figure 26).

Figure 20. Upstream-Downstream Atrazine Relations from KDHE Atrazine Data

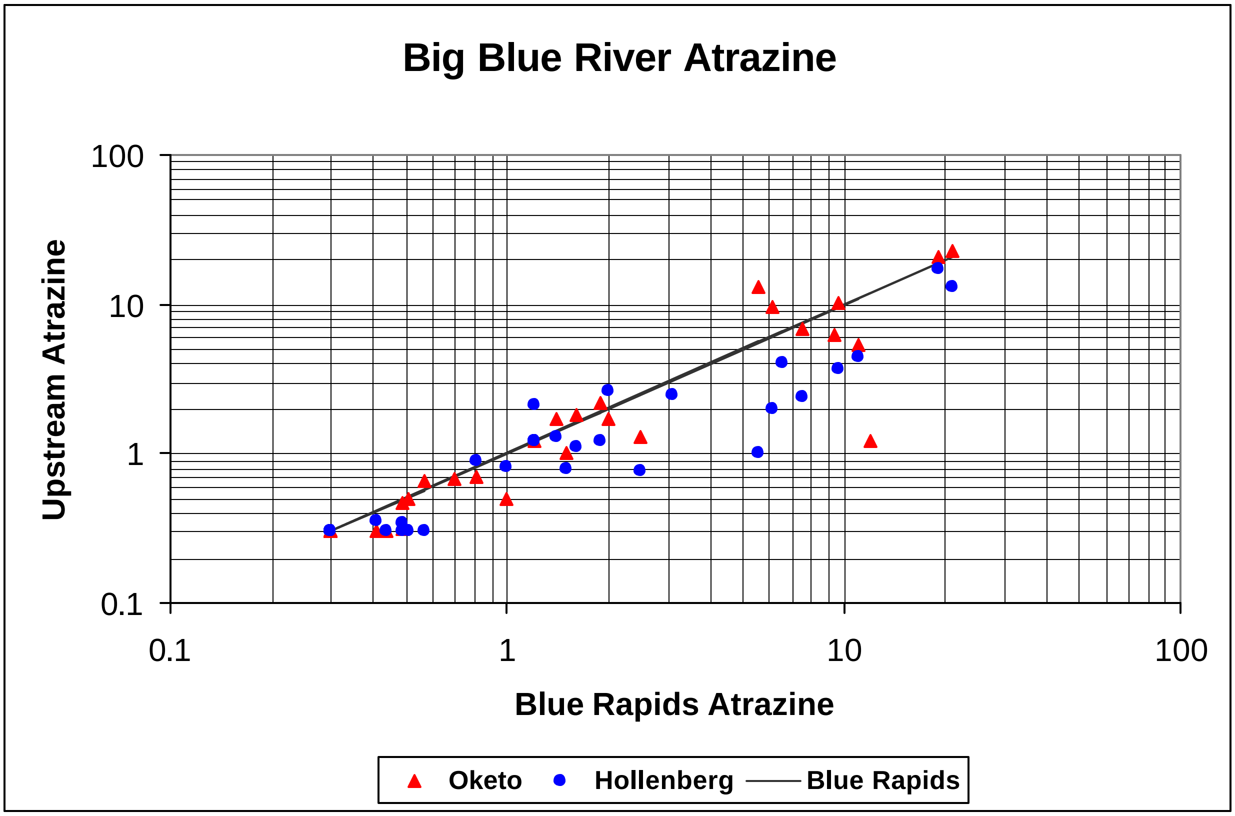


Figure 21. Monthly KSU Atrazine Data from Big Blue River at the Stateline and in Kansas

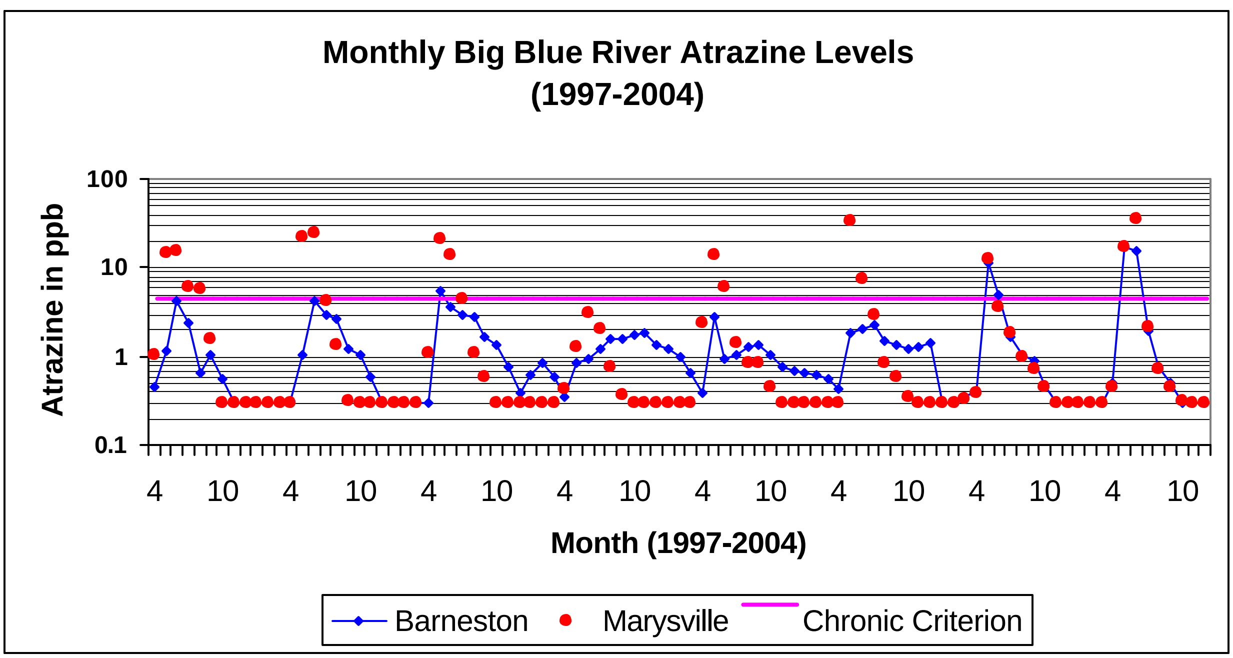


Figure 22. Average Monthly Flows and Atrazine Concentrations on Big Blue River

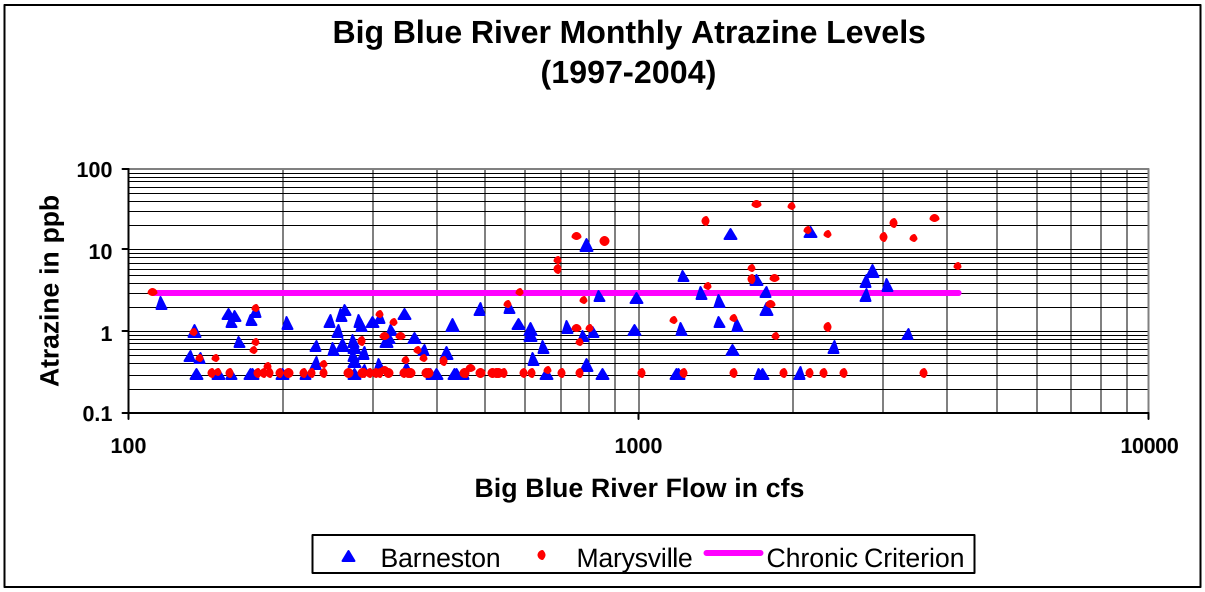


Figure 23. Monthly KSU Atrazine Data from the Little Blue River at the Stateline and in Kansas.

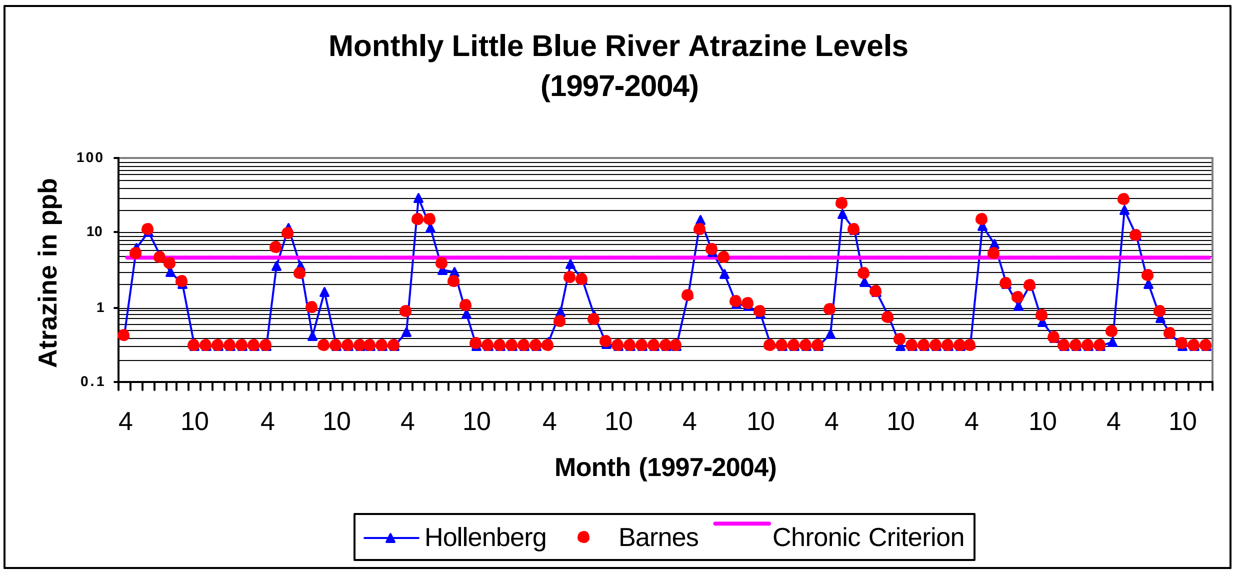


Figure 24. Monthly Flows and Atrazine Concentrations on the Little Blue River.

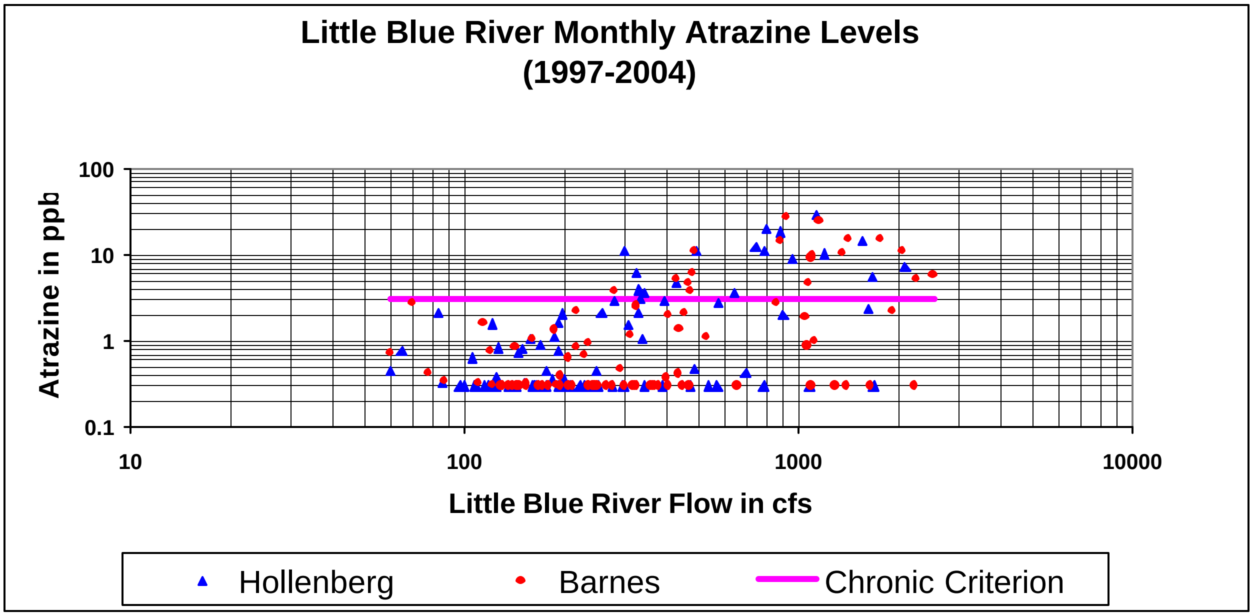


Figure 25. Monthly KSU Atrazine Data from the Black Vermillion River

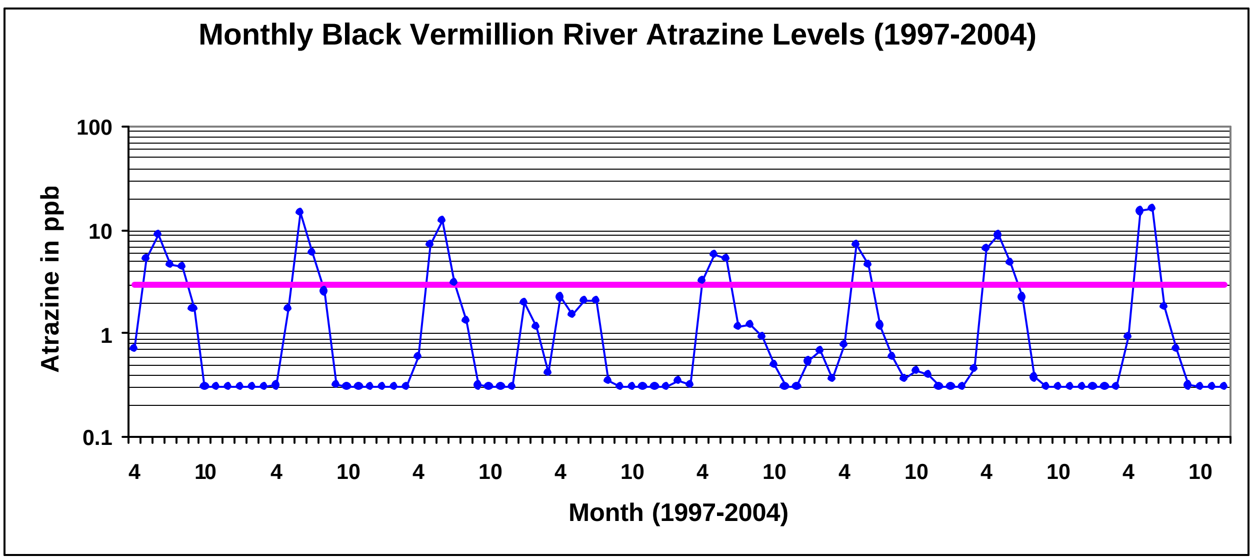
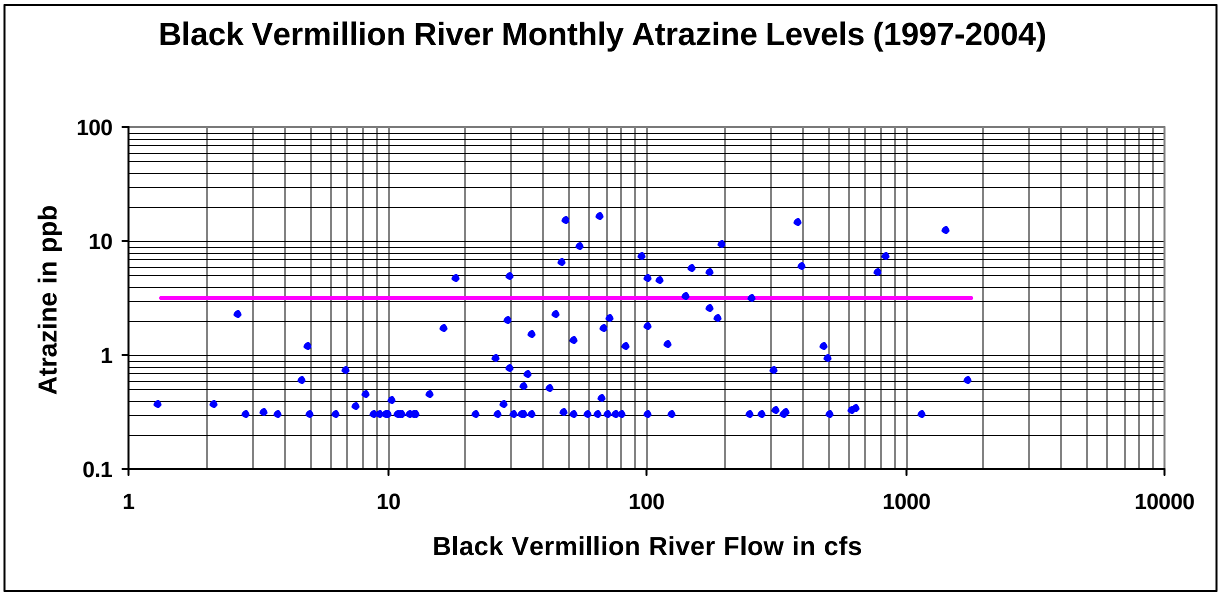


Figure 26. Average Monthly Flows and Atrazine Concentrations on the Black Vermillion River.



Atrazine on Mill Creek in Washington County follows the same seasonal pattern with spikes during the May and June runoff season, followed by months of compliant conditions (Figure 27). Although a couple of digressions were seen at very low flows, most elevated concentrations occur at flows greater than 50 cfs (Figure 28).

During 1996-1998, Governor Graves conducted a water quality initiative in the Black Vermillion River watershed to promote the reduction of atrazine, bacteria and sediment. During that period, KDHE sampled 8 sites above Station 505 on a bi-weekly basis. Two of the sites, Site 128 and Site 133 were located on the North Fork of the Black Vermillion River. Site 130 was located on Weyer Creek in Nemaha County and Site 141 was located on the Black Vermillion River above Vliets. The other four sites (129,131,132 & 134) were on small tributaries to the North Fork, none of which are on the Kansas Surface Water Register.

Figure 29 shows the concurrent atrazine concentrations in 1996-1998 when at least one of the stations had a digression, plotted against the percentile frequency of flow that day at the USGS Frankfort gage. The samples fall into two groupings, the first occurs at normal flows (median to upper quartile). This group is dominated by elevated atrazine on the Black Vermillion River flowing west from Centralia, as monitored at Station 141. Weyer Creek and the other eastern tributary to the North Fork (134) also exhibited digressions.

The second group occurs at high flows exceeded 20 percent of the time or less. Of ten samplings at high flow, nine samples at the downstream North Fork station (128) reflected high atrazine levels coming from upstream tributaries and reaches (Figure 30). Only two samples on the Black Vermillion River (141) were below the criterion. In many cases, the tributary concentrations were higher than the concentration seen at the downstream station.

Figure 27. Monthly KSU Atrazine Data from Mill Creek

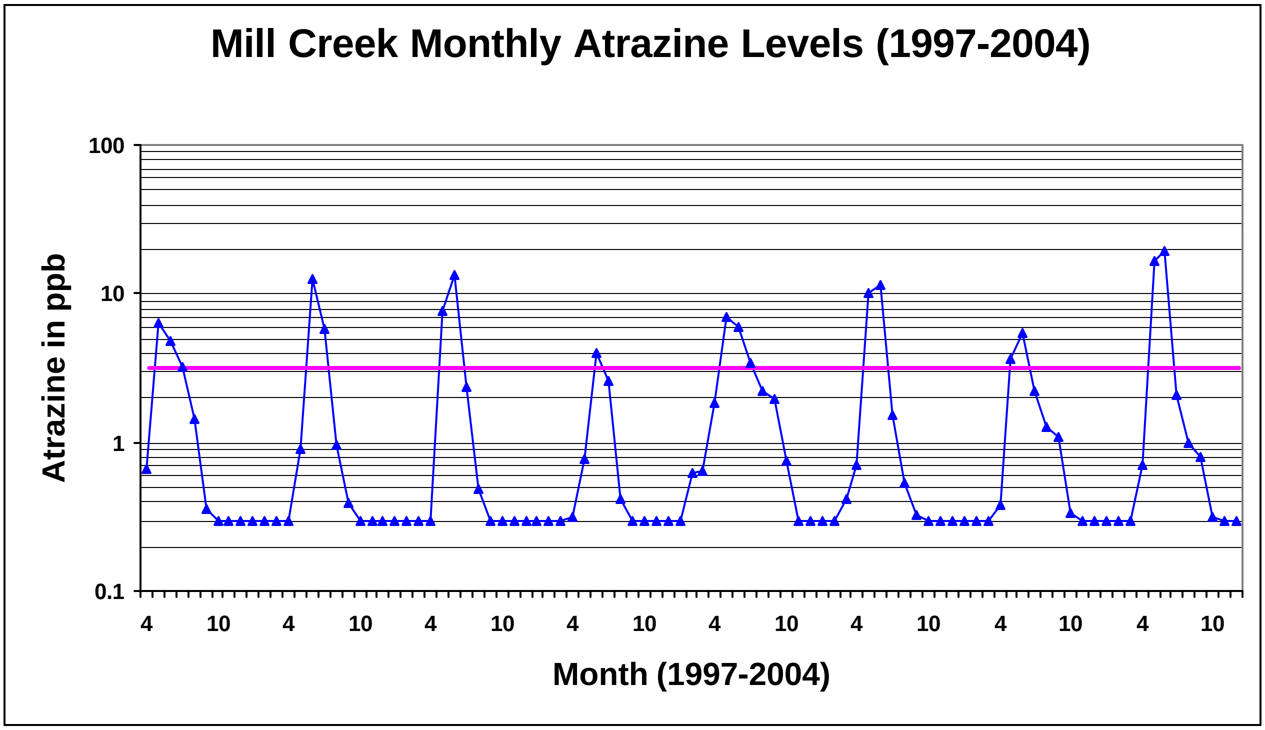
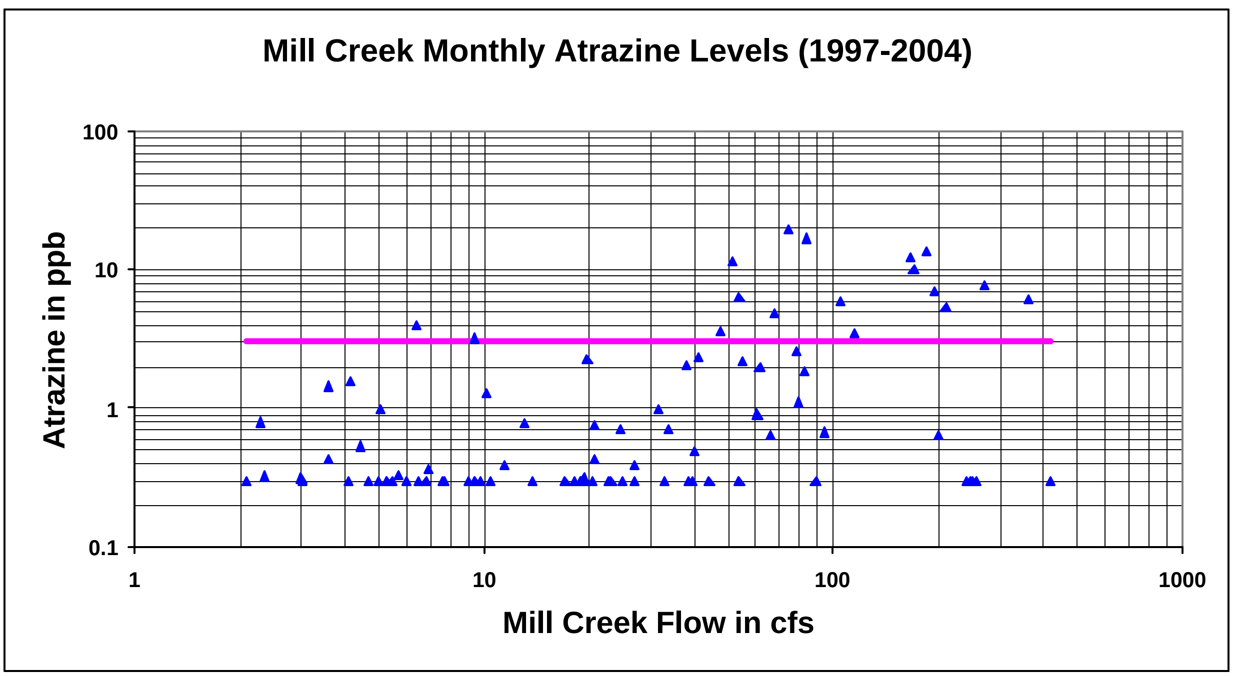


Figure 28. Average Monthly Flows and Atrazine Concentrations from Mill Creek



Only Station 129 showed lower atrazine levels, typically below the criterion, except in four cases of very high flow (exceedance less than eleven percent). Table 3 shows the average concentrations when atrazine levels are high or low at the terminal site of the North Fork Black Vermillion River (128) and the overall May thru July averages for the three years. Concentrations are elevated throughout the watershed during high flow periods (implied by the high concentrations seen at 128). The exception to this is Station 129. At more moderate conditions, the Nemaha County stations (Weyer Creek (130), Station 134 and Station 141 monitoring the Black Vermillion River coming from Nemaha County) still show elevated average atrazine concentrations.

Table 3. Average Atrazine Concentrations on Black Vermillion River Tributaries

Station	128	129	130	131	132	133	134	141
128 > 3 ppb	13.26	3.82	9.44	10.47	11.95	11.18	15.41	7.83
128 < 3 ppb	1.67	0.51	3.06	1.55	1.9	1.88	3.76	3.22
May-July	6.97	2.03	5.47	5.53	6.59	6.03	8.47	4.85

Figure 29. Elevated Atrazine Concentrations on Black Vermillion River Tributaries

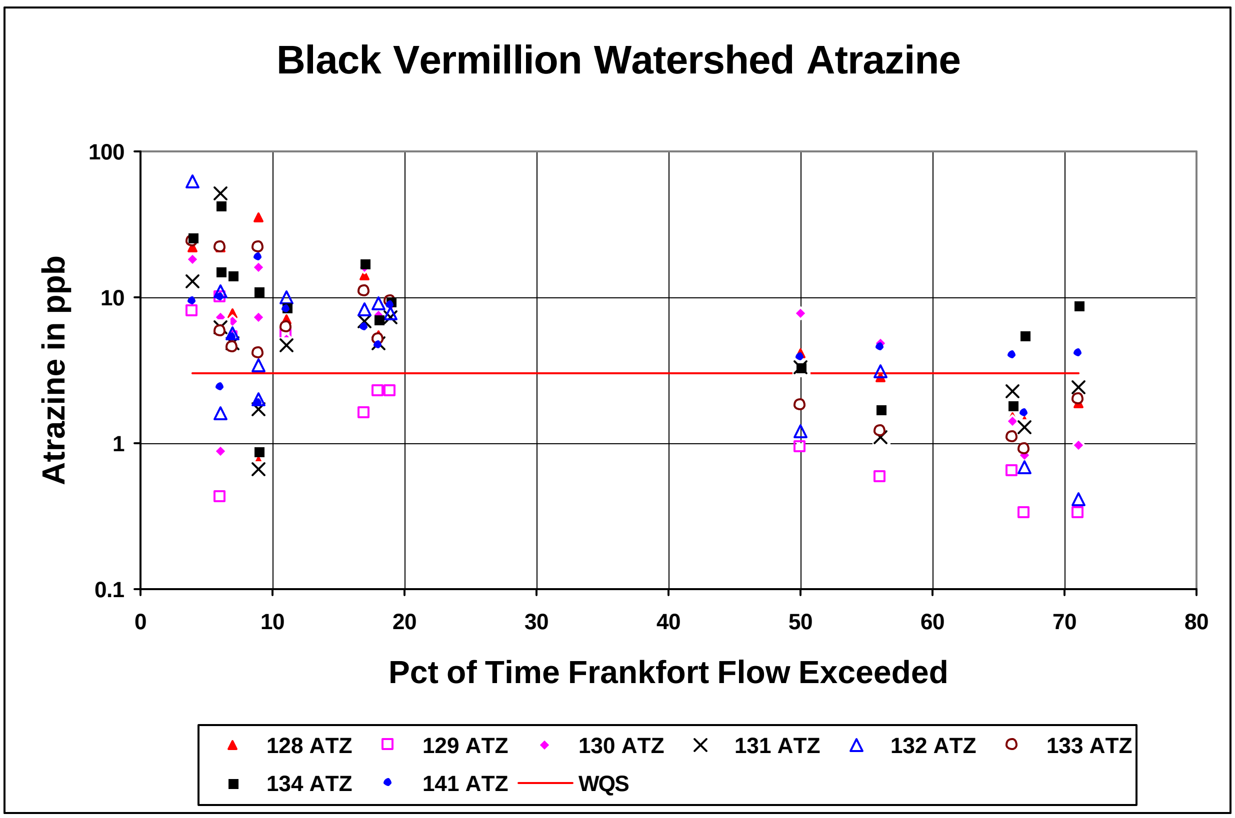
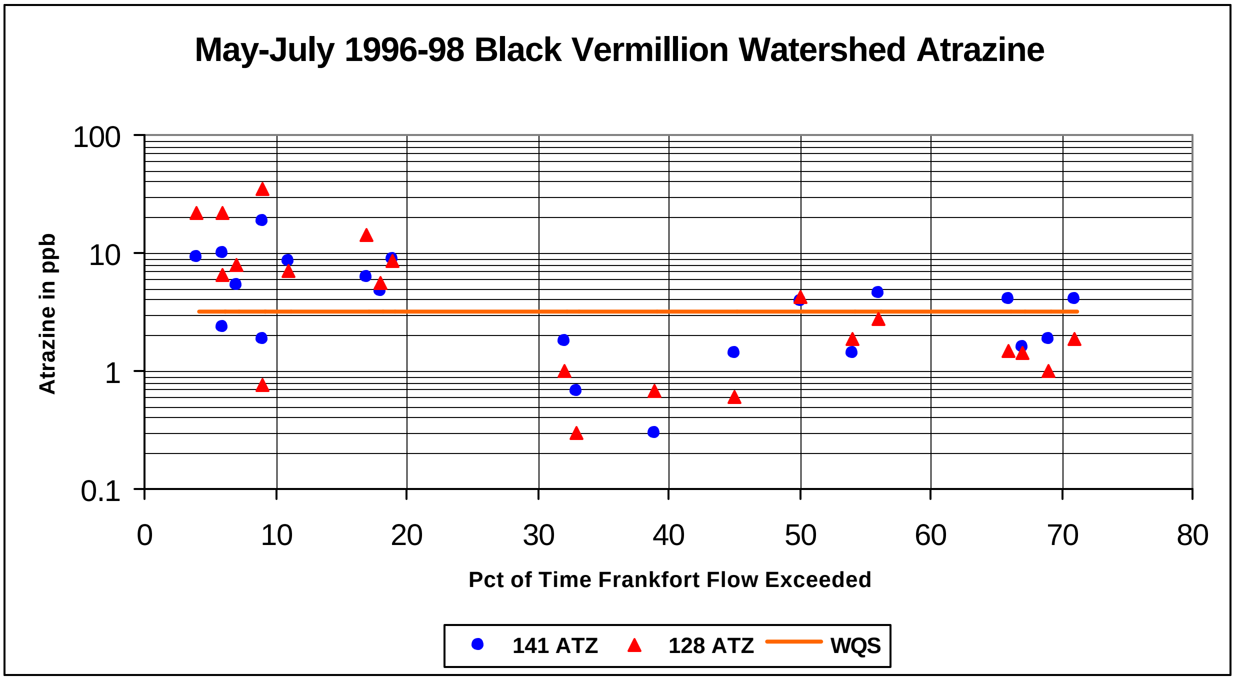


Figure 30. Runoff Season Atrazine Concentrations at Terminal Sites of Black Vermillion and North Fork Black Vermillion Rivers above Vliets, 1996-1998



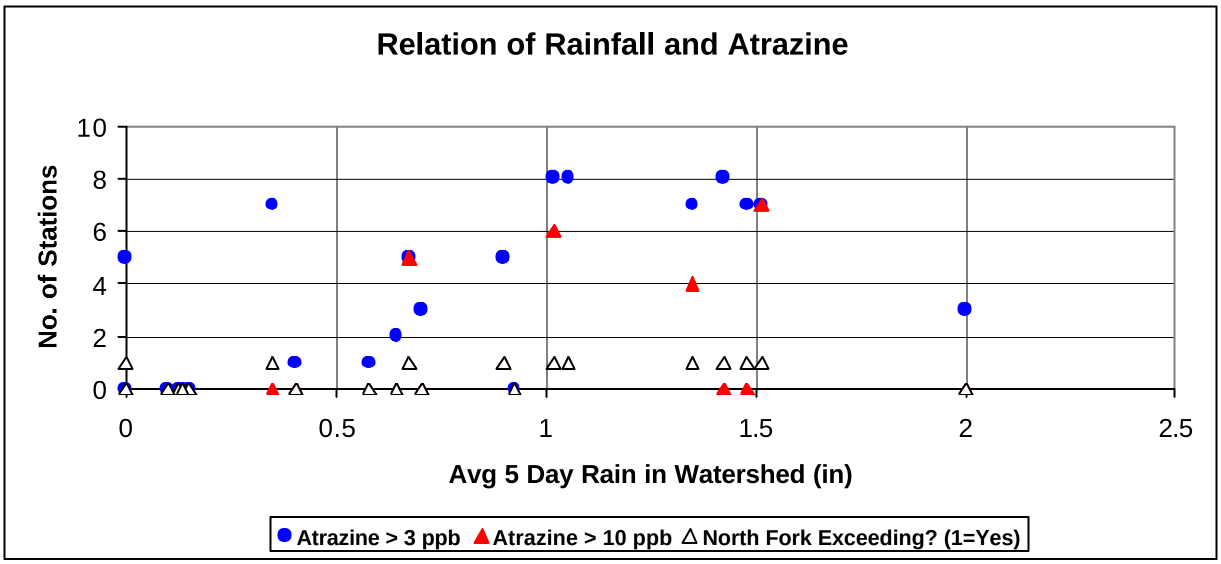
The obvious trigger to elevated atrazine is rainfall-runoff events. Examining rainfall at Frankfort and Axtell for the period of each sampling and the previous four days gives mixed results on this relationship (Figure 31). Generally, rains of more than half an inch falling on the watershed spurs some digressions in some of the streams. A one-inch rain tends to trigger atrazine loading throughout the watershed. The actual timing of atrazine application in each sub-watershed, the localized rainfall over each stream, the slope and soil conditions in each sub-watershed and the impact of any pesticide Best Management Practice utilized by individual farmers complicates the true relation between rain and atrazine loading.

Table 4 indicates the average soil permeability, percent of watershed likely to produce runoff and general land use proportions for five watersheds within the Tuttle Creek Lake drainage. The eastern drainage area is more likely to produce runoff, although contributions throughout the drainage increase with larger rains on the high proportion of cropland present above the lake.

Table 4. Land Use and Runoff Potential for Major Watersheds in Tuttle Creek Drainage

Watershed	Avg Permeability	% Watershed with Runoff from 0.5" Rain	% Watershed with Runoff from 1.0" Rain	% Cropland	% Grassland	% Woodland	% Urban
Big Blue R	0.5"	66.7%	83.9%	41.3%	48.9%	6.9%	0.3%
Black Vermillion R	0.4"	81.0%	86.5%	54.9%	41.3%	3.2%	0.3%
Little Blue R	0.9"	15.8%	76.6%	56.8%	37.4%	4.9%	0.2%
Mill Creek	0.9"	9.1%	72.4%	54.0%	40.3%	5.1%	0.3%
Fancy Creek	0.6"	41.0%	88.5%	43.4%	37.4%	4.9%	0.2%

Figure 31. Relationship between May-July Watershed Rainfall and Atrazine Concentrations in Streams



4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

The source assessment has ascertained that application and subsequent runoff of atrazine from croplands in the Tuttle Creek Lake drainage area is the primary factor for the elevated amounts of atrazine seen in streams and Tuttle Creek Lake, notably in May and June.

Point Sources: Since this pollutant is associated with agricultural non-point source pollution, a Wasteload Allocation of zero will be assigned to point sources for atrazine under this TMDL.

Non-Point Sources: As described in the Source Assessment, all of the subwatersheds will runoff and produce elevated atrazine concentrations in the Blue River system and

Tuttle Creek Lake. At more moderate rainfalls, the eastern drainage will likely load atrazine moreso than the western drainages. The Load Allocations for atrazine will be made for each of the watersheds in the drainage and be expressed as reductions from current monthly average loads. Loadings were determined from the KSU data sampled from 1997-2004. These load allocations are gross estimates of necessary reduction to achieve the endpoints of this TMDL and are not to be used as the measure of success for this TMDL.

Big Blue River: Allocations need to be made for both Nebraska and Kansas. As seen in the Source Assessment, there appears to be significant loading of atrazine in the Kansas drainage below the stateline. Table 5 provides estimates of May and June loadings for each of the eight years of sampling, desired loadings and necessary reductions on either side of the stateline to achieve those loadings, resulting in a seasonal average concentration at or below the criterion of 3 µg/l. Monthly flows in cfs were obtained from USGS. Atrazine averages in µg/l were provided by Kansas State. Loads in tons per day were computed as the product of the concentration and flow. Desired loads were computed as the product of the monthly flow and the criterion of 3 µg/. Stateline (Nebraska) reductions were computed as the difference between the desired and existing loads at Barneston. The Kansas reductions were computed as the difference between the total load reduction and the Nebraska load reduction. The percent load reduction was taken as the Kansas reduction divided by the incremental existing load between Marysville and Barneston. The estimated necessary average load reductions for May and June atrazine are 45 percent for actual excessive loads in Nebraska and 90% for excessive loads arising in Kansas. Overall average reductions are 23% and 74% for Nebraska and Kansas, respectively. Actual Load Reductions are given in the columns for Desired Barneston and Marysville Loads in Table 5 and graphed in Appendix B.

Table 5. May-June Average Atrazine Loadings, Desired Loadings and Necessary Reductions on Big Blue River (Flow in cfs, Atz in ppb, Loads and Reductions in pounds per day).

Year	Month	Brnstn Flow	Brnstn Atz	Mrysvll Flow	Mrysvll Atz	Brnstn Load	Mrysvll Load	Desired Brnstn Load	Desired Mrysvll Load	Total Reduct	Neb Reduct	Ks Reduct
1997	5	725	1.14	759	14.54	4.5	59.6	11.7	12.3	47.3	00.0	47.3(86%)
1997	6	1701	4.27	2353	15.60	39.2	198.2	27.6	38.1	160.1	11.7(30%)	148.4(93%)
1998	5	1212	1.06	1361	22.03	6.9	161.9	19.6	22.0	139.9	00.0	139.9(90%)
1998	6	2787	4.21	3811	24.27	63.4	499.5	45.1	61.7	437.7	18.2(29%)	419.5(96%)
1999	5	2863	5.49	3165	20.82	84.9	355.8	46.4	51.3	304.6	38.5(45%)	266.1(98%)
1999	6	3066	3.67	3477	13.73	60.8	257.8	49.7	56.3	201.5	11.1(18%)	190.4(97%)
2000	5	323	0.82	332	1.27	1.4	2.3	5.2	5.4	00.0	00.0	00.0
2000	6	615	0.91	585	3.02	3.0	9.5	10.0	9.5	00.0	00.0	00.0
2001	5	2785	2.77	3033	14.02	41.7	229.6	45.1	49.1	180.5	00.0	180.5(96%)
2001	6	3363	0.93	4229	6.03	16.9	137.7	54.5	68.5	69.2	00.0	69.2(57%)
2002	5	1778	1.88	2005	34.09	18.1	369.1	28.8	32.5	336.6	00.0	336.6(96%)
2002	6	558	2.01	697	7.44	6.1	28.0	9.0	11.3	16.7	00.0	16.7(76%)
2003	5	792	11.39	860	12.59	48.7	58.5	12.8	13.9	44.5	35.9(74%)	8.7(89%)
2003	6	1223	4.87	1365	3.58	32.2	26.4	19.8	22.1	4.3	4.3(13%)	00.0
2004	5	2170	16.83	2156	17.16	197.2	199.8	35.2	34.9	164.9	162.0(82%)	00.0
2004	6	1513	15.43	1708	35.62	126.1	328.5	24.5	27.7	300.9	101.6(81%)	199.3(98%)
	Ave.	**1717**	**4.86**	**1994**	**15.36**	**46.9**	**182.6**	**27.8**	**32.3**	**150.5**	**23.8(23%)**	**126.7(74%)**
							Average of Actual Pct Reductions				**46%**	**89%**

Little Blue River: As with the Big Blue River, Load Allocations on the Little Blue River have to be established for both Nebraska and Kansas. Unlike the Big Blue, there appears to be marginal gain in atrazine below the stateline station at Hollenberg. Table 6 provides estimates of May and June loadings for the eight years of sampling. The values were obtained or computed similarly to those in Table 5. The estimated necessary average load reductions for May and June atrazine are 63% for actual loading events in Nebraska and 77% for the small loads arising in Kansas. Overall average reductions would be 55% and 48%, respectively, for Nebraska and Kansas. Actual Load Reductions are given in the columns for Desired Hollenberg and Barnes Loads in Table 6 and graphed in Appendix B.

Table 6. May-June Average Atrazine Loadings Desired Loadings and Necessary Reductions on Little Blue River (Flow in cfs, Atz in ppb, Loads and Reductions in pounds per day).

Year	Month	Hollen Flow	Hollen Atz	Barnes Flow	Barnes Atz	Hollen Load	Barnes Load	Desired Hollen Load	Desired Barnes Load	Total Reduct	Neb Reduct	Ks Reduct
1997	5	329	6.22	430	5.19	11.1	12.1	5.3	7.0	5.1	5.1(46%)	00.0
1997	6	1197	10.2	1349	10.53	65.9	76.7	19.4	21.9	54.9	46.5(71%)	8.3(77%)
1998	5	346	3.52	483	6.09	6.6	15.9	5.6	7.8	8.1	1.0(15%)	7.1(76%)
1998	6	496	11.3	1101	9.64	30.3	57.3	8.0	17.8	39.5	22.2(73%)	17.2(64%)
1999	5	1136	28.92	1751	15.11	177.4	142.9	18.4	28.4	114.5	114.5(65%)	00.0
1999	6	789	11.27	1414	14.96	48.024.0	114.2	12.8	22.9	91.3	35.2(73%)	56.1(85%)
2000	5	168	0.89	204	0.63	0.8	0.7	2.7	3.3	00.0	00.0	00.0
2000	6	334	3.91	328	2.49	7.1	4.4	5.4	5.3	00.0	00.0	00.0
2001	5	1559	14.34	2039	11.05	120.7	121.7	25.3	33.0	88.6	88.6(73%)	00.0
2001	6	1670	5.53	2534	5.73	49.9	78.4	27.1	41.1	37.4	22.8(46%)	14.5(51%)
2002	5	884	18.31	1156	24.27	87.4	151.5	14.3	18.7	132.8	73.1(84%)	59.7(93%)
2002	6	302	10.81	489	10.78	17.6	28.5	4.9	7.9	20.5	12.7(72%)	7.8(72%)
2003	5	744	12.05	885	14.68	48.4	70.2	12.1	14.3	55.8	36.4(75%)	19.5(89%)
2003	6	2088	7.27	2257	5.13	82.0	62.5	33.8	36.6	26.0	26.0(32%)	00.0
2004	5	799	19.79	919	27.01	85.4	134.0	12.9	14.9	119.2	72.4(85%0	46.7(96%)
2004	6	958	9.07	1095	9.17	46.9	54.2	15.5	17.7	36.5	31.4(67%)	5.1(70%)
	Ave.	**862**	**10.84**	**1152**	**10.78**	**55.3**	**70.3**	**14.0**	**18.7**	**51.9**	**36.8(55%)**	**15.1(48%)**
							Average of Actual Pct Reductions				**63%**	**77%**

Black Vermillion River: The watershed is wholly within Kansas, thus, the responsibility for reductions to meet Load Allocations in Marshall and Nemaha Counties lies with Kansas. Table 7 displays the estimated loads, desired loads and necessary load reductions to achieve the endpoints of the TMDL. Estimated May-June loads are to be reduced by 48%. Actual Load Reductions are given in the column for Desired Frankfort Loads in Table 7 and graphed in Appendix B.

Table 7. May-June Average Atrazine Loadings Desired Loadings & Necessary Reductions on Black Vermillion R. (Flow in cfs, Atz in ppb, Loads and Reductions in pounds per day).

Year	Month	Frankfort Flow	Frankfort Atrazine	Frankfort Load	Frankfort Des.Load	Total Reduction
1997	5	177	5.22	5.0	2.9	2.1 (43%)
1997	6	195	9.07	9.6	3.2	6.4 (67%)
1998	5	68.6	1.72	0.6	1.1	00.0
1998	6	383	14.35	29.7	6.2	23.5 (79%)
1999	5	838	7.24	32.8	13.6	19.2 (59%)
1999	6	1431	12.24	94.6	23.2	71.4 (75%)
2000	5	36.6	1.52	0.3	0.6	00.0
2000	6	72.7	2.1	0.8	1.2	00.0
2001	5	151	5.69	4.6	2.4	2.2 (47%)
2001	6	789	5.30	22.6	12.8	9.8 (43%)
2002	5	97.3	7.14	3.8	1.6	2.2 (58%)
2002	6	18.4	4.68	0.5	0.3	0.2 (36%)
2003	5	55.2	8.81	2.6	0.9	1.7 (66%)
2003	6	29.9	4.82	0.8	0.5	0.32 (38%)
2004	5	49.5	14.97	4.0	0.8	3.2 (80%)
2004	6	66.8	16.27	5.9	1.1	4.8 (82%)
	Ave.	**250**	**7.57**	**13.6**	**4.5**	**9.2 (48%)**
			Avg of Actual Pct Reductions			**59%**

Mill Creek: The watershed is mostly in Kansas, for the purposes of this TMDL, all Load Reductions will be applied to drainage lying in Washington County in Kansas. Table 8 displays the estimated loads, desired loads and necessary load reductions to achieve the endpoints of the TMDL. Estimated May-June loads are to be reduced by 51%. Actual Load Reductions are given in the columns for Desired Washington Loads in Table 8 and graphed in Appendix B.

Table 8. May-June Average Atrazine Loadings Desired Loadings and Necessary Reductions on Mill Creek

Year	Month	Washington Flow	Washington Atrazine	Washington Load	Washington Des Load	Total Reduction
1997	5	53.9	6.34	1.8	0.9	1.0 (53%)
1997	6	68.3	4.78	1.8	1.1	0.7 (37%)
1998	5	60.7	0.9	0.3	1.0	00.0
1998	6	166	12.37	11.1	2.7	8.4 (76%)
1999	5	271	7.64	11.2	4.4	6.8 (61%)
1999	6	185	13.46	13.4	3.0	10.4 (78%)
2000	5	13	.77	0.1	0.2	00.0
2000	6	6.38	3.96	0.1	0.1	00.03 (24%)
2001	5	195	7.07	7.4	3.2	4.3 (58%)
2001	6	362	6.04	11.8	5.9	5.9 (50%)
2002	5	170	10.12	9.3	2.8	6.5 (70%)
2002	6	51.4	11.51	3.2	0.8	2.4 (74%)
2003	5	47.8	3.63	0.9	0.8	0.2 (17%)
2003	6	210	5.38	6.1	3.4	2.7 (44%)
2004	5	83.7	16.82	7.6	1.4	6.2 (82%)
2004	6	74.4	19.28	7.7	1.2	6.5 (84%)
	Ave.	**101**	**8.13**	**5.9**	**2.0**	**3.9 (51%)**
			Avg of Actual Pct Reductions			**58%**

Rose Creek: This stream flows out of Republic County in Kansas into Nebraska. There are few data, but half of the samples are over the 3 µg/l. The Load Allocation will be assigned to Kansas with an estimated 70% reduction in loading occurring in Republic County. Estimated desired loads would be 0.06 pounds per day at median flow (3.4 cfs); 0.15 pounds per day at 25% exceedance flow (9.2 cfs) and 0.39 pounds per day at the 10% exceedance flow (24 cfs).

Summary of Load Reductions: Table 9 summarizes the necessary load reductions to be accomplished by Nebraska and Kansas to achieve the endpoints of this TMDL.

Table 9. Summary of Atrazine Load Reductions by Nebraska and Kansas in Tuttle Creek Drainage

	Nebraska Reduction		Kansas Reduction	
Watershed	Overall Loads	Excessive Loads	Overall Loads	Excessive Loads
Big Blue	23%	46%	75%	89%
Little Blue	55%	63%	48%	77%
Black Vermillion	N/A	N/A	48%	59%
Mill Creek	N/A	N/A	51%	58%
Rose Creek	N/A	N/A	70%	N/A

Any reductions should also minimize the entry of elevated atrazine loads into Tuttle Creek Lake. While an occasional loading event will be expected in the upper lake, these reductions will ensure that loads will be sufficiently assimilated by the lake, such that the main portion of the lake below Randolph will not suffer any excursions from the water quality standards.

Defined Margin of Safety: This TMDL will be monitored by the atrazine levels in the seasonal runoff events in May and June. The Load Allocations were established by examining the data during these seasons over the past eight years and computing necessary reductions. In some months and years, there was no need for reduction since the atrazine levels were below the 3 µg/l criterion. The Margin of Safety for this TMDL is explicit in that the average load reduction to be made was based on those events where atrazine levels exceeded the criterion. The compliant data from the occasional months of no impairment were not used to compute the reductions. This had the impact of increasing the necessary percent reduction over that derived from the 16 months of data produced by Kansas State. Therefore, this approach ensures that if these reductions are achieved, there is a high probability of achieving the endpoints of this TMDL, notwithstanding favorable climate conditions, such as was seen in 2000.

State Water Plan Implementation Priority: The 1999 atrazine and alachlor TMDLs for Tuttle Creek Lake were designated High Priority because of the lake's importance in influencing the water supply and water quality of the Kansas River and the investment made by the state in the water supply conservation storage of the lake. Subsequent 303d listings identified impairments in the streams flowing to the lake and the need to comprehensively package implementation measures to handle impairments in the lake by watershed management requires this TMDL remain a High Priority for implementation.

Unified Watershed Assessment Priority Ranking: This lake's watersheds encompass both the Lower Big Blue Subbasin (HUC8: 10270205) and the Lower Little Blue Subbasin (HUC8: 10270207). The Unified Watershed Assessment assigned a priority ranking of 2 to the Lower Big Blue and 10 to the Lower Little Blue subbasins (Both Highest Priority for restoration work).

Priority HUC 11s and Stream Segments: In 1999, certain subwatersheds were deemed highest priority because of their high proportion of cropland, proximity to the lake and ability to generate runoff. Knowledge gained after five years of implementation leads one to target toward smaller order streams draining less than 25 square miles. This targeting philosophy is based on the efficiency of Best Management Practices to influence water quality on smaller drainages, the biological importance of these small drainages and their susceptibility to extremely high concentrations of atrazine occurring during flashy storm events. Over time, insertion of BMPs in these smaller drainages should accrue sufficient density of practices, such that water quality on larger order streams should begin to benefit.

Therefore, the small stream drainages of the Lower Big Blue and Lower Little Blue Subbasins designated in Tables 10 and 11 have high priority for implementing this TMDL. Focus should be made on the smaller unnamed tributaries feeding into these stream segments.

Table 10. Priority Tributaries for TMDL Implementation in Lower Big Blue Subbasin (HUC: 10270205)

County	Major Drainage	Priority Tributary Streams and Segment Numbers
Marshall	Big Blue River (7,17,18,20,21)	North Elm Creek (41)
Marshall		Bommer Creek (40)
Marshall		Scotch Creek (38)
Marshall		Deer Creek (36)
Marshall		Hop Creek (43)
Marshall		Dutch Creek (44)
Marshall		Elm Creek (46)
Marshall		Timber Creek (64)
Marshall	Horseshoe Creek (26)	Raemer Creek (33)
Marshall		Indian Creek (37)
Marshall		Meadow Creek (34)
Marshall		Little Indian Creek (35)
Marshall	Spring Creek (19)	Lily Creek (39)
Marshall		Schell Creek (45)
Marshall	Roubidoux Creek (16)	Perkins Creek (47)
Marshall		Dog Walk Creek (53)
Marshall	Black Vermillion River (8,10,11,13,14)	Corndodger Creek (52)
Marshall		DeShazer Creek (55)
Marshall		Johnson Fork (51)
Marshall		Cedar Creek (56)
Nemaha	North Fork, Black Vermillion River (15)	Weyer Creek (50)
Marshall	South Fork, Black Vermillion River (12)	Kearney Branch (58)
Marshall	Clear Fork, Black Vermillion River (9)	Jim Creek (57)
Riley	Fancy Creek (9029)	School Branch (63)
Clay	West Fancy Creek (29)	Deadman Creek (60)
Washington		Carter Creek (59)

Table 11. Priority Tributaries for TMDL Implementation in Lower Little Blue Subbasin (HUC: 10270207)

County	Major Drainage	Priority Tributary Streams and Segment Numbers
Washington	Little Blue River (1,2,3,4)	Cedar Creek (40)
Washington		Lane Branch (39)
Washington		Beaver Creek (38)
Washington		Malone Creek (37)
Washington		Mercer Creek (43)
Washington		Bolling Creek (41)
Washington	Coon Creek (23)	Camp Creek (44)
Washington	Mill Creek (14,16,18,20)	Camp Creek (35)
Washington		Buffalo Creek (32)
Washington		Melvin Creek (33)
Washington		Salt Creek (19)
Washington		Iowa Creek (34)
Washington		Jones Creek (29)
Washington	Rose Creek (12)	

5. IMPLEMENTATION

Desired Implementation Activities

1. Implement proper mix of pesticide use best management practices, including soil incorporation, application timing and rates, split and band application, alternative weed control and buffer zones
2. Implement necessary best management practices at storage and handling sites
3. Install necessary grass buffer strips along streams.
4. Ensure label compliance by applicators
5. Harmonize water quality protection measures and use directions on labels of products containing atrazine
6. Establish a long term watershed protection plan to coordinate and synchronize watershed management activities to reduce loading of pollutants (sediment, nutrient, pathogen and pesticide) to the Blue River stream system and Tuttle Creek Lake.
7. Incorporate pesticide management and load reduction into the Targeted Watershed Initiative Grant for the Tuttle Creek watershed, as well as the Tuttle Creek Watershed Restoration and Protection Strategy.

Implementation Programs Guidance

Non-Point Source Pollution Technical Assistance - KDHE

a. Support Section 319 demonstration projects for reduction of atrazine runoff from corn and grain sorghum cropland.
b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
c. Guide federal programs, such as the Environmental Quality Improvement Program & Conservation Security Program, to support installation of pesticide Best Management Practices to the cropland drained by the small tributaries within the identified priority stream drainages in the Lower Big Blue and Lower Little Blue Subbasins.
d. Establish a long-term Watershed Restoration and Protection Plan for the Tuttle Creek Lake Drainage to comprehensively reduce the loading and delivery of pesticides, sediment and nutrients to the lake and its watershed.
e. Coordinate with Nebraska on the Targeted Watershed Initiatives Grant for Tuttle Creek watershed to ensure bi-state reduction in atrazine loadings.

Water Resource Cost Share & Non-Point Source Pollution Control Programs - SCC

a. Support installation of pesticide management sites for storage, mixing and handling of atrazine and other pesticides.
b. Support pesticide best management practices to minimize pesticide runoff

Water Quality Standards - KDHE

a. Prepare an agency position to admonish EPA to finalize its aquatic life criteria for atrazine.
b. Incorporate revised atrazine criteria into Kansas surface water quality standards once criteria are finalized by EPA.

Riparian Protection Program - SCC

a. Establish or reestablish natural riparian systems, including vegetative filter strips along small tributaries
b. Develop riparian restoration projects in cropland areas

Buffer Initiative Program - SCC

a. Install grass buffer strips along small streams.
b. Work in conjunction with federal Conservation Reserve Enhancement Program and Conservation Security Program to hold marginal riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

a. Educate corn and grain sorghum producers on pesticide management
b. Provide technical assistance on buffer strip design, techniques to minimize cropland runoff and construction of pesticide handling pads.
c. Continue to conduct watershed scale monitoring of atrazine and other pesticides, focusing on the period of April to July, to capture the seasonal runoff period when the greatest atrazine loads are expected.
d. Provide planning assistance to local interests to support WRAPS activities in the Tuttle Creek Lake drainage.

Pesticide Management Program

a. Implement pesticide bulk containment regulations
b. Ensure label compliance by pesticide applicators
c. Harmonize product labels regarding use and protection measures
e. Implement any applicable provisions of the Atrazine Interim Reregistration Eligibility Decision by EPA
f. Continue basin pesticide education efforts through Kansas State and commodity associations

Big Blue River Compact - KDA

a. Continue to support bistate efforts to reduce atrazine runoff
b. Continue to coordinate activities among the two states' Departments of Agriculture and Environment in the Blue River Watershed.

Timeframe for Implementation: Pollution reduction practices should continue to be installed along the small tributaries of the priority stream over 2006-2011. Comprehensive long term watershed management and protection should proceed under the Kansas WRAPS process, commencing in 2006.

Targeted Participants: Primary participants for implementation will be grain sorghum and corn producers operating within the small drainages of tributaries to the Big Blue, Little Blue and Black Vermillion Rivers and Mill and Rose Creeks. Emphasis is initially made on the small drainages (less than 25 sq.mi) previously identified in this TMDL and the following activities located within one mile of the streams including:

1. Total corn and sorghum acreage
2. Location of any tile drain outlets draining into streams.
3. Location of pesticide storage, mixing and handling sites
4. Cultivated riparian areas

Some updates to the inventory of local needs in Marshall, Nemaha, Washington and Republic Counties should be conducted by each county conservation district in 2006-2007 to identify such activities. Such an inventory would direct state assistance programs to the principal activities influencing the quality of the streams in the watershed during the implementation period of this TMDL.

As suggested by the Source Assessment, the priority for Nebraska should be producers along the Little Blue River, while the first priority for Kansas should be the producers in Marshall County along the Big Blue River, followed by those along the Little Blue River and Mill Creek in Washington County and finally, the producers within the Black Vermillion watershed. Producers along Rose Creek in Republic County can be engaged at any time, although this drainage is somewhat removed from the overall objectives of this TMDL achieving water quality standards on the main streams flowing into Tuttle Creek Lake.

Milestones for 2010: The year 2004 marked the midpoint of the initial ten-year implementation period for the original TMDL for the watershed. Information is being gathered by state and federal conservation agencies on the number of producers involved in the targeted activities and participating in the implementation programs provided by the state and NRCS. Additionally, sampled data from Tuttle Creek Lake indicates evidence of reduced atrazine levels throughout the lake with notable reductions in the lower portions of the lake and during periods outside the May-June runoff season. Atrazine levels in streams also seem more restricted to the May-June runoff periods, although the magnitude of digressions continues to be large during very high flows. Dry years such as 2000, result in loads and concentrations below state standards.

The year 2010 will reflect ten years of implementation thoughout the watershed and should result in achievement of the endpoints described by this TMDL. Some episodic high loads are expected, but the frequency, duration and magnitude of such events should continue to be reduced from conditions seen prior to 2000. 2010 is also the next year of visitation to develop and revise TMDLs in the Kansas-Lower Republican Basin.

Delivery Agents: The primary delivery agents for program participation will be the conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension and agricultural interest groups, such as the Kansas Corn Growers Association and the Kansas Grain Sorghum Producers Association.

Reasonable Assurances:

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

1. K.S.A. 2-2439 empowers the Secretary of Agriculture to oversee pesticide management, registration and use in the state.

2. K.S.A. 2-2472 empowers the Secretary of Agriculture to establish Pesticide Management Areas to protect public health, safety and welfare and the natural resources of the state from pesticide pollution.

3. K.S.A. 82a-529 is the Big Blue River Compact that supports bistate pollution abatement in the Big Blue River Basin.

4. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

5. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control non-point source pollution.

6. 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.

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

8. The *Kansas Water Plan* and the Kansas-Lower 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.

9. The Federal Insecticide, Fungicide and Rodenticide Act authorizes the state to initiate the process of making label changes on the use, application and provision of environmental protection of pesticides.

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 is a **High Priority** consideration. Most pesticide application management practices can be made without cost-share considerations. Development of a Watershed Restoration and Protection Strategy in the watershed has begun using Clean Water Act Section 319 funding to initiate planning assistance.

Effectiveness: Pesticide management has proven to be effective in reducing atrazine levels in Perry and Hillsdale Lakes. Many voluntary approaches were promoted through the Pesticide Management Area established on the Delaware River Subbasin. Most of those producers raised corn. The key to effectiveness will be equivalent participation by grain sorghum producers in the Tuttle Creek drainage area. Equally important is similar participation by agricultural producers in Nebraska. Research by Kansas State indicates that incorporation into the soil can reduce atrazine runoff losses by two-thirds. Timing applications before April 15 can decreases losses by half. Splitting applications before planting time can reduce runoff by one-third, while banding applications to the planted row reduces runoff by an additional one-third. Filter strips reduce atrazine loss by 25%.

6. MONITORING

KDHE will continue to collect seasonal samples from Tuttle Creek Lake twice in the five year period 2007-2011. Over the period 2006-2011, the Corps of Engineers will collect monthly samples over April to September from Tuttle Creek Lake. It would be desirable to collect a majority of samples at elevations between 1075' and 1078'. The Corps should continue to collect at the three locations on the lake as well as the entry points for the Big Blue and Black Vermillion Rivers.

Routine bimonthly sampling from the permanent and rotational KDHE stream stations should be maintained throughout the period 2006-2011. Kansas State University should continue to collect April through July grab and runoff samples within the drainage area, particularly at Barnes and Marysville. Samples from the outlet of Tuttle Creek Lake should be collected, particularly from May to October of each year.

7. FEEDBACK

Public Notice: Public notification of the second round of TMDLs in the Kansas-Lower Republican Basin was made in the Kansas Register in January 5, 2006. An active Internet Web site was established at http://www.kdheks.gov/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Kansas-Lower Republican Basin. Comments on the draft TMDL were received by the Kansas Corn Growers Association, Syngenta, Inc. and the Kansas City District, Corps of Engineers. The Corps expressed support for the TMDL and cooperation in monitoring lake quality.

Public Hearing: Public Hearings on the second round of TMDLs for the Kansas-Lower Republican Basin were held in Olathe on January 19, and in Topeka on January 30, 2006.

Basin Advisory Committee: The Kansas-Lower Republican Basin Advisory Committee met to discuss the second round of TMDLs in the basin on April 7, 2005 in Lawrence, July 26, 2005 in Concordia, October 20, 2005 in Lawrence and January 24, 2006 in Topeka.

Blue River Compact: The water quality committee of the Compact and the Compact Administration met on May 3 and May 12, 2005 to discuss this TMDL.

Milestone Evaluation: This TMDL is a revision to the original atrazine TMDL for Tuttle Creek established in June 1999 and approved in January 2000. It reflects subsequent information on the condition of Tuttle Creek Lake and the streams of the Lower Big Blue and Lower Little Blue Subbasins. Modifications to the implementation approach have been made based on this recent information. The next evaluation will be in 2012 in conjunction with the development of the Section 303d list that year. Should modifications be made to the applicable water quality criteria during the remaining five years of the original implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly in 2012.

Consideration for 303d Delisting: Tuttle Creek Lake, the Big Blue River, Black Vermillion River, Mill Creek and Rose Creek will be evaluated for attainment of the atrazine water quality standards, based on the monitoring data from the period 2006-2011. Therefore, the decision to declare these waters un-impaired by atrazine will come about in the preparation of the 2012 303d list.

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 after 2006 which will emphasize revision of the State Water Quality Management Plan to incorporate adaptive implementation of TMDLs and development of the Watershed Restoration and Protection Planning Process. By reference, incorporation of this TMDL is made into the Continuing Planning Process, via the *Kansas Water Plan* directing implementation decisions under the State Water Planning Process for Fiscal Years 2007-2011.

Revised February 22, 2007

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7. Bevans, H.E., Fromm, C.A. and Watkins, S.A., 1993, The Occurrence and Transport of Agricultural Pesticides in the Tuttle Creek Lake-Stream System, Kansas and Nebraska, USGS Open-File 93-87, 44 p.

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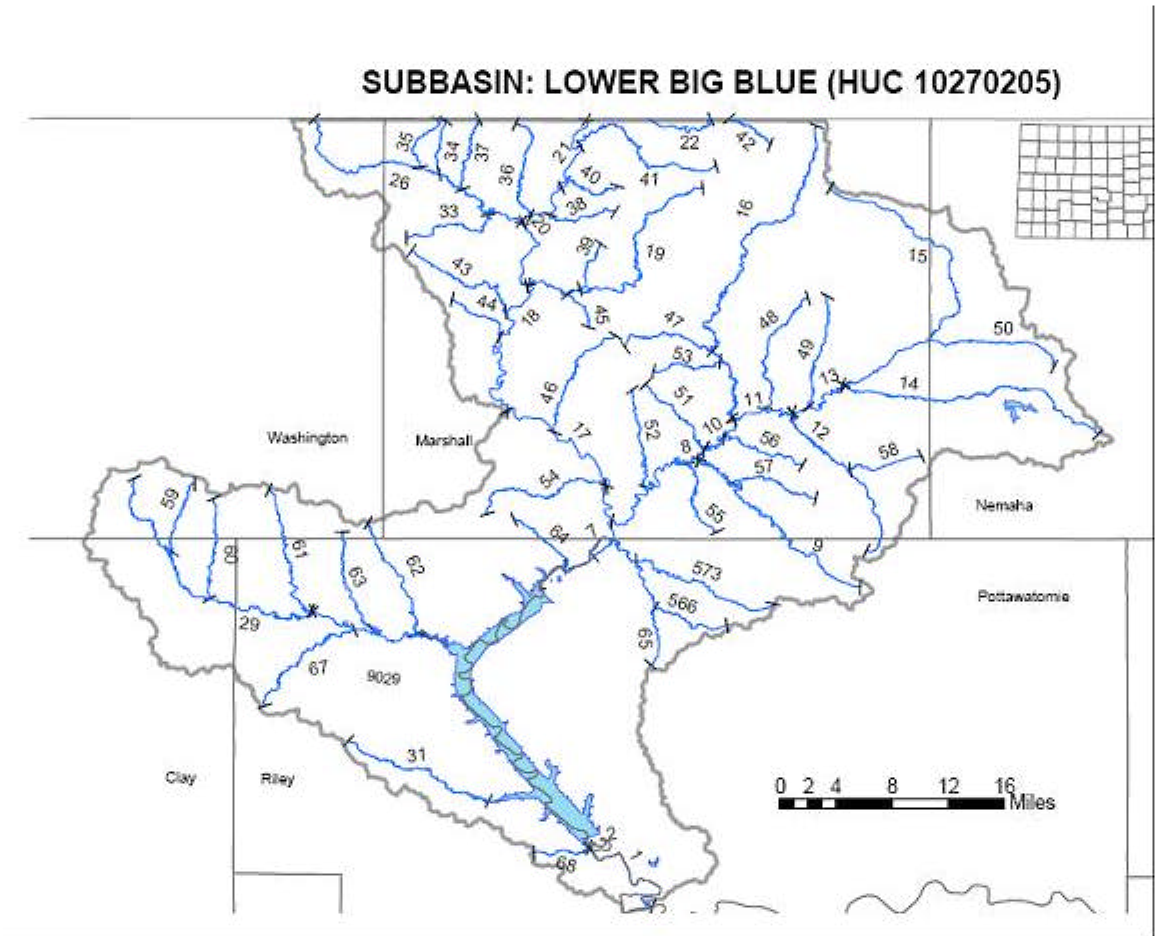
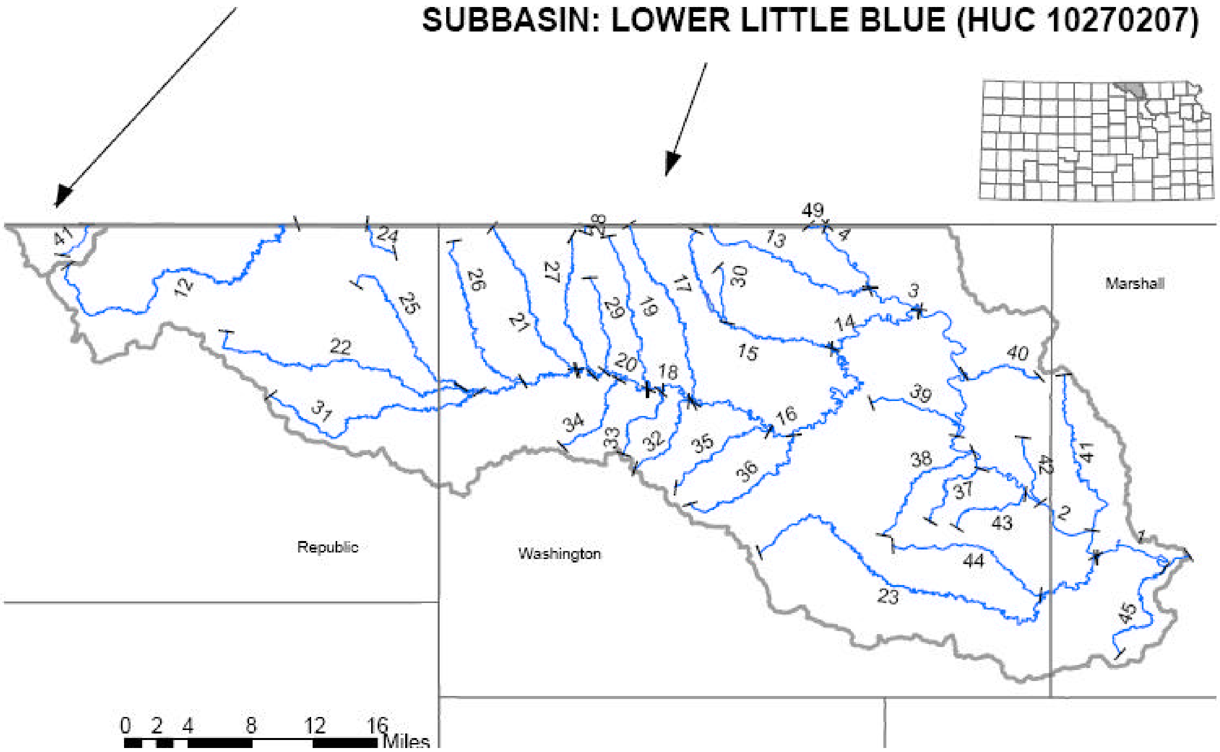
10. Devlin, D.L. and Regehr, D.L., 1996, Water Quality Best Management Practices for Atrazine, Kansas State University, Cooperative Extension Service Publication MF-2182.
11. U.S. Environmental Protection Agency, October, 2003; Ambient Aquatic Life Water Quality Criteria for Atrazine – Revised Draft; EPA-822-R-03-023; 178 p.

Appendix A. Stream Segment Maps of the Lower Big Blue and Lower Little Blue Subbasins

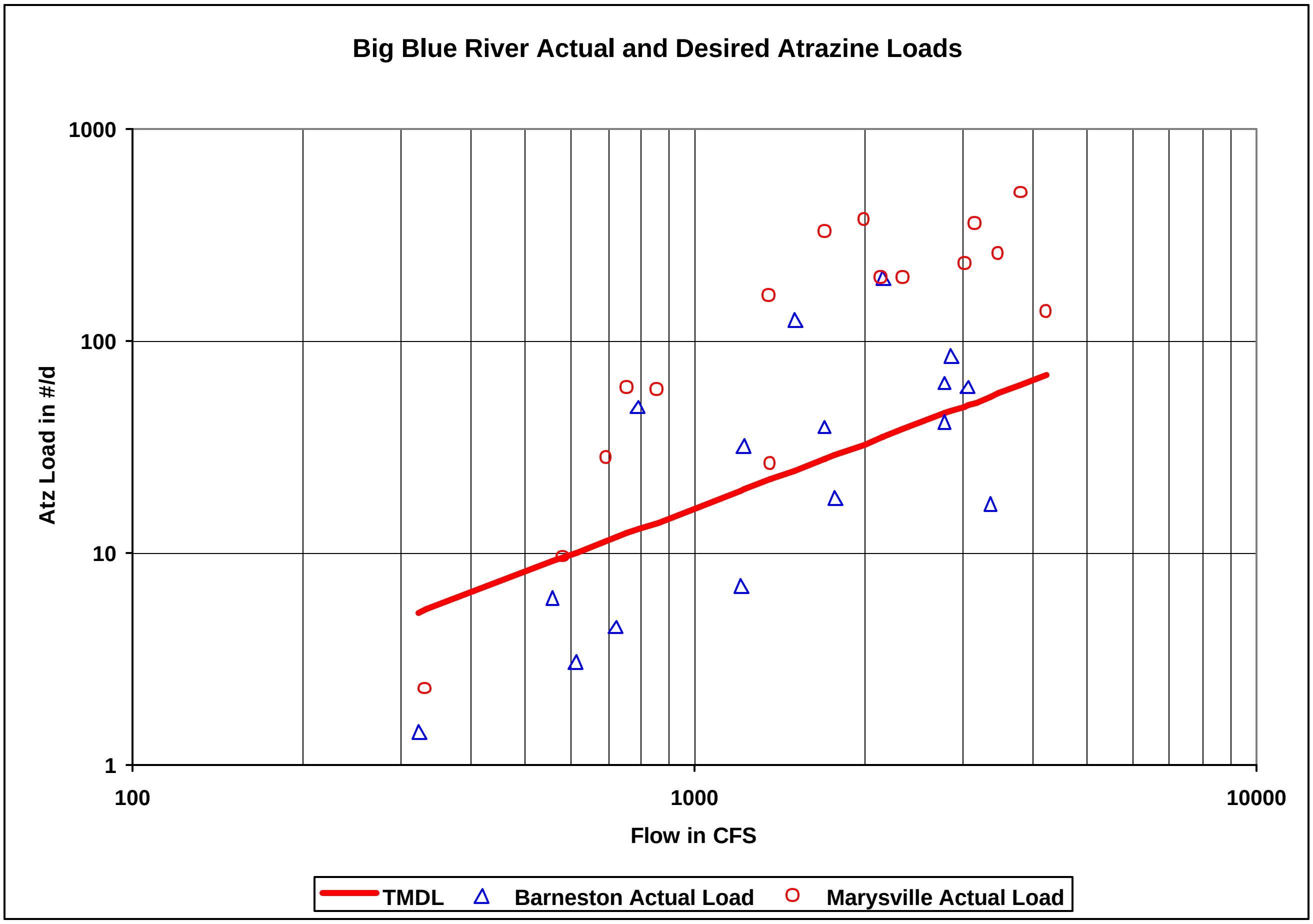


SUBBASIN: UPPER LITTLE BLUE (HUC 10270206)

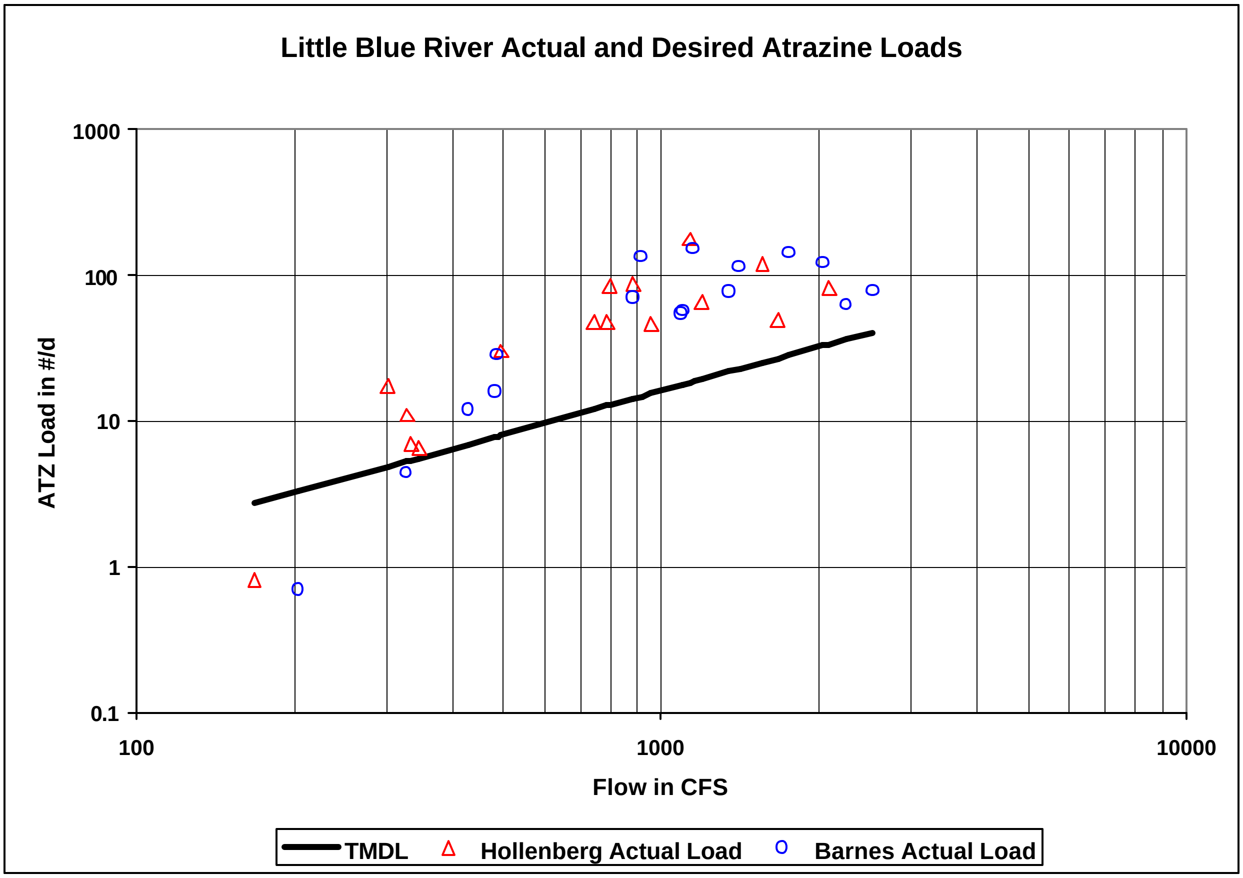
SUBBASIN: LOWER LITTLE BLUE (HUC 10270207)



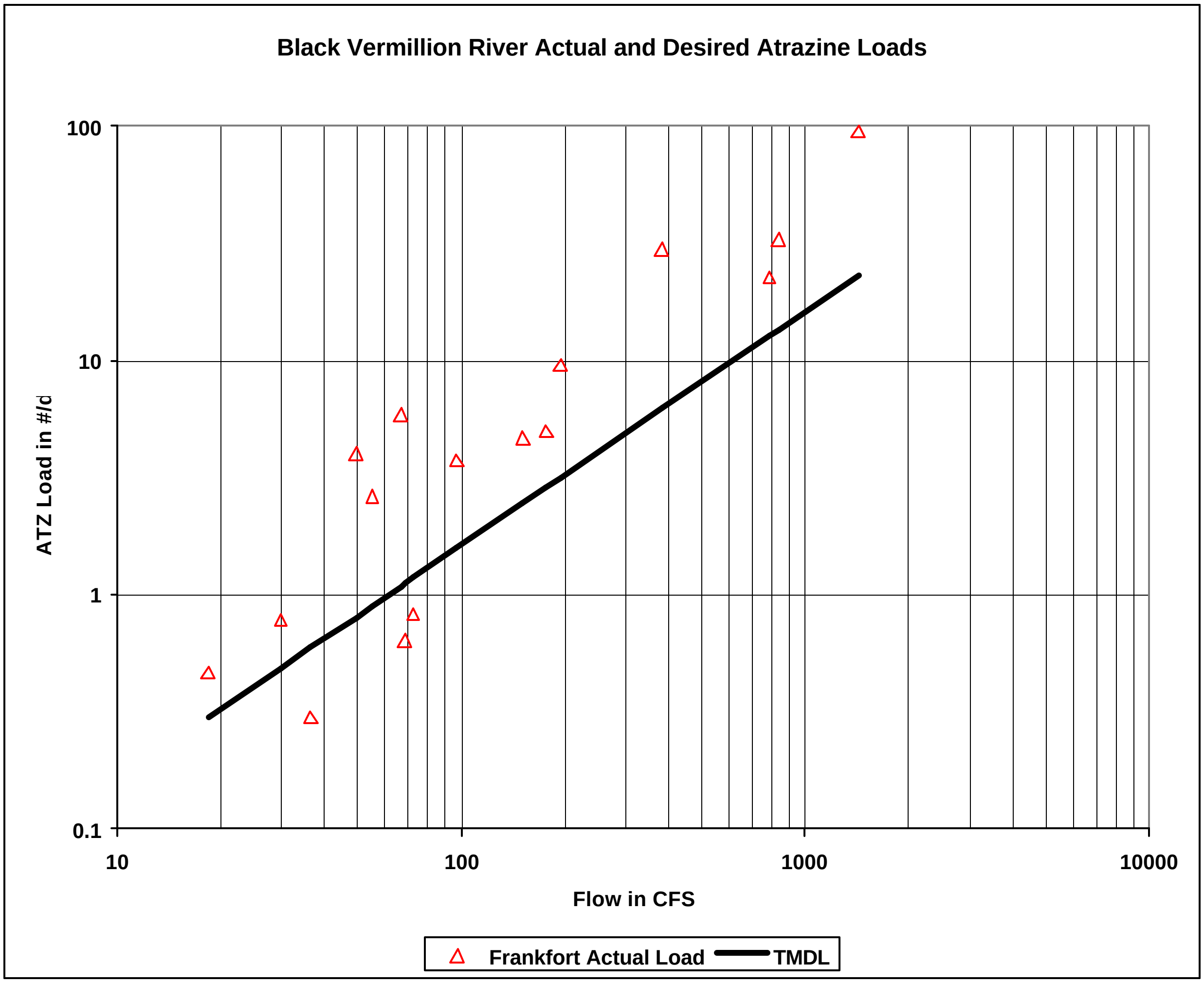
Appendix B. Atrazine Load Capacity Curves for Blue River Watershed Streams



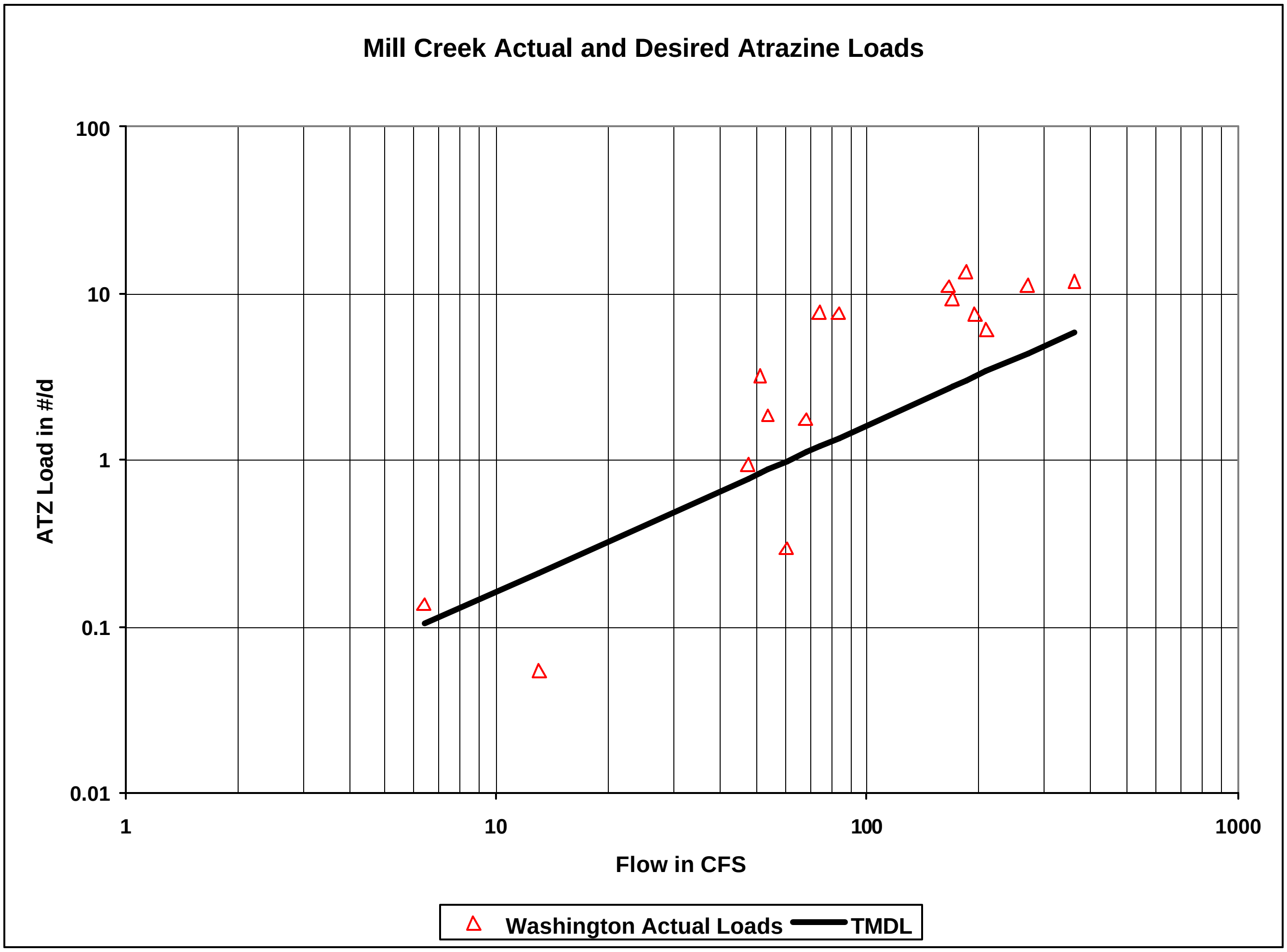
Big Blue River Atrazine Load Allocations and Current May and June Loads



Little Blue River Atrazine Load Allocations and Current May and June Loads



Black Vermillion River Atrazine Load Allocations and Current May and June Loads



Mill Creek Atrazine Load Allocations and Current May and June Loads