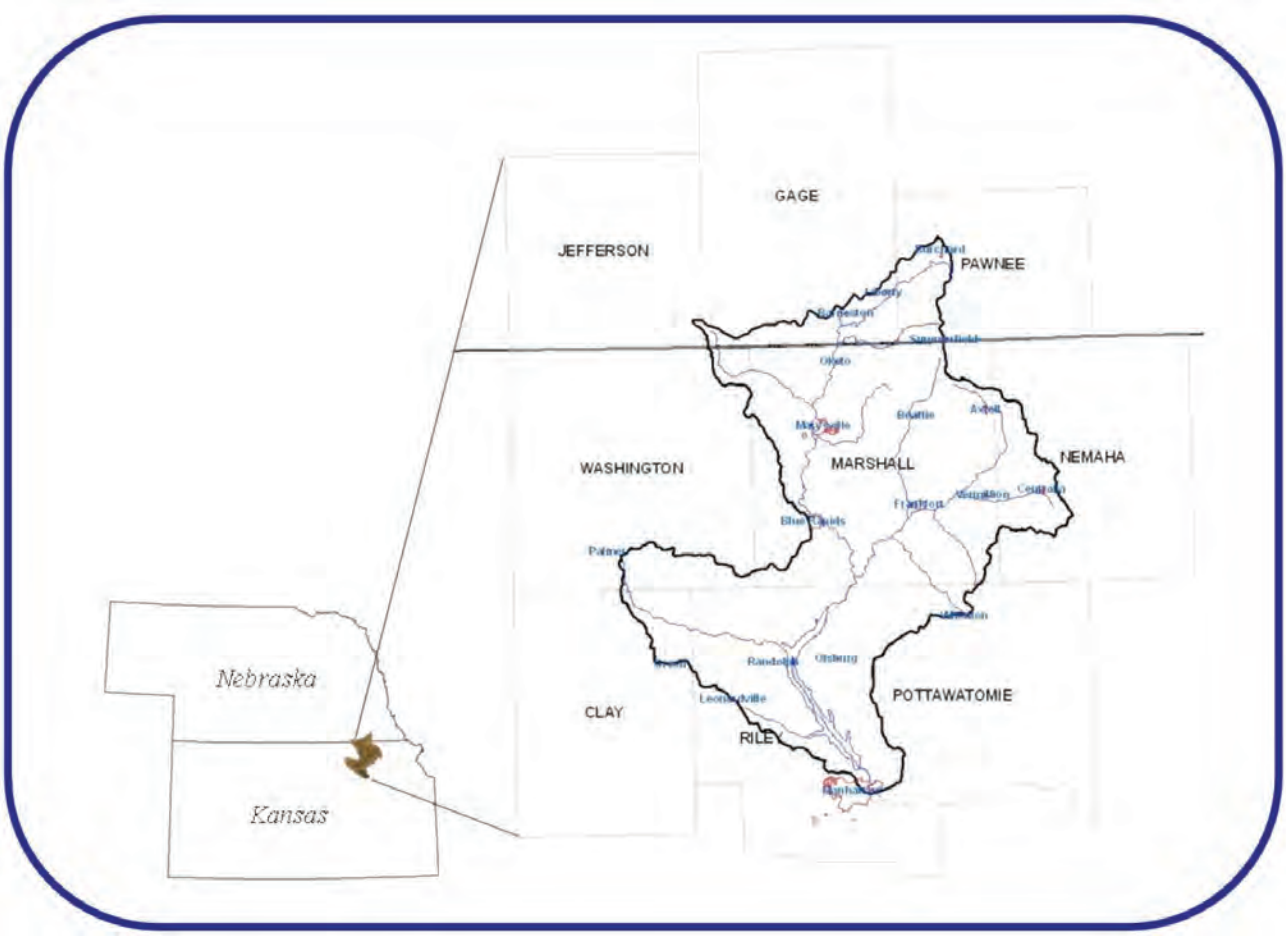
Lower Big Blue Watershed Assessment: Preliminary Report



2009

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Publication # EP-140

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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1.0 Lower Big Blue Watershed Assessment

1.1 Watershed Summary

The Lower Big Blue Watersheds is located primarily in Washington, Marshall, Nemaha, Clay, Riley and Pottawatomie counties in northeast Kansas. It contains the Big Blue River, which originates in Nebraska, in addition to the Black Vermillion River and Fancy Creek. Tuttle Creek Lake is an important lake in the watershed, providing recreation and flood control. In addition, Centralia Lake and Pottawatomie County State Fishing Lake are located in the watersheds. The Lower Big Blue Watershed has a Category I designation, indicating the watershed is in need of restoration and protection to sustain water quality.

Crop production is the predominant land usage (42.5 percent) for the watershed. Grassland is the second largest land usage at 41.2 percent. Woodland, water, and urban areas constitute the remaining 16.3 percent of land cover[1].

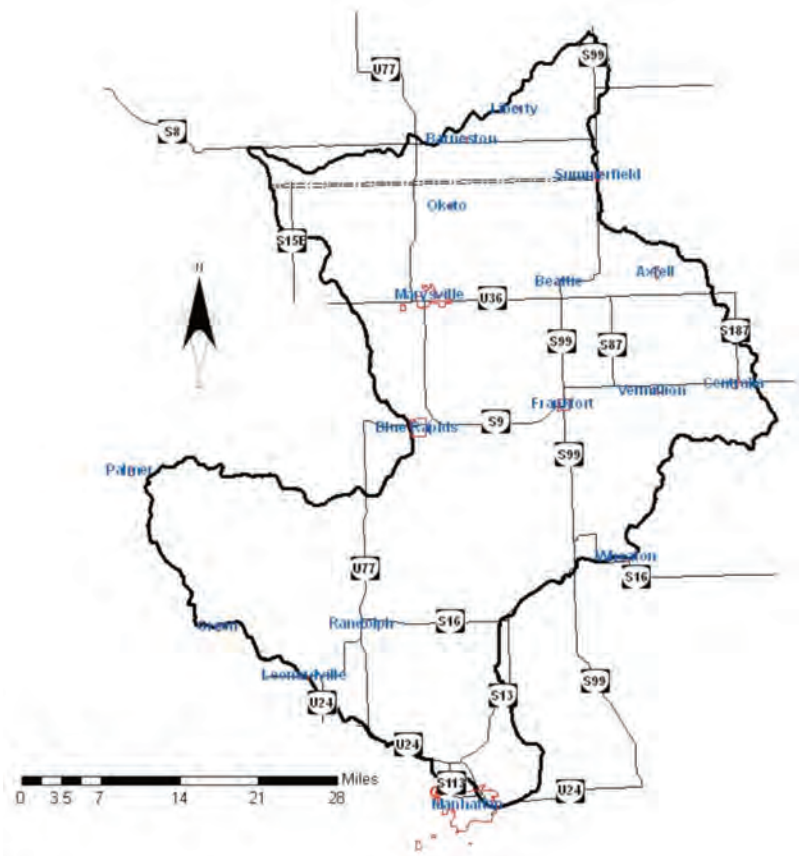

Figure 1. Major roads and cities – Lower Big Blue Watershed

1.2 Overview of Water Quality Issues and Potential Pollution Sources

When river segments or lakes that are monitored by Kansas Department of Health and Environment (KDHE) have experienced poor quality, a Total Maximum Daily Load (commonly referred to as a TMDL) is established. A TMDL is the maximum amount of pollution that a surface water body can receive and still meet water quality standards.

Fecal coliform bacteria is listed as a TMDL in Fancy Creek, and the Big Blue and Black Vermillion Rivers. The presence of fecal coliform bacteria indicates the water has been in contact with warm-blooded animals. Potential sources include feedlots, wastewater treatment plants, failing septic systems, and wildlife. Target TMDL endpoint is less than 200 colony forming units per 100 ml water for swimming, and less than 2,000 colony forming units per 100ml water for boating and fishing.

Eutrophication is a primary pollutant for Tuttle Creek Lake and Centralia Lake. Excess nutrient loading from the watershed creates conditions favorable for algae blooms and aquatic plant growth resulting in low dissolved oxygen rates and an unfavorable habitat for aquatic life. Surplus nutrients originate from manure and fertilizer runoff in rural and urban areas. Many agricultural producers in the watershed implement best management practices (known as BMPs) to prevent nutrient runoff. Centralia Lake also has a medium TMDL for pH and a threat to aquatic life due to high chlorophyll concentrations. This is also a result from eutrophication. Some common BMPs include: the use of conservation tillage and cover crops, maintaining buffer strips along field edges, and proper timing of fertilizer application.

Tuttle Creek Lake is impaired by siltation. Silt or sediment accumulation in lakes and wetlands reduces reservoir volume and limits public access to the lakes. Reducing erosion is necessary for a reduction in sediment. Agricultural best management practices such as conservation tillage, grass buffer strips around cropland, and reducing activities within the riparian areas will reduce erosion and improve water quality.

Atrazine is under review by the EPA as a high priority TMDL in Tuttle Creek Lake. Atrazine is also under consideration as a high priority TMDL in the rivers and creeks that drain into Tuttle Creek Lake. After field application to crops (corn, sorghum and soybeans) these highly soluble herbicides are susceptible to overland runoff during rainfall events. BMPs that prevent rainfall runoff from cropland and proper timing of herbicide application will help reduce the amount of atrazine in Tuttle Creek Lake. Alachlor is also a TMDL for Tuttle Creek Lake[2].

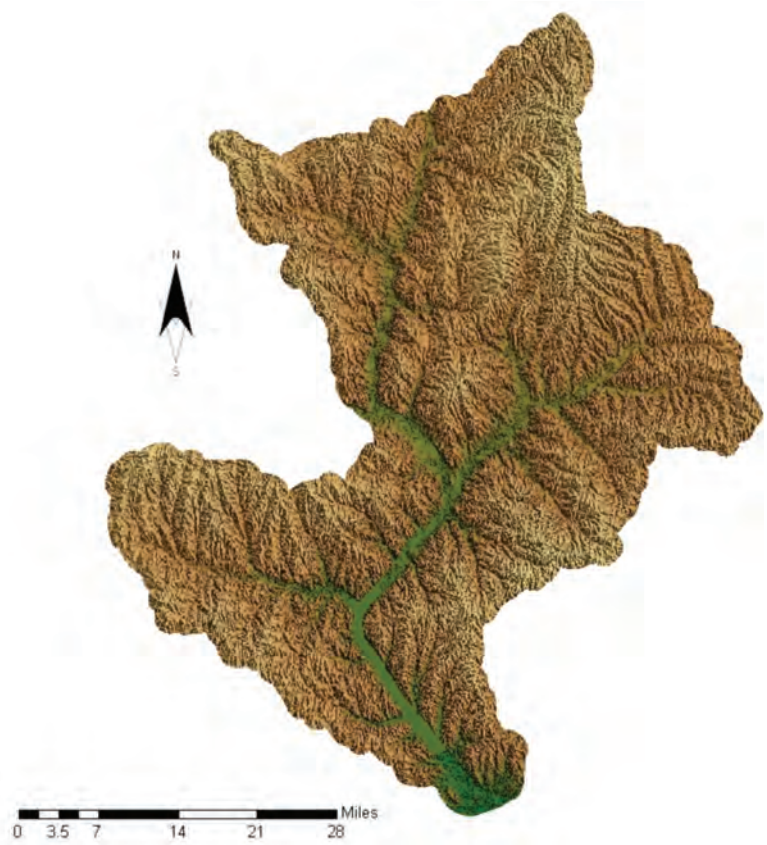

Figure 2. Relief Maps – Lower Big Blue Watershed [3]

2.0 Climate Mapping System

2.1 Precipitation Map[4]

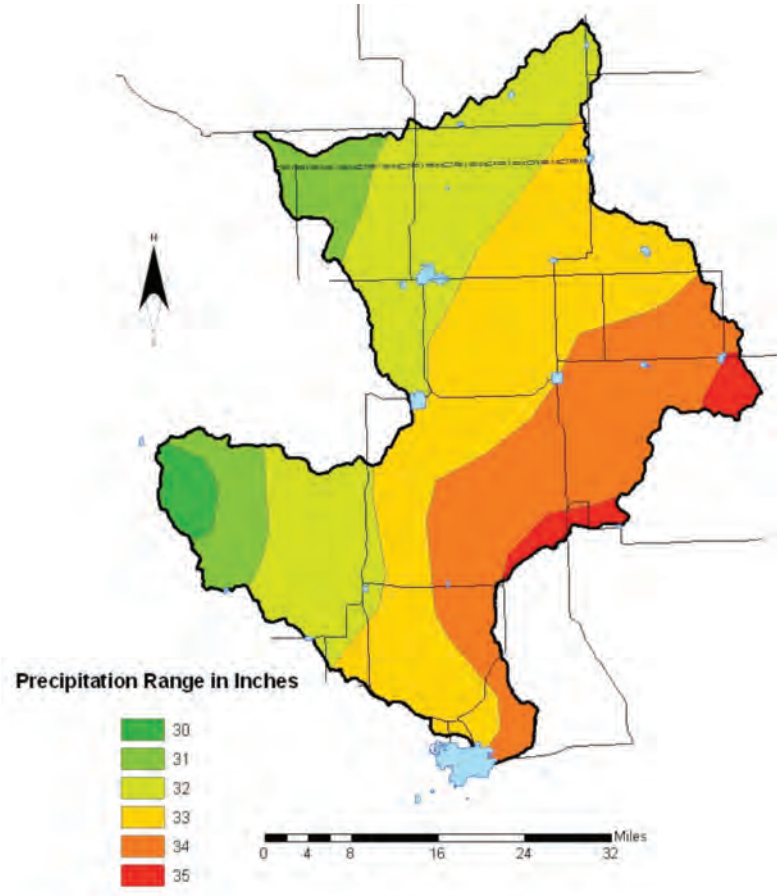

Figure3. 30-year average annual precipitation in inches, 1971 – 2000.

2.2 30-Year Average Daily Maximum Temperature Map[5]

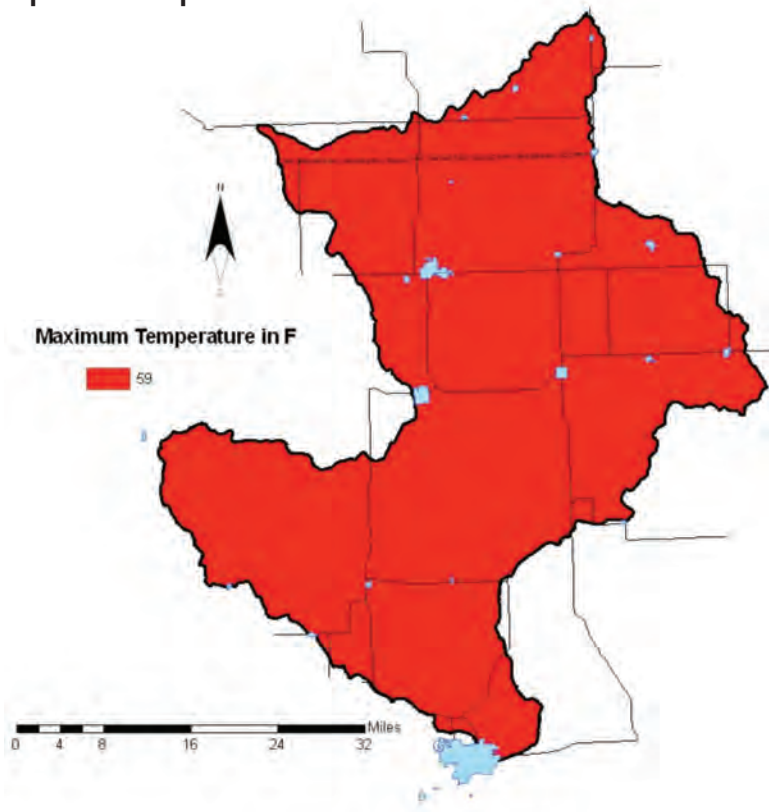

Figure 4. 30-year average daily maximum temperature in degrees Fahrenheit, 1971 – 2000

2.3 30-Year Average Daily Minimum Temperature Map[6]

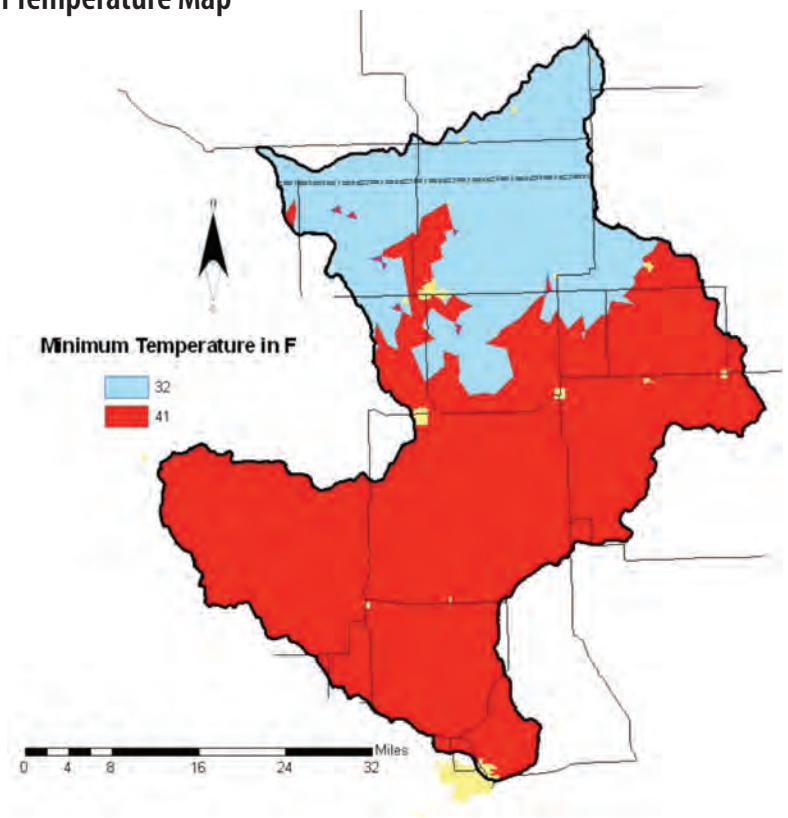

Figure 5. 30-year average daily minimum temperature in degrees Fahrenheit, 1971 – 2000

3.0 Land Use/ Land Cover

3.1 Land Use (GIRAS 1980s)[7]

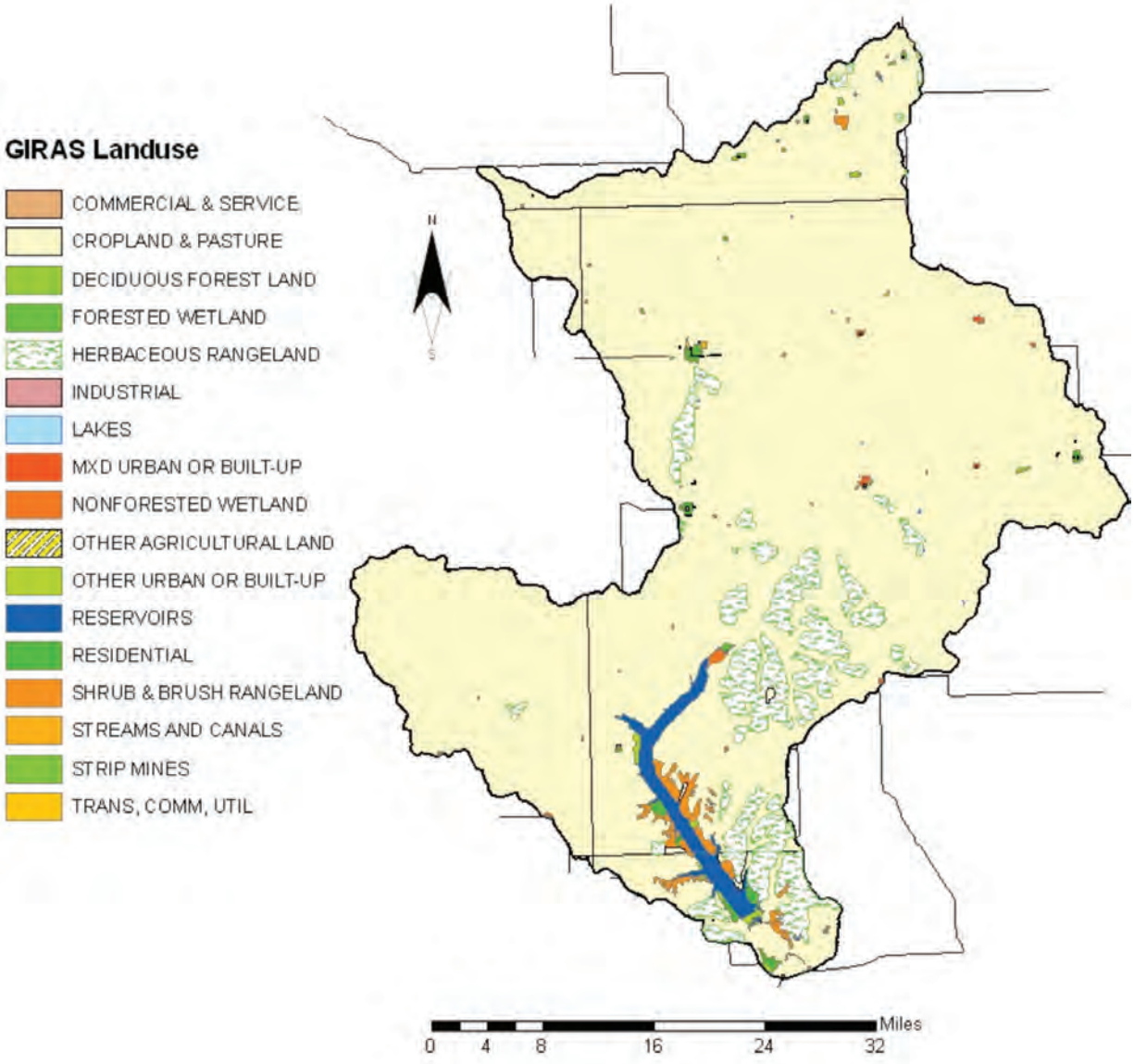

Figure 6. GIRAS 1980s land use classification.

3.2 Land Use (NLCD 1992)[8]

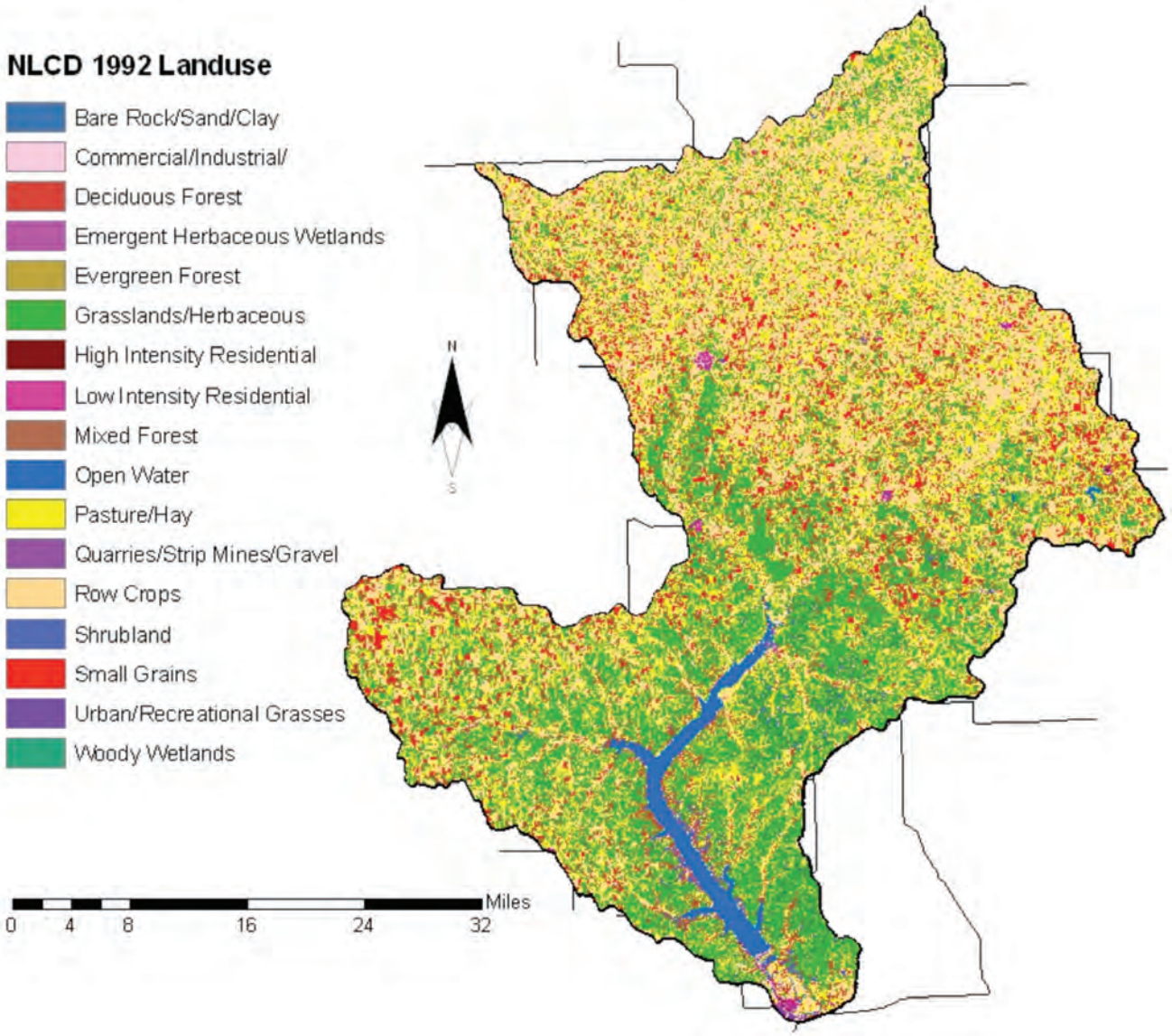

Figure 7. NLCD 1992 land use classification.

3.2.1 NLCD 1992 Land Cover Class Definitions[34]

The following definitions are from the EPA's National Land Cover Database, found at: *http://www.epa.gov/mrlc/definitions.html#1992*

11. Open Water – all areas of open water, generally with less than 25% cover of vegetation/land cover.

21. Low Intensity Residential – Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

22. High Intensity Residential – Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80 to100 percent of the cover.

23. Commercial/Industrial/Transportation – Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

31. Bare Rock/Sand/Clay – Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.

32. Quarries/Strip Mines/Gravel Pits – Areas of extractive mining activities with significant surface expression.

41. Deciduous Forest – Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest – Areas dominated by trees where 75 percent or more of the tree species` maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest – Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

51. Shrubland – Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms.

71. Grasslands/Herbaceous – Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

81. Pasture/Hay – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

82. Row Crops – Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.

83. Small Grains – Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.

85. Urban/Recreational Grasses – Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

91. Woody Wetlands – Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

3.3 Land Use (NLCD 2001)[1]

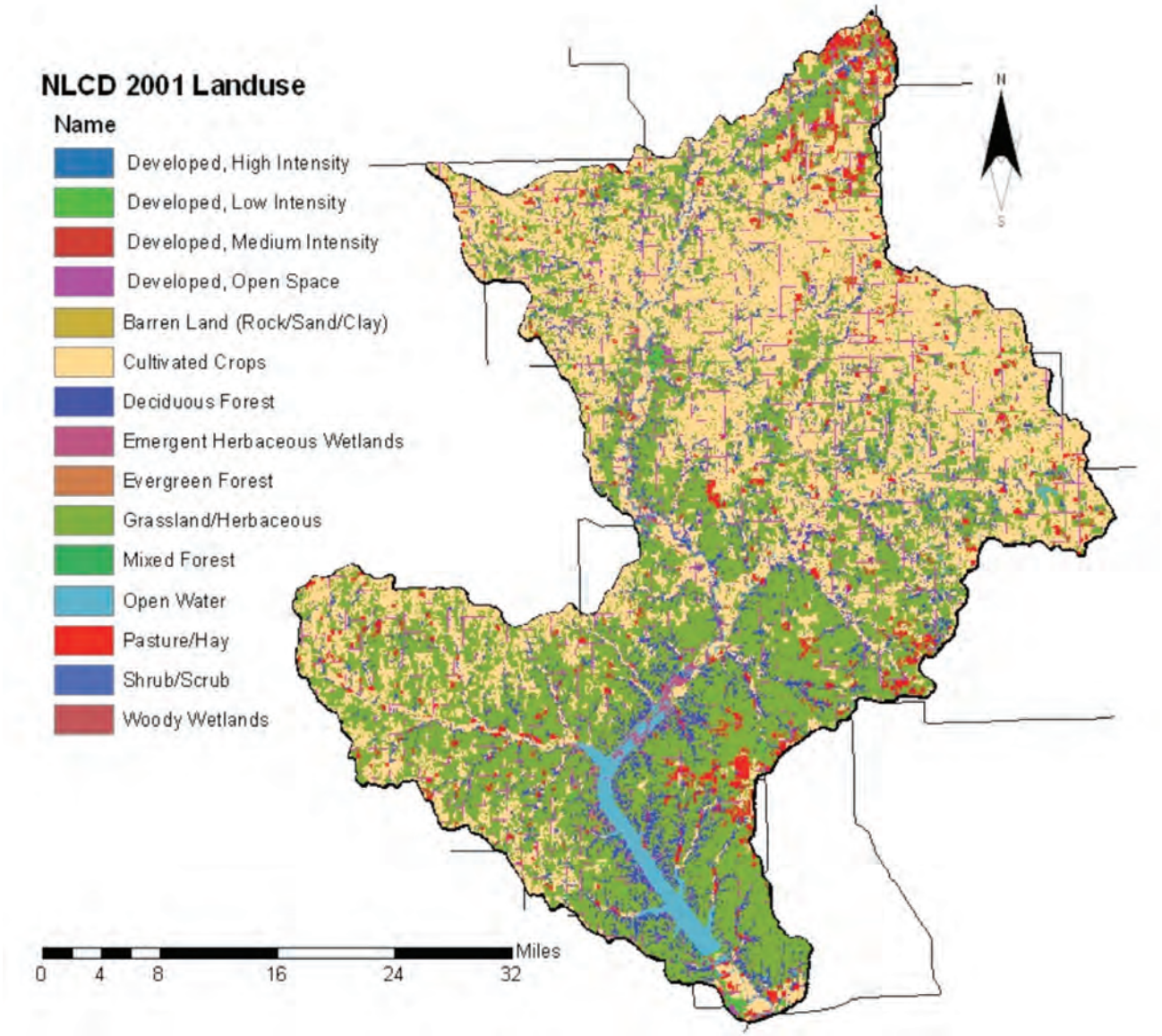

Figure 8. NLCD 2001 land use classification.

3.3.1 NLCD 2001 Land Cover Class Definitions[35]

The following definitions are from the EPA's National Land Cover Database, found at: *http://www.epa.gov/mrlc/definitions.html#2001*

11. **Open Water –** All areas of open water, generally with less than 25% cover of vegetation or soil.
21. **Developed, Open Space –** Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
22. **Developed, Low Intensity –** Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.
23. **Developed, Medium Intensity –** Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24. Developed, High Intensity – Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

31. Barren Land (Rock/Sand/Clay) – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

41. Deciduous Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. Evergreen Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. Mixed Forest – Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. Shrub/Scrub – Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions.

71. Grassland/Herbaceous – Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. Pasture/Hay – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. Cultivated Crops – Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. Woody Wetlands – Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

92. Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

Table 1. Summary of land use covers

Land Use Type	Agriculture			Barren Land	Forest Land	Grassland	Urban	Wetlands/ Water	Shrub	Total
	Cropland	Pasture	Total							
GIRAS 1980s	968792		968792	230	705	85486	8101	18101	0	1081415
NLCD 1992	380855	193774	574629	223	36722	332485	5459	28494	13465	991477
NLCD 2001	424312	34635	458947	83	95366	445166	47746	32984	370	1080662

4.0 River Network[9]

Figure 9. River network – Lower Big Blue Watershed.

5.0 Hydrologic Soil Groups[10]

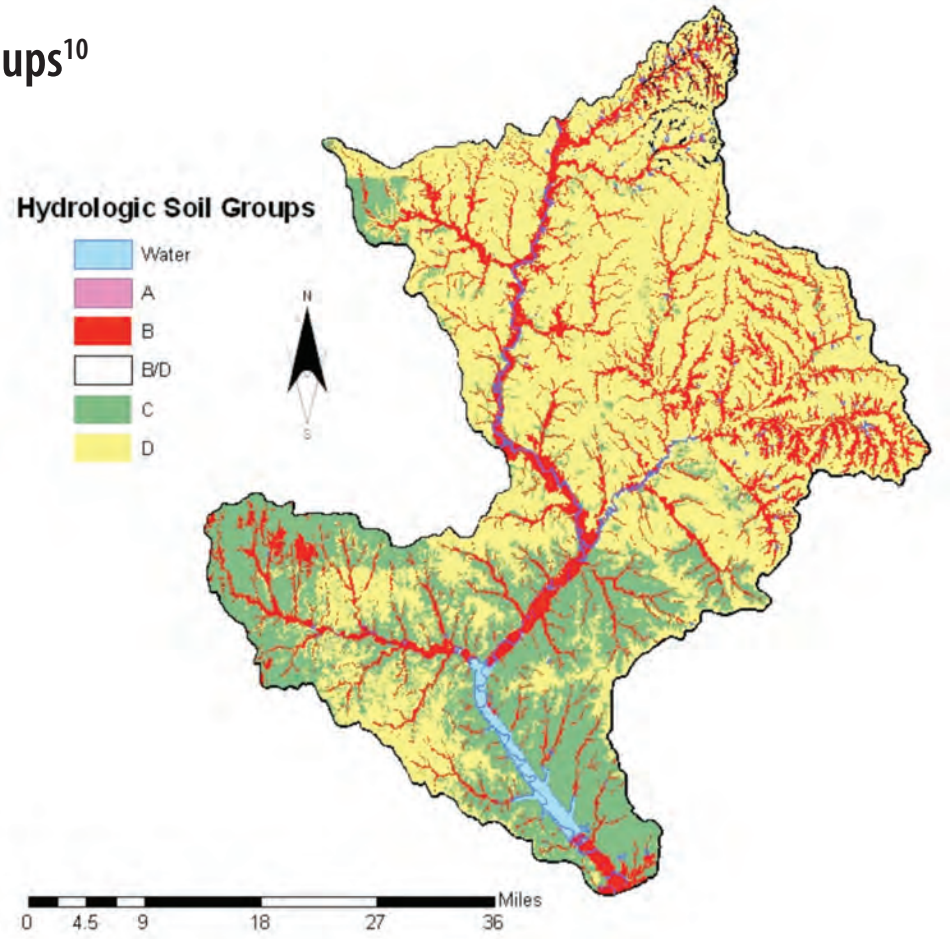

Figure 10. Hydrologic Soil Groups – SSURGO Database – Lower Big Blue Watershed

6.0 Water Quality Conditions

6.1 The 303d List of Impaired Waterbodies[2]

This map shows all impaired streams that are not meeting their designated uses (impaired waters) because of excess pollutants as defined in Section 303(d) of the Clean Water Act. The list of impaired waterways is updated by the states every two years. This can be used to identify specific stream segments and lakes for which, in accordance with their priority ranking, TMDLs may need to be developed.

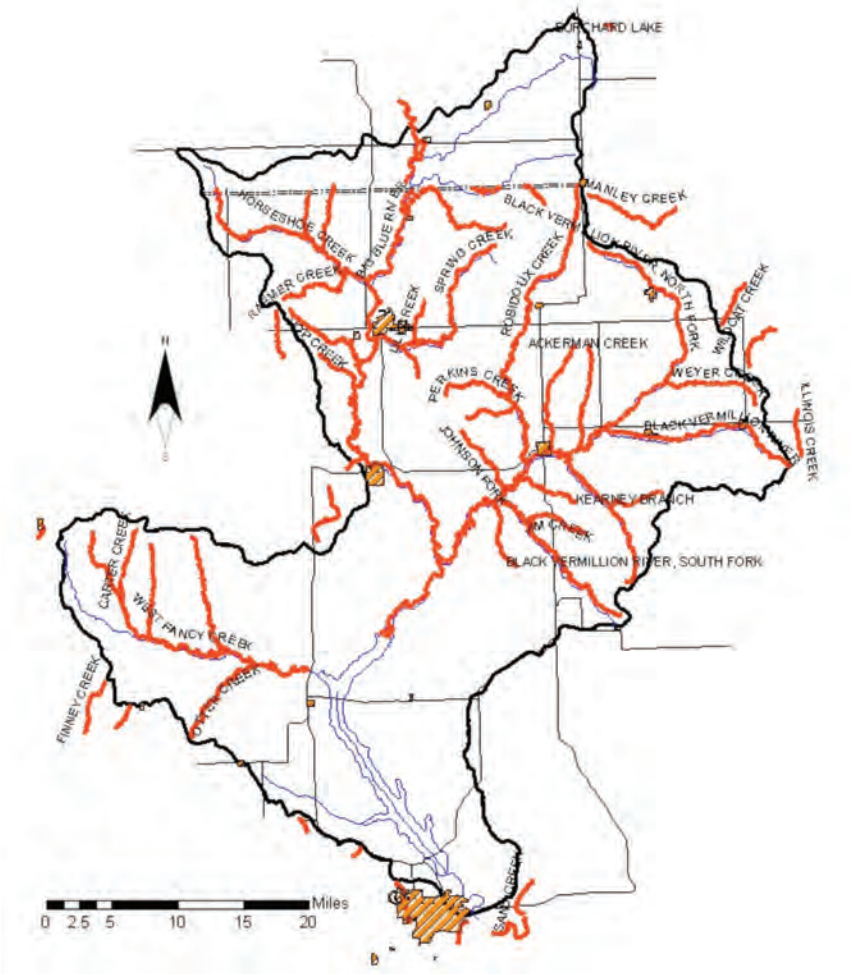

Figure 11. Impaired Waterbodies based on the 303d list – Lower Big Blue Watershed.

Table 2. The 303d List of Impaired Waterbodies

State	Waterbody Name	Impairment
KS	Ackerman Creek	Fecal Coliform
NE	Burchard Lake	Arsenic, Nutrients
NE	Big Blue River	Pesticides, Ammonia (Un-Ionized), Pathogens
KS	Big Blue River	Fecal Coliform
KS	Black Vermillion River	Fecal Coliform
KS	Black Vermillion River, Clear Fork	Fecal Coliform
KS	Carter Creek	Fecal Coliform
KS	De Shazer Creek	Fecal Coliform
KS	Deadman Creek	Fecal Coliform
KS	Dog Walk Creek	Fecal Coliform
KS	Dutch Creek	Fecal Coliform
KS	Fancy Creek, North Fork	Fecal Coliform

State	Waterbody Name	Impairment
KS	Fawn Creek	Fecal Coliform
KS	Finney Creek	Fecal Coliform
KS	Fisher Creek	Fecal Coliform
KS	Hop Creek	Fecal Coliform
KS	Horseshoe Creek	Fecal Coliform
KS	Illinois Creek	Selenium
KS	Indian Creek	Fecal Coliform
KS	Jim Creek	Fecal Coliform
KS	Johnson Fork	Fecal Coliform
KS	Kansas River	Chlorine, Sulfate, Fecal Coliform
KS	Kearney Branch	Fecal Coliform
KS	Kitten Creek	Fecal Coliform, Low Dissolved Oxygen
KS	Lily Creek	Fecal Coliform
KS	Lincoln Creek	Fecal Coliform
KS	Little Blue River	Fecal Coliform
KS	Little Kitten Creek	Fecal Coliform, Low Dissolved Oxygen
KS	Little Timber Creek	Fecal Coliform
KS	Manley Creek	Fecal Coliform
KS	Meadow Creek	Fecal Coliform
KS	Mission Creek	Fecal Coliform
KS	Murdock Creek	Fecal Coliform
KS	North Elm Creek	Fecal Coliform
KS	Otter Creek	Fecal Coliform
KS	Peel Creek	Fecal Coliform
KS	Perkins Creek	Fecal Coliform
KS	Raemer Creek	Fecal Coliform
KS	Robidoux Creek	Fecal Coliform
KS	Sand Creek	Fecal Coliform
KS	Schell Creek	Fecal Coliform
KS	Silver Creek	Fecal Coliform, Low Dissolved Oxygen
KS	Spring Creek	Fecal Coliform
KS	Walnut Creek	Fecal Coliform
KS	West Fancy Creek	Fecal Coliform
KS	Weyer Creek	Fecal Coliform
KS	Wildcat Creek	Fecal Coliform

6.2 Water Quality Observation Stations[11]

USEPA Observation-level water quality monitoring data is useful for identifying the location of water quality data in a given watershed.

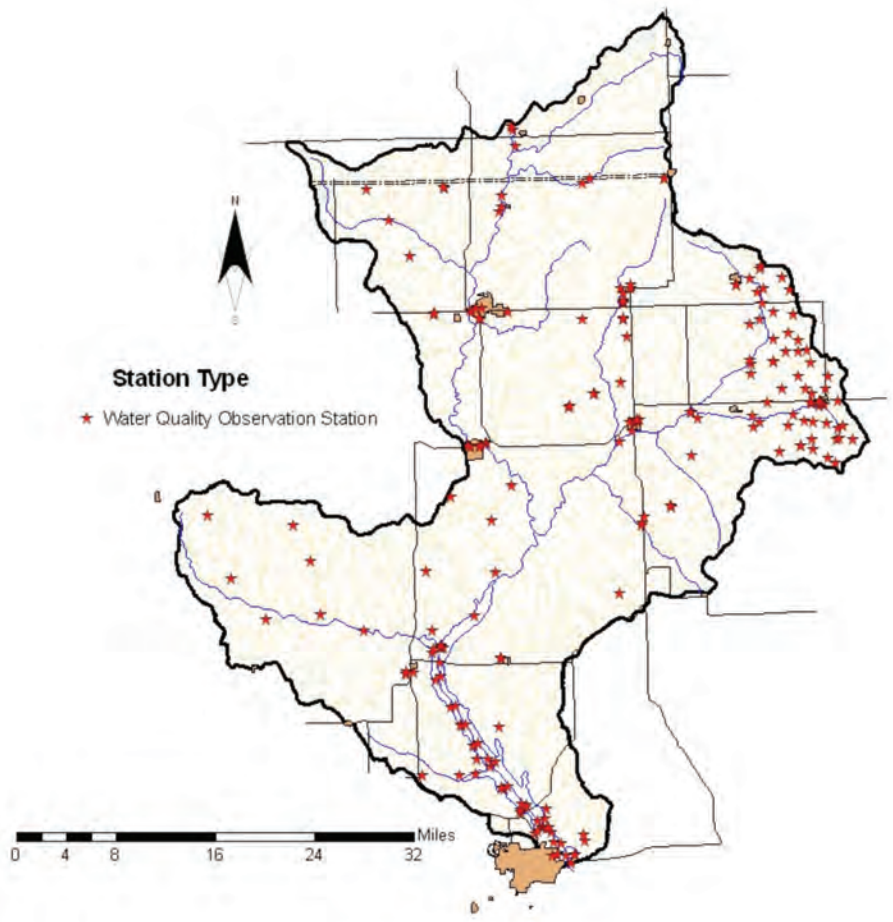

Figure 12. Lakes and Streams Water Quality Observation Stations – Lower Big Blue Watershed.

Table 3. Water Quality Observation Station

State	Agency	Station ID	Station Name
NE	USGS	06882000	Big Blue R At Barneston NE
KS	USGS	06882510	Big Blue R At Marysville, KS
KS	USGS	06885490	Black Vermillion R At Frankfort, KS
KS	USGS	06885500	Black Vermillion R Nr Frankfort, KS
KS	USGS	06887000	Big Blue R Nr Manhattan, KS
KS	KDHE	000233	Big Blue R. Near Oketo
KS	KDHE	000240	Big Blue River Near Blue Rapids
KS	KDHE	000261	Big Blue R. Bl Tuttle Cr. Res.
NE	NDEQ	300905	Big Blue River
KS	USGS	06882400	Big Blue R Nr Oketo, KS
KS	USGS	06884700	Big Blue R At Blue Rapids, KS
KS	USGS	06884900	Robidoux C At Beattie, KS
KS	USGS	06886000	Big Blue R At Randolph, KS
KS	USGS	06886500	Fancy C At Winkler, KS
KS	USGS	06886900	Tuttle C Lk Nr Manhattan, KS
KS	USGS	06887200	Cedar C Nr Manhattan, KS
KS	USGS	391136096314601	10S 08E 09CAD 01

State	Agency	Station ID	Station Name
KS	USGS	391209096312901	10S 08E 09ABA 01
KS	USGS	391209096321001	10S 08E 09BBB 01
KS	USGS	391209096332601	10S 08E 07AAA 01
KS	USGS	391215096312101	10S 08E 04DDC 01
KS	USGS	391215096312102	10S 08E 04DDC 02
KS	USGS	391216096325901	10S 08E 05CDC 01
KS	USGS	391301096323501	10S 08E 05ABA 01
KS	USGS	391308096331601	09S 08E 32CCC 01
KS	USGS	391311096302901	09S 08E 34DC 01
KS	USGS	391337096302901	09S 08E 34AC 01
KS	USGS	391347096332701	09S 08E 31AAD 01
KS	USGS	391347096345101	09S 08E 31BBD 01
KS	USGS	391354096343701	09S 08E 31BAB 01
KS	USGS	391407096335501	09S 08E 30DCA 01
KS	USGS	391413096334101	09S 08E 30DAC 01
KS	USGS	391440096343701	09S 08E 30BAC 01
KS	USGS	391446096335501	09S 08E 30ABA 01
KS	USGS	391529096361000	Tuttle Creek Reservoir, KS Site 1
KS	USGS	391539096354300	09S 07E 24ABB
KS	USGS	391547096353500	Tuttle Creek Reservoir, KS Site 2
KS	USGS	391551096360300	Tuttle Creek Reservoir, KS Site 25
KS	USGS	391659096373700	Tuttle Creek Reservoir, KS Site 3
KS	USGS	391703096374900	Tuttle Creek Reservoir, KS Site 21
KS	USGS	391704096374800	Tuttle Creek Reservoir, KS Site 22
KS	USGS	391708096371300	Tuttle Creek Reservoir, KS Site 4
KS	USGS	391800096413601	09S 07E 06BC 01
KS	USGS	391801096445301	09S 06E 03BD 01
KS	USGS	391803096400800	09S 07E 05ADB
KS	USGS	391833096384500	Tuttle Creek Reservoir, KS Site 5
KS	USGS	391851096382100	Tuttle Creek Reservoir, KS Site 6
KS	USGS	391902096385900	08S 07E 33AAC
KS	USGS	391908096400101	08S 07E 32AAA 01
KS	USGS	392003096401900	Tuttle Creek Reservoir, KS Site 23
KS	USGS	392005096400700	Tuttle Creek Reservoir, KS Site 7
KS	USGS	392012096394800	Tuttle Creek Reservoir, KS Site 8
KS	USGS	392119096375001	08S 07E 15DAB 01
KS	USGS	392127096411300	Tuttle Creek Reservoir, KS Site 9
KS	USGS	392132096412300	Tuttle Creek Reservoir, KS Site 24
KS	USGS	392135096405100	Tuttle Creek Reservoir, KS Site 10
KS	USGS	392248096421101	08S 06E 01DC 01
KS	USGS	392250096414200	08S 07E 06CCB
KS	USGS	392446096432700	Tuttle Creek Reservoir, KS Site 12
KS	USGS	392457096430200	Tuttle Creek Reservoir, KS Site 11
KS	USGS	392512096460701	07S 06E 28BA 01
KS	USGS	392512096460702	07S 06E 28BA 02
KS	USGS	392515096452701	07S 06E 28AAA 01
KS	USGS	392525096460701	07S 06E 21CDD 01

State	Agency	Station ID	Station Name
KS	USGS	392555096430900	Tuttle C Lake At Hwy K-16 Nr Randolph, KS
KS	USGS	392606096372701	07S 07E 23BBA 01
KS	USGS	392613096373601	07S 07E 14CCC 01
KS	USGS	392639096434500	Tuttle Creek Reservoir, KS Site 13
KS	USGS	392652096433600	Tuttle Creek Reservoir, KS Site 14
KS	USGS	392701096424500	Tuttle Creek Reservoir, KS Site 16
KS	USGS	392706096425500	07S 06E 12CCC
KS	USGS	392709096425400	Tuttle Creek Reservoir, KS Site 15
KS	USGS	392814096434501	07S 06E 02CA 01
KS	USGS	392913096394800	Tuttle Creek Reservoir, KS Site 17
KS	USGS	392918096584201	06S 04E 33ADD 01
KS	USGS	392934096534601	06S 05E 32BA 01
KS	USGS	393026096264201	06S 09E 29BBB 01
KS	USGS	393209096375301	06S 07E 15AA 01
KS	USGS	393214097014501	06S 04E 18BAB 01
KS	USGS	393222096440501	06S 06E 11CC 01
KS	USGS	393316096543501	06S 05E 06DC 01
KS	USGS	393514096242901	05S 09E 28DAA 01
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KS	USGS	393629096214401	05S 09E 24BA 01
KS	USGS	393632096214801	05S 09E 24BAB 01
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KS	USGS	393735096414401	05S 06E 12DD 01
KS	USGS	393814096360801	05S 07E 11AA 01
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KS	USGS	394026096095202	04S 11E 27DAA 02
KS	USGS	394046096051101	04S 12E 28BBC 01
KS	USGS	394046096063701	04S 12E 30AAC 01
KS	USGS	394052096085301	04S 11E 26AAB 01
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KS	USGS	394100096390001	04S 07E 21CDC 01
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KS	USGS	394104096385601	04S 07E 21CD 01
KS	USGS	394104096400301	04S 07E 20CD 01
KS	USGS	394132096062901	04S 12E 19ADA 01
KS	USGS	394145096060301	04S 12E 20BAB 01
KS	USGS	394151096105901	04S 11E 16DDD 01
KS	USGS	394151096140401	04S 11E 18CCD 01
KS	USGS	394158096072901	04S 12E 18CCB 01

State	Agency	Station ID	Station Name
KS	USGS	394204096084401	04S 11E 14DAD 01
KS	USGS	394209096092700	Centralia Lake, KS 04S 11E 14CAA
KS	USGS	394210096133001	04S 11E 18DBA 01
KS	USGS	394218096245402	04S 09E 16ACC 02
KS	USGS	394224096252001	04S 09E 16BCA 01
KS	USGS	394231096243702	04S 09E 16AAC 02
KS	USGS	394233096191001	04S 10E 17AB 01
KS	USGS	394236096102501	04S 11E 15BAA 01
KS	USGS	394236096141201	04S 11E 18BBB 01
KS	USGS	394237096242901	04S 09E 16AAA 01
KS	USGS	394237096243701	04S 09E 16AAB 01
KS	USGS	394237096243702	04S 09E 16AAB 02
KS	USGS	394259096194401	04S 10E 08CB 01
KS	USGS	394302096194801	04S 10E 08CBB 01
KS	USGS	394309096080201	04S 11E 12ACC 01
KS	USGS	394316096073704	04S 11E 12ADA 04
KS	USGS	394322096075401	04S 11E 12ABD 01
KS	USGS	394322096084401	04S 11E 11AAD 01
KS	USGS	394329096062001	04S 12E 08BBB 01
KS	USGS	394329096075401	04S 11E 12ABA 01
KS	USGS	394329096080201	04S 11E 12ABB 01
KS	USGS	394329096085301	04S 11E 11AAB 01
KS	USGS	394329096085303	04S 11E 11AAB 03
KS	USGS	394335096124801	04S 11E 05CDC 01
KS	USGS	394336096304601	04S 08E 03CDC 01
KS	USGS	394339096304201	04S 08E 03CD 01
KS	USGS	394401096084401	04S 11E 02ADD 01
KS	USGS	394421096072901	04S 12E 06BBB 01
KS	USGS	394427096091801	03S 11E 35CDD 01
KS	USGS	394427096112401	03S 11E 33DCC 01
KS	USGS	394428096282501	03S 08E 36CDD 01
KS	USGS	394431096282901	03S 08E 36CD 01
KS	USGS	394513096071101	03S 12E 31BAB 01
KS	USGS	394513096260203	03S 09E 32ABB 03
KS	USGS	394519096095101	03S 11E 27DDD 01
KS	USGS	394532096141201	03S 11E 30CBC 01
KS	USGS	394612096084401	03S 11E 23DDD 01
KS	USGS	394618096141201	03S 11E 19CCB 01
KS	USGS	394625096120601	03S 11E 20DAD 01
KS	USGS	394625096120602	03S 11E 20DAD 02
KS	USGS	394631096141201	03S 11E 19CBB 01
KS	USGS	394704096090101	03S 11E 14DCD 01
KS	USGS	394704096095101	03S 11E 15DDD 01
KS	USGS	394704096105801	03S 11E 16DDD 01
KS	USGS	394749096095101	03S 11E 15AAA 01
KS	USGS	394756096120601	03S 11E 08DDD 01
KS	USGS	394822096104201	03S 11E 10BCD 01

State	Agency	Station ID	Station Name
KS	USGS	394826096252301	03S 09E 09BC 01
KS	USGS	394901096141201	03S 11E 06CBC 01
KS	USGS	394921096131301	03S 11E 06ADA 01
KS	USGS	394940096100801	02S 11E 34DCD 01
KS	USGS	394941096253601	02S 09E 32DDD 01
KS	USGS	394944096254001	02S 09E 32DD 01
KS	USGS	394944096291801	02S 08E 35DC 01
KS	USGS	394953096115701	02S 11E 33CBC 01
KS	USGS	394958096383801	02S 07E 33DB 01
KS	USGS	395001096384301	02S 07E 33DBB 01
KS	USGS	395024096360801	02S 07E 35AA 01
KS	USGS	395024096425101	02S 06E 35AA 01
KS	USGS	395027096392401	02S 07E 32AAA 01
KS	USGS	395027096424701	02S 06E 35AAA 01
KS	USGS	395032096125601	02S 11E 29CCD 01
KS	USGS	395044096383001	02S 07E 28D 01
KS	USGS	395044096390301	02S 07E 28C 01
KS	USGS	395046096253601	02S 09E 29DAD 01
KS	USGS	395052096253601	02S 09E 29DAA 01
KS	USGS	395059096253601	02S 09E 29ADD 01
KS	USGS	395118096132101	02S 11E 30AAB 01
KS	USGS	395125096102401	02S 11E 22CDD 01
KS	USGS	395131096124701	02S 11E 20CDB 01
KS	USGS	395131096253601	02S 09E 20DDA 01
KS	USGS	395151096245401	02S 09E 21ACC 01
KS	USGS	395154096151501	02S 10E 24BC 01
KS	USGS	395154096151502	02S 10E 24BC 02
KS	USGS	395204096245401	02S 09E 21ABC 01
KS	USGS	395217096110601	02S 11E 16DDC 01
KS	USGS	395217096140301	02S 11E 18CCD 01
KS	USGS	395256096130401	02S 11E 17BBC 01
KS	USGS	395309096125601	02S 11E 08CCD 01
KS	USGS	395432096445201	02S 06E 03BC 01
KS	USGS	395702096464301	01S 06E 20 01
KS	USGS	395747096362501	01S 07E 14DB 01
KS	USGS	395915096413601	01S 06E 01DDD 01
KS	USGS	395918096290001	01S 08E 02DD 01
KS	USGS	395918096414101	01S 06E 01DD 01
KS	USGS	395918096484001	01S 05E 01DC 01
KS	USGS	395927096213401	01S 09E 01DBC 01
KS	USGS	395930096213001	01S 09E 01DB 01
KS	USGS	395937096281801	01S 08E 01DBB 01
NE	USGS	400325096351701	1N 7E13BACC1
NE	USGS	400325096351702	1N 7E13BACC2

6.3. USGS Gage Stations[12]

USGS inventory of surface water gaging station data including 7Q10 low and monthly mean stream flow.

Figure 13. USGS Gage Stations – Lower Big Blue Watershed.

Table 4. USGS Gage Station[12]

Gage ID	Stream Flow (cfs)												
	Mean	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
USGS06882000	792.57	37.71	289.31	584.93	1426.98	752.77	1064.43	2017.29	1041.23	633.88	694.83	536.96	244.89
USGS06882050	-	-	-	-	-	-	-	-	-	-	-	-	-
USGS06882500	455.16	20.61	172.04	381.13	409.34	375.03	726.84	1124.85	571.15	475.03	392.69	346.77	252.45
USGS06884900	-	-	-	-	-	-	-	-	-	-	-	-	-
USNWS14-5063-3	-	-	-	-	-	-	-	-	-	-	-	-	-
USGS06885000	2.45	0.00	0.02	2.48	3.80	0.75	2.62	1.59	10.77	0.57	4.62	0.05	0.02
USNWS470918N	-	-	-	-	-	-	-	-	-	-	-	-	-
USGS06885500	143.72	0.11	60.79	145.15	252.39	130.63	235.01	272.71	137.57	57.08	193.07	137.22	58.81
USGS06886500	46.35	0.00	21.53	42.48	41.34	34.07	108.04	112.25	49.95	25.96	52.20	36.70	14.30
USGS06886000	1696.1	114.84	610.06	1123.50	1718.99	1707.38	2486.97	4630.84	2502.25	1620.58	1602.81	1091.08	672.30
USGS06887200	-	-	-	-	-	-	-	-	-	-	-	-	-
USGS06886900	-	-	-	-	-	-	-	-	-	-	-	-	-
USCE171-3	-	-	-	-	-	-	-	-	-	-	-	-	-
USGS06887000	2126.2	26.07	782.21	1309.85	2650.70	2995.21	2886.38	4044.75	3382.75	1531.02	1776.23	1509.16	1603.39
USGS06882510	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 5. Estimated peak-streamflow frequencies for selected gaging stations with at least 10 years of annual peak-discharge data for unregulated, rural streams in Kansas[13]

USGS ID	Station Name	Drainage Area (mi^2)	2-year ft^3/s	5-year ft^3/s	10-year ft^3/s	25-year ft^3/s	50-year ft^3/s	100-year ft^3/s	200-year ft^3/s
06884900	Robidoux Creek at Beattie	40.0	1850	3930	5780	8700	11300	14300	17600
06885500	Black Vermillion River near Frankfort	410	7030	15700	24100	38000	51200	66900	85700
06886500	Fancy Creek at Winkler	174	5690	10600	14600	20500	25400	30700	36500
06886000	Big Blue River at Randolph	9100	23600	40700	54500	74700	91900	111000	132000
06887200	Cedar Creek near Manhattan	13.4	1530	3560	5470	8560	11400	14600	18400
06882510	Big Blue River at Marysville	4780	19100	32800	42900	56700	67500	78800	90500

Table 6. USGS gaging stations period of record for Lower Big Blue[12]

USGS ID	Drainage Area (mi^2)	Period of record	
		Begin	End
06887000	9640	09/30/50	present
06885500	410	10/01/53	present
06882510	4777	07/25/85	Present
06885000	18	08/19/54	09/30/58
06882500	4540	08/23/19	09/30/40
06886000	9100	04/17/18	09/30/60
06886500	174	12/01/53	09/30/71

6.4 Permitted Point Source Facilities[14]

NPDES permit-holding facility information; contains parameter-specific loadings to surface waters computed using the EPA Effluent Decision Support System (EDSS) for 1990-1999. The summary of discharge concentrations and loads allows the user to perform a planning-level assessment of the magnitude and severity of point source contributions. Analyzing the data for different years can provide information to evaluate changes in contributions from various point sources over time and support trend analysis.

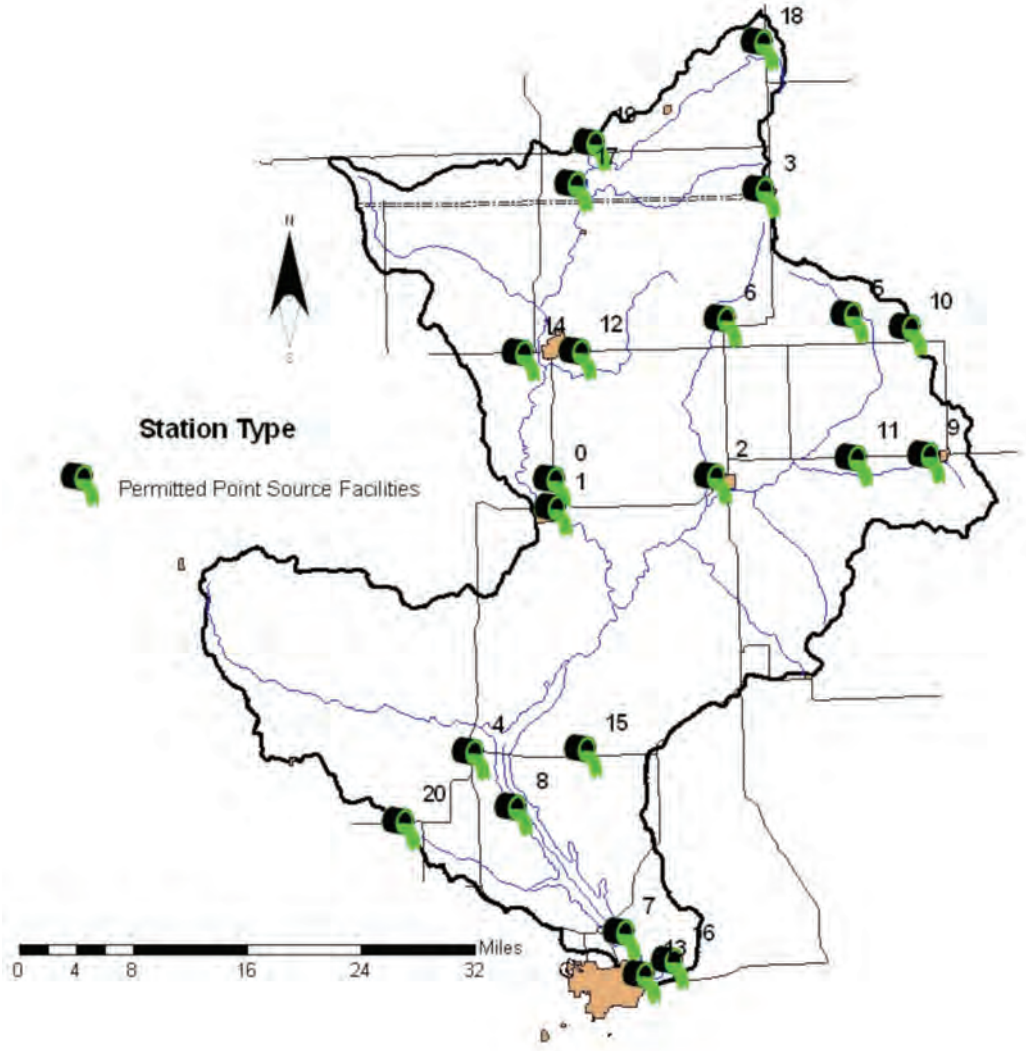

Figure 14. NPDES permit-holding facilities – Lower Big Blue Watershed.

Table 7. Permitted Point Source Facilities[14]

ID	NPDES	Facility Name	Ownership	Description	Industrial Classification	City	County	Flow Rate (million gallons/day)
0	KS0002135	Ga-Pacific Corp Blue Rapids	Private	Gypsum Products	Not On El	Blue Rapids	Marshall	0.00000
1	KS0024775	Blue Rapids City Of Stp	Public	Sewerage Systems	Municipal	Blue Rapids	Marshall	0.16000
2	KS0024881	City Frankfort W Stab Lagoon	Public	Sewerage Systems	Municipal	Frankfort	Marshall	0.24000
3	KS0025500	Summerfield City Of Stp	Public	Sewerage Systems	Municipal	Summerfield	Marshall	0.00000
4	KS0031721	Randolph City Of Wwtf	Public	Sewerage Systems	Municipal	Randolph	Riley	0.02000
5	KS0047228	Axtell City Of Stp	Public	Sewerage Systems	Municipal	Axtell	Marshall	0.00000
6	KS0047236	Beattie, City Of Wwt Fac	Public	Sewerage Systems	Municipal	Beattie	Marshall	0.00000
7	KS0079201	Rocky Ford Trailer Court	Private	Oper Of Res Mobile Home Sites	Not On El	Manhattan	Riley	0.00000
8	KS0079243	University Park Wwtp	Public	Sewerage Systems	Municipal	Manhattan	Riley	0.00000
9	KS0081418	Centralia City Of Wwtp	Public	Sewerage Systems	Municipal	Centralia	Nemaha	0.00000
10	KS0081442	Baileyville Impr. Dist. #1 Wwt	Public	Sewerage Systems	Municipal	Baileyville	Nemaha	1.30000
11	KS0085529	Vermillion Wwt Facility	Public	Sewerage Systems	Municipal	Vermillion	Marshall	0.00000
12	KS0091022	Super 8 Motel	Pub Pri			Marysville	Marshall	0.00000
13	KS0091286	Mccall Pattern Company	Pub Pri			Manhattan	Riley	0.00000
14	KS0092142	Marysville - Proposed	Pub Pri			Marysville	Marshall	0.00000
15	KS0093297	Olsburg	Pub Pri			Olsburg	Pottawatomie	0.00000
16	KS0119580	Timber Creek Development	Pub Pri	Contractors-Single Family Hous	Not On El	Manhattan	Riley	0.00000
17	NE0105830	Brownawell Terry	Private	Beef Cattle Feedlots	On Elg	Wymore	Gage	0.00000
18	NE0113638	Burchard Wwtf	Public	Sewerage Systems	Municipal	Burchard	Pawnee	0.01600
19	NE0121711	Barneston Wwtf	Public	Sewerage Systems	Municipal	Barneston	Gage	0.00000
20	KS0025631	Leonardville City Of		Gypsum Products	Not On El	Blue Rapids	Marshall	0.00000
21	KS0080365	Winifred Feedlots	Private	Sewerage Systems	Municipal	Blue Rapids	Marshall	0.00000
22	NE0129500	Diller Wwtf		Sewerage Systems	Municipal	Frankfort	Marshall	0.00000

6.5 Confined Animal Feeding Operations (CAFOs)[15]

Animal feeding operations classified as large or presenting a high risk to discharge can be classified as CAFOs and are likely required to have an NPDES permit. This map shows the locations and permit numbers for these sites in the Lower Big Blue watershed.

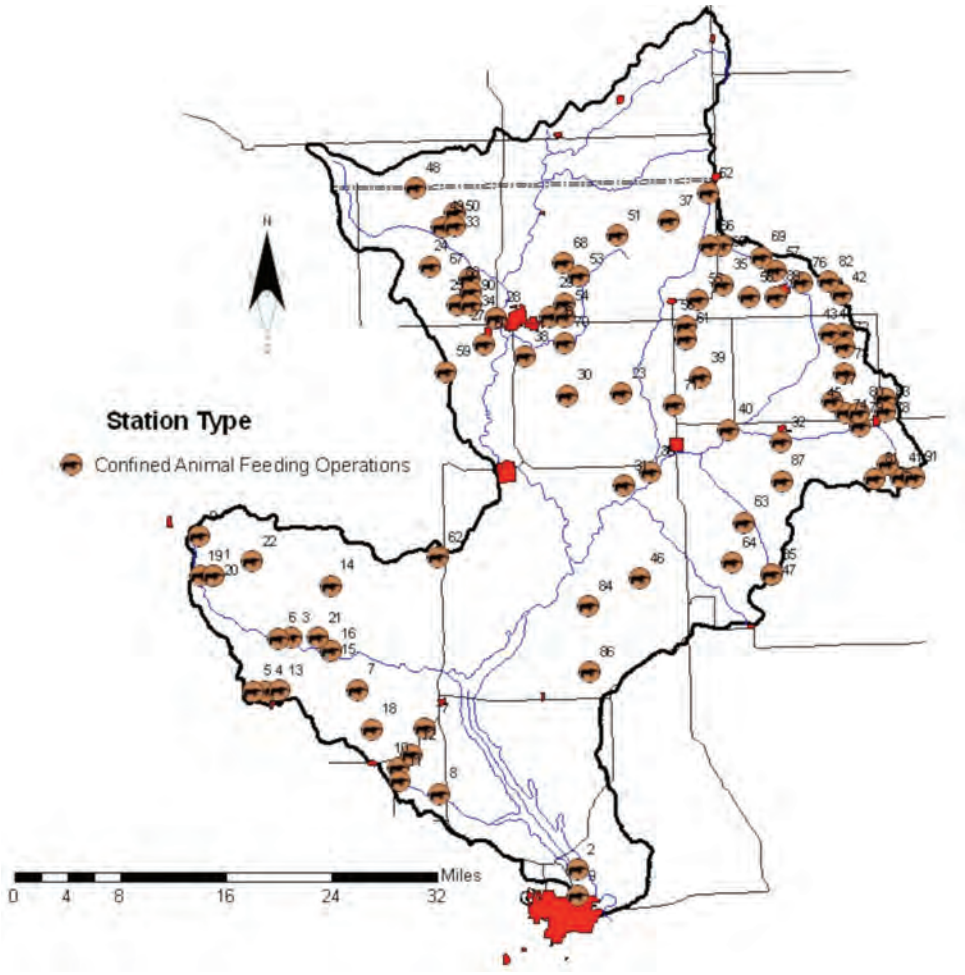

Figure 15. Confined Animal Feeding Operations facilities – Lower Big Blue Watershed.

Table 8. Confined Animal Feeding Operations[15]

ID	Permit No.	Total Head	Animal Unit System	Animal Type
0	A-BBWS-D001	720	1008	Dairy
1	A-BBWS-C001	4999	4999	Beef
2	A-BBRL-B003	750	750	Beef
3	A-BBCY-BA03	250	250	Beef
4	A-BBCY-BA02	200	200	Beef
5	A-BBCY-BA01	200	200	Beef
6	A-BBCY-BA04	250	250	Beef
7	A-BBRL-MA05	35	49	Dairy
8	A-BBRL-MA03	80	112	Dairy
9	A-BBRL-BA02	225	225	Beef
10	A-BBRL-MA01	37	52	Dairy
11	A-BBRL-BA01	320	320	Beef
12	A-BBRL-MA04	60	84	Dairy
13	A-BBCY-S001	450	180	Swine, Truckwash
14	A-BBRL-B001	900	900	Beef
15	A-BBRL-B002	900	900	Beef
16	A-BBRL-S001	1700	320	Swine
17	A-BBRL-S015	800	320	Swine
18	A-BBRL-S011	525	120	Swine
19	A-BBWS-S039	2400	960	Swine
20	A-BBWS-B012	870	570	Swine, Beef
21	A-BBRL-S012	2500	700	Swine
22	A-BBWS-B004	900	900	Beef
23	A-BBMS-C001	2950	2900	Beef, Kennel
24	A-BBMS-SA01	280	112	Swine
25	A-BBMS-SA14	550	175	Swine
26	A-BBMS-BA05	120	120	Beef
27	A-BBMS-BA04	185	185	Beef
28	A-BBMS-KA01	65	0	Kennel
29	A-BBMS-BA03	300	225	Beef
30	A-BBMS-M018	50	70	Dairy
31	A-BBMS-MA06	40	56	Dairy
32	A-BBMS-SA13	500	200	Swine
33	A-BBMS-M019	200	211	Dairy
34	A-BBMS-BA01	500	500	Beef
35	A-BBMS-MA08	45	63	Dairy
36	A-BBMS-SA12	800	320	Swine
37	A-BBMS-MA09	50	70	Dairy
38	A-BBMS-SA05	120	48	Swine
39	A-BBMS-SA11	300	120	Swine
40	A-BBMS-MA10	50	70	Dairy
41	A-KSNM-MA07	40	56	Dairy
42	A-BBNM-BA02	140	100	Dairy
43	A-BBNM-BA01	525	288	Beef
44	A-BBNM-BA03	450	225	Beef

ID	Permit No.	Total Head	Animal Unit System	Animal Type
45	A-BBNM-MA11	50	70	Dairy
46	A-BBPT-MA01	100	140	Dairy
47	A-KSPT-MA03	35	49	Dairy
48	A-BBMS-S025	575	275	Swine, Beef
49	A-BBMS-S005	550	160	Swine
50	A-BBMS-S036	1882	417	Swine
51	A-BBMS-B005	500	350	Beef
52	A-BBMS-S002	1000	510	Swine, Beef
53	A-BBMS-S001	850	340	Swine
54	A-BBMS-S050	770	233	Swine
55	A-BBMS-M016	112	140	Dairy
56	A-BBMS-S029	850	375	Swine, Beef
57	A-BBMS-S043	680	212	Swine
58	A-BBMS-S051	610	294	Beef,Swine
59	A-BBMS-S006	1450	865	Swine, Beef
60	A-BBMS-S023	2053	593	Swine
61	A-BBMS-S030	1495	466	Swine
62	A-BBMS-S012	616	162	Swine
63	A-BBMS-B002	496	296	Beef
64	A-BBMS-S039	2000	800	Swine
65	A-BBMS-S049	1340	320	Swine, Beef
66	A-BBMS-S040	3280	991	Swine
67	A-BBMS-S047	1860	585	Swine, Beef
68	A-BBMS-K001	410	0	Kennel
69	A-BBMS-S027	510	215	Swine, Beef
70	A-BBMS-S020	1100	290	Swine
71	A-BBMS-S038	1254	340	Swine
72	A-BBNM-M009	140	148	Dairy
73	A-BBNM-M012	281	153	Dairy, Swine
74	A-BBNM-S011	900	360	Swine
75	A-BBNM-M001	125	175	Dairy
76	A-BBNM-S003	641	208	Swine
77	A-BBNM-S002	922	216	Swine
78	A-BBNM-S006	1890	408	Swine
79	A-BBNM-S007	1450	605	Swine, Beef
80	A-BBNM-B001	990	495	Beef
81	A-BBNM-M003	140	147	Dairy
82	A-BBNM-M010	242	250	Dairy
83	A-BBNM-S045	1700	680	Swine
84	A-BBPT-M003	50	70	Dairy
85	A-BBPT-S007	1180	223	Swine
86	A-BBPT-S005	975	270	Swine
87	A-BBMS-S041	500	80	Swine
88	A-BBMS-S045	500	200	Swine
89	A-BBMS-M014	274	299	Dairy
90	A-BBMS-S044	450	180	Swine
91	A-BBNM-S001	480	192	Swine

6.6 1990 Population and Sewerage by Census Tract[16]

The 1990 Population and Sewerage by Census Tract can be used to examine specific areas for population density and the prevalence of septic systems, which can be significant sources of pathogens, household chemicals, and nutrients (especially nitrate) escaping into groundwater and nearby receiving water bodies.

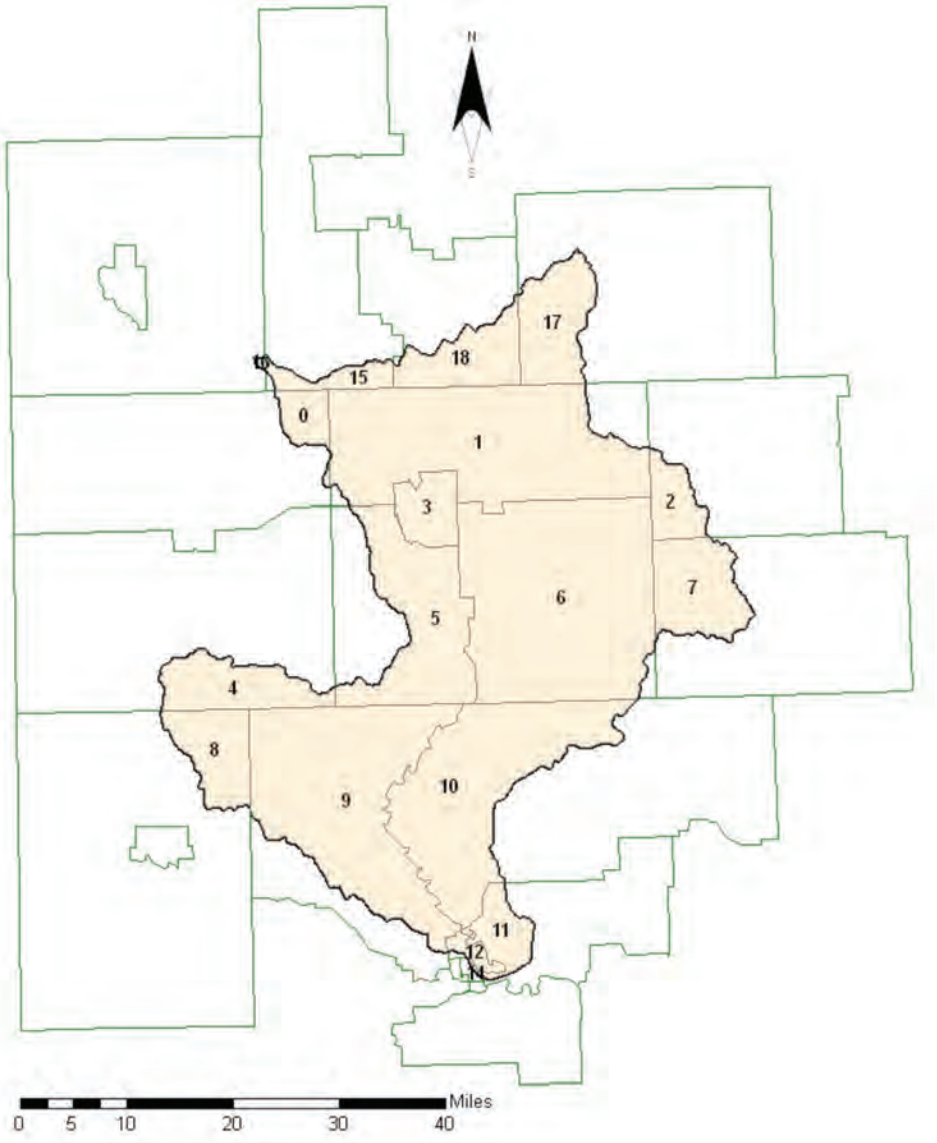

Figure 16. Population and Sewerage by Census – Lower Big Blue Watershed.

Table 9. 1990 Population and Sewerage by Census Tract[16]

ID	Tract	Population	House Units	Sewerage Public	Sewerage Septic	Sewerage Other
0	9786	3944	1876	1290	490	96
1	9791	2905	1176	462	669	45
2	9802	4574	1846	1179	594	73
3	9792	4045	1891	1611	260	20
4	9787	3129	1479	813	634	32
5	9793	2547	1191	839	330	22
6	9794	2208	1011	537	397	77
7	9803	2671	1160	567	552	41
8	9581	4271	1831	711	1099	21
9	0001	6191	2758	1437	1257	64
10	0004	3816	1706	769	848	89
11	0001	4589	1882	582	1244	56
12	0002	6705	2588	2237	329	22
13	0004	4444	705	690	0	15
14	0005	4583	1996	1988	8	0
15	9947	3654	1420	600	739	81
16	9936	4065	1688	724	897	67
17	9978	3317	1674	973	648	53
18	9952	3193	1475	1012	421	42

7.0. Agricultural Economy

7.1 Corn Cost-Return Budget[17]

Table 10. Cost-return projections for corn crops in the Lower Big Blue Watershed, 2006.

Corn	Yield Level (bu)		
	88	**110**	**133**
Income Per Acre			
A. Yield per acre	88	110	133
B. Price per bushel	$2.73	$2.73	$2.73
C. Net government payment	$12.51	$13.60	$14.69
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$252.75	$313.90	$377.78
Costs Per Acre			
1. Seed	$51.57	$51.57	$51.57
2. Herbicide	30.80	30.80	30.80
3. Insecticide/Fungicide	0.27	0.27	0.27
4. Fertilizer and Lime	35.36	44.82	54.80
5. Crop Consulting			
6. Crop Insurance			
7. Drying	11.44	14.30	17.29
8. Miscellaneous	8.25	8.25	8.25
9. Custom Hire / Machinery Expense	65.27	71.63	78.28
10. Non-machinery Labor	7.38	8.09	8.85
11. Irrigation			
12. Land Charge/Rent	48.80	61.00	73.20
G. Sub Total	$258.86	$290.46	$323.04
13. Interest on ½ Nonland Costs	8.94	9.68	10.46
H. Total Costs	$267.80	$300.15	$333.50
I. Returns Over Costs (F-H)	**-$15.05**	**$13.75**	**$44.28**
J. Total Costs/bushel (H/A)	$3.04	$2.73	$2.51
K. Return To Annual Cost (I+13)/G	-2.36%	8.07%	16.95%

7.2 Soybean Cost-Return Budget[17]

Table 11. Cost-return projections for soybean crops in the Lower Big Blue Watershed, 2006.

Soybeans	Yield Level (bu)		
	26	33	40
Income Per Acre			
A. Yield per acre	26	33	40
B. Price per bushel	$5.92	$5.92	$5.92
C. Net government payment	$12.51	$13.60	$14.69
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$166.43	$208.96	$251.49
Costs Per Acre			
1. Seed	$36.30	$36.30	$36.30
2. Herbicide	10.34	10.34	10.34
3. Insecticide/Fungicide			
4. Fertilizer and Lime	10.96	12.51	14.07
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	8.25	8.25	8.25
9. Custom Hire / Machinery Expense	47.98	50.06	52.13
10. Non-machinery Labor	5.42	5.66	5.89
11. Irrigation			
12. Land Charge / Rent	48.80	61.00	73.20
G. Sub Total	$168.04	$184.11	$200.18
13. Interest on ½ Nonland Costs	5.37	5.54	5.71
H. Total Costs	$173.41	$189.65	$205.89
I. Returns Over Costs (F-H)	**-$6.98**	**$19.31**	**$45.59**
J. Total Costs/bushel (H/A)	$6.67	$5.75	$5.15
K. Return To Annual Cost (I+13)/G	-0.96%	13.50%	25.63%

7.3 Wheat Cost-Return Budget[17]

Table 12. Cost-return projections for wheat crops in the Lower Big Blue-Watershed, 2006.

Wheat	Yield Level (bu)		
	40	50	60
Income Per Acre			
A. Yield per acre	40	50	60
B. Price per bushel	$4.65	$4.65	$4.65
C. Net government payment	$12.51	$13.60	$14.69
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$198.51	$246.10	$293.69
Costs Per Acre			
1. Seed	$9.90	$13.20	$13.20
2. Herbicide	1.68	5.09	5.09
3. Insecticide/Fungicide			
4. Fertilizer and Lime	35.41	43.32	50.61
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	8.25	8.25	8.25
9. Custom Hire / Machinery Expense	45.83	48.84	56.43
10. Non-machinery Labor	5.18	5.52	6.38
11. Irrigation			
12. Land Charge / Rent	48.80	61.00	73.20
G. Sub Total	$155.04	$185.21	$219.45
13. Interest on ½ Nonland Costs	4.78	5.59	6.30
H. Total Costs	$159.83	$190.80	$219.45
I. Returns Over Costs (F-H)	**$38.69**	**$55.30**	**$74.24**
J. Total Costs/bushel (H/A)	$4.00	$3.82	$3.66
K. Return To Annual Cost (I+13)/G	28.04%	32.88%	37.78%

7.4 Grain Sorghum Cost-Return Budget[17]

Table 13. Cost-return projections for grain sorghum crops in the Lower Big Blue Watershed, 2006.

Grain Sorghum	Yield Level (bu)		
	61	76	90
Income Per Acre			
A. Yield per acre	61	76	90
B. Price per bushel	$2.79	$2.79	$2.79
C. Net government payment	$12.51	$13.60	$14.69
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$182.70	$225.64	$265.79
Costs Per Acre			
1. Seed	$12.74	$12.74	$12.74
2. Herbicide	27.41	27.41	27.41
3. Insecticide/Fungicide			
4. Fertilizer and Lime	23.27	30.01	35.96
5. Crop Consulting			
6. Crop Insurance			
7. Drying	7.93	9.88	11.70
8. Miscellaneous	8.25	8.25	8.25
9. Custom Hire / Machinery Expense	58.31	62.84	67.07
10. Non-machinery Labor	6.59	7.10	7.58
11. Irrigation			
12. Land Charge / Rent	48.80	61.00	73.20
G. Sub Total	$193.30	$219.24	$243.91
13. Interest on ½ Nonland Costs	6.15	6.68	7.16
H. Total Costs	$199.45	$225.91	$251.07
I. Returns Over Costs (F-H)	**-$16.74**	**-$0.27**	**$14.72**
J. Total Costs/bushel (H/A)	$3.27	$2.97	$2.79
K. Return To Annual Cost (I+13)/G	-5.48%	2.92%	8.97%

7.5 Alfalfa Cost-Return Budget[17]

Table 14. Cost-return projections for alfalfa crops in the Lower Big Blue Watershed, 2006.

Alfalfa	Yield Level (ton)		
	3.0	**3.5**	**4.0**
Income Per Acre			
A. Yield per acre	3.0	3.5	4.0
B. Price per bushel	$101.00	$101.00	$101.00
C. Net government payment	$12.30	$13.37	$14.44
D. Indemnity payments			
E. Miscellaneous income			
F. Returns/acre ((AxB)+C+D+E)	$315.30	$366.87	$418.44
Costs Per Acre			
1. Seed	$10.17	$10.17	$10.17
2. Herbicide	2.51	2.51	2.51
3. Insecticide/Fungicide	7.08	7.08	7.08
4. Fertilizer and Lime	19.90	26.89	33.88
5. Crop Consulting			
6. Crop Insurance			
7. Drying			
8. Miscellaneous	6.38	6.38	6.38
9. Custom Hire / Machinery Expense	109.42	118.08	126.61
10. Non-machinery Labor	12.36	13.34	14.31
11. Irrigation			
12. Land Charge / Rent	31.60	39.50	47.40
G. Sub Total	$199.43	$223.96	$248.34
13. Interest on ½ Nonland Costs	7.55	8.30	9.04
H. Total Costs	$206.98	$232.26	$257.38
I. Returns Over Costs (F-H)	**$108.32**	**$134.61**	**$161.06**
J. Total Costs/bushel (H/A)	$68.99	$66.36	$64.35
K. Return To Annual Cost (I+13)/G	58.10%	63.81%	68.50%

7.6 Common Cropland BMPs in Lower Big Blue Watershed

BMPs help reduce the amount of soil and nutrients that run off of cropland fields. Keeping these valuable inputs (soil and nutrients) in the field can be of benefit to both the landowner/producer and to society as a whole. Here are just a couple of the benefits:

1. Top soil savings can result in higher yields and lower fertilizer costs.
2. Certain BMPs can offer both water quality protection and wildlife habitat.

Below are some of the more popular BMPs in use throughout the state of Kansas and in the Lower Big Blue Watershed.

Contour farming[24] is farming the land, tillage and planting of the crop, on the level around the hill. By doing this, each furrow or ridge left by the different implements acts as a miniature dam, trapping water, allowing more to soak into the ground. Each row of crop also slows the water. Combined, less water runs off. Soil is erosion reduced. Crop yields are increased in arid areas.

Grassed waterways[25] are used as outlets to prevent silt and gully formation. The vegetation cover slows the water flow and minimizes channel surface erosion. They can also be used as outlets for water from terraces.

Vegetative buffers[25] are areas of land that are maintained in permanent vegetation to help reduce nutrient and sediment loss from agricultural fields, improve runoff water quality, and provide habitat for wildlife. Because of these societal benefits, there are several federal and state programs that encourage the installation and maintenance of vegetative buffers.

No-till[25] is a form of conservation tillage in which chemicals are used in place of tillage for weed control and seedbed preparation. In other words, the soil surface is never disturbed except for planting or drilling operations in a 100 percent no-till system. Two other forms of tillage, **reduced tillage** and **rotational no-till**, involve a light to moderate use of tillage equipment. These forms of tillage also control erosion and nutrient runoff, but are not as effective as 100 percent no-till.

Terraces[25] are embankments constructed perpendicular to the slope of the field and are designed to reduce the length of a field slope and catch water flowing off the slope. Terraces reduce the rate of runoff and allow soil particles to settle out.

7.7 Economic Contributions of Recreation at Tuttle Creek Lake[26, 27, 28, 29, 30, 31, 32, 33]

This study estimated the regional economic effects arising from recreation at Tuttle Creek Lake (Figure 17). This analysis can help local Watershed Restoration & Protection Strategies leaders and others appreciate the value of preserving recreational amenities at Tuttle Creek Lake.

Tuttle Creek Lake is a 12,617 acre impoundment located in northeastern Kansas at the lower end of the Big Blue River. The watershed supplying the lake is largely agricultural and consists of 9,628 square miles. The majority of the watershed extends north into Nebraska with the lower quarter located in Kansas. Tuttle Creek Lake was built in 1963 by the U.S. Army Corps of Engineers (COE) for flood control, irrigation, water supply, recreation, fish and wildlife, low-flow augmentation, and navigation-flow supplementation for Missouri River barge traffic.

This analysis estimated two types of regional recreation effects associated with Tuttle Creek Lake. The first type includes the economic impact to the region arising from direct recreation expenditures in the area and the associated indirect effects which occur as the money "ripples" throughout the region. This impact is modeled using an economic accounting system that charts the financial connections between businesses, governments and households in the region.

In 2007, the Army COE reported 454,996 visits to Tuttle Creek Lake for a total of 1,781,549 visitor-hours from 10/2006 to 9/2007. Using this data (together with visitor-type and expenditure profiles shown in Tables 15 and 16 and Figure 18) and accounting for imported purchases, it was estimated that visitor expenditures generated $3.74 million (2007$) in direct economic activity (sales) within the regional economy, $1.74 million in all types of income associated with the production of economic activities, and 82 area full- and part-time jobs. After calculating the indirect economic impacts, it was estimated that visitor expenditures were closely associated with $5.18 million (2007$) in overall economic activity, $2.53 million in total income, and 97 jobs in the region. The total economic contributions to the local region are displayed in Table 17.

Not all of the economic effects of recreation are captured by observable market transactions. A second type of economic effect considered here includes certain non-market benefits derived through the self-reported value of participation in recreation activities. This notion acknowledges the value of benefit an individual experiences through participation in an activity exceeds what it actually costs, thereby motivating participation. These benefits are estimated through a process known as non-market valuation. Through surveys, economists have developed general estimates of what people report being willing to pay over and above what they actually are required to spend. This net willingness-to-pay value represents the additional incremental value of benefits afforded to the recreation participant. Net willingness-to-pay has been acknowledged by a U.S. governmental interagency committee as an appropriate measure of the economic benefits associated with outdoor recreation programs. Accepting the legitimacy of purported and generalized willingness-to-pay values and applying them to Tuttle Creek Lake recreation, it was estimated that Tuttle Creek Lake visitors receive up to $4.46 million (2007$) in additional non-market recreation benefits annually. The values by recreation activity are reported in Table 18.

On average, the annual visitation rates for Tuttle Creek Lake has declined slightly from 1996-2007 (Figure 19). Among the 17 Army COE Lakes in Kansas, Tuttle Creek Lake ranked 6th in number of visits and 11th in terms of visitor-hours in 2007. A graphical comparison of visits and visitor-hours for all 17 Army COE reservoirs in Kansas can be found in Figures 20 and 21.

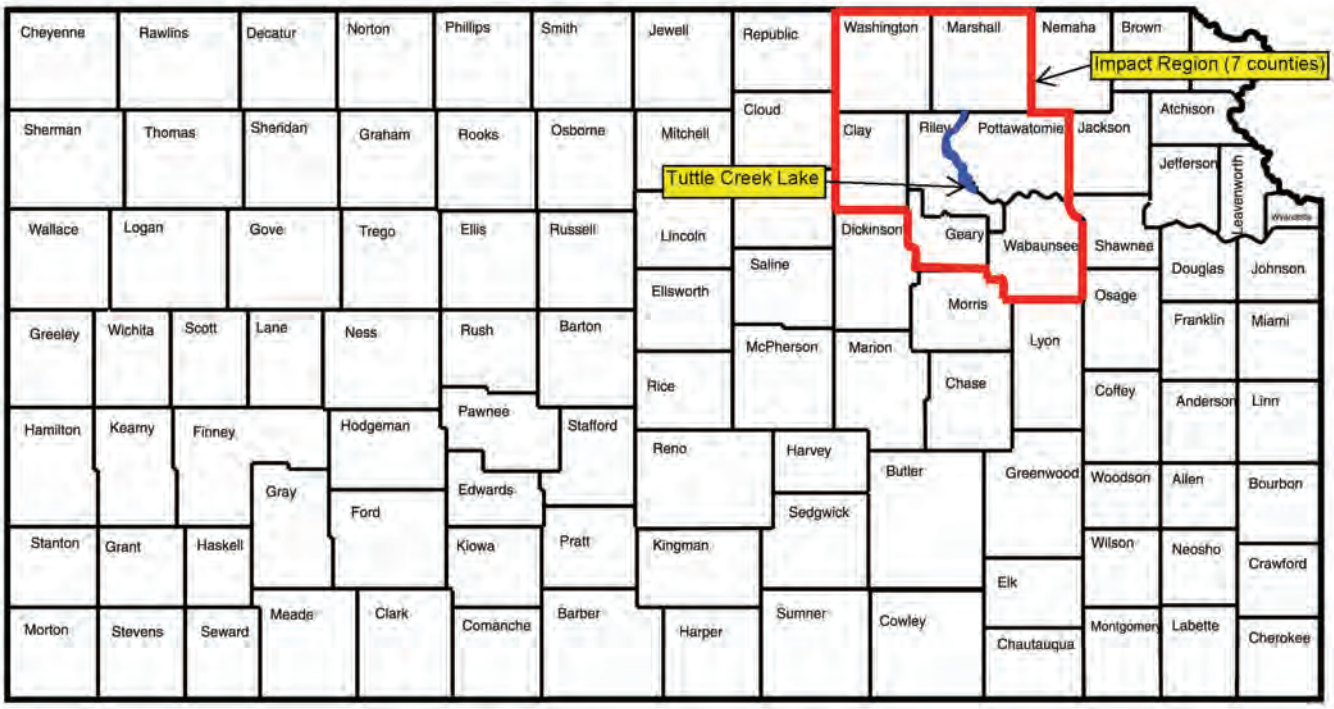

Figure 17. Tuttle Creek Lake economic impact region

Table 15. Visitation and spending for visits made to Tuttle Creek Lake, 2007

Visitation	Camper		Day User		Other Overnight		Total
	Boater	Nonboater	Boater	Nonboater	Boater	Nonboater	
Percent of Total	0.0%	0.2%	5.8%	91.0%	0.2%	2.7%	100.0%
2007 Tuttle Creek visits	68	1,088	26,442	414,240	785	12,365	454,989
Spending	$5,042	$67,991	$592,603	$5,583,416	$74,406	$685,740	$7,009,199

Table 16. Spending categories by visitor type (dollars per visit, 2007$)

Spending Category	Campers		Day Users		Other Overnight			Weighted Average
	Boater	Nonboater	Boater	Nonboater	Boater	Nonboater		
Hotels, motels, cabins, B&B, and rental homes	0.83	0.12	0.00	0.00	19.46	20.17		0.58
Camping fee	15.47	16.01	0.00	0.00	0.11	0.03		0.04
Restaurants, bars, etc.	8.00	9.18	2.66	3.32	14.14	15.84		3.66
Groceries and take out food	20.41	16.62	4.39	4.39	14.71	6.31		4.49
Gas & oil	12.62	8.71	6.96	2.75	15.36	7.39		3.16
Other auto expenses	0.97	1.51	1.70	0.31	6.09	0.00		0.39
Other boat expenses	4.97	0.00	2.13	0.00	12.19	0.00		0.15
Entertainment and recreation fees	2.34	2.91	0.97	0.52	4.35	1.66		0.59
Sporting goods and boat equipment	4.76	1.51	3.09	0.86	4.95	2.37		1.04
Other expenses	3.34	5.94	0.50	1.33	3.37	1.69		1.30
Total (within 30 miles)	**$73.71**	**$62.51**	**$22.41**	**$13.48**	**$94.74**	**$55.46**		**$15.40**

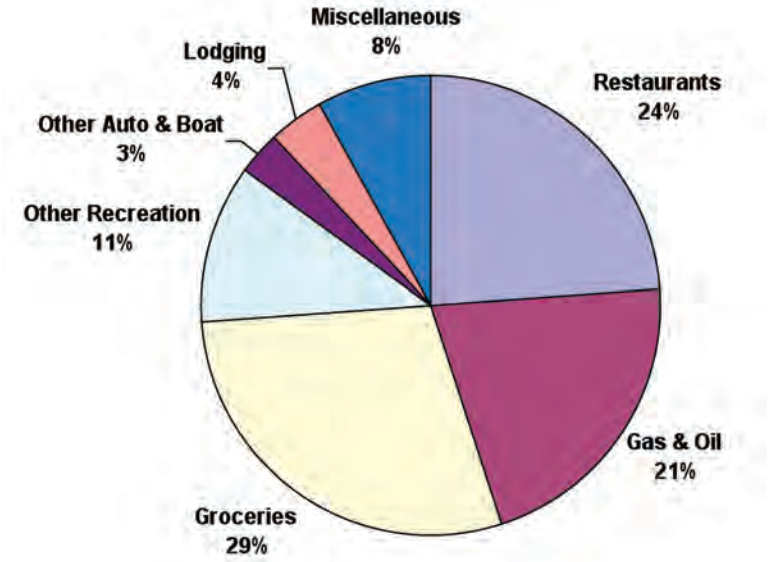

Figure 18. Trip spending by category

Table 17. Tuttle Creek Lake total economic contributions

Impact Measure	Direct	Indirect	Total
Output	$3,743,718	$1,436,971	$5,180,689
Total Value Added	$1,741,255	$790,029	$2,531,284
Employment	82	15	97

Table 18. Non-market benefits of Tuttle Creek Lake recreation, 2007$

Activity	Days Spent in Activity	Activity Value per Day (2007$)	Total Value per Year
Fish	62,651	$38.58	$2,417,139
Swim	33,849	$19.75	$668,456
Camp	18,112	$29.54	$535,017
Boat	12,174	$27.45	$334,143
Picnic	6,978	$30.42	$212,249
Other	14,698	$19.94	$293,045
Total	**148,462**	-------	**$4,460,048**

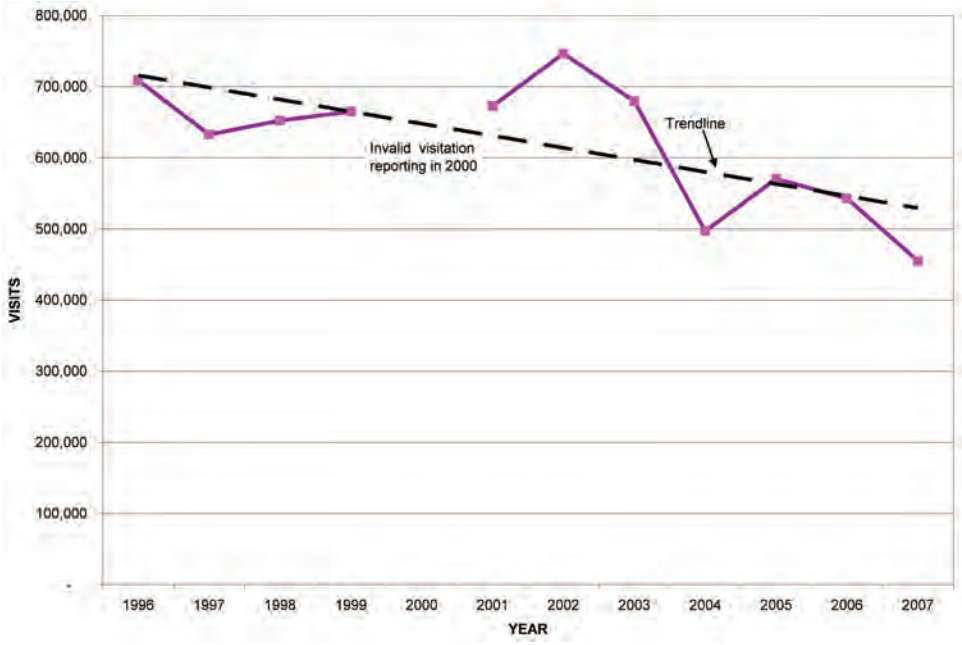

Figure 19. Trends in Tuttle Creek Lake visitation

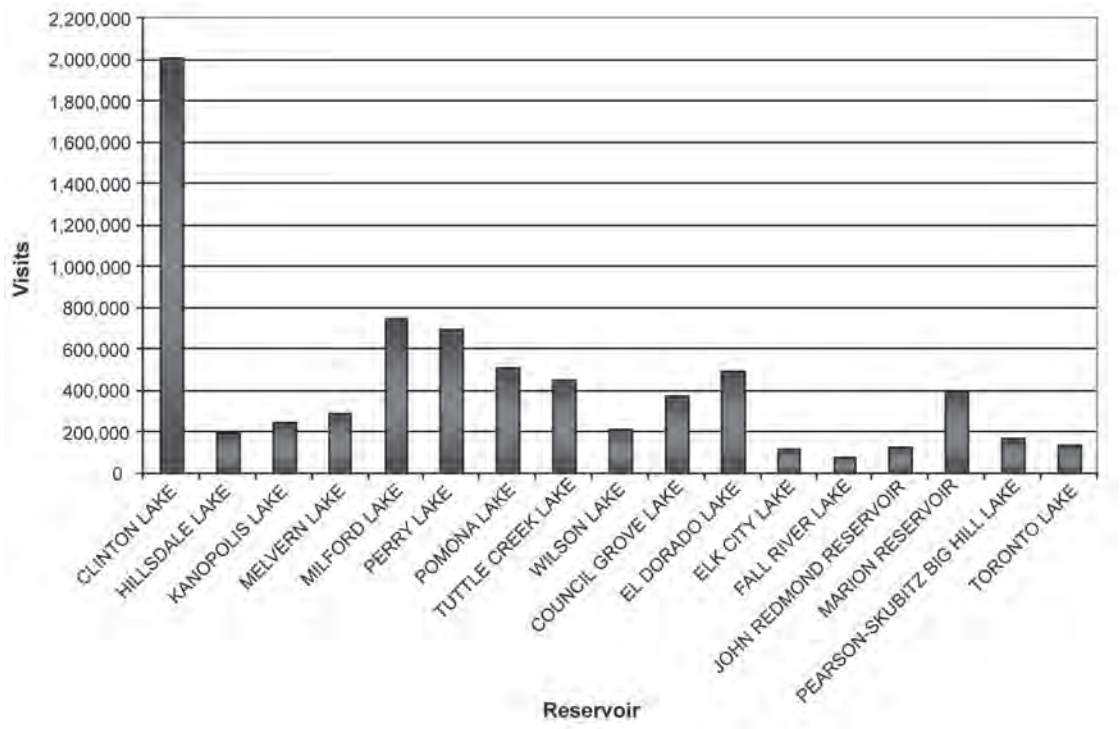

Figure 20. Visits to Kansas Reservoirs in 2007

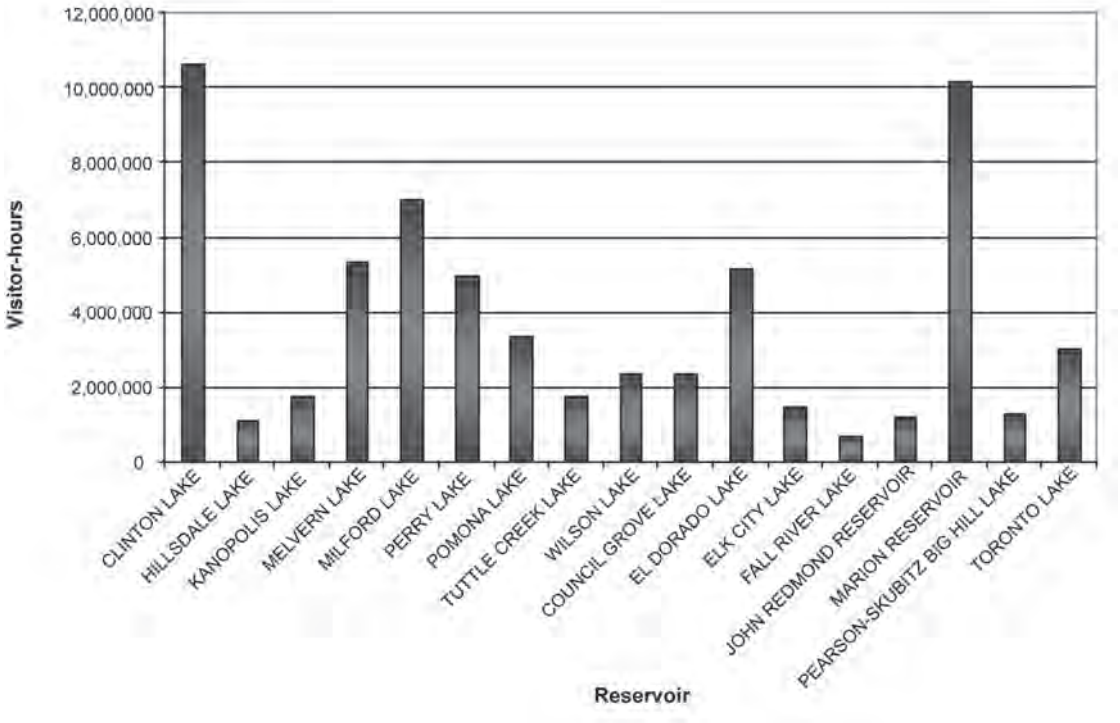

Figure 21: Visitor-hours at Kansas Reservoirs in 2007

7.8 Census Data[18]

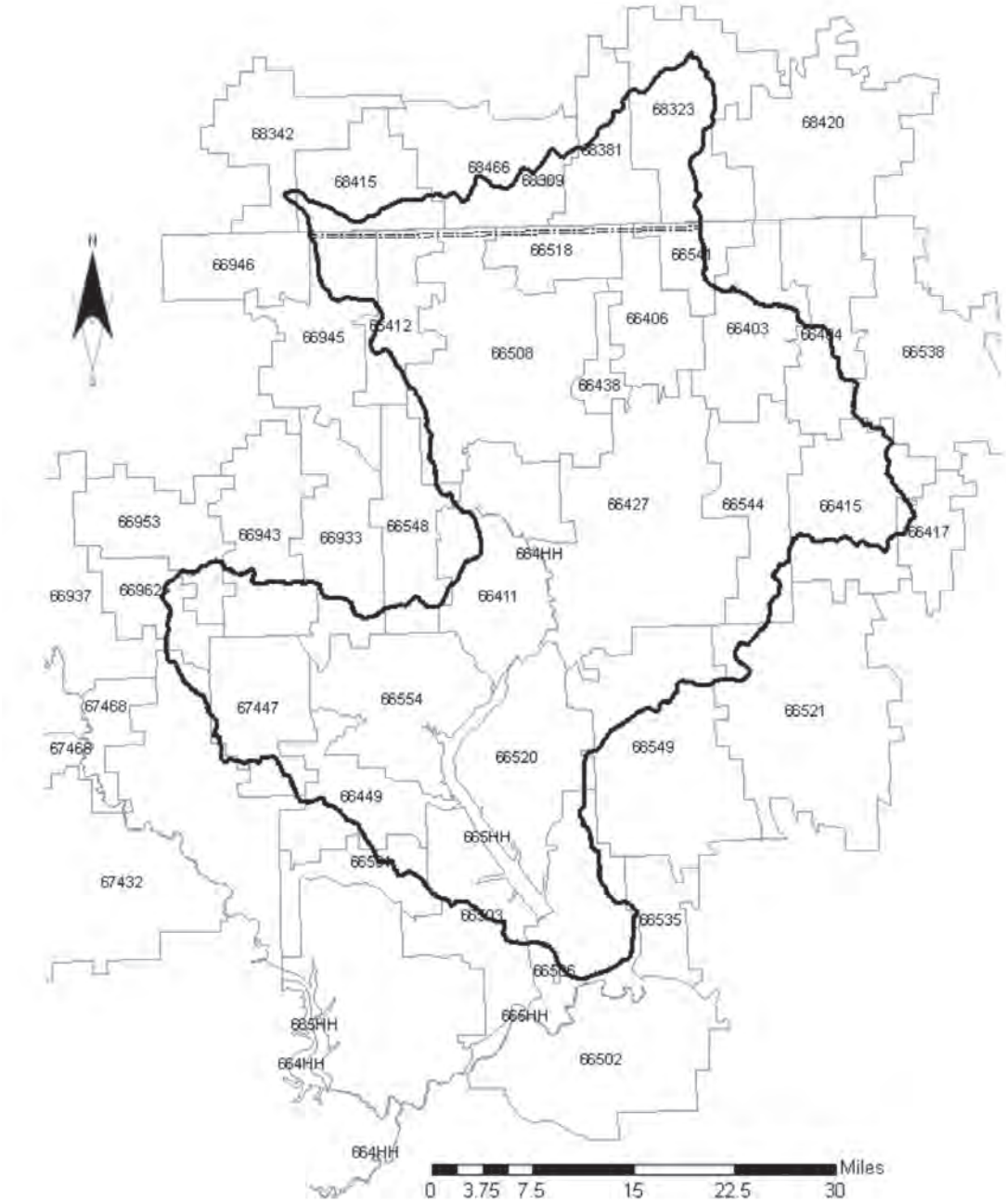

Figure 22. Zip Code Boundary Map.

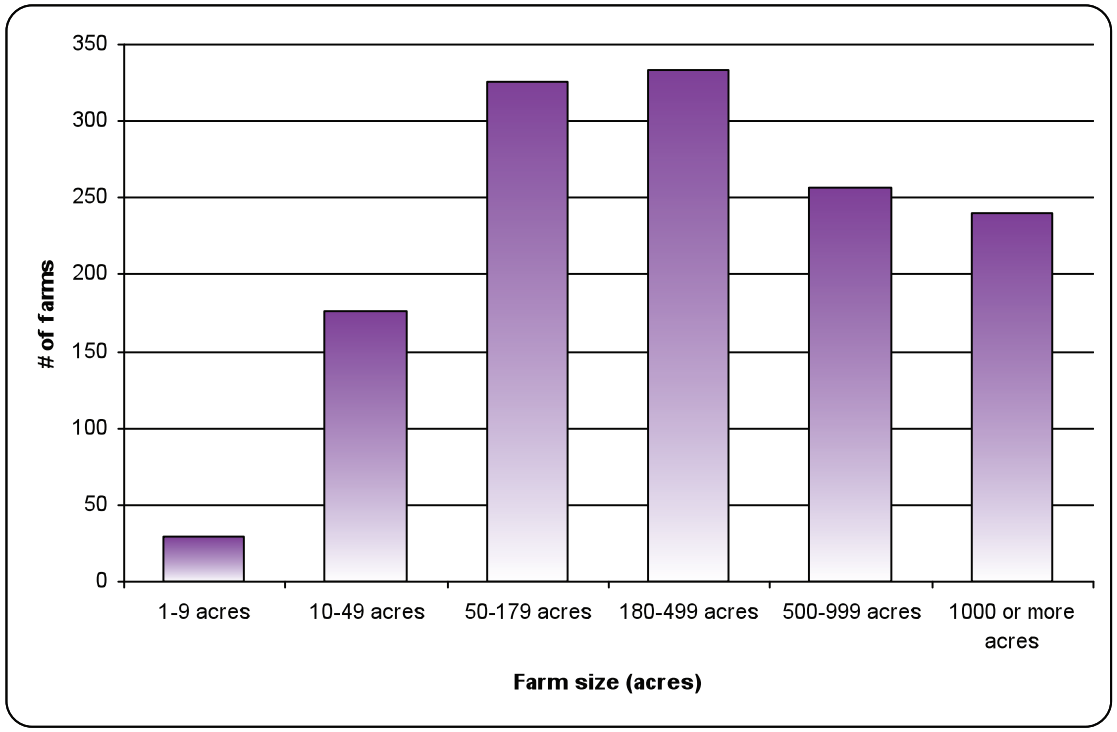

Figure 23. Size Distribution of Farms in Lower Big Blue Watershed, 2002[18]

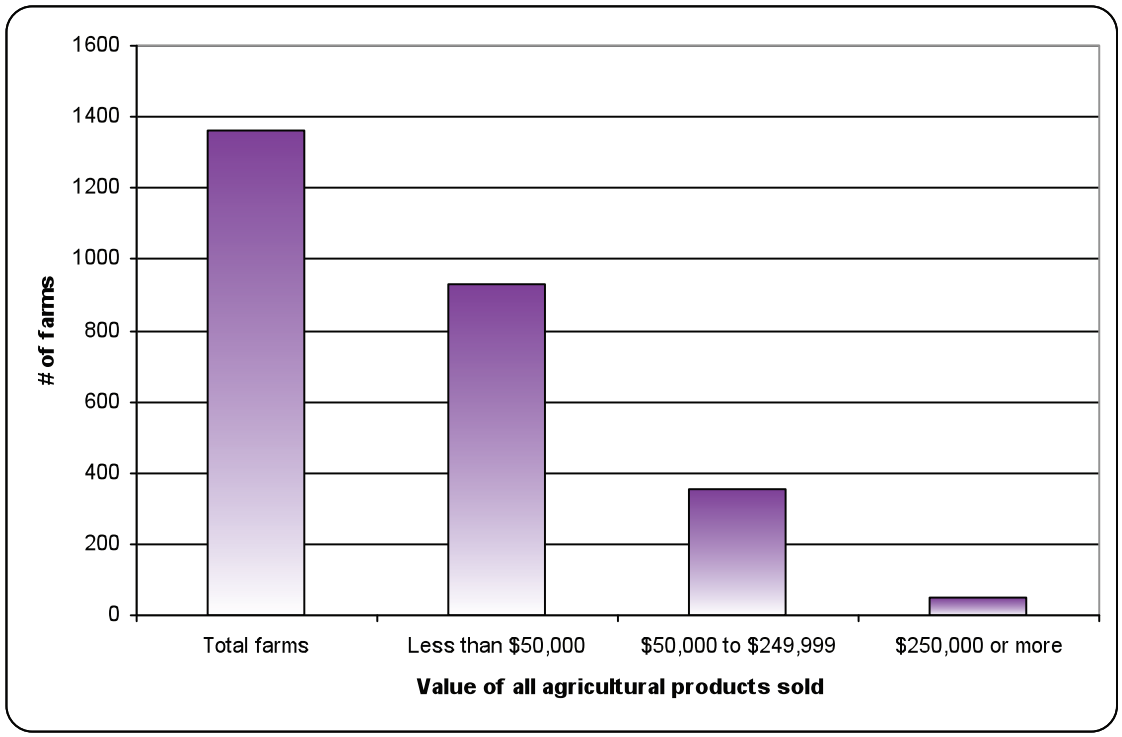

Figure 24. Sales Distribution of Farms in Lower Big Blue Watershed, 2002[18]

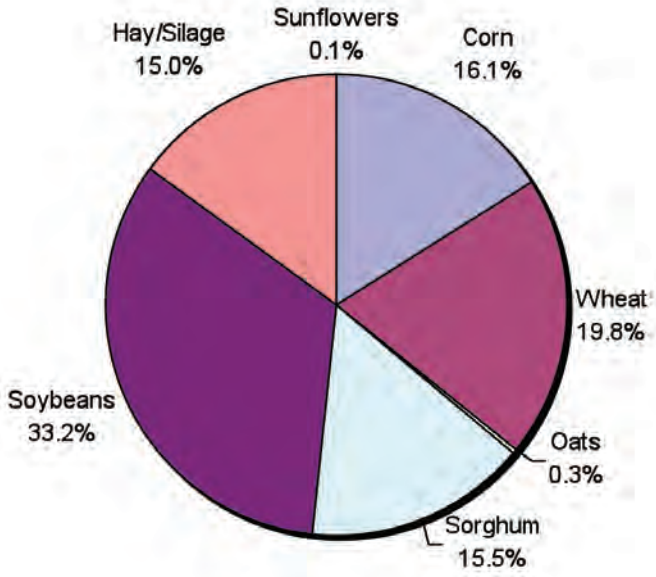

Figure 25. Harvested Crop Acreage in Lower Big Blue Watershed, 2002[18]

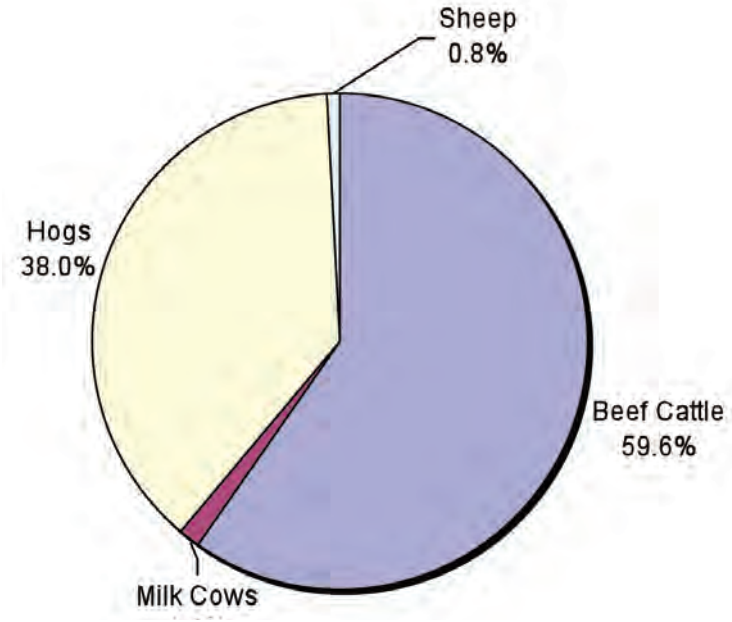

Figure 26. Livestock Number Distribution in Lower Big Blue Watershed, 2002[18]

8.0 Modeling

8.1 Subbasin Map[19]

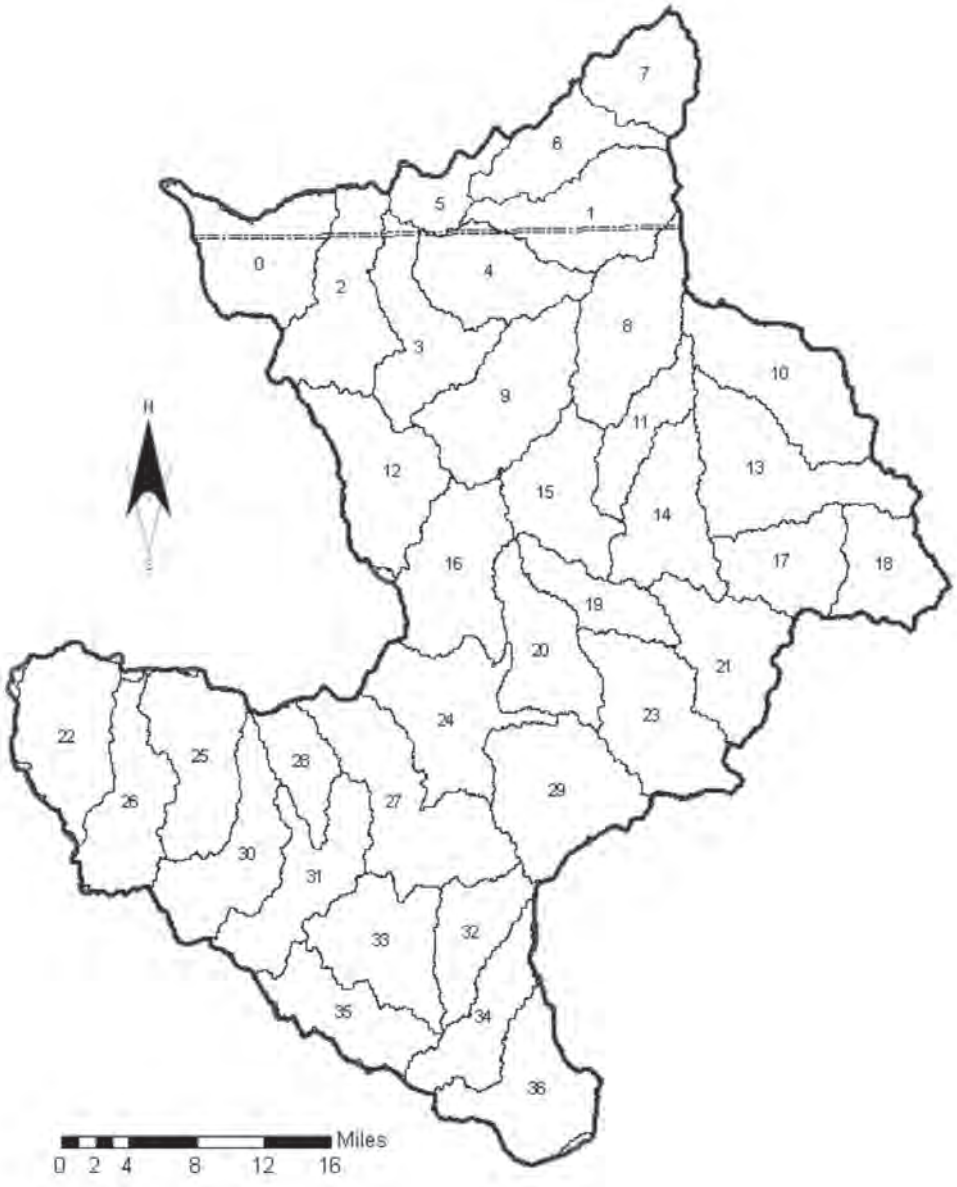

Figure 27. Subbasin Map – Lower Big Blue Watershed.

Table 19. Lower Big Blue Watershed Subbasin Area

Subbasin	State	HUC ID	Area (acres)
0	KS,NE	102702050202	31605
1	KS,NE	102702050103	34977
2	KS,NE	102702050203	34392
3	KS,NE	102702050204	29080
4	KS,NE	102702050201	27587
5	KS,NE	102702050104	12396
6	NE	102702050102	22511
7	NE	102702050101	21165
8	KS,NE	102702050401	34537
9	KS	10270205070010	38064
10	KS	10270205050010	36777
11	KS	10270205060020	16604
12	KS	10270205070020	34003
13	KS	10270205050020	40796
14	KS	10270205050060	28494
15	KS	10270205060030	27263
16	KS	10270205070030	34097
17	KS	10270205050040	23665
18	KS	10270205050030	21663
19	KS	10270205060040	16793
20	KS	10270205060060	26189
21	KS	10270205050050	29751
22	KS	10270205080010	32944
23	KS	10270205060050	36440
24	KS	10270205070040	35883
25	KS	10270205080030	31936
26	KS	10270205080020	28034
27	KS	10270205070060	44019
28	KS	10270205080050	14599
29	KS	10270205070050	39062
30	KS	10270205080040	30100
31	KS	10270205080060	30496
32	KS	10270205090030	19798
33	KS	10270205090010	30324
34	KS	10270205090040	22227
35	KS	10270205090020	24199
36	KS	10270205090050	30925
Total			**1073395**

8.2 Input Data

Figure 28. County Map - Lower Big Blue Watershed.

Figure 29. HUCO Map (overlay of county and 8-digit hydrologic unit boundary) – Lower Big Blue Watershed[23]

Table 20. Lower Big Blue Watershed Summary[23]

Polygon ID	County Name	State	HUC	Area (acre)	% in County	% in HUC
8432	Pawnee	NE	10270205	49242.95	17.47%	4.57%
8536	Gage	NE	10270205	64807.68	11.54%	6.02%
8678	Jefferson	NE	10270205	206.90	0.06%	0.02%
8764	Washington	KS	10270205	12396.45	2.17%	1.15%
8768	Marshall	KS	10270205	499377.41	86.87%	46.39%
8884	Nemaha	KS	10270205	60353.62	12.98%	5.61%
9230	Washington	KS	10270205	50683.38	8.89%	4.71%
9375	Clay	KS	10270205	35669.09	8.40%	3.31%
9378	Riley	KS	10270205	164546.23	41.68%	15.29%
9385	Pottawatomie	KS	10270205	139096.47	25.43%	12.92%

Table 21. Landuse Area (acre)[20]

Polygon ID	Urban/ Transportation	Cropland	Pasture/ Rangeland	Forest	Feedlots	Water	Others
8432	2200.00	23400.00	20100.00	2300.00	2.28	600.00	6800.00
8536	1000.00	40200.00	0.00	0.00	4.94	600.00	5900.00
8678	0.00	0.00	0.00	0.00	0.01	0.00	0.00
8764	78.61	5561.52	962.95	491.30	1.04	19.65	137.56
8768	12800.00	291400.00	144400.00	12800.00	16.46	7700.00	36800.00
8884	3100.00	39800.00	7200.00	2400.00	6.29	1100.00	5100.00
9230	321.39	22738.48	3937.05	2008.70	4.24	80.35	562.44
9375	600.00	20400.00	9700.00	2000.00	1.51	400.00	1900.00
9378	5400.00	58300.00	85600.00	11300.00	5.79	6700.00	12100.00
9385	2700.00	15900.00	70300.00	18500.00	6.27	9000.00	10900.00
Total	28200.00	517700.00	342200.00	51800.00	48.82	26200.00	80200.00

Table 22. Agricultural Animals[18]

Polygon ID	Beef Cattle	Dairy Cattle	Swine (Hog)	Sheep	Horse	Chicken	Turkey	Duck
8432	1943	123	2763	263	46	88	D	1
8536	1762	352	10189	73	81	0	D	0
8678	7	1	23	0	0	0	D	0
8764	465	62	2051	28	0	6	D	0
8768	16651	878	16515	453	303	297	21	9
8884	2749	621	11804	86	56	96	0	0
9230	1903	256	8388	117	0	25	D	0
9375	1202	49	2147	46	23	120	2	0
9378	4766	182	7634	138	222	298	D	3
9385	6959	113	5263	209	314	0	D	4
Total	**38407**	**2637**	**66777**	**1413**	**1045**	**930**	**23**	**17**

D = data withheld to avoid disclosing information for individual farms

Table 23. Septic System[21]

Polygon ID	No. of Septic Systems	Population per Septic System	Septic Failure Rate,%
8432	113	1.98	0.27
8536	229	2.34	0.27
8678	0	2.15	0.27
8764	24	2.11	0.93
8768	1438	2.22	0.93
8884	179	2.42	0.93
9230	99	2.11	0.93
9375	107	2.21	0.93
9378	1142	2.94	0.93
9385	660	2.49	0.93
Total	**3991**	**2.48**	**0.87**

Table 24. Hydrological Soil Group[22]

Polygon ID	Hydrological Group
8432	C
8536	C
8678	C
8764	C
8768	C
8884	D
9230	C
9375	C
9378	C
9385	C

A = well to excessively drained soil

B = moderately-well to well drained soil

C = poorly drained soil

D = very poorly drained soil

Table 25. Modify the Universal Soil Loss Equation (USLE) parameters[23]

Polygon ID	Land Cover	R	K	LS	C	P
8432	Crop land	175.000	0.338	0.683	0.200	0.832
8536	Crop land	175.000	0.348	0.544	0.200	0.842
8678	Crop land	175.000	0.338	0.518	0.200	0.919
8764	Crop land	175.000	0.343	0.566	0.200	0.785
8768	Crop land	200.000	0.323	0.324	0.200	0.954
8884	Crop land	200.000	0.335	0.580	0.200	0.781
9230	Crop land	175.000	0.343	0.566	0.200	0.785
9375	Crop land	175.000	0.345	0.428	0.200	0.759
9378	Crop land	200.000	0.350	1.002	0.200	0.899
9385	Crop land	200.000	0.334	0.947	0.200	0.945
8432	Pasture Land	175.000	0.338	0.683	0.040	1.000
8536	Pasture Land	175.000	0.348	0.544	0.040	1.000
8678	Pasture Land	175.000	0.338	0.518	0.040	1.000
8764	Pasture Land	175.000	0.343	0.566	0.040	1.000
8768	Pasture Land	200.000	0.323	0.324	0.040	1.000
8884	Pasture Land	200.000	0.335	0.580	0.040	1.000
9230	Pasture Land	175.000	0.343	0.566	0.040	1.000
9375	Pasture Land	175.000	0.345	0.428	0.040	1.000
9378	Pasture Land	200.000	0.350	1.002	0.040	1.000
9385	Pasture Land	200.000	0.334	0.947	0.040	1.000
8432	Forest	175.000	0.338	0.683	0.003	1.000
8536	Forest	175.000	0.348	0.544	0.003	1.000
8678	Forest	175.000	0.338	0.518	0.003	1.000
8764	Forest	175.000	0.343	0.566	0.003	1.000
8768	Forest	200.000	0.323	0.324	0.003	1.000
8884	Forest	200.000	0.335	0.580	0.003	1.000
9230	Forest	175.000	0.343	0.566	0.003	1.000
9375	Forest	175.000	0.345	0.428	0.003	1.000
9378	Forest	200.000	0.350	1.002	0.003	1.000
9385	Forest	200.000	0.334	0.947	0.003	1.000

8.3 Model Outputs

Table 26. Total Pollution Load[23]

Polygon ID	N Load (lb/year)	P Load (lb/year)	BOD Load (lb/year)	Sediment Load (t/year)
8432	216949.7	30341.9	586968.1	5805.9
8536	171664.1	32406.9	358267.6	6630.6
8678	24.5	4.9	32.7	0.0
8764	31753.4	5418.9	70655.9	910.3
8768	2083257.2	294659.6	5358408.6	39028.1
8884	298982.3	49122.7	711823.2	7824.3
9230	129785.7	22147.7	288827.4	3721.6
9375	142406.3	20429.5	360968.1	2700.6
9378	773454.4	108327.6	2156838.8	29040.5
9385	489404.1	57192.4	1454370.5	11145.9
Total	**4337681.8**	**620052.1**	**11347161.0**	**106807.7**

Table 27. Total Load by Land Uses[23]

Sources	N Load (lb/yr)	P Load (lb/yr)	BOD Load (lb/yr)	Sediment Load (t/yr)
Urban	171403.52	26413.40	664337.67	3931.71
Cropland	2147892.22	401117.32	4493152.32	85280.44
Pastureland	1853678.26	156260.33	5954960.55	17373.45
Forest	10627.29	5231.90	26212.81	222.14
Feedlots	152968.86	30593.77	203958.48	0.00
User Defined	0.00	0.00	0.00	0.00
Septic	1111.62	435.38	4539.12	0.00
Gully	0.00	0.00	0.00	0.00
Streambank	0.00	0.00	0.00	0.00
Groundwater	0.00	0.00	0.00	0.00
Total	**4337681.78**	**620052.10**	**11347160.95**	**106807.74**

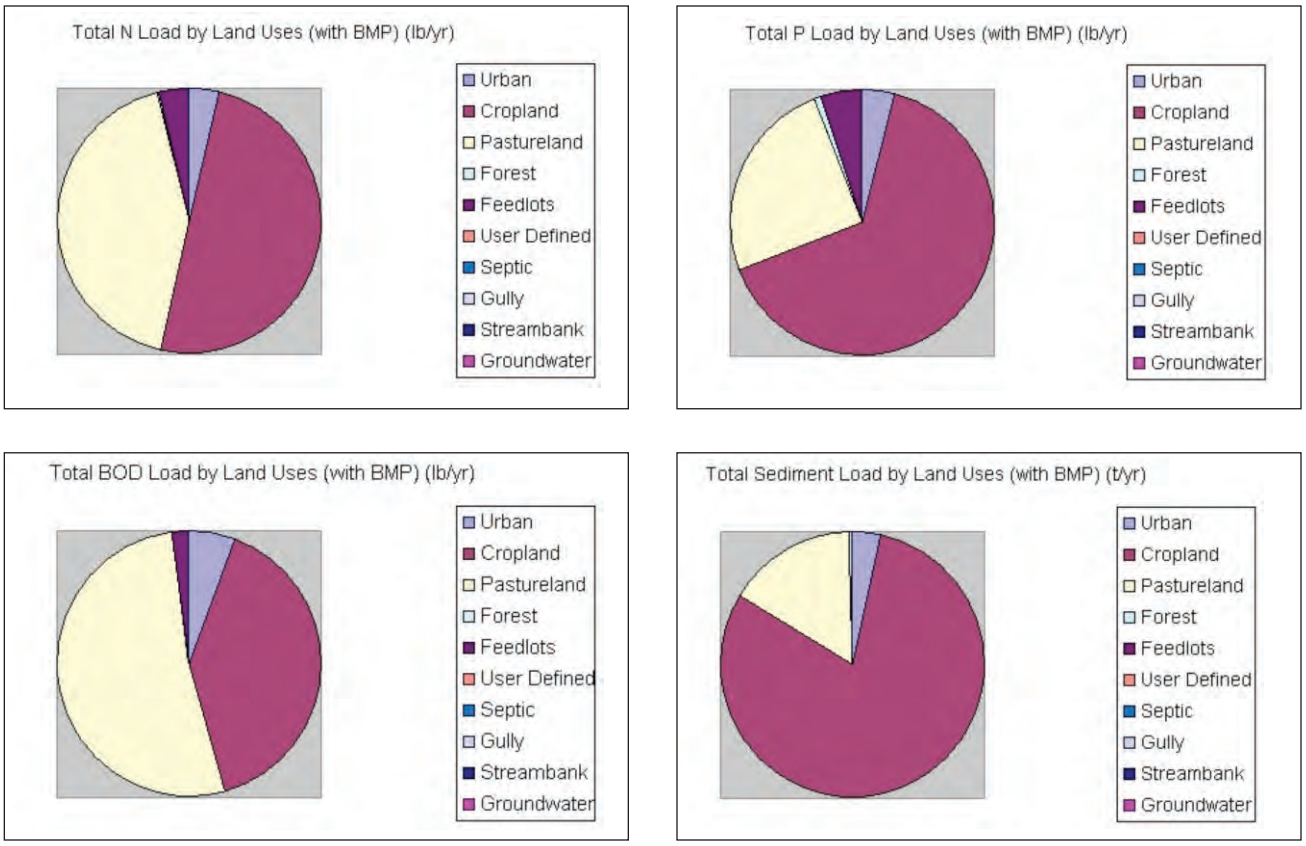

Figure 30. Total Load by Land Uses – Lower Big Blue Watershed.

9.0 Acknowledgment

The authors would like to acknowledge Dr. William Hargrove, Dr. Danny Rogers, Ms. Judy Willingham, and Mr. Don Snethen for their help and comments.

Funding for this project was provided in part by the Kansas Water Plan; U.S. Environmental Protection Agency (Section 319 funds) through the Kansas Department of Health and Environment, Watershed Management Section; and U.S. Geological Survey through the Kansas Water Resources Institute.

10.0 Footnotes/Bibliography

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4. *Precipitation Map*: "Point estimates of precipitation originated from some or all of the following sources: 1) National Weather Service (NWS) Cooperative (COOP) stations, 2) Natural Resources Conservation Service (NRCS) SNOTEL, 3) United States Forest Service (USFS) and Bureau of Land Management (BLM) RAWS Stations, 4) Bureau of Reclamation (AGRIMET) stations, 5) California Data Exchange Center (CDEC) stations, 6) Storage gauges, 7) NRCS Snowcourse stations, 8) Other State and local station networks, 9) Estimated station data, 0) Canadian stations, 10) Upper air stations, and 11) NWS/Federal Aviation Administration (FAA) Automated surface observation stations (ASOS). All COOP station data were subjected to quality control checks by the National Climatic Data Center (NCDC). All COOP, SNOTEL and other data were subjected to further quality control checks by the PRISM Group."
Online reference information available at: h*ttp://prism.oregonstate.edu/docs/meta/ppt_30s_meta.htm#7*

5. *Maximum Temperature Map*: "Point estimates of temperature originated from some or all of the following sources: 1) National Weather Service (NWS) Cooperative (COOP) stations, 2) Natural Resources Conservation Service (NRCS) SNOTEL, 3) United States Forest Service (USFS) and Bureau of Land Management (BLM) RAWS Stations, 4) Bureau of Reclamation (AGRIMET) stations, 5) California Data Exchange Center (CDEC) stations, 6) Storage gauges, 7) NRCS Snowcourse stations, 8) Other State and local station networks, 9) Estimated station data, 0) Canadian stations, 10) Upper air stations, and 11) NWS/Federal Aviation Administration (FAA) Automated surface observation stations (ASOS). All COOP station data were subjected to quality control checks by the National Climatic Data Center (NCDC). All COOP, SNOTEL and other data were subjected to further quality control checks by the PRISM Group."
Online reference information available at: *http://prism.oregonstate.edu/docs/meta/tmax_30s_meta.htm*

6. *Minimum Temperature Map*: "Point estimates of temperature originated from some or all of the following sources: 1) National Weather Service (NWS) Cooperative (COOP) stations, 2) Natural Resources Conservation Service (NRCS) SNOTEL, 3) United States Forest Service (USFS) and Bureau of Land Management (BLM) RAWS Stations, 4) Bureau of Reclamation (AGRIMET) stations, 5) California Data Exchange Center (CDEC) stations, 6) Storage gauges, 7) NRCS Snowcourse stations, 8) Other State and local station networks, 9) Estimated station data, 0) Canadian stations, 10) Upper air stations, and 11) NWS/Federal Aviation Administration (FAA) Automated surface observation stations (ASOS). All COOP station data were subjected to quality control checks by the National Climatic Data Center (NCDC). All COOP, SNOTEL and other data were subjected to further quality control checks by the PRISM Group."
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Online reference information available at: *http://www.epa.gov/waterscience/basins/metadata/giras.htm*

8. *National Land Cover Database 1992 (NLCD 1992)*: "Derived from the early to mid-1990s Landsat Thematic Mapper satellite data, the National Land Cover Data (NLCD) is a 21-class land cover classification scheme applied consistently over the United States. The spatial resolution of the data is 30 meters and mapped in the Albers Conic Equal Area projection, NAD 83. The NLCD are provided on a state-by-state basis. The state data sets were cut out from larger "regional" data sets that are mosaics of Landsat TM scenes. At this time, all of the NLCD state files are available for free download as 8-bit binary files and some states are also available on CD-ROM as a Geo-TIFF."
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Online reference information available at: *http://nhd.usgs.gov/*
USEPA Reach File, Version 1.0.
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Online reference information available at: *http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/*

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

EP140 February 2009

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