FINAL

TMDLs for Lead and Siltation/Turbidity for Big Creek near Sheridan, Arkansas

(HUC-reach 08040203-904)

Prepared for:

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EXECUTIVE SUMMARY

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for impaired waterbodies. A TMDL establishes the amount of a pollutant that a waterbody can assimilate without exceeding its water quality standard for that pollutant. TMDLs provide the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the lack of knowledge concerning the relationship between pollutant loads and the water quality of the receiving waterbody. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The study area for this TMDL is the Big Creek watershed, which is near Sheridan in central Arkansas and is in Planning segment 2C. Big Creek is a tributary to Hurricane Creek in the Saline River Basin. Big Creek is a relatively small stream (the drainage area at the mouth is 21.7 square miles) that normally experiences periods of zero flow in the summer. Forest is the dominant land use in the Big Creek watershed (58 percent).

The Arkansas Department of Environmental Quality (ADEQ) included Big Creek on the state's 2004 section 303(d) list for impairments caused by lead and siltation/turbidity (Table ES-1). The impaired designated use for Big Creek is fisheries (subcategory streams, Typical Gulf Coastal Ecoregion).

The numeric water quality criteria that apply to Big Creek and were used to calculate the total allowable loads are presented in Table ES-2.

Table ES-1. Section 303(d) and Integrated Report information for Big Creek

Reach number	Reach name	Impaired use	Causes of impairment	Sources of impairment
904	Big Creek	Aquatic life	Siltation/turbidity (SI)	Municipal point source, unknown
~~904~~	~~Big Creek~~	~~Aquatic life~~	~~Lead (Pb)~~	~~Municipal point source~~

Source: ADEQ 2005.

Table ES-2. Numeric water quality criteria for Big Creek

Reach number	Reach name	~~Acute dissolved Pb~~[a]	~~Chronic dissolved Pb~~[b]	Turbidity (siltation) (primary values)	Turbidity (siltation) (storm-flow values)
		~~µg/L~~	~~µg/L~~	NTU	NTU
904	Big Creek	~~16.1~~	~~0.6~~	21	32

Note: ~~µg/L = micrograms per liter;~~ NTU = nephelometric turbidity units.
[a] ~~The acute dissolved lead criterion was calculated using the following equation with a hardness of 28.5 mg/L: (e^[1.273(lnhardness)] - 1.460) × (1.46203 - [(lnhardness)(0.145712)]).~~
[b] ~~The chronic dissolved lead criterion was calculated using the following equation with a hardness of 28.5 mg/L: (e^[1.273(lnhardness)]-4.705) × (1.46203-[(lnhardness)(0.145712)]).~~

Turbidity cannot be expressed as a mass load, therefore, the turbidity TMDL was expressed using total suspended solids (TSS) as a surrogate for turbidity. Historical water quality data were analyzed for relationships between turbidity and TSS. A regression between turbidity and TSS was developed for Big Creek using turbidity and TSS data from the stream, resulting in a surrogate TSS endpoint of 29.51 milligrams per liter (mg/L).

The TMDL~~s~~ for ~~all pollutants (~~siltation/turbidity ~~and dissolved lead) were~~ was developed using the load duration curve methodology. This method illustrates allowable loading at a wide range of stream flow conditions. The steps for applying the methodology were as follows: (1) develop a flow duration curve; (2) convert the flow duration curve to load duration curves; (3) plot observed loads with load duration curves; and (4) calculate the TMDL, MOS, WLA, and LA. The TMDL~~s were~~ was not developed for a particular season, ~~and they apply~~ it applies year-round.

In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls. WLAs were given to permitted point source discharges. The LA~~s~~ include background loadings as well as human-induced nonpoint sources. ~~An explicit MOS of 10 percent was included for lead.~~ Siltation had an implicit MOS.

A summary of the TMDL~~s~~ for the Big Creek Basin is presented in Table ES-3.

Table ES-3. Summary of TMDL~~s~~, MOS, WLA~~s~~, and LA~~s~~ for Big Creek

HUC-reach number	Water quality station	Pollutant	Total allowable loading	MOS	Σ WLA	Σ LA
			lb/day			
~~08040203-904~~	~~OUA0018~~	~~Dissolved lead~~	~~0.0710~~	~~0.0071 (explicit; 10%)~~	~~0.0008~~	~~0.0631~~
08040203-904	OUA0018	TSS (stormflow)	3,433.4	Implicit	0.0	3,433.4
08040203-904	OUA0018	TSS (baseflow)	40.9	Implicit	0.0	40.9

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1 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (at Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not supporting their designated uses even after pollutant sources have implemented technology-based controls. A TMDL establishes the maximum allowable load (mass per unit of time) of a pollutant that a waterbody is able to assimilate and still support its designated uses. The maximum allowable load is determined on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources to restore and maintain the quality of the state's water resources (USEPA 1991).

Monitoring data collected by the Arkansas Department of Environmental Quality (ADEQ) indicate that observed pollutant levels sometimes exceed water quality criteria for Big Creek near Sheridan. The impaired designated use for Big Creek is fisheries (subcategory streams, Typical Gulf Coastal Ecoregion). The pollutants causing these impairments are dissolved lead and is siltation/turbidity (SI). Table 1-1 presents information from Arkansas's 2004 Integrated Report (ADEQ 2005) for Big Creek.

Table 1-1. Section 303(d) and Integrated Report information for Big Creek

Reach number	Stream reach name	Impaired use	Causes of impairment	Sources of impairment
904	Big Creek	Aquatic life	Siltation/turbidity (SI)	Municipal point source, unknown
904	Big Creek	Aquatic life	Lead (Pb)	Municipal point source

Source: ADEQ 2005.

2 BACKGROUND INFORMATION

2.1 General Description

Big Creek is near Sheridan in central Arkansas (Figure 2-1) and is entirely within Grant County. It is in U.S. Geological Survey (USGS) hydrologic unit code (HUC) 08040203. Big Creek is a tributary to Hurricane Creek, which flows into the Saline River through Arkansas and into Louisiana. Big Creek is a relatively small stream (the drainage area at the mouth is 21.7 square miles) that normally experiences periods of zero flow in the summer.

2.2 Land Use

Land use data were obtained from the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas in Fayetteville (2005). Forest constitutes 77 percent of the land area in the Big Creek watershed; the remaining land uses are pasture (13 percent), urban (9 percent), barren (1 percent), and water (1 percent). Figure 2-2 shows the land use coverage.

2.3 Soils

General soil data for the United States are provided as part of the Natural Resources Conservation Service's (NRCS) State Soil Geographic (STATSGO) database. Soil data from this database and a geographic information system (GIS) coverage from NRCS were used to characterize soils in the Big Creek Basin.

One of the soil characteristics provided in the STATSGO database is the K-factor. The K-factor is a component of the Universal Soil Loss Equation, or USLE (Wischmeier and Smith 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and values can range from 0 to 1.00. In practice, maximum factor values usually do not exceed 0.67. Large K-factor values reflect greater inherent soil erodibility. The soils in the basin have K-factors that range from 0.10 to 0.43, suggesting a wide range of soil erosion potential. Erosion is influenced by a number of other factors, including rainfall and runoff, land slope, vegetation cover, and land management practices.

The hydrologic soil group classification is another commonly used soil characteristic provided in the STATSGO database. The hydrologic soil group is a means for grouping soils by similar infiltration and runoff characteristics. Clay soils that are poorly drained tend to have the lowest infiltration rates, whereas sandy soils that are well drained have the highest infiltration rates. NRCS has defined four hydrologic groups for soils (Table 2-1). The STATSGO data were summarized using the major hydrologic group in the soil surface layers (Figure 2-3).

The basin is made up mostly of soil types in the C hydrologic group, with a small portion of D soils along the creek. These soil types suggest that the Big Creek Basin is dominated by slow infiltration rates and fine-textured soils.

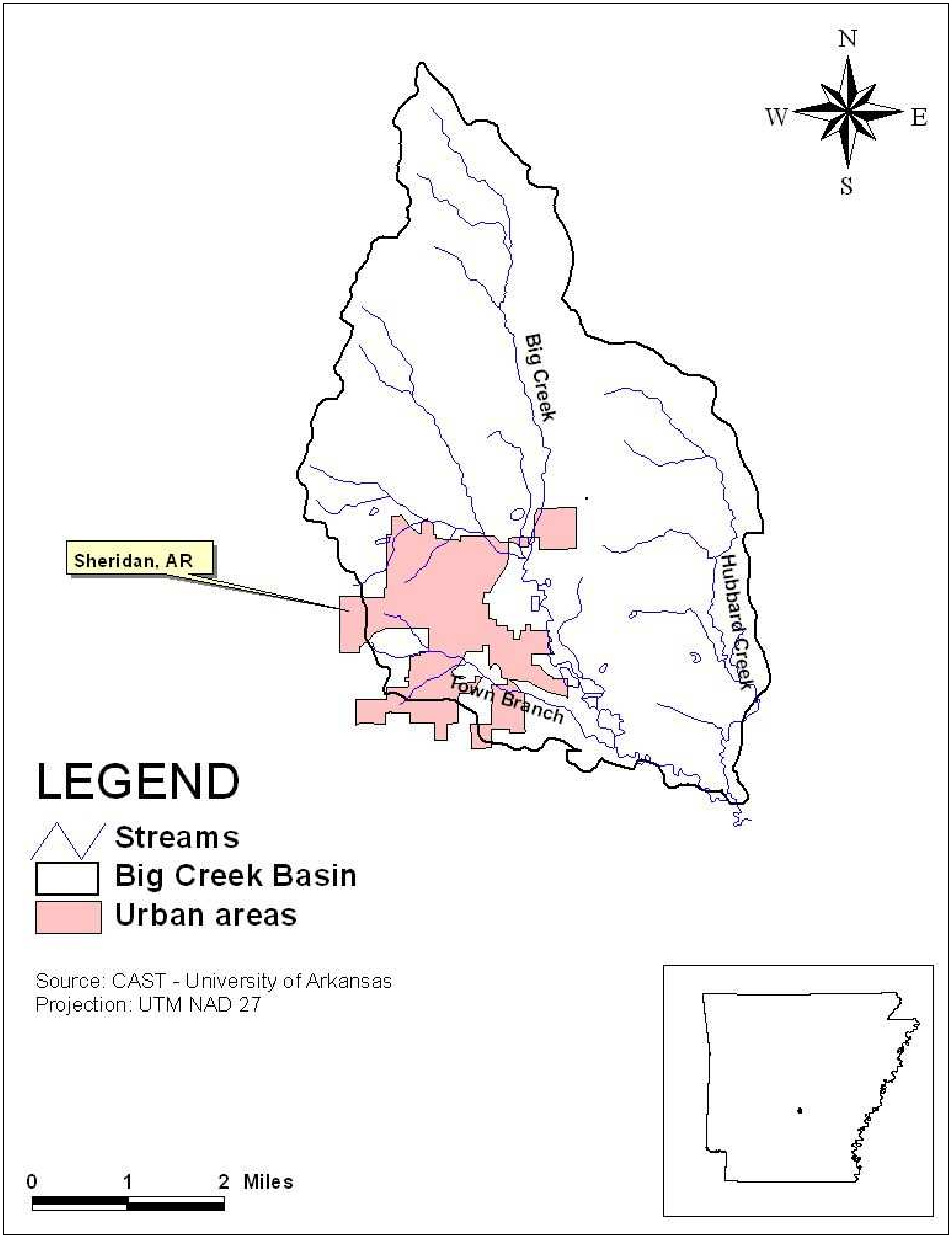

Figure 2-1. Location of the Big Creek Basin.

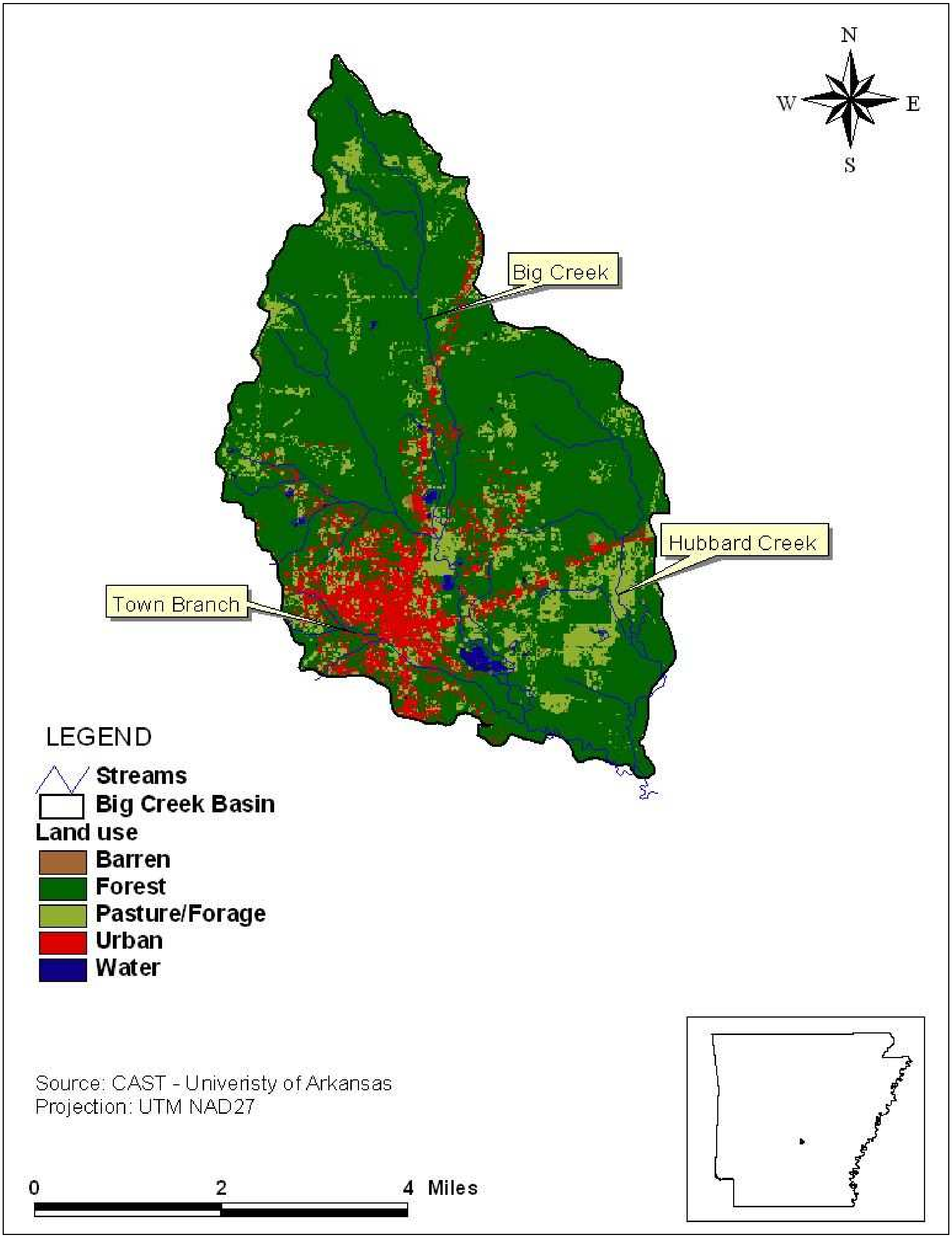

Figure 2-2. Land use distribution in the Big Creek Basin.

Table 2-1. Hydrologic soil groups

Hydrologic soil group	Description
A	Soils with high infiltration rates. Usually deep, well-drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well-drained soils.
C	Soils with slow infiltration rates. Soils with fine textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

2.4 Flow Characteristics

There are no USGS stream flow gauges for Big Creek. The average annual stream flow for watersheds in this area is approximately 16 inches per year, or 1.2 cubic feet per second (cfs) per square mile of drainage area (USGS 1984). Big Creek normally experiences periods of zero flow in the summer. The 7Q10[1] flow for the stream is assumed to be zero (USGS 1983, 1992).

2.5 Water Quality Standards

2.5.1 Designated Uses

The designated uses for Big Creek are primary contact recreation; secondary contact recreation; domestic, industrial, and agricultural water supply; and fisheries (subcategory streams, Typical Gulf Coastal Ecoregion) (APCEC 2007). Arkansas's 2004 Integrated Report (ADEQ 2005) indicates that the impaired designated use for Big Creek is aquatic life. While aquatic life is noted as an impaired use in Arkansas's 2004 Integrated Report (ADEQ 2005), the actual impaired designated use is fisheries (subcategory streams, Typical Gulf Coastal Ecoregion).

The designated use of fisheries "provides for the protection and propagation of fish, shellfish, and other forms of aquatic life (APCEC 2007, p. 3-1)". The subcategory of "streams" indicates "water which is suitable for the protection and propagation of fish and other forms of aquatic life adapted to flowing water systems whether or not the flow is perennial (APCEC 2007, p. 3-2)". The subcategory of "Typical Gulf Coastal Ecoregion" designates "Streams supporting diverse communities of indigenous or adapted species of fish and other forms of aquatic life. Fish communities are characterized by a limited proportion of sensitive species; sunfishes are distinctly dominant followed by darters and minnows (APCEC 2007, p. 3-4)". The Typical Gulf Coastal Ecoregion fish community may generally be characterized by the key species of redfin shiner, spotted sucker, yellow bullhead, warmouth, slough darter, and grass pickerel and the indicator species of pirate perch, flier, spotted sunfish, dusky darter, creek chubsucker, and banded pygmy sunfish. Agricultural water supply designates waters that will be protected for irrigation of crops and/or consumption by livestock (APCEC 2007). Industrial water supply indicates waters that will be protected for use as process or cooling water (APCEC 2007).

[1] The 7Q10 is the lowest flow for 7 consecutive days that occurs once every 10 years.

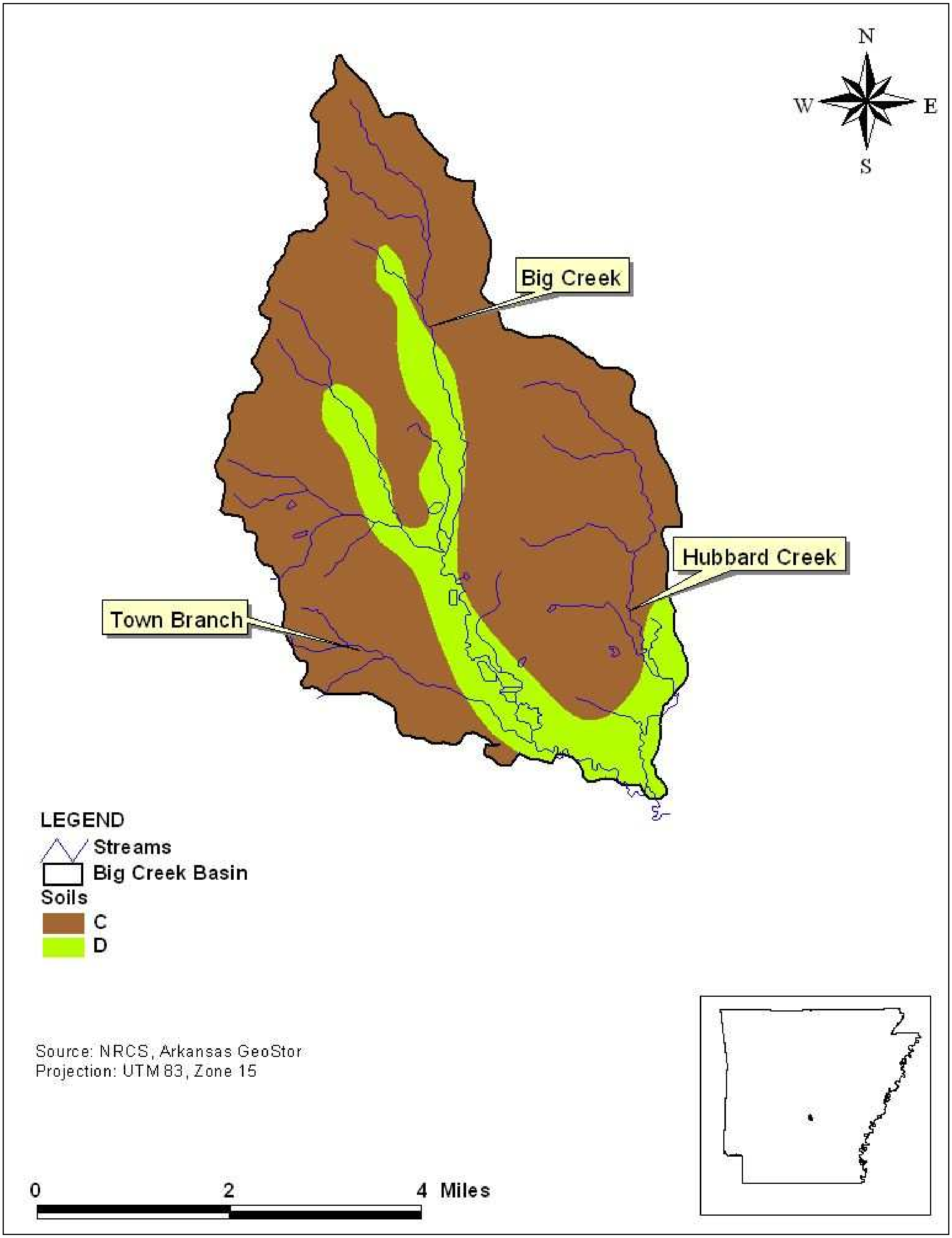

Figure 2-3. Hydrologic soil groups in the Big Creek Basin.

2.5.2 Water Quality Criteria

The Arkansas water quality standards provide both narrative and numeric criteria for toxic substances like dissolved lead. The narrative criterion states that "toxic substances shall not be present in receiving waters, after mixing, in such quantities as to be toxic to human, animal, plant or aquatic life or to interfere with the normal propagation, growth and survival of the indigenous aquatic biota (APCEC 2007, p.5-5)." The numeric water quality criterion for dissolved lead is based on hardness and applies to both acute and chronic conditions. The acute criteria are based on toxicity resulting from short-term exposure to high pollutant concentrations, whereas the chronic criteria are based on toxicity resulting from long-term exposure to lower pollutant concentrations. This TMDL focuses on critical conditions over the long term, therefore, the chronic criteria were used to calculate the TMDL for dissolved lead. Based on ADEQ's dissolved lead monitoring data, the average hardness in Big Creek is 28.5 milligrams per liter (mg/L). The average hardness value of 28.5 mg/L was used to calculate the lead water quality criteria for Big Creek as opposed to the default ecoregion value of 31 mg/L in ADEQ's Continuing Planning Process (CPP) (ADEQ 2000) based on best professional judgment because it is more protective of downstream waterbodies.

Regarding siltation and turbidity, Arkansas's water quality standards (APCEC 2007) state that "there shall be no distinctly visible increase of receiving waters attributable to municipal, industrial, agricultural, other waste discharges or instream activities. Specifically in no case shall any such waste discharge or instream activity cause turbidity values to exceed the primary values [listed below]. Additionally, the non-point source runoff shall not result in the exceedance of the instream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples (APCEC 2007, p. 5-2)." The siltation water quality criteria presented in Table 2-2 are specifically for the Gulf Coastal Plain ecoregion.

The aquatic life water quality criteria for lead and siltation/turbidity are is discussed below and presented in Table 2-2.

Table 2-2. Numeric water quality criteria for Big Creek

Reach number	Reach name	Acute dissolved Pb[a]	Chronic dissolved Pb[b]	Turbidity (siltation) (primary values)	Turbidity (siltation) (storm-flow values)
		µg/L	µg/L	NTU	NTU
904	Big Creek	16.1	0.6	21	32

Note: µg/L = micrograms per liter; NTU = nephelometric turbidity units.
Note: The hardness of 28.5 mg/L used to calculate the metals criteria is the average site-specific hardness for Big Creek at water quality station OUA0018.
[a] The acute dissolved lead criterion was calculated using the following equation with a hardness of 28.5 mg/L: (e^[1.273(lnhardness)] - 1.460) × (1.46203 - [(lnhardness)(0.145712)]).
[b] The chronic dissolved lead criterion was calculated using the following equation with a hardness of 28.5 mg/L: (e^[1.273(lnhardness)]-4.705) × (1.46203-[(lnhardness)(0.145712)]).

2.5.3 Antidegradation Policy

The Arkansas water quality standards also include an antidegradation policy (APCEC 2007), which states that existing in-stream water uses and the level of water quality necessary to protect the existing uses must be maintained and protected.

State water exhibiting high water quality must be maintained and protected unless the state finds that allowing lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located. In allowing such degradation or lower water quality, the state must ensure water quality adequate to protect the existing uses fully.

Those uses and water quality for which the outstanding resource waters were designated must be protected by (1) implementing water quality controls, (2) maintaining the natural flow regime, (3) protecting in-stream habitat, and (4) encouraging land management practices protective of the watershed.

In cases where potential water quality impairment associated with a thermal discharge is involved, the antidegradation policy and implementing method must be consistent with section 316 of the federal Clean Water Act.

2.6 Point Sources

The City of Sheridan's wastewater treatment plant (WWTP) is the only facility with a point source discharge in the Big Creek watershed (Figure 2-4). The discharge from this facility is regulated by National Pollutant Discharge Elimination System (NDPES) Permit No. AR0034347. The plant's treatment system consists of three large ponds in series, and it has a design flow of 0.676 million gallons per day (mgd). The sizes of the ponds are 26 acres, 16 acres, and 14 acres. The ponds provide a large amount of wastewater storage, which is necessary because the facility currently discharges to Big Creek according to a hydrograph-controlled release (HCR). With the HCR, the allowable effluent flow rate can be as much as 32 percent of the stream flow in Big Creek upstream of the outfall. This also means, however, that the facility cannot discharge when Big Creek is not flowing. Permit requirements for the HCR expire on March 1, 2008, or until they are otherwise discontinued. ~~The city's WWTP does not have permit limits for lead.~~ The facility information and permit limits related to siltation/turbidity are presented in Table 2-3.

Table 2-3. Point source discharge information for siltation/turbidity in Big Creek

Permit number	Facility name	Location	Outfall	Flow (mgd)	Receiving water	Monthly average TSS permit limit (mg/L)	7-day average TSS permit limit (mg/L)
AR0034347	City of Sheridan WWTP	1800 Hwy 167 South	001	0.676	Big Creek	20	30

Note: TSS = total suspended solids; mg/L = milligrams per liter.

The City of Sheridan uses land application in addition to discharging to Big Creek. Treated wastewater is applied to a 10-acre land application site along the east side of Big Creek directly

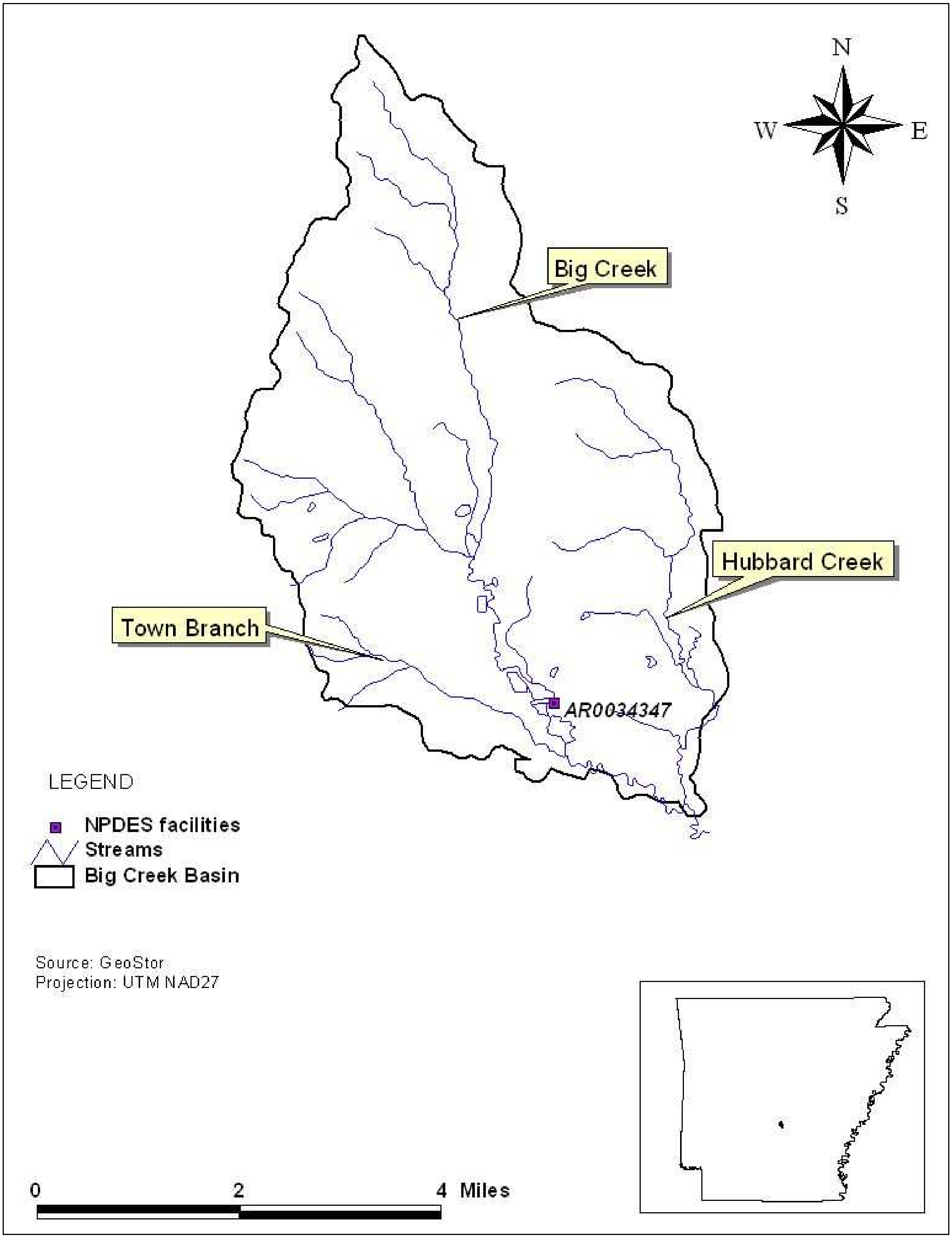

Figure 2-4. Location of point source discharges in the Big Creek Basin.

across from the WWTP. Future plans include applying treated wastewater to an additional 30 acres of adjacent land. Land application is beneficial because it allows the city to dispose of treated wastewater during dry times when there is little or no upstream flow in Big Creek.

2.7 Nonpoint Sources

Land use data and firsthand observations of the stream indicate that Big Creek is likely affected by nonpoint source runoff from pasture, forestry operations, and urban areas. A possible source of contaminants is illegal dumping that occurs at the bridge where monitoring station OUA0018 is located. ADEQ uses OUA0018 to asses the water quality of Big Creek.

3 CHARACTERIZATION OF EXISTING WATER QUALITY

ADEQ has collected water quality data for dissolved lead, siltation/turbidity, and other parameters in Big Creek at station OUA0018, which is approximately 2 miles downstream of the City of Sheridan WWTP (Figure 3-1).

3.1 Comparison of Observed Data to Criteria

3.1.1 Siltation/Turbidity

There are 145 turbidity observations at station OUA0018 for the period of record, September 1990 through April 2007. Table A-1 in Appendix A provides a summary of the observations, including the number of observations; the minimum, maximum, mean, and median observations; the number of exceedances of the criteria; and the percentage of observations exceeding the criteria at the station. Appendix B contains the original turbidity water quality data. The maximum turbidity observation is 143 NTU, and the minimum is 1.2 NTU. Ninety-six percent of the turbidity observations at station OUA0018 exceed the 21 NTU primary turbidity criterion for Big Creek, and 50 percent exceed the 32 NTU storm flow turbidity criterion.

There are 142 total suspended solids (TSS) observations at station OUA0018 for the period of record, September 1990 through April 2007. Table A-2 in Appendix A presents a summary of the observations, including the number of observations and the minimum, maximum, mean, and median observations. Arkansas does not have TSS criteria to which the data can be compared. Appendix B contains the original TSS water quality data. The maximum TSS observation is 216 mg/L, and the minimum is 1 mg/L.

3.1.2 Lead

There are 33 dissolved lead observations at station OUA0018, taken between January 1999 through March 2007. Table A-3 in Appendix A presents a summary of the observations, including the number of observations; the minimum, maximum, mean, and median observations; the number of exceedances of the criterion; and the percentage of observations exceeding the criterion at each station. Appendix B contains the original dissolved lead water quality data.

The percent exceedance of the 0.6 µg/L chronic dissolved lead criterion at station OUA0018 is 21 percent. The maximum observation is 1.3 µg/L, and the minimum observation is 0.2 µg/L.

The 0.6 µg/L chronic dissolved lead criterion was calculated based on the average value (28.5 mg/L) of 51 hardness observations at station OUA0018 from 1/17/1995 through 3/27/07.

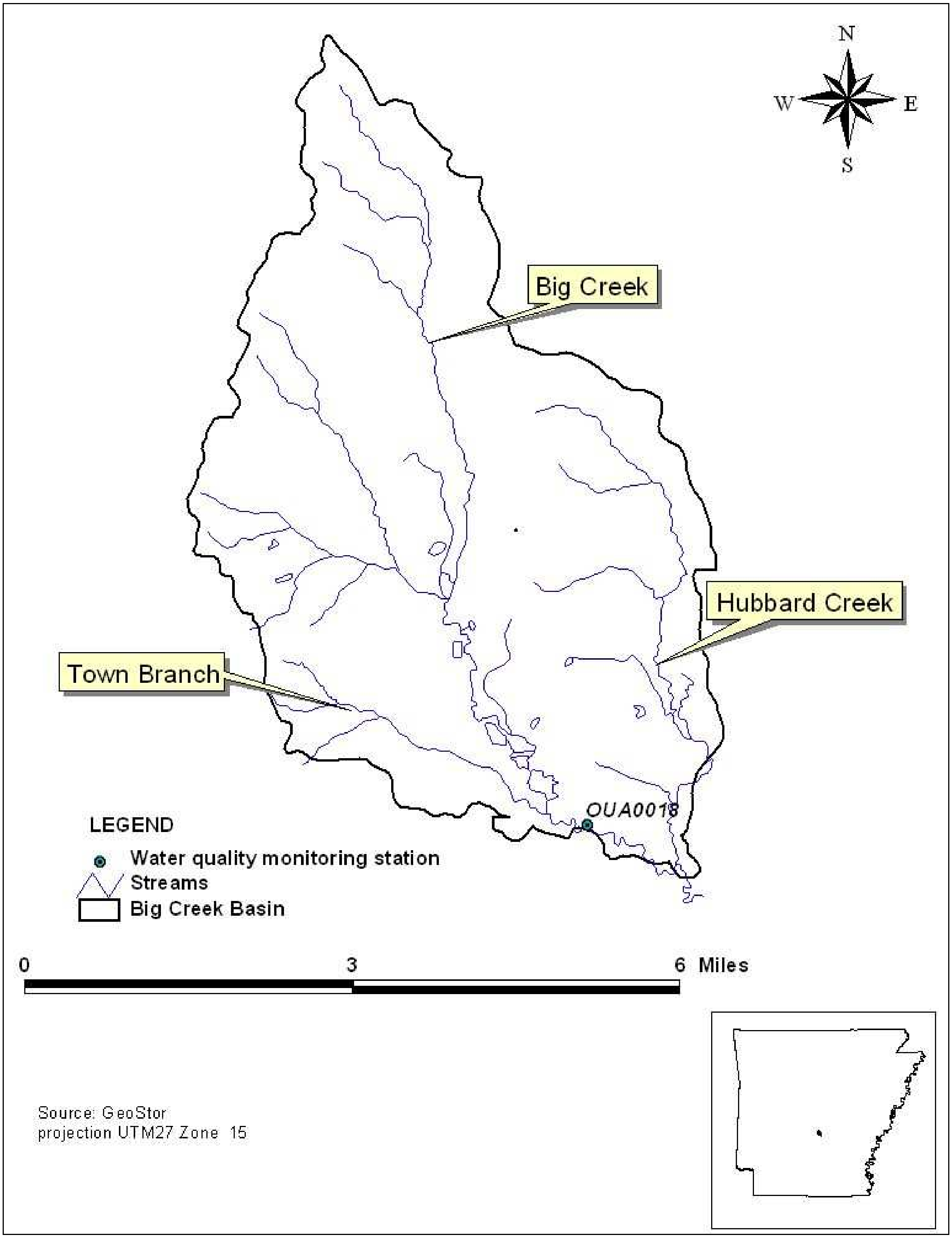

Figure 3-1. Location of the water quality monitoring station in the Big Creek Basin.

3.2 Trends and Patterns in Observed Data

3.2.1 Siltation/Turbidity

Turbidity and TSS observations at station OUA0018 do not show a strong correlation with season. High turbidity and TSS levels were observed during low flows; however, not enough samples were collected during high flows to allow a valid comparison. Appendix C contains the turbidity and TSS sampling results plotted over time, seasonally, and versus flow.

~~3.2.2 Lead~~

~~The highest dissolved lead concentrations at station OUA0018 were observed during the month of May and usually during low-flow conditions. This observation could indicate a point source of dissolved lead to the creek. Otherwise, higher concentrations would be expected at high-flow conditions after a precipitation event, when dissolved lead associated with runoff could be washed off the surrounding land into the waterbody. However, not enough samples were collected during high flows to allow a valid comparison. Appendix D contains the dissolved lead sampling results plotted over time, seasonally, and versus flow.~~

4 TMDL DEVELOPMENT

A TMDL is the total amount of a pollutant that can be assimilated by the receiving waterbody while still achieving water quality standards. In TMDL development, allowable loadings from all pollutant sources that cumulatively amount to no more than the TMDL must be established, thereby providing the basis for establishing water quality-based controls.

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include an implicit or explicit margin of safety (MOS) to account for the lack of knowledge in the relationship between pollutant loads and the water quality of the receiving waterbody. The TMDL components are illustrated using the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

TMDLs are generally expressed on a mass loading basis (e.g., kilograms per day).

4.1 TMDL Analytical Approach

The methodology used to determine the TMDLs for Big Creek is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represents a continuum of desired loads over all flow conditions, rather than a fixed, single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment Web site (KDHE 2003). This method was used to illustrate allowable loading for a wide range of flows. The steps for applying this methodology to develop the TMDLs in this report can be summarized as follows:

1. Develop a flow duration curve.
2. Convert the flow duration curve to load duration curves for each impairment.
3. Plot the observed loads with load duration curves.
4. Calculate the TMDL, MOS, WLA, and LA (see Section 4.2).
5. Calculate the loadings required to meet Arkansas's water quality standards.

4.1.1 Flow Duration Curve

A flow duration curve was developed for the USGS gauge used for these TMDLs. Daily stream flow measurements from the USGS gauge were sorted in increasing order, and the percentile ranking of each flow was calculated. The load duration curve methodology requires that the same flow period be used for both developing the flow duration and calculating observed loads from sampling data.

Figure 4-1 is the flow duration curve for Big Creek Baisn. The plot shows the flow (e.g., cubic feet per second) on the Y axis. The X axis shows the percentage of days on which the plotted flow is exceeded. Points at the low end of the plot (0 through 10 percent) represent high-flow conditions, where only 0 through 10 percent of the flow exceeds the plotted point. Conversely, points at the high end of the plot (90 to 100 percent) represent low-flow conditions.

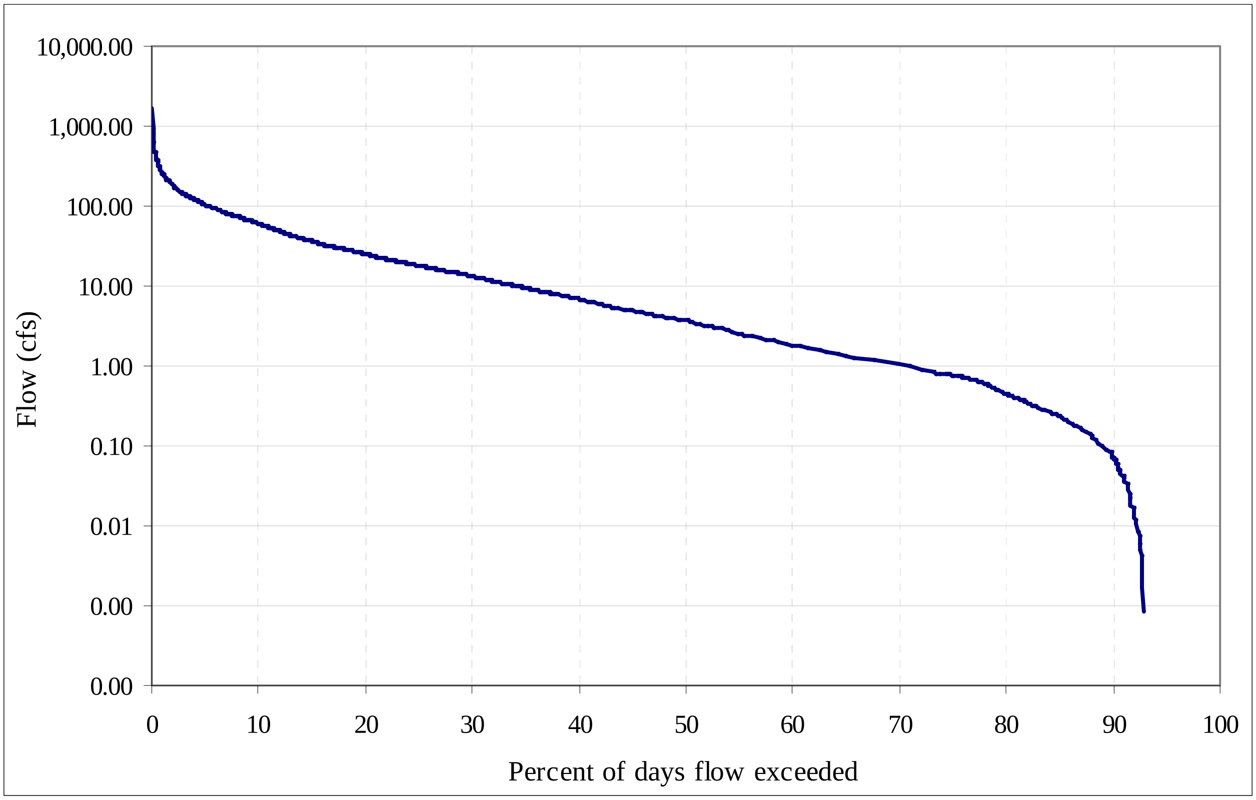

Figure 4-1. Flow duration curve for Big Creek Basin

Because there was no active USGS gauge in the area of concern, a nearby gauge in a similar watershed (Hurricane Creek watershed) was assigned to the segment to represent flow. Table 4-1 presents the USGS gauge that was used, the period of record used in the TMDL analysis, and the segment represented. Flows were area weighted for each stream segment and those flows were used to create a unique flow duration curve for each segment.

For the TMDL calculations, the most recent flow data were used. Data from 1995 through the present were used for USGS station 07363400.

Table 4-1. USGS flow gauge and represented segments for the Big Creek Basin

Station number	Station name	Drainage Area (square miles)	Period of record used in TMDL development	HUC-reachs represented
07363400	Hurricane Creek near Sheridan, AR	261	11/05/1995–10/22/2006	08040203-904

4.1.2 Load Duration Curve

~~For each TMDL parameter (dissolved lead and siltation), t~~The flows from the flow duration curves were multiplied by the appropriate numeric criterion concentration (Table 2-5) to compute an allowable load duration curve. Each load duration curve is a plot of mass per day versus the percent flow exceedance from the flow duration curves.

The load duration curve is beneficial when analyzing monitoring data with their corresponding flow information plotted as a load. This approach allows the monitoring data to be placed in relation to their position in the flow continuum. Assumptions of the probable source or sources of the impairment can then be made from the plotted data. The load duration curve shows the calculation of the TMDL at any flow rather than at a single critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. This approach will allow analysis of load cases in the future for different flow regimes.

Turbidity is a measure of the water's optical properties that cause light to be scattered or absorbed, therefore, the load duration curve and the percent reduction were based on a surrogate parameter, TSS. Turbidity can be affected by different suspended particles, such as clay, silt, and microorganisms, many of which are the same substances that form TSS. Turbidity can also be affected by algae and water color; however, for the~~se~~ TMDL~~s~~, TSS is assumed the dominant source of turbidity. Because Arkansas has not developed numeric criteria for TSS, a regression analysis of turbidity and TSS data was performed.

The original correlation between TSS and turbidity was poor (R^2 = 0.27) at Big Creek water quality monitoring station OUA0018. Therefore, the data set was divided and separate regressions were done for "storm flow conditions" (upper 60 percent of flows) and "base flow conditions" (lower 40 percent of flows). This approach resulted in better correlations and R^2 values of 0.47 and 0.58 for storm flow and base flow conditions, respectively. These values demonstrate that there is a correlation between turbidity and TSS, albeit not strong, and that TSS can be used as a surrogate. Table 4-2 presents the regression equations and results.

Table 4-2. Surrogate turbidity, TSS, and siltation criteria for the Big Creek Basin

Flow condition	Regression equation[a]	R^2 value	Turbidity endpoint (NTU)	Calculated TSS endpoint (mg/L)
Base flow	y = 1.2544x + 5.1041	0.5799	21	12.67
Storm flow	y = 0.9734x + 14.911	0.4675	32	17.56

[a] Turbidity is *y* and TSS is *x*.

4.1.3 Observed Loads

For each sampling station, observed loads were calculated by multiplying the observed concentration of the parameter of concern by the flow on the sampling day. These observed loads were then plotted versus the percent flow exceedance of the flow on the sampling day and placed on the same plot as the load duration curve. Reductions were applied to the observed loads for each parameter until its water quality criteria and allowable percent exceedance were met to obtain an overall percent reduction for each reach. These plots are shown in the appendices to this report as follows:

Appendix E: Load Duration Calculations for All TMDLs (CD-ROM)
Appendix F: Load Duration Curve Summaries and Plots for Siltation/Turbidity
~~Appendix G: Load Duration Curve Summaries and Plots for Dissolved Lead~~

These plots provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions under which observed water quality concentrations exceed the numeric criterion concentrations. Observed loads plotted below the load duration curve represent conditions under which observed water quality concentrations are less than the numeric criterion concentrations (i.e., do not exceed the water quality standards).

4.2 TMDL

~~Each~~ The TMDL was calculated as the area under the load duration curve. Table 4-3 presents the siltation ~~and dissolved lead~~ TMDLs and allocations for Big Creek (segment 904).

Both section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for lack of knowledge in the available data or in the actual effect that controls will have on the loading reductions and receiving water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly by using conservative assumptions in establishing the TMDL. For a more detailed discussion of the MOS, see section 4.4.

Table 4-3. Summary of TMDLs, MOS, WLAs, and LAs for the Big Creek Basin

HUC-reach number	Water quality station	Pollutant	Total allowable loading	MOS	Σ WLA	Σ LA
			lb/day			
~~08040203-904~~	~~OUA0018~~	~~Dissolved lead~~	~~0.0710~~	~~0.0071 (explicit; 10%)~~	~~0.0008~~	~~0.0631~~
08040203-904	OUA0018	TSS (stormflow)	3,433.4	Implicit	0.0	3,433.4
08040203-904	OUA0018	TSS (baseflow)	40.9	Implicit	0.0	40.9

4.3 Wasteload Allocation

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. The only point source in the Big Creek Basin is a wastewater treatment facility.

~~No domestic wastewater facilities with permit limits for lead could be found in the Big Creek Basin, although it is possible that discharges from such facilities could have slightly elevated levels of lead. Permit limits might not be assigned if a waterbody receiving the discharge is not listed and thus the discharge does not adversely affect water quality in the waterbody, or if the effluent from a facility does not contain a particular pollutant. For impaired waterbodies, permit limits are typically assigned. ADEQ designates permit limits during the permitting process on a case-by-case basis.~~

~~As noted above, because domestic wastewater facilities might discharge lead, the WWTP was given a WLA using facility flow and water quality criteria. As long as point source discharges of treated wastewater contain parameter levels at or below these permit limits, they should not cause exceedances of the state's water quality criteria.~~

The siltation WLA for the WWTP were set to zero because the surrogate being used for turbidity, TSS, is considered to represent inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension). The suspended solids discharged by point sources in Big Creek are assumed to consist primarily of organic solids rather than inorganic solids. Discharges of organic suspended solids from point sources are already addressed by ADEQ through their permitting of point sources to maintain water quality standards for dissolved oxygen.

~~Table 4-4 lists the individual lead WLA for the point source in the Big Creek Basin. Both dissolved and total lead WLAs are presented. Federal regulations at Title 40 of the *Code of Federal Regulations* [CFR] Part 130 require permit limits to be expressed as total metals. WLAs for dissolved metals are provided to allow a comparison with the TMDLs in Table 4-3. The total lead value was derived from the dissolved water quality criteria using the translator mechanism described in Attachment V of the *State of Arkansas Continuing Planning Process* (ADEQ 2000).~~

~~**Table 4-4. Dissolved Lead WLAs for the Big Creek Basin**~~

~~Permit number~~	~~Outfall~~	~~Permitted flow (gpd)~~	~~Estimated dissolved lead limit (μg/L)~~	~~Dissolved lead load (lb/day)~~	~~Total lead load (lb/day)~~
~~AR0034347~~	~~001~~	~~676,000~~	~~0.7~~	~~0.0008~~[a]	~~0.0039~~[a]

[a] ~~During reduced flow conditions, these loads will be based on the facility discharge and water quality criteria. For instance if the flow is 460,000 gpd the loads would be 0.00054 lb/day and 0.0027 lb/day for dissolved and total lead respectively.~~

4.4 Load Allocation

The LA is the portion of the TMDL assigned to natural background loadings, as well as nonpoint sources like urban runoff and agricultural practices. For this TMDL, the LA was calculated by subtracting the WLA and MOS from the total TMDL. LAs were not allocated to separate nonpoint sources because there was a lack of available source characterization data. The LAs are presented in Tables 4-2 and 4-3.

4.5 Margin of Safety

The MOS is the portion of the pollutant loading reserved to account for any lack of knowledge in the data. There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate it by using conservative model assumptions to develop the allocations. The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations. In this analysis, for all pollutants except turbidity, the MOS is explicit: 10 percent of each targeted TMDL was reserved as the MOS to account for any lack of knowledge in the TMDL. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the reaches of concern. For the turbidity TMDL, an implicit MOS was incorporated by using conservative assumptions. The primary conservative assumption was calculating the turbidity TMDLs assuming that TSS is a conservative parameter and does not settle out of the water column.

4.6 Seasonality and Critical Conditions

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for stream flow, loading, and water quality parameters. For this TMDL, the sampling results for all pollutants were plotted over time and reviewed for any seasonal patterns (see Section 3.2).

By accounting for critical conditions, the TMDL makes sure that water quality standards are maintained for infrequent occurrences and not only for average conditions.

Because of the way the criteria are written (i.e., including critical and noncritical conditions), the TMDL for a pollutant of concern can be developed by reviewing pollutant loads at all flow conditions within applicable periods of the year and evaluating the percentage of values exceeding the criteria. The load duration curve, which determines the allowable loading at a wide range of flows, was chosen as the approach for the~~se~~ TMDL~~s~~ (see Section 4.1). Therefore, the TMDL~~s were~~ was calculated at all flows rather than at a single critical flow.

4.7 Future Growth

Compliance with the~~se~~ ~~lead and~~ turbidity/siltation TMDL~~s~~ is based on keeping loadings in the stream below the assimilative capacity of the stream. Allocations between the WLA and LA may be re-evaluated if there is future growth of existing or new point sources discharging to the impaired reaches or their tributaries.

5 FUTURE WATERSHED ACTIVITIES

In accordance with section 106 of the federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the state's surface waters. ADEQ collects surface water samples at various locations, using appropriate sampling methods and procedures to ensure the quality of the data collected. One of the locations where ADEQ will continue to monitor water quality is Big Creek downstream of Sheridan (OUA0018). The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term database for long-term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the state's biennial 305(b) report and 303(d) list of impaired waters, which were most recently published as the *State of Arkansas 2004 Integrated Water Quality Monitoring and Assessment Report* (ADEQ 2005).

6 PUBLIC PARTICIPATION

The federal regulations at 40 CFR 130.7(c)(1)(ii) specify that TMDLs "shall be subject to public review as defined in the State's CPP." The~~se~~ TMDL~~s~~ ~~were~~ was developed under contract to EPA, and EPA held a public review period seeking comments, information, and data from the public and any other interested parties. The notice for the public review period was published in the *Federal Register* on December 17, 2007, and the review period closed on January 16, 2008.

Audubon Arkansas submitted general comments for several TMDLs listed in the same public notice. The city of Sheridan submitted comments specific to this TMDL document. Comments and additional information submitted during the public comment period were used to inform or revise this TMDL document. The comments and responses to the~~se~~ TMDL~~s~~, along with comments on similar TMDLs with the same public review period, will be included in the document: *EPA Responses to Comments for TMDLs in the Big Creek, Caddo River, Cornie Bayou, Bayou de L'Outre, Ouachita River, and Saline River Basins, in Arkansas.*

EPA will submit the final TMDL~~s~~ to ADEQ for implementation and incorporation into ADEQ's current water quality management plan.

7 REFERENCES

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Appendix A
Summary of Water Quality Data

Table A-1. Summary of turbidity data for Big Creek

Pollutant	Station number	Station name	Period of record	Number of observations	Minimum	Maximum	Mean	Median	Number of observations above criterion[a]	% of observations above criterion[a]
					NTU	NTU	NTU	NTU	Primary/ storm flow	Primary/ storm flow
Turbidity	OUA0018	Big Creek downstream of Sheridan, AR	9/4/90–4/24/07	145	1.2	143	31	28	96/50	66/34

[a] The water quality data were compared to the primary and storm flow values for SI, which are 21 and 32 NTU, respectively.

Table A-2. Summary of TSS data for Big Creek

Pollutant	Station number	Station name	Period of record	Number of observations	Minimum	Maximum	Mean	Median	Number of observations above criterion[a]	% of observations above criterion[a]
					mg/L	mg/L	mg/L	mg/L		
TSS	OUA0018	Big Creek downstream of Sheridan, AR	9/4/90–4/24/07	142	1	216	21.03908	14	NA	NA

[a] There are no TSS water quality criteria to which TSS data could be compared.

~~**Table A-3. Summary of dissolved lead data for Big Creek**~~

~~Pollutant~~	~~Station number~~	~~Station name~~	~~Period of record~~	~~Number of observations[a]~~	~~Minimum~~	~~Maximum~~	~~Mean~~	~~Median~~	~~Number of observations above criterion[b]~~	~~% of observations above criterion[b]~~
					~~µg/L~~	~~µg/L~~	~~µg/L~~	~~µg/L~~		
~~Dissolved lead~~	~~OUA0018~~	~~Big Creek downstream of Sheridan, AR~~	~~1/19/99–3/27/07~~	~~33~~	~~0.2~~	~~1.33~~	~~0.42~~	~~0.30~~	~~7~~	~~21~~

[a] ~~Note that 15 lead observations were below the detection limit (DL) of 0.4 µg/L; therefore one-half the DL was used for data analysis.~~
[b] ~~The water quality data were compared to the chronic water quality criterion for dissolved lead, which is 0.6 µg/L.~~

Appendix B
Water Quality Data by Sampling Location

Table B-1. Dissolved lead and hardness data at station OUA0018

Date collected	Dissolved lead	Hardness
	(µg/L)	(mg/L)
1/17/1995		19
2/21/1995		21
3/21/1995		18
4/11/1995		8
5/30/1995		29
6/27/1995		37
12/12/1995		92
1/16/1996		40
2/20/1996		40
3/26/1996		29
4/16/1996		20
4/30/1996		22
6/11/1996		18
7/9/1996		35
9/24/1996		29
11/19/1996		26
1/7/1997		18
3/18/1997		19
1/6/1998		17
1/19/1999	0.3	24
3/8/1999	0.55	17
5/18/1999	1.04	24
5/30/2000	0.71	35
11/14/2000	0.2	77.7
1/30/2001	0.2	13
3/20/2001	0.2	17
5/22/2001	1.04	23
7/17/2001	0.2	53
9/4/2001	0.2	59
11/6/2001	0.2	55
1/2/2002	0.2	17
3/5/2002	0.2	13
5/7/2002	0.53	15
1/28/2003	0.2	20
3/18/2003	0.2	23
5/20/2003	0.8	17
7/22/2003	0.67	21
1/20/2004	0.58	19
3/9/2004	0.2	20
5/25/2004	1.33	27
7/27/2004	0.2	42
8/31/2004	0.2	73
11/9/2004	0.44	
3/22/2005	0.39	17
5/17/2005	0.42	30

Table B-1 (continued)

Date collected	Dissolved lead	Hardness
	(µg/L)	(mg/L)
9/26/2005	0.25	19
1/17/2006	0.66	21
3/28/2006	0.2	21
5/30/2006	0.4	37
9/26/2006	0.43	18
1/30/2007	0.2	26
3/27/2007	0.48	22

Table B-2. Turbidity and TSS data at station OUA0018

Date collected	Turbidity	TSS
	(NTU)	(mg/L)
9/4/90	17	14
10/2/90	23	45
10/30/90	28	14
11/27/90	5.9	6
1/22/91	9	10
2/19/91	46	4
3/26/91	17	8
4/16/91	25	22
5/7/91	30	22
6/4/91	18	15
7/2/91		20
7/30/91	56	38
9/17/91	8.5	35
10/8/91	28	38
11/12/91	7.8	10
12/10/91	34	25
1/28/92	15	6
2/25/92	17	10
3/3/92	12	9
4/7/92	22	15
5/19/92	16	10
6/22/92	29	18
7/14/92	14	11
8/11/92	20	17
11/23/92	44	20
1/5/93	44	32
2/2/93	14	14
3/2/93	45	65
3/30/93	10	6
5/4/93	26	23
6/1/93	33	13
6/14/93	28	11.5
10/12/93	24	1
11/16/93	22	12

Table B-2. (continued)

Date collected	Turbidity (NTU)	TSS (mg/L)
12/21/93	12	4.5
1/11/94	28	27
2/22/94	105	216
3/1/94	16	7
4/12/94	52	75.5
5/17/94	28	13.5
7/5/94	32	26
8/2/94	25	5.5
8/30/94	20	30
10/11/94	53	50
11/8/94	30	14
12/6/94	17	7.5
1/17/95	17	6
2/21/95	14	10
3/21/95	18	13.5
4/11/95	58	106.5
5/30/95	21	8
6/27/95	26	17
12/12/95	19	21.5
1/16/96	2.5	9.5
2/20/96	61	55
3/26/96	35	20
4/16/96	20	
4/30/96	34	14.5
6/11/96	41	10
7/9/96	25	16
9/24/96	24	9.5
11/19/96	29	8.5
12/10/96	18	4.5
1/7/97	20	6.5
2/4/97	64	
3/18/97	18	12
4/22/97	14	12.5
5/20/97	18	10
6/10/97	24	11
7/8/97	28	9.5
8/5/97	28	3
12/9/97	27	5.5
1/6/98	67	
2/3/98	22	13
3/3/98	22	9.5
3/31/98	29	55.5
5/5/98	30	6.5
12/21/98	29	6

Table B-2. (continued)

Date collected	Turbidity (NTU)	TSS (mg/L)
1/19/99	17	3
2/9/99	20	12.5
3/8/99	38	41.6
4/13/99	21	22
5/18/99	40	
6/8/99	28	14
12/20/99	16	27.5
4/11/00	32	44
5/30/00	48	36.5
6/27/00	29	24.5
11/14/00	38	44.7
1/30/01	40	25.3
2/20/01	11	8.2
3/20/01	12	12.8
4/24/01	25	21.3
5/22/01	34	27
6/19/01	27	13.75
7/17/01	35	35.5
9/4/01	48	31.3
10/2/01		
11/6/01	1.2	21
12/11/01	23	20.3
1/2/02	16	3.8
2/12/02	19	15.5
3/5/02	15	3.2
4/2/02	22	12.3
5/7/02	38	33.5
6/4/02	38	29.5
12/10/02	55.9	38.5
1/28/03	15.6	5
2/18/03	27.5	10.5
3/18/03	16	16.8
4/15/03	19.5	12.5
5/20/03	53.6	34.8
6/24/03	46.2	12.5
7/22/03	34.8	11.8
8/19/03	8.21	4.8
10/21/03	16.1	11.8
1/20/04	33.8	9.2
2/10/04	33.2	10.2
3/9/04	28.1	10.2
4/13/04	44.1	23.2
5/25/04	67.8	37.5
7/6/04	58.9	31.2
7/27/04	25.9	7.8

Table B-2. (continued)

Date collected	Turbidity	TSS
	(NTU)	(mg/L)
8/10/04	33.3	26.8
8/31/04	41.9	26.3
10/12/04	143	50
11/9/04	40.4	15
12/14/04	27.6	11.2
2/15/05	35.7	18
3/22/05	83.1	61
4/19/05	29.7	22.2
5/17/05	54.1	16.5
9/26/05	19.8	5.5
1/17/06	56.7	29.8
1/31/06	53.2	14.2
3/28/06	31.6	5.8
4/25/06	35.4	33.5
5/30/06	41.9	15
6/20/06	67.9	39.2
8/22/06	121	70.6
9/26/06	25.9	4.5
10/24/06	32.5	16.8
12/19/06	30.1	24.5
1/30/07	13	2.5
2/27/07	30.2	6
3/27/07	18.9	4.5
4/24/07	24.7	8.8

Appendix C
Turbidity and TSS Figures for Big Creek

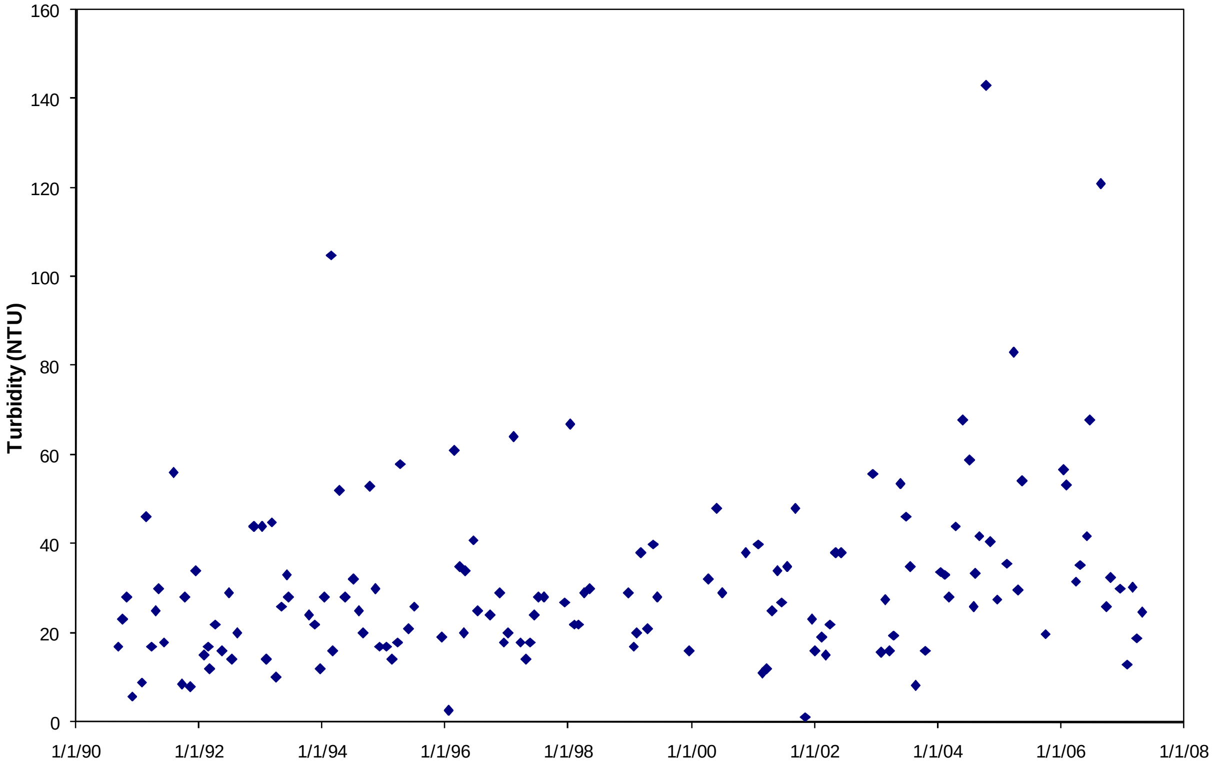

Figure C-1. Time series turbidity observations at Big Creek below Sheridan, Arkansas (station OUA0018).

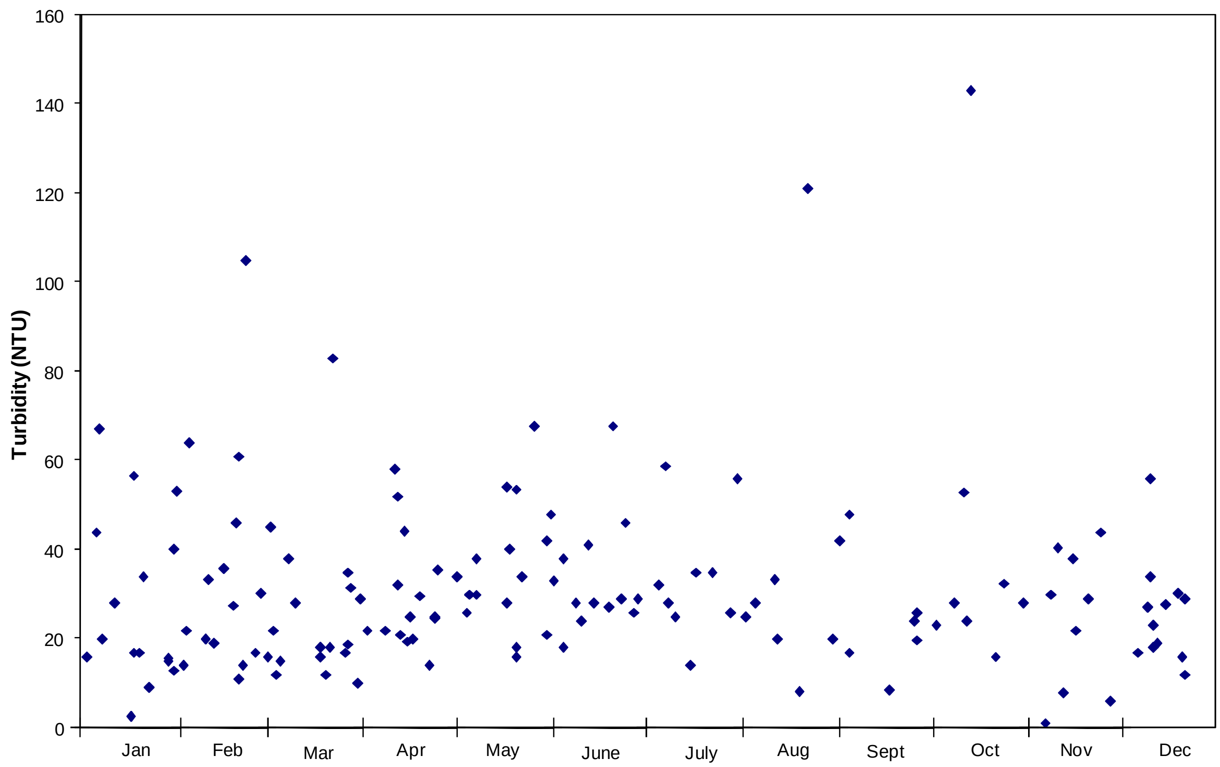

Figure C-2. Seasonal turbidity observations at Big Creek below Sheridan, Arkansas (station OUA0018).

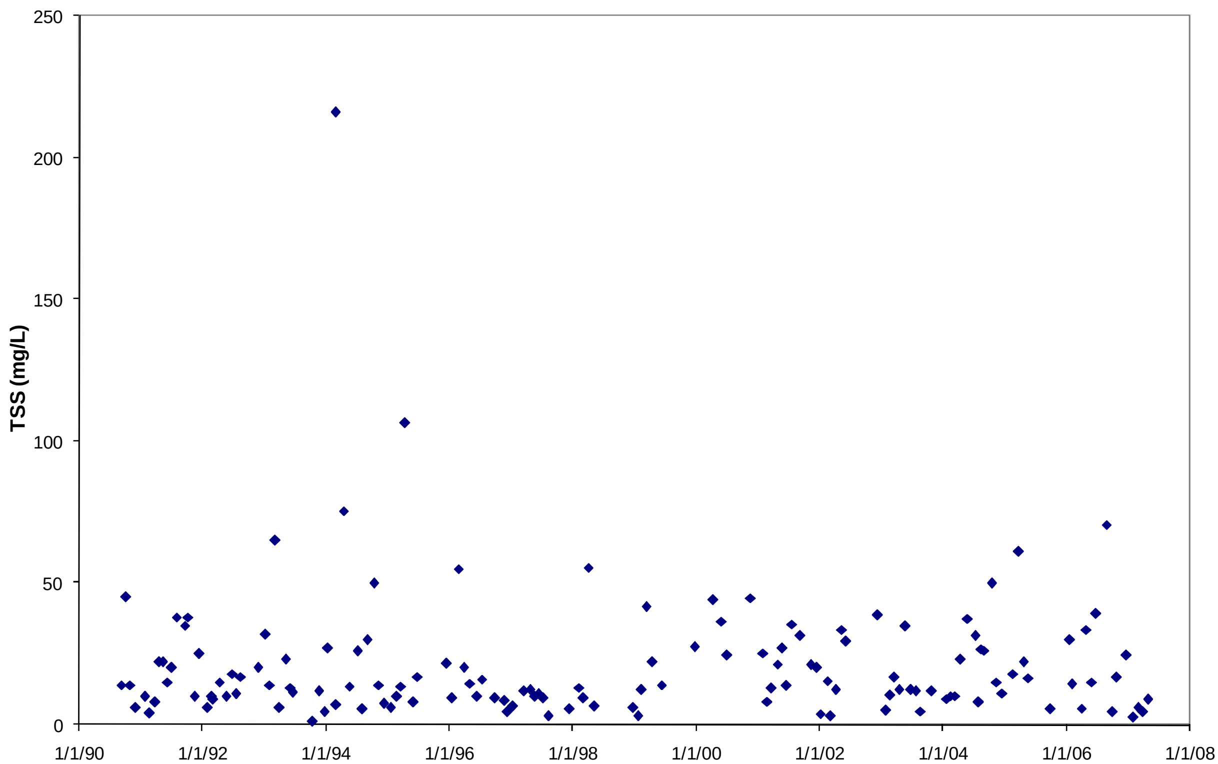

Figure C-3. Time series TSS observations at Big Creek below Sheridan, Arkansas (station OUA0018).

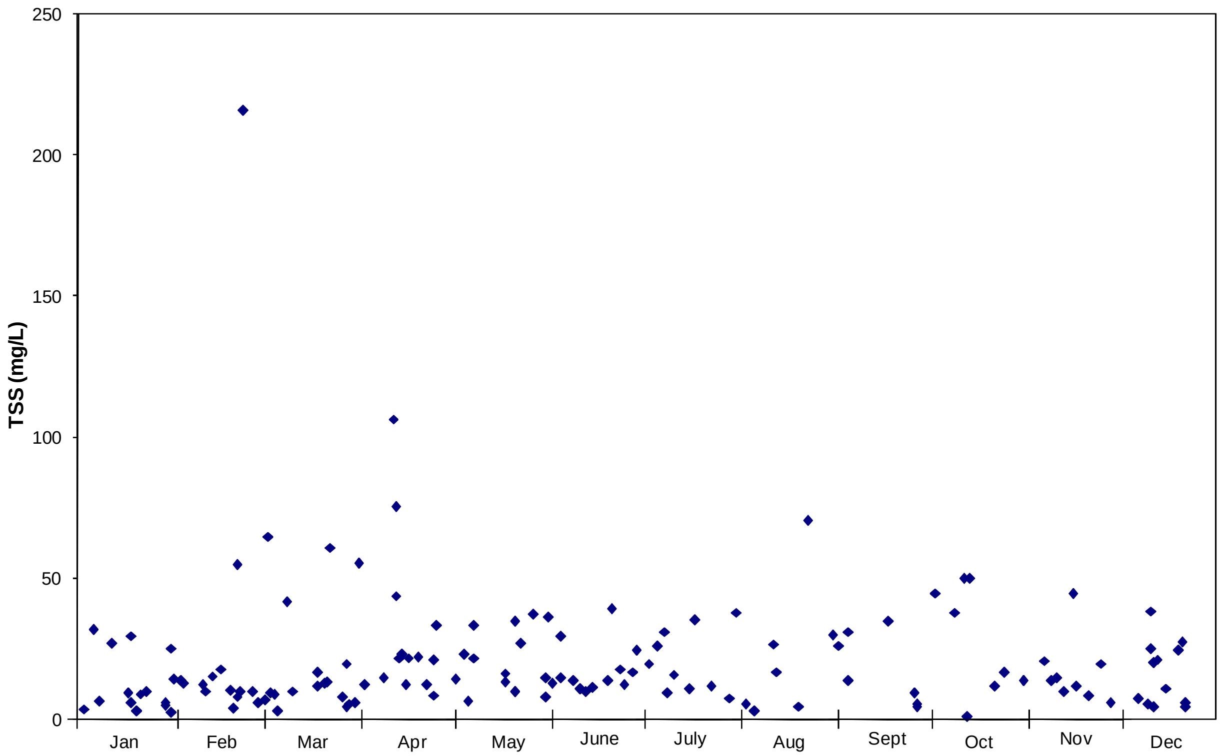

Figure C-4. Seasonal TSS observations at Big Creek below Sheridan, Arkansas (station OUA0018).

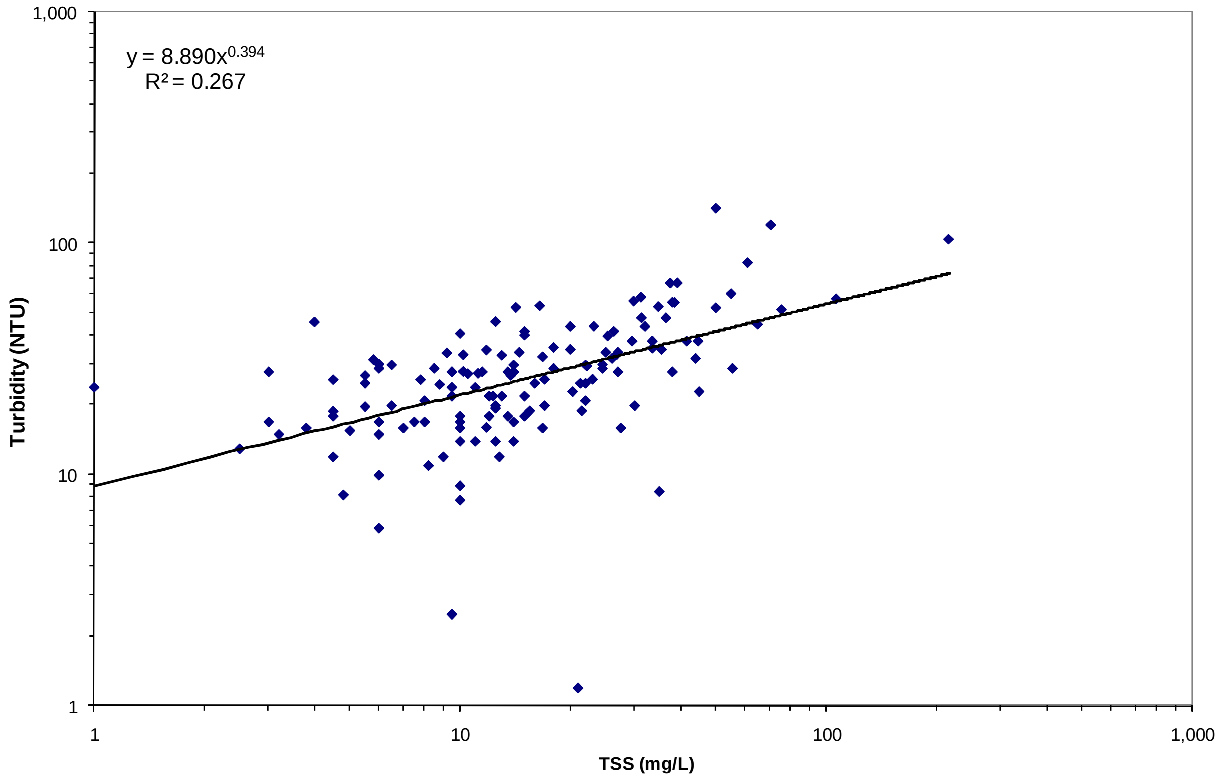

Figure C-5. TSS versus turbidity observations at Big Creek below Sheridan, Arkansas (station OUA0018).

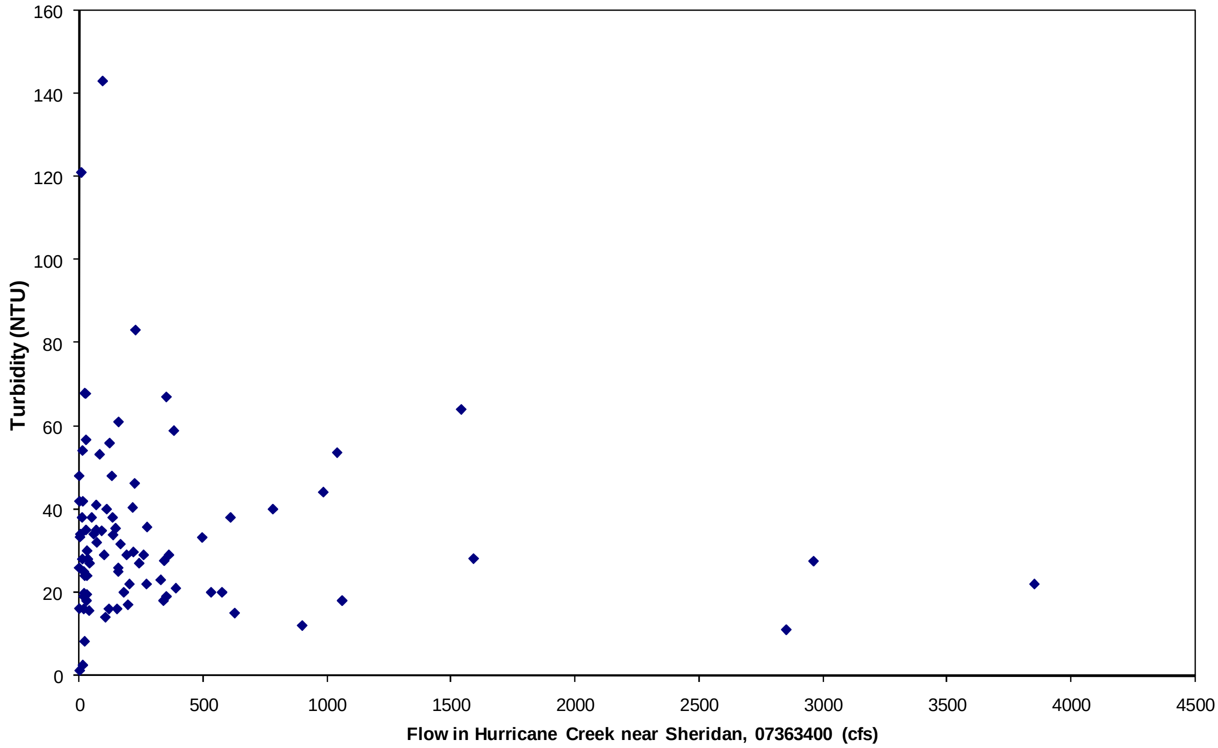

Figure C-6. Turbidity versus flow at Big Creek below Sheridan, Arkansas (station OUA0018).

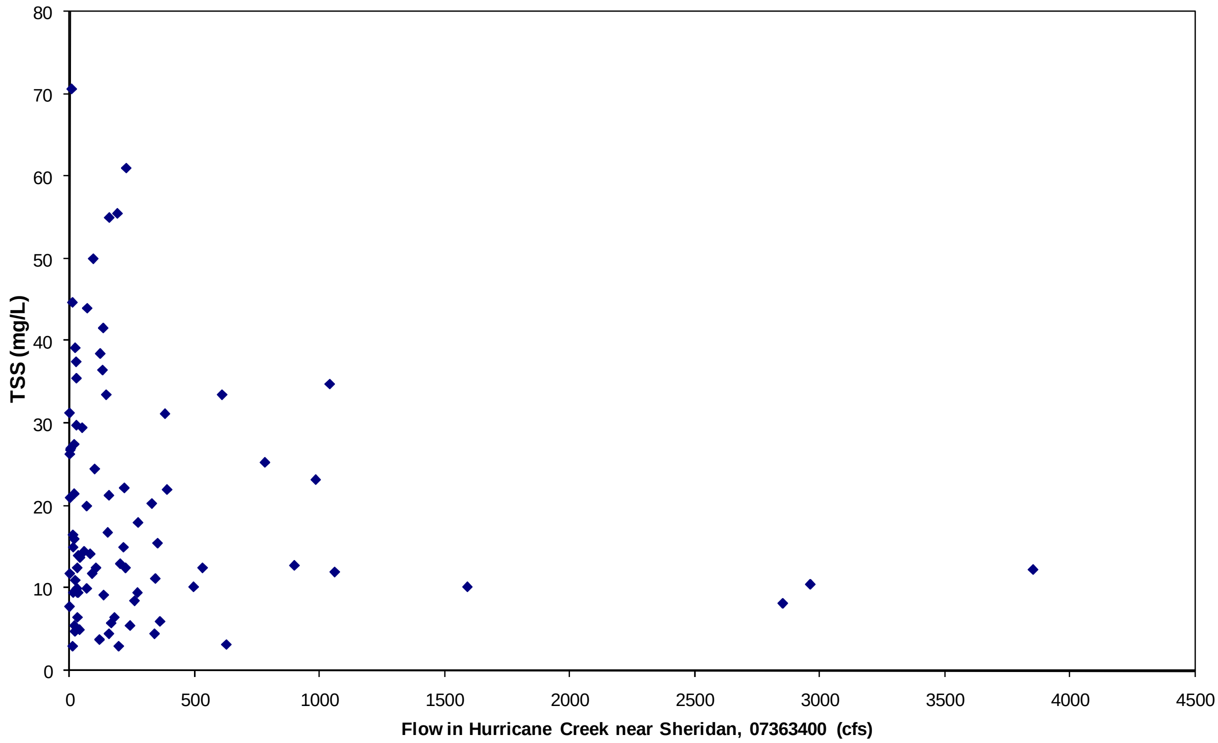

Figure C-7. TSS versus flow observations at Big creek below Sheridan, Arkansas (station OUA0018).

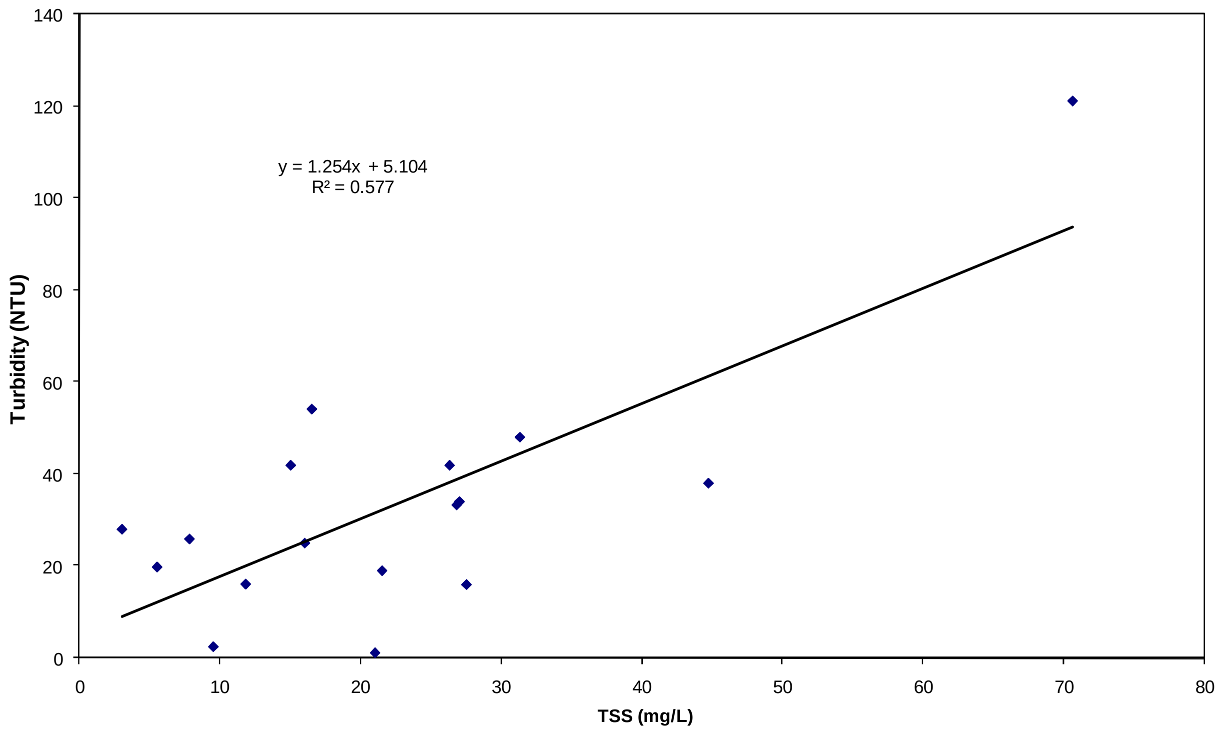

Figure C-8. Turbidity versus TSS for base flow (lower 40% of flows) at Big Creek below Sheridan, Arkansas (station OUA0018).

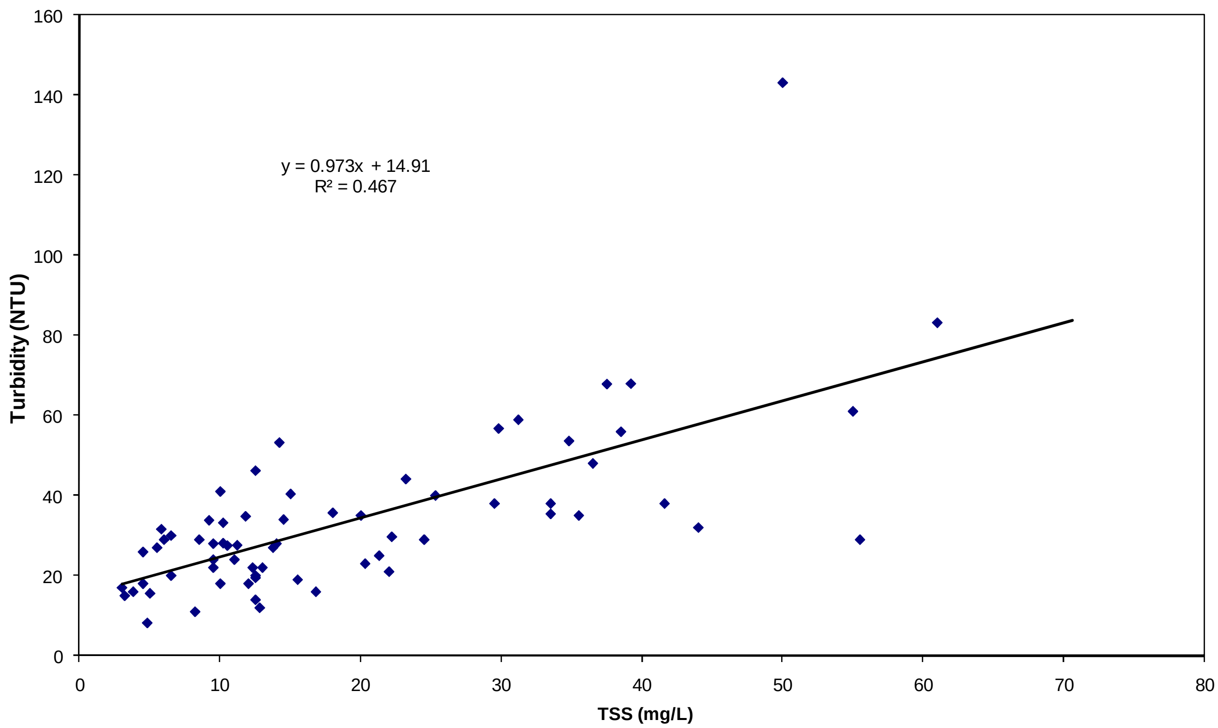

Figure C-9. Turbidity versus TSS for storm flow (top 60% of flows) at Big Creek below Sheridan, Arkansas (station OUA0018).

~~Appendix D~~
~~Lead Figures for Big Creek~~

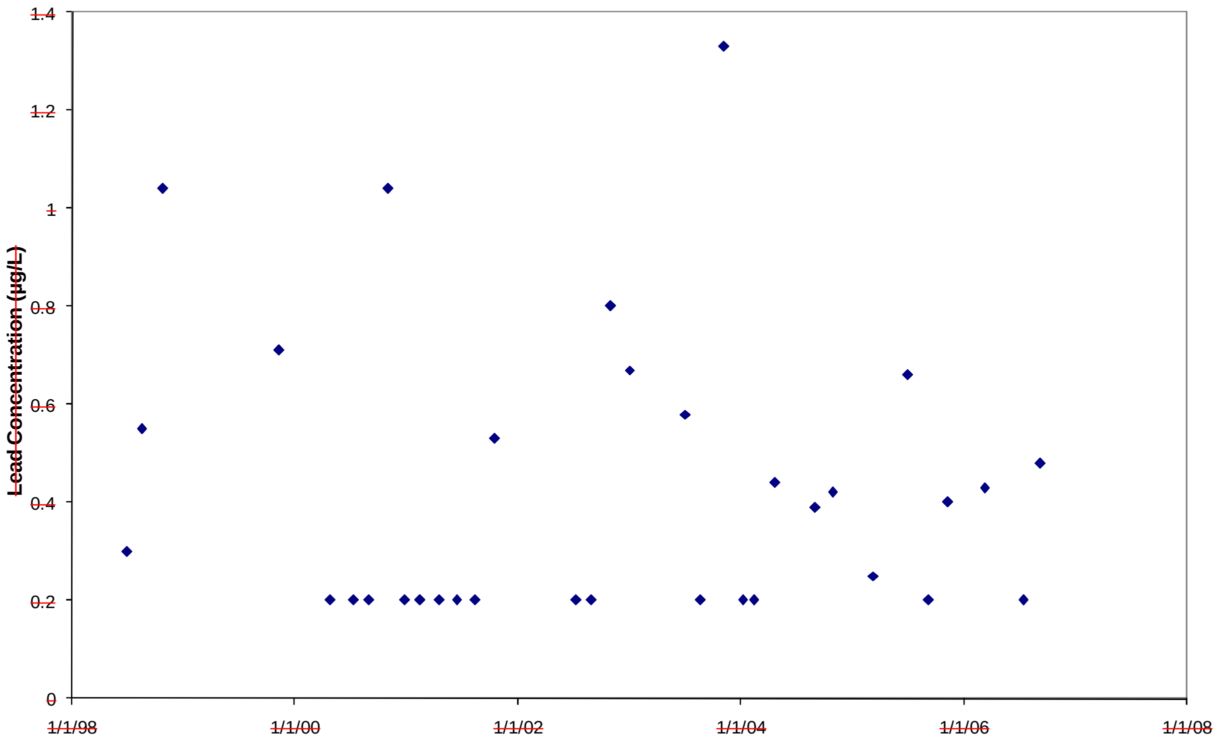

Figure D-1. Time series dissolved lead observations at Big Creek near Sheridan Arkansas (station OUA0018).

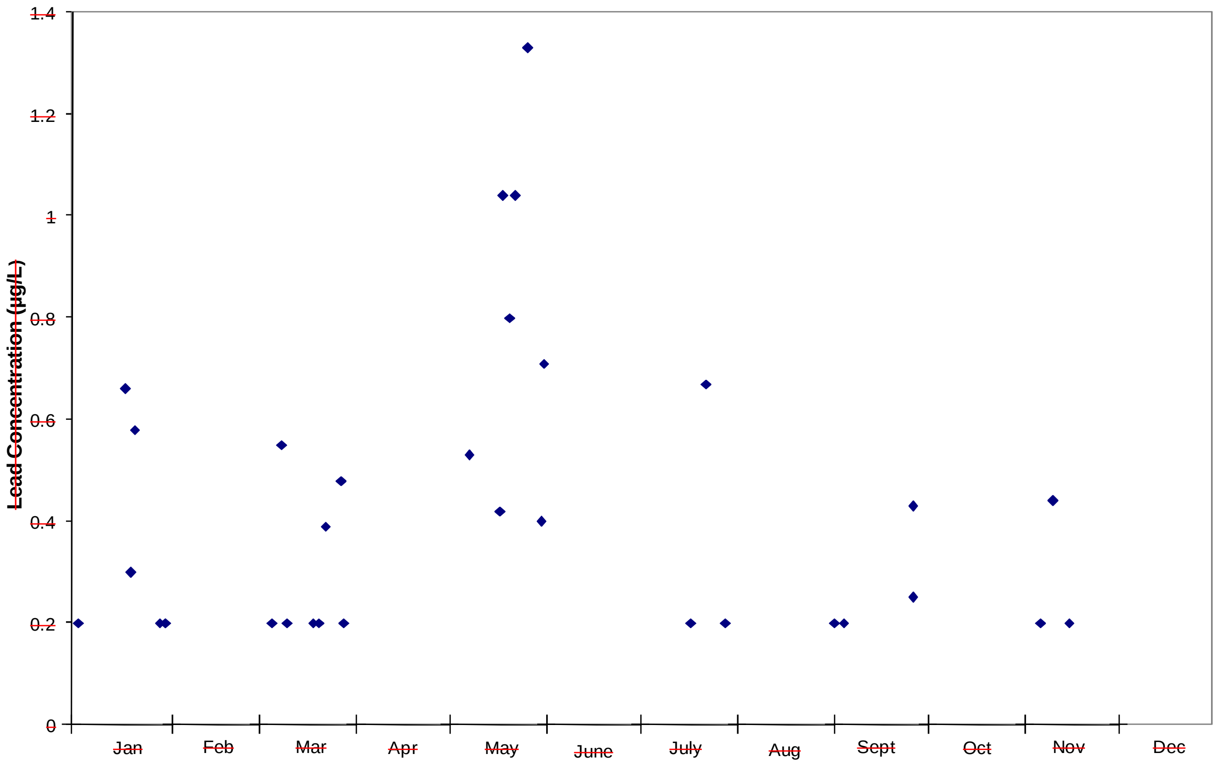

Figure D-2. Seasonal dissolved lead observations at Big Creek near Sheridan, Arkansas (station OUA0018).

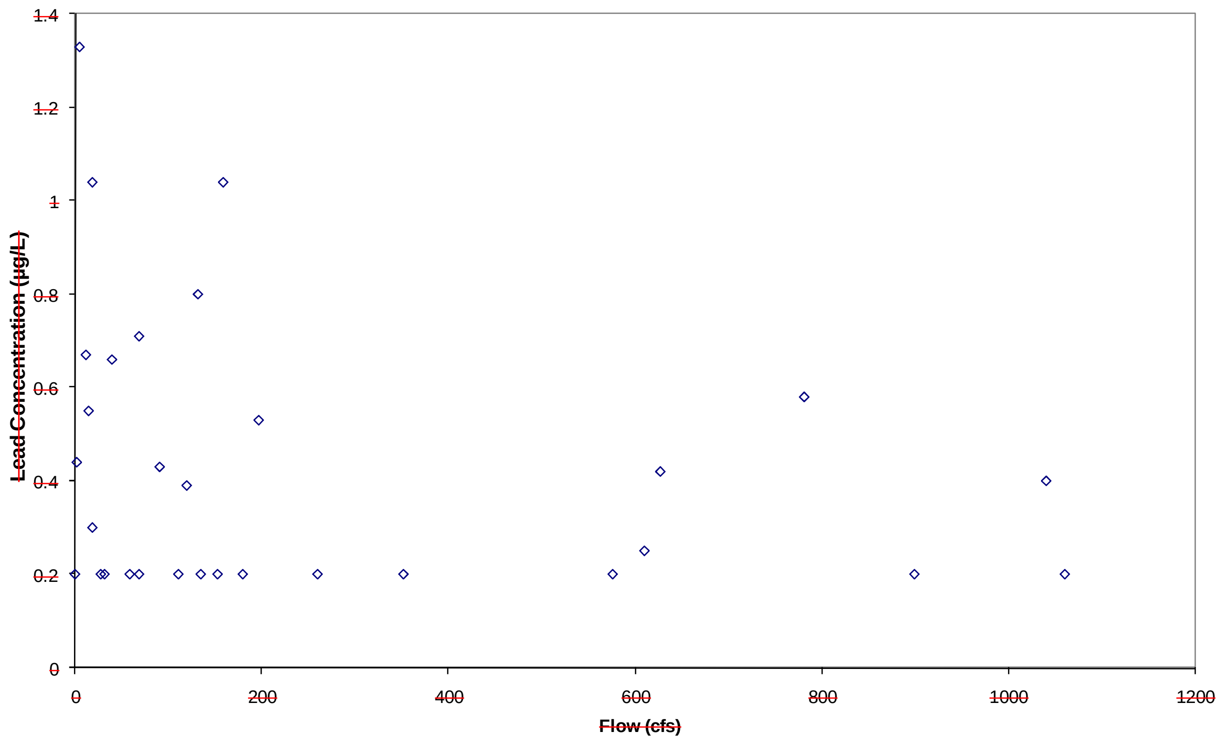

Figure D-3. Dissolved lead versus flow at Big Creek near Sheridan, Arkansas (station OUA0018).

Appendix E
Load Duration Curve Calculations for ~~All~~ TMDL~~s~~
(CD-ROM)

This appendix contains extremely large files, which are provided only on a CD-ROM. To obtain a copy of this appendix, please contact EPA.

Appendix F
Load Duration Curve Summaries and Plots for Siltation/Turbidity

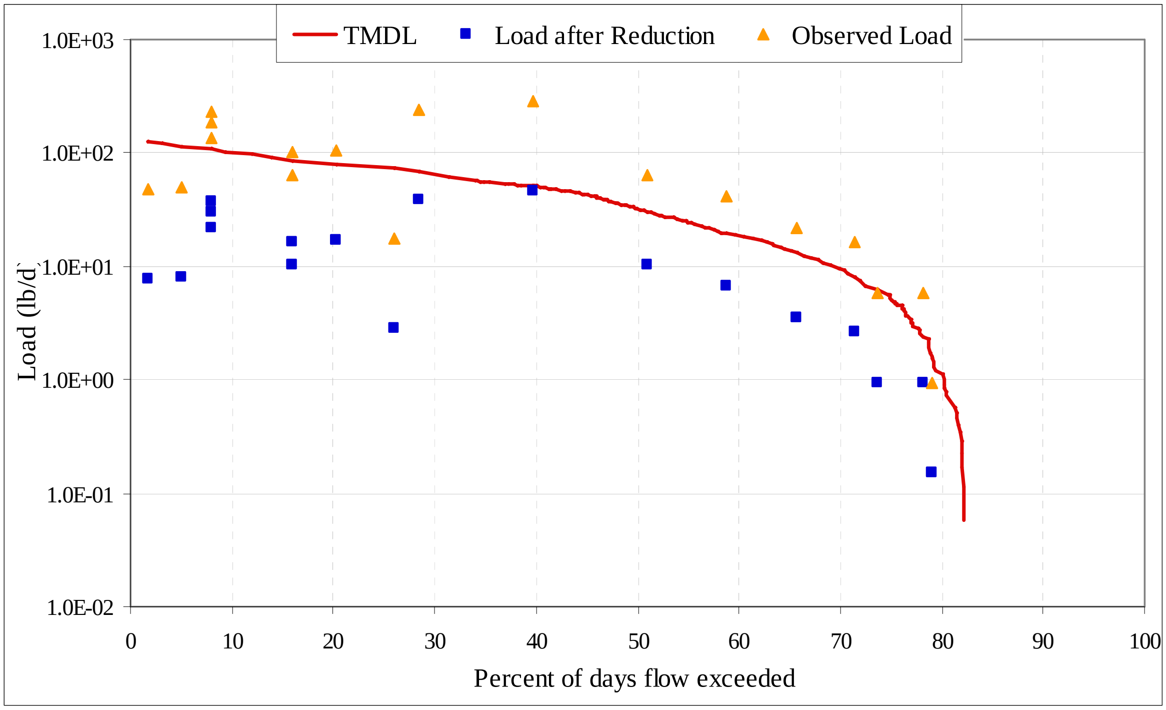

Figure F-1. Base flow TSS load duration curve for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904).

Table F-1. Base flow allowable TSS load for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						40.9
7/31/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/1/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/2/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/3/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/4/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/5/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/6/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
For brevity, most cells in this spreadsheet have been hidden						
8/10/2003	22	1.700	1.829	0.00	125.0201	0.00E+00
8/19/2003	22	1.700	1.829	0.00	125.0201	0.00E+00
11/10/2003	22	1.700	1.829	0.00	125.0201	0.00E+00
11/24/2003	22	1.700	1.829	0.00	125.0201	0.00E+00
6/21/2004	22	1.700	1.829	0.00	125.0201	0.00E+00
5/9/2005	22	1.700	1.829	0.00	125.0201	0.00E+00
3/10/2006	22	1.700	1.829	0.00	125.0201	0.00E+00
4/21/2006	22	1.700	1.829	0.00	125.0201	0.00E+00
5/25/2006	22	1.700	1.829	0.00	125.0201	0.00E+00
6/6/2006	22	1.700	1.829	1.70	125.0201	2.13E+00

Table F-2. Base flow existing load and percent reduction for TSS for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
8/22/2006	70.6	0.748	39.7	2.849E+02	4.603E+01	4.603E+01	Yes
11/14/2000	44.7	0.998	28.5	2.405E+02	3.886E+01	6.137E+01	Yes
9/4/2001	31.3	0.035	78.1	5.895E+00	9.523E-01	2.148E+00	Yes
12/20/1999	27.5	1.580	7.9	2.343E+02	3.785E+01	9.717E+01	Yes
5/22/2001	27	0.441	51	6.417E+01	1.037E+01	2.711E+01	Yes
8/10/2004	26.8	0.283	58.8	4.086E+01	6.601E+00	1.739E+01	Yes
8/31/2004	26.3	0.116	71.4	1.651E+01	2.667E+00	7.160E+00	Yes
12/12/1995	21.5	1.580	7.9	1.832E+02	2.959E+01	9.717E+01	Yes
11/6/2001	21	0.191	65.7	2.166E+01	3.499E+00	1.176E+01	Yes
5/17/2005	16.5	1.164	20.2	1.036E+02	1.673E+01	7.160E+01	Yes
7/9/1996	16	1.580	7.9	1.363E+02	2.202E+01	9.717E+01	Yes
5/30/2006	15	1.247	15.9	1.009E+02	1.630E+01	7.672E+01	Yes
10/21/2003	11.8	0.091	73.7	5.821E+00	9.403E-01	5.626E+00	Yes
1/16/1996	9.5	1.247	15.9	6.390E+01	1.032E+01	7.672E+01	Yes
7/27/2004	7.8	0.022	79.1	9.444E-01	1.526E-01	1.381E+00	Yes
9/26/2005	5.5	1.663	5	4.933E+01	7.969E+00	1.023E+02	Yes
8/19/2003	4.8	1.829	1.7	4.736E+01	7.650E+00	1.125E+02	Yes
8/5/1997	3	1.081	26	1.749E+01	2.825E+00	6.649E+01	Yes

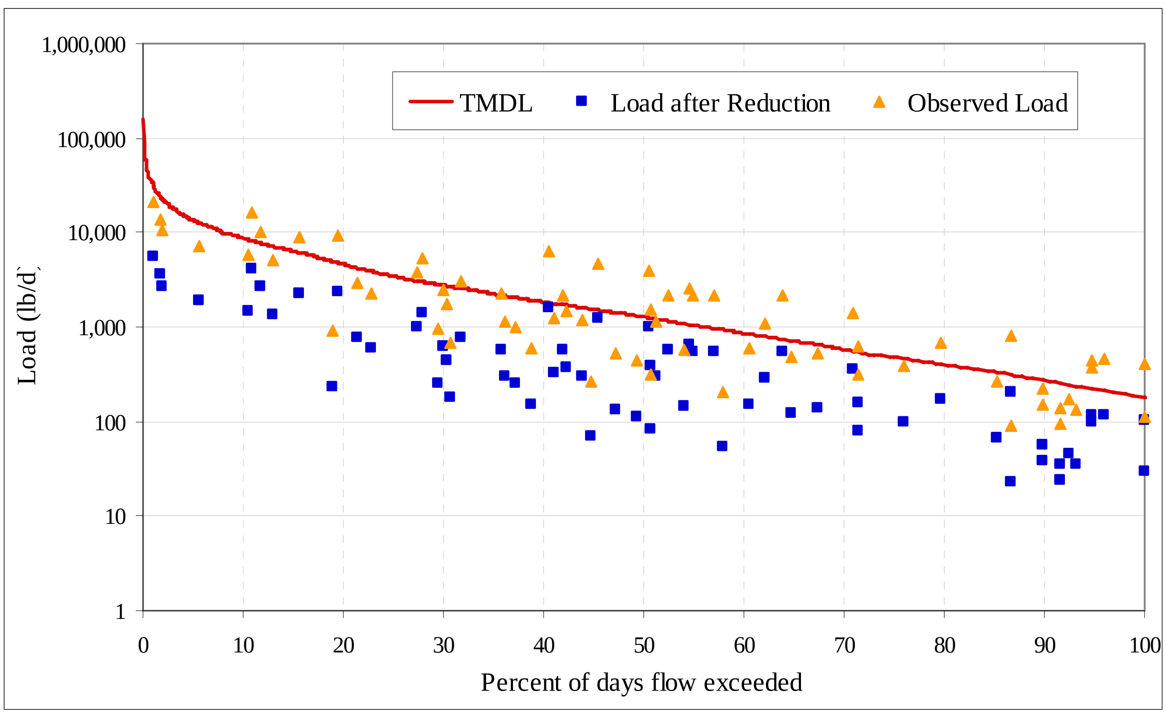

Figure F-2. Storm flow TSS load duration curve for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904).

Table F-3. Storm flow allowable TSS load for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						3,433.4
1/14/1996	23	100.000	1.912	0.00	181.0779	0.00E+00
5/22/1996	23	100.000	1.912	0.00	181.0779	0.00E+00
8/10/1996	23	100.000	1.912	0.00	181.0779	0.00E+00
6/9/1997	23	100.000	1.912	0.00	181.0779	0.00E+00
6/10/1997	23	100.000	1.912	0.00	181.0779	0.00E+00
9/28/1998	23	100.000	1.912	0.00	181.0779	0.00E+00
11/21/1998	23	100.000	1.912	0.00	181.0779	0.00E+00
7/7/1999	23	100.000	1.912	0.00	181.0779	0.00E+00
For brevity, most cells in this spreadsheet have been hidden						
4/29/1997	5690	0.400	473.077	0.00	44797.1081	0.00E+00
6/13/2003	5850	0.400	486.379	0.10	46056.7807	4.61E+01
4/1/2002	6160	0.300	512.153	0.00	48497.3964	0.00E+00
6/19/2003	6450	0.300	536.264	0.00	50780.5531	0.00E+00
2/18/2001	7330	0.300	609.429	0.10	57708.7526	5.77E+01
12/19/2001	7410	0.200	616.080	0.00	58338.5889	0.00E+00
2/17/2001	7740	0.200	643.517	0.10	60936.6637	6.09E+01
12/18/2001	9350	0.100	777.375	0.00	73612.1196	0.00E+00
4/5/1997	11500	0.100	956.130	0.10	90538.9706	9.05E+01
4/6/1997	20100	0.000	1671.149	0.00	158246.3747	0.00E+00

Table F-4. Storm flow existing load and percent reduction for TSS for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Date	Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
3/22/2005	61	18.873	40.5	6.210E+03	1.608E+03	1.608E+03	Yes
3/31/1998	55.5	15.963	45.4	4.779E+03	1.238E+03	1.360E+03	Yes
2/20/1996	55	13.220	50.6	3.922E+03	1.016E+03	1.127E+03	Yes
10/12/2004	50	7.898	63.8	2.130E+03	5.518E+02	6.731E+02	Yes
4/11/2000	44	5.903	70.9	1.401E+03	3.629E+02	5.031E+02	Yes
3/8/1999	41.6	11.224	54.5	2.518E+03	6.523E+02	9.566E+02	Yes
6/20/2006	39.2	1.912	100	4.043E+02	1.047E+02	1.630E+02	Yes
12/10/2002	38.5	10.226	57	2.124E+03	5.501E+02	8.715E+02	Yes
5/25/2004	37.5	2.245	96	4.541E+02	1.176E+02	1.913E+02	Yes
5/30/2000	36.5	10.975	54.9	2.161E+03	5.597E+02	9.353E+02	Yes
7/17/2001	35.5	2.328	94.7	4.458E+02	1.155E+02	1.984E+02	Yes
5/20/2003	34.8	86.467	10.9	1.623E+04	4.204E+03	7.369E+03	Yes
5/7/2002	33.5	50.716	19.4	9.164E+03	2.374E+03	4.322E+03	Yes
4/25/2006	33.5	12.222	52.5	2.208E+03	5.720E+02	1.042E+03	Yes
7/6/2004	31.2	31.760	27.9	5.345E+03	1.384E+03	2.707E+03	Yes
1/17/2006	29.8	2.328	94.7	3.742E+02	9.692E+01	1.984E+02	Yes
6/4/2002	29.5	4.240	79.6	6.747E+02	1.748E+02	3.614E+02	Yes
1/30/2001	25.3	64.934	15.7	8.861E+03	2.295E+03	5.534E+03	Yes
6/27/2000	24.5	8.397	62.1	1.110E+03	2.874E+02	7.157E+02	Yes
4/13/2004	23.2	81.811	11.7	1.024E+04	2.652E+03	6.972E+03	Yes
4/19/2005	22.2	18.208	42	2.180E+03	5.647E+02	1.552E+03	Yes
4/13/1999	22	32.425	27.4	3.848E+03	9.966E+02	2.763E+03	Yes
4/24/2001	21.3	13.136	50.7	1.509E+03	3.909E+02	1.120E+03	Yes
12/11/2001	20.3	27.354	31.8	2.995E+03	7.758E+02	2.331E+03	Yes
3/26/1996	20	5.737	71.4	6.189E+02	1.603E+02	4.889E+02	Yes
2/15/2005	18	22.781	35.8	2.212E+03	5.729E+02	1.941E+03	Yes
3/18/2003	16.8	12.721	51.3	1.153E+03	2.986E+02	1.084E+03	Yes
10/24/2006	16.8	8.730	86.6	7.911E+02	2.049E+02	7.440E+02	Yes
2/12/2002	15.5	29.266	30	2.447E+03	6.338E+02	2.494E+03	Yes
11/9/2004	15	17.959	42.3	1.453E+03	3.764E+02	1.531E+03	Yes
4/30/1996	14.5	4.905	75.9	3.836E+02	9.937E+01	4.181E+02	Yes
1/31/2006	14.2	6.901	67.3	5.285E+02	1.369E+02	5.881E+02	Yes
6/8/1999	14	2.910	89.9	2.197E+02	5.692E+01	2.480E+02	Yes
6/19/2001	13.75	3.492	85.3	2.590E+02	6.708E+01	2.976E+02	Yes
2/3/1998	13	16.878	43.9	1.183E+03	3.065E+02	1.438E+03	Yes
3/20/2001	12.8	74.744	13	5.160E+03	1.337E+03	6.370E+03	Yes
4/22/1997	12.5	8.813	60.5	5.942E+02	1.539E+02	7.511E+02	Yes
2/9/1999	12.5	44.231	21.4	2.982E+03	7.725E+02	3.770E+03	Yes
4/15/2003	12.5	2.577	92.4	1.738E+02	4.501E+01	2.197E+02	Yes
6/24/2003	12.5	18.624	41	1.256E+03	3.252E+02	1.587E+03	Yes
4/2/2002	12.3	320.096	1.1	2.124E+04	5.501E+03	2.728E+04	Yes
3/18/1997	12	88.130	10.6	5.704E+03	1.478E+03	7.511E+03	Yes
7/22/2003	11.8	7.566	64.8	4.815E+02	1.247E+02	6.448E+02	Yes
12/14/2004	11.2	28.518	30.4	1.723E+03	4.462E+02	2.430E+03	Yes
6/10/1997	11	1.912	100	1.135E+02	2.939E+01	1.630E+02	Yes
2/18/2003	10.5	246.100	1.8	1.394E+04	3.610E+03	2.097E+04	Yes
2/10/2004	10.2	41.238	22.8	2.269E+03	5.877E+02	3.514E+03	Yes
3/9/2004	10.2	132.195	5.7	7.273E+03	1.884E+03	1.127E+04	Yes
6/11/1996	10	5.737	71.4	3.094E+02	8.015E+01	4.889E+02	Yes
5/20/1997	10	2.494	93.1	1.345E+02	3.485E+01	2.126E+02	Yes
9/24/1996	9.5	2.661	91.5	1.363E+02	3.531E+01	2.267E+02	Yes
7/8/1997	9.5	2.910	89.9	1.491E+02	3.862E+01	2.480E+02	Yes
3/3/1998	9.5	22.615	36.1	1.159E+03	3.002E+02	1.927E+03	Yes
1/20/2004	9.2	11.390	54	5.652E+02	1.464E+02	9.707E+02	Yes
11/19/1996	8.5	21.617	37.2	9.911E+02	2.567E+02	1.842E+03	Yes
2/20/2001	8.2	236.954	1.9	1.048E+04	2.715E+03	2.019E+04	Yes
1/7/1997	6.5	14.966	47.2	5.247E+02	1.359E+02	1.275E+03	Yes
5/5/1998	6.5	2.661	91.5	9.328E+01	2.416E+01	2.267E+02	Yes
12/21/1998	6	30.097	29.4	9.740E+02	2.523E+02	2.565E+03	Yes
3/28/2006	5.8	13.885	49.3	4.344E+02	1.125E+02	1.183E+03	Yes
12/9/1997	5.5	20.120	38.8	5.969E+02	1.546E+02	1.715E+03	Yes
1/28/2003	5	3.326	86.6	8.969E+01	2.323E+01	2.834E+02	Yes
12/10/1996	4.5	28.268	30.7	6.861E+02	1.777E+02	2.409E+03	Yes

~~Appendix G~~
~~Load Duration Curve Summaries and Plots for Dissolved Lead~~

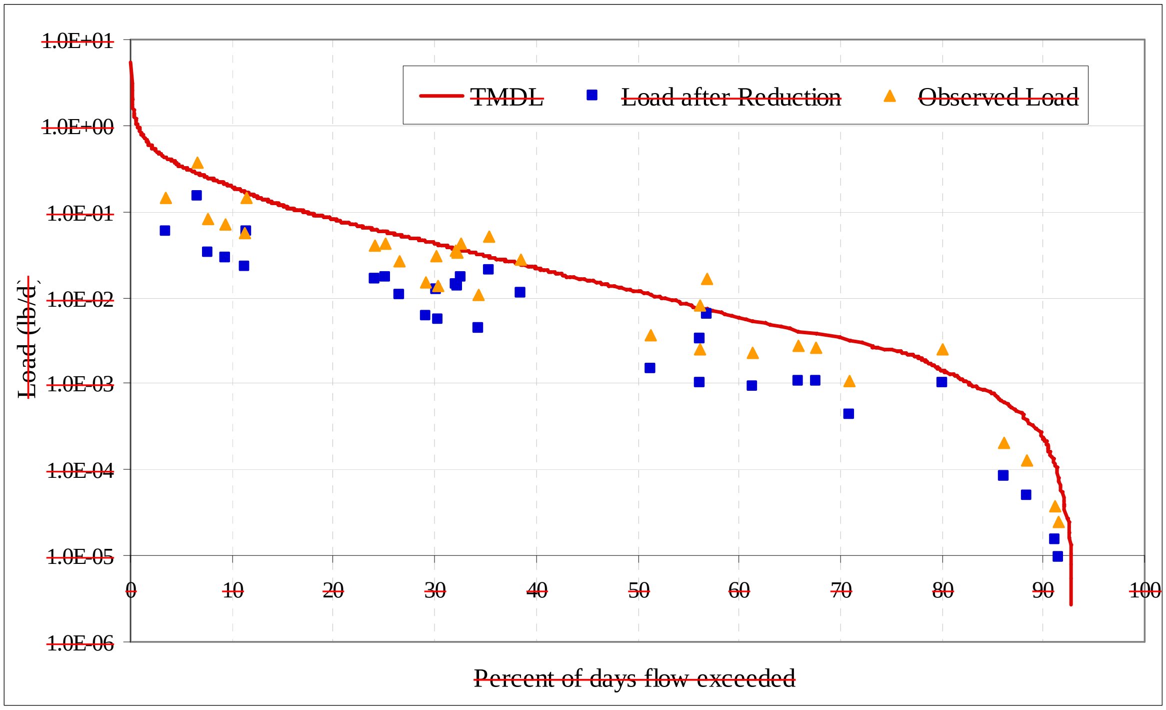

Figure G-1. Dissolved lead load duration curve for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904).

Table G-1. Allowable dissolved lead load for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Date	Observed flow (cfs)	Percent exceedance for observed flow	Adjusted flow for entire basin (cfs)	Width for area under curves (%)	Allowable load to meet standard (lb/day)	Area under TMDL curve (lb/day)
						0.1
7/31/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/1/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/2/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/3/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/4/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/5/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
8/6/1998	0	100.000	0.000	0.00	0.0000	0.00E+00
For brevity, most cells in this spreadsheet have been hidden						
4/29/1997	5690	0.300	473.077	0.10	1.5310	1.53E-03
6/13/2003	5850	0.200	486.379	0.00	1.5741	0.00E+00
4/1/2002	6160	0.200	512.153	0.00	1.6575	0.00E+00
6/19/2003	6450	0.200	536.264	0.00	1.7355	0.00E+00
2/18/2001	7330	0.200	609.429	0.10	1.9723	1.97E-03
12/19/2001	7410	0.100	616.080	0.00	1.9938	0.00E+00
2/17/2001	7740	0.100	643.517	0.00	2.0826	0.00E+00
12/18/2001	9350	0.100	777.375	0.00	2.5158	0.00E+00
4/5/1997	11500	0.100	956.130	0.10	3.0943	3.09E-03
4/6/1997	20100	0.000	1671.149	0.00	5.4083	0.00E+00

Table G-2. Existing load for dissolved lead for station OUA0018 for Big Creek near Sheridan (HUC-reach 08040203-904)

Observed Concentration (mg/L)	Flow/unit area on sampling day (cfs)	Percent exceedance for flow on sampling day	Current load (lbs/day)	Reduced load (lbs/day)	Allowable load with MOS incorporated (lbs/day)	Reduced load less than or equal to allow load?
0.00133	2.245	56.9	1.610E-02	6.538E-03	6.538E-03	Yes
0.00104	9.229	35.3	5.177E-02	2.102E-02	2.688E-02	Yes
0.00104	0.441	80.1	2.472E-03	1.004E-03	1.283E-03	Yes
0.0008	86.467	6.5	3.731E-01	1.515E-01	2.518E-01	Yes
0.00071	10.975	32.6	4.203E-02	1.706E-02	3.197E-02	Yes
0.00067	7.566	38.5	2.734E-02	1.110E-02	2.204E-02	Yes
0.00066	2.328	56.2	8.287E-03	3.365E-03	6.781E-03	Yes
0.00058	11.390	32	3.563E-02	1.447E-02	3.318E-02	Yes
0.00055	11.224	32.3	3.330E-02	1.352E-02	3.269E-02	Yes
0.00053	50.716	11.5	1.450E-01	5.887E-02	1.477E-01	Yes
0.00044	17.959	25.1	4.262E-02	1.730E-02	5.231E-02	Yes
0.00043	13.136	30.1	3.047E-02	1.237E-02	3.826E-02	Yes
0.00042	1.164	67.6	2.637E-03	1.071E-03	3.390E-03	Yes
0.0004	1.247	65.8	2.691E-03	1.092E-03	3.632E-03	Yes
0.00039	18.873	24.1	3.970E-02	1.612E-02	5.497E-02	Yes
0.0003	16.379	26.5	2.650E-02	1.076E-02	4.771E-02	Yes
0.00025	1.663	61.4	2.242E-03	9.104E-04	4.843E-03	Yes
0.0002	0.998	70.9	1.076E-03	4.370E-04	2.906E-03	Yes
0.0002	64.934	9.3	7.005E-02	2.844E-02	1.891E-01	Yes
0.0002	74.744	7.7	8.063E-02	3.274E-02	2.177E-01	Yes
0.0002	2.328	56.2	2.511E-03	1.020E-03	6.781E-03	Yes
0.0002	0.035	91.1	3.767E-05	1.529E-05	1.017E-04	Yes
0.0002	0.191	86.1	2.063E-04	8.376E-05	5.570E-04	Yes
0.0002	9.977	34.3	1.076E-02	4.370E-03	2.906E-02	Yes
0.0002	52.130	11.3	5.624E-02	2.283E-02	1.518E-01	Yes
0.0002	3.326	51.3	3.588E-03	1.457E-03	9.686E-03	Yes
0.0002	12.721	30.4	1.372E-02	5.572E-03	3.705E-02	Yes
0.0002	132.195	3.4	1.426E-01	5.790E-02	3.850E-01	Yes
0.0002	0.022	91.5	2.422E-05	9.832E-06	6.538E-05	Yes
0.0002	0.116	88.4	1.256E-04	5.098E-05	3.390E-04	Yes
0.0002	13.885	29.2	1.498E-02	6.081E-03	4.044E-02	Yes