

TMDL FOR TURBIDITY FOR TYRONZA RIVER, AR

**FINAL
January 6, 2005**

TMDL FOR TURBIDITY
FOR TYRONZA RIVER, AR

Prepared for

EPA Region VI
Water Quality Protection Division
Permits, Oversight, and TMDL Team
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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily pollutant loads for those waterbodies. A total maximum daily load (TMDL) is the amount of a pollutant that a waterbody can assimilate without exceeding the established water quality standards for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody.

The study area for this project is the Tyronza River watershed in northeast Arkansas. The study area is part of the Arkansas Department of Environmental Quality (ADEQ) Planning Segment 5A and is located within the Delta ecoregion. Land use in the study area is 93% cropland.

The Tyronza River is included on the draft 2004 Arkansas 303(d) list as not supporting the aquatic life use due to exceedances of numeric criteria for turbidity. For this TMDL, the Tyronza River was considered to be a “channel-altered” stream rather than a “least altered” stream. The applicable numeric criteria for turbidity for channel-altered streams in the Delta ecoregion are 75 NTU (“primary” value) and 250 NTU (“storm-flow” value).

ADEQ historical water quality data were available for one location along the Tyronza River. These data were analyzed for long term trends, seasonal patterns, relationships between concentration and stream flow, and relationships between turbidity and total suspended solids (TSS). The seasonal analysis showed that values of turbidity and TSS tend to be higher in the winter and spring and lower in the late summer and fall. The plots of concentration versus flow showed some correlation, with the high stream flows tending to result in higher TSS and turbidity values.

This TMDL was expressed using TSS as a surrogate for turbidity because turbidity cannot be expressed as a mass load. Two regressions between TSS and turbidity were developed using the ADEQ data. Using the base flow regression equation with the turbidity criteria, the target TSS concentration of 148 mg/L (corresponding to the primary turbidity criterion of 75 NTU) was identified. Using the storm-flow regression equation with the turbidity criteria, the

target TSS concentration of 269 mg/L (corresponding to the storm-flow turbidity criterion of 250 NTU) was identified.

The TMDL in this report 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 this methodology for the TMDL in this report were:

1. Developing a flow duration curve,
2. Converting the flow duration curve to a load duration curve,
3. Plotting observed loads with the load duration curve,
4. Calculating the TMDL components, and
5. Calculating percent reductions.

The load duration curve was developed using multiple target TSS concentrations because Arkansas has different turbidity criteria for different flow conditions. The target TSS concentration corresponding to the primary turbidity criterion was applied between the 100% exceedance of stream flow and the 60% exceedance of stream flow. The target TSS concentration corresponding to the storm-flow turbidity criterion was applied between the 60% exceedance of stream flow and the 0% exceedance of stream flow.

The wasteload allocation (WLA) for point source contributions was set to zero because TSS in this TMDL was 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 the study area 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. The WLA to support this TMDL will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by this turbidity TMDL.

An implicit margin of safety (MOS) was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the TMDL assuming that TSS is a conservative parameter and does not settle out of the water column.

The TMDL and percent reductions needed are summarized in Table ES.1.

Table ES.1. Summary of TMDL and percent reductions.

| Reach ID | Stream Name | Flow Category | Loads (tons/day of TSS) | | | | Percent Reduction Needed |
|--------------|---------------|---------------|-------------------------|------|-----|------|--------------------------|
| | | | WLA | LA | MOS | TMDL | |
| 08020203-012 | Tyronza River | Base flow | 0 | 24.0 | 0 | 24.0 | 0% |
| | | Storm-flow | 0 | 394 | 0 | 394 | 0% |

The percent reductions shown in Table ES.1 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 draft 303(d) list. These differences caused the assessment for the 2004 draft 303(d) list to indicate that the Tyronza River is impaired and the TMDL analysis to indicate that it is not impaired. The 2004 draft 303(d) list is still being reviewed by EPA and has not been finalized yet.

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1.0 INTRODUCTION

This report presents a total maximum daily load (TMDL) for siltation/turbidity for one reach of the Tyronza River in northeast Arkansas. This stream reach was included on the draft 2004 Arkansas 303(d) list (Arkansas Department of Environmental Quality (ADEQ) 2005a) as not supporting its designated use of aquatic life. The sources of contamination and causes of impairment from the 303(d) listing are shown below in Table 1.1. The TMDL in this report was developed in accordance with Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standards for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the wasteload allocation (WLA), the load allocation (LA), and a margin of safety (MOS). The WLA is the load allocated to point sources of the pollutant of concern. The LA is the load allocated to nonpoint sources (NPS), including natural background. The MOS is a percentage of the TMDL that takes into account any lack of knowledge concerning the relationship between pollutant loadings and water quality.

Table 1.1. 303(d) listing for stream reaches in this task order.

| Reach No. | Stream Name | Sources | Causes | Category | Priority |
|--------------|---------------|-------------|---------------------|----------|----------|
| 08020203-012 | Tyronza River | Agriculture | Siltation/turbidity | 5b | Low |

2.0 BACKGROUND INFORMATION

2.1 General Information

The study area for this project is the Tyronza River watershed in northeast Arkansas (see Figure A.1 in Appendix A). This watershed lies within the Delta ecoregion. The Tyronza River is in United States Geological Survey (USGS) Hydrologic Unit 08020203 and is in ADEQ Planning Segment 5A. The impaired reach (08020203-012) is from the headwaters to the confluence with Big Creek. At the downstream end of the impaired reach, the drainage area of the Tyronza River is 408 square miles. The Tyronza River watershed is in Poinsett and Mississippi Counties. The Tyronza River eventually empties into the St. Francis River.

2.2 Soils and Topography

The soils and topography information was obtained from the soil survey for Mississippi County (USDA 1971). Most of the soils in the study area are poorly to moderately well drained and are usually composed of clay and/or sand. The west and northwest part of the study area has soils described as poorly drained to somewhat poorly drained loamy soils to excessively drained sandy soils.

The study area is very flat with a few rolling hills and ridges. While there are a few slopes as steep as 12% on river banks and some hillsides, most slopes are less than 1%.

2.3 Land Use

Land use data for the Tyronza River watershed were obtained from the GEOSTOR database, which is maintained by the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in Fayetteville. These data were based on satellite imagery from 1999. The spatial distribution of these land uses is shown on Figure A.2 (located in Appendix A) and land use percentages are shown in Table 2.1. These data indicate that over 93% of the study area is cropland (soybeans, cotton, rice, sorghum, and corn).

Table 2.1. Land use percentages for the study area.

| Land use | Percentage of study area |
|--------------------|--------------------------|
| Urban | 2.7% |
| Water | 0.4% |
| Forest (all types) | 3.4% |
| Soybeans | 58.9% |
| Rice | 9.6% |
| Cotton | 20.8% |
| Sorghum/Corn | 4.2% |
| Total | 100.0% |

2.4 Description of Hydrology

Average precipitation for the study area is about 50-52 inches per year (USGS 1985). There were no USGS flow gages on Tyronza River so a gage in a nearby watershed had to be used. The USGS gage on the L'Anguille River near Colt, Arkansas (07047942) was chosen since it was close to Tyronza River, in the same ecoregion, and had similar land use in its watershed. Information about this flow gage is summarized in Table 2.2.

Table 2.2. Information for USGS stream flow gaging station (USGS 2005).

| | |
|-----------------------|--|
| Gage name: | L'Anguille River near Colt, AR |
| Gage number: | 07047942 |
| Descriptive location: | State Highway 306, 3.9 miles northwest of Colt |
| Period of record: | October 1970 to September 2003 |
| Drainage area: | 535 square miles |
| Mean annual flow: | 724 cfs |

2.5 Channel Network

Figure A.3 shows the stream channel network for the study area based on EPA's "Reach File 3" data. According to the Integrated Water Quality Monitoring and Assessment Report (ADEQ 2002), streams in this planning segment have been ditched and channelized to facilitate the drainage of lowland areas. The discussion of water quality for planning segment 5A further states that "The continuation of such activities and the continuous maintenance dredging of the ditches and streams aggravates and further deteriorates the conditions" (ADEQ 2002).

2.6 Water Quality Standards

Water quality standards for Arkansas waterbodies are listed by ecoregion in Regulation No. 2 (APCEC 2004a). The Tyronza River is entirely within the Delta ecoregion. Designated uses for the Tyronza River include primary and secondary contact recreation; public, industrial, and agricultural water supply; and perennial Delta ecoregion fishery (where the drainage area is at least 10 square miles).

Section 2.503 of Regulation No. 2 provides both a narrative criterion and numeric criteria that apply to siltation/turbidity. The general narrative criterion is: “There shall be no distinctly visible increase in turbidity of receiving waters attributable to municipal, industrial, agricultural, other waste discharges or instream activities.” There are two sets of numeric criteria for turbidity in this ecoregion, “least-altered” and “channel-altered” streams, but the state regulations do not say which apply to Tyronza River. Based on the extensive channelization in the Tyronza River watershed discussed in Section 2.5, the Tyronza River is considered to be a channel-altered stream for this TMDL. The numeric turbidity criteria for channel-altered streams in the Delta ecoregion are 75 NTU for “primary” values and 250 NTU for “storm-flow” values. The regulation also states that “the non-point source runoff shall not result in the exceedence 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.”

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is listed in Sections 2.201 – 2.204 of Regulation No. 2. These sections impose the following requirements:

- Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
- Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or social development, although water quality must still be adequate to fully protect existing uses.
- For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.

- For potential water quality impairments associated with a thermal discharge, the antidegradation policy and implementing method shall be consistent with Section 316 of the Clean Water Act.

2.7 Nonpoint Sources

Nonpoint sources of pollution in the study area are discussed in the Integrated Water Quality Monitoring and Assessment Report. For planning segment 5A, this report states that “essentially all of the streams within these segments have high turbidity and silt loads carried into the streams from row crop agriculture activities” (ADEQ 2002a). This is consistent with the 2004 303(d) list, which specifies agriculture as the source of turbidity for the Tyronza River.

2.8 Point Sources

Information for point source discharges in the study area was obtained by searching the Permit Compliance System on the EPA web site (PCS 2005). The search yielded four facilities with point source discharges. Search results, including flow rate and permit limits for total suspended solids (TSS), are included in Table 2.3. Locations of the permitted facilities are shown on Figure A.4 in Appendix A.

Table 2.3. Inventory of point source dischargers.

| NPDES Permit No. | Facility Name | Receiving Water | Flow Rate (MGD) | Monthly Average TSS Limits (mg/L) |
|------------------|-----------------------------|---|-----------------|-----------------------------------|
| AR0034754 | City of Keiser | Ditch #31, Tyronza River, St. Francis River | 0.15 | 90 |
| AR0039047 | City of Dyess | Tyronza River, St. Francis River | 0.06 | 30 |
| AR0044237 | Burdette WWTF | Ditch #24, #6, Tyronza River, St. Francis River | 0.10 | 90 |
| ARG160029 | Mississippi County Landfill | Ditch #31, Tyronza River | 0.56 | 100 |

3.0 EXISTING WATER QUALITY FOR TURBIDITY AND TSS

3.1 General Description of Data

Turbidity and total suspended solids (TSS) data have been collected by ADEQ at one site within the study area. The location of this sampling site is shown on Figure A.3 (located in Appendix A). TSS data are discussed here because TSS is needed as a surrogate parameter for expressing the siltation/turbidity TMDL. These TSS and turbidity data were obtained from the ADEQ web site (ADEQ 2005b) and are summarized in Table 3.1. The individual data are listed in Table B.1 and shown graphically as time series plots on Figures B.1 and B.2 (in Appendix B).

Table 3.1. Summary of ADEQ data for turbidity and TSS.

| Station | Description | Parameter | Count | Min. | Median | Average | Max. |
|---------|--------------------------------|-----------|-------|------|--------|---------|------|
| FRA0033 | Tyronza River near Tyronza, AR | Turbidity | 6 | 19.0 | 43.5 | 205 | 910 |
| | | TSS | 6 | 25.3 | 73.8 | 228 | 1038 |

Table B.1 includes a comparison between the observed turbidity data and the numeric water quality criteria. This comparison required the observed data to be separated into base flow data (to be compared with the “primary” criterion) and storm-flow data (to be compared with the “storm-flow” criterion). It was assumed here that the lowest 40% of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. The turbidity data were considered to be base flow data when the flow on the sampling day at the USGS gage on the L’Anguille River near Colt was 235 cfs or less (the 40th percentile flow, or the flow that was exceeded 60% of the time). The turbidity data were considered to be storm-flow data when the flow on the sampling day at the USGS gage on the L’Anguille River near Colt was greater than 235 cfs. Table B.1 shows that, for the entire period of record (2000 through 2001), the turbidity data at station FRA0033 exceeded the applicable criterion 0% of the time during base flow conditions and 50% of the time during storm-flow conditions.

3.2 Seasonal Patterns

Seasonal plots of turbidity and TSS data at station FRA0033 are shown on Figures C.1 and C.2 (in Appendix C). There were insufficient data to determine a seasonal pattern, but the fact that the highest turbidity and TSS values occurred in early spring is consistent with seasonal patterns for the L'Anguille River, which is a similar watershed (FTN 2001).

3.3 Relationships Between Concentration and Flow

Plots of turbidity and TSS versus stream flow were also developed to examine any correlation between these two parameters and flow (Figures D.1 and D.2; located in Appendix D). The data are limited, but there appears to be a positive correlation between flow and values of turbidity and TSS because the highest values of turbidity and TSS occurred on the sampling day with the highest flow. This pattern is consistent with findings from previous turbidity TMDLs for the L'Anguille River, which is a similar watershed (FTN 2001).

3.4 Relationships Between TSS and Turbidity

Plots and regression analyses were used to examine relationships between TSS and turbidity. The regressions were performed using the natural logarithms of the data (rather than the raw data values) because most data such as turbidity and TSS fit a lognormal distribution better than a normal distribution.

Separate plots and regression analyses were developed for base flow conditions and storm-flow conditions to be consistent with the numeric criteria for turbidity. The plot and linear regression for base flow conditions (Figure E.1) uses only the base flow data. The plot and linear regression for storm-flow conditions (Figure E.2) uses all of the data regardless of flow on the sampling day. The data collected under base flow conditions were included in the storm-flow regression in order to maximize the accuracy of the lower end of the regression line that corresponds to turbidity values near the numeric criteria.

Both plots show a noticeable correlation, with higher turbidity levels tending to correspond with higher TSS concentrations. The results of the linear regression analyses are summarized in Table 3.2.

Table 3.2. Results of regressions between TSS and turbidity.

| Sampling Station | Category | Regression Equation | Number of Data | R ² | Significance Level (P value) |
|------------------|------------|---|----------------|----------------|------------------------------|
| FRA0033 | Base flow | $\ln \text{TSS} = 1.339 * \ln \text{Turbidity} - 0.787$ | 4 | 0.99 | 7.4×10^{-3} |
| | Storm-flow | $\ln \text{TSS} = 0.895 * \ln \text{Turbidity} + 0.654$ | 6 | 0.95 | 9.2×10^{-4} |

The strength of the linear relationship is measured by the coefficient of determination (R^2) calculated during the regression analysis (Zar 1996). The R^2 value is the percentage of the total variation in \ln TSS that is explained or accounted for by the fitted regression (\ln turbidity). For example, in the base flow regression above, 99% of the variation in TSS is accounted for by turbidity and the remaining 1% of variation in TSS is unexplained. The unexplained portion is attributed to factors other than the measured value of turbidity.

These regressions show a majority of the measurement of the turbidity (NTU) is explained by the measured concentration of TSS. The perfect explanation of the measurement of turbidity to the measurement of TSS would require collecting and analyzing a large amount of data. A number of the items effecting this perfect explanation of the relationship would need to be known. A partial list of the items effecting the relationship follows:

- Velocity of the water at the time of sampling;
- Carbonaceous biochemical oxygen demand (CBOD) concentration;
- Ammonia concentration;
- Nitrate concentration;
- Phosphorus concentration;
- Algal mass in the water column;
- Bacteria mass in the water;
- Measured color of the water;
- Mass of the organic component of the TSS;
- Mass of the material passing through the filter during the TSS analysis;
- Grain size distribution of the inorganic portion of the TSS;
- Specific gravity of the different sizes of inorganic solids particles;
- Hydrograph for the stream;
- Position on the hydrograph (i.e., rising limb, falling limb) at the time of sampling;

- Number of overlapping rainfall events represented by this sample day;
- Magnitude of each of the rainfall events represented by this sample day; and
- Lags of the overlapping rainfall events represented by this sample day.

The collection of the above data would not change the fact that inorganic particles represented in the TSS measurements is the major contributor to the turbidity reading and is the major constituent reduced when sediment BMPs are applied to nonpoint sources. The BMPs used on nonpoint sources for sediment also reduce the load of many of the unexplained contributors in the regression. The effort to have a perfect explanation of turbidity may not result in a better selection of BMPs. The regressions presented above between TSS and turbidity are adequate for the preparation of this TMDL. A stakeholder group of knowledgeable persons from the watershed may need additional information to set a plan of action for this TMDL.

The correlations between turbidity and TSS for Tyronza River were considered to be good; the R^2 values for these regressions (0.99 and 0.95) are higher than R^2 values for turbidity and TSS from other approved TMDLs in Arkansas (FTN 2001, FTN 2003, FTN 2005).

The statistical significance of the regression was evaluated by computing the “P value” for the slope of the regression line. The P value is essentially the probability that the slope of the regression line is really zero. Thus, a low P value indicates that a non-zero slope calculated from the regression analysis is statistically significant. For these regressions, the P values are small and are considered good.

4.0 TMDL DEVELOPMENT

4.1 Seasonality and Critical Conditions

EPA's regulations at 40 CFR 130.7 require the determination of TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. Also, both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to consider seasonal variations for meeting water quality standards. The historical data analysis in Section 3 showed that there were insufficient data for the Tyronza River to conclusively determine seasonal patterns. Therefore, a critical season was not established for this TMDL. The methodology used to develop this TMDL (load duration curve) addresses allowable loading for a wide range of flow conditions.

4.2 Water Quality Targets

Turbidity is an expression of the optical properties in a water sample that cause light to be scattered or absorbed and may be caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms (Standard Methods 1999). Turbidity cannot be expressed as a load as preferred for TMDLs. To achieve a load based value, turbidity is often correlated with a surrogate parameter such as TSS that may be expressed as a load. In general, activities that generate varying amounts of suspended sediment will proportionally change or affect turbidity (EPA 1991). Research by Relyea et. al. (2000) states, "increased turbidity by sediments can reduce stream primary production by reducing photosynthesis, physically abrading algae and other plants, and preventing attachment of autotrophs to substrate surfaces".

For the turbidity TMDL in this report, the relationships between turbidity and TSS presented in Table 3.2 were used to develop target TSS concentrations (i.e., numeric endpoints for the TMDLs). The two target TSS concentrations developed for this TMDL were 148 mg/L (using the base flow regression and the primary turbidity criterion of 75 NTU) and 269 mg/L (using the storm-flow regression and the storm-flow turbidity criterion of 250 NTU). The discussion in Section 3.1 associating the primary turbidity criterion with the base flow portion of

the duration curve is the basis for using the descriptor “base flow” in this document for the conditions when the primary turbidity criterion should apply.

4.3 Methodology for TMDL Calculations

The methodology used for the TMDL in this report is the load duration curve. Because loading capacity varies as a function of the flow present in the stream, this TMDL represents a continuum of desired loads over all flow conditions, rather than fixed at a single value. The basic elements of this procedure are documented on the Kansas Department of Health and Environment web site (KDHE 2005). This method was used to illustrate allowable loading at a wide range of flows. The steps for how this methodology was applied for the TMDL in this report can be summarized as follows:

1. Develop a flow duration curve (Section 4.4);
2. Convert the flow duration curve to load duration curves (Section 4.5);
3. Plot observed loads with load duration curves (Section 4.6);
4. Calculate TMDL, MOS, WLA, and LA (Sections 4.7-4.9); and
5. Calculate percent reductions (Section 4.10).

4.4 Flow Duration Curve

A flow per unit area duration curve was developed for the study area (see Table F.1 in Appendix F for details). Daily streamflow measurements from the L'Anguille River near Colt (USGS Gage No. 07047942) were sorted in increasing order and the percent exceedance of each flow was calculated. The flow was divided by the drainage area of the gage to get a flow per square mile. The flow per unit area duration curve is shown on Figure F.1 in Appendix F.

4.5 Load Duration Curves

Each flow per unit area from the flow duration curve was multiplied by the appropriate TSS target concentration to develop plots of allowable load versus flow exceedance (load duration curves). The water quality standards for Arkansas (APCEC 2004a) do not specify a range of flows or flow exceedances at which each of the turbidity criteria (primary and storm-flow) is applicable. As discussed in Section 3.1, it was assumed here that the lowest 40%

of stream flow values represent flow conditions without significant influence from storm runoff and that stream flow values above the 40th percentile would have some influence from storm runoff. Therefore, the TSS target corresponding to the primary turbidity criterion was applied to the lowest 40% of flows (from 100% exceedance of stream flow to 60% exceedance stream flow) and the TSS target corresponding to the storm-flow turbidity criterion was applied from 60% exceedance of stream flow to 0% exceedance of stream flow. The load duration curves for storm-flow conditions and base flow conditions are shown on Figures F.2 and F.3 (in Appendix F).

4.6 Observed Loads

The observed loads per unit of drainage area for the Tyronza River were calculated for each sampling day. Each observed load per unit of drainage area was calculated by simply multiplying the observed TSS concentration times the flow per unit of drainage area on the sampling day (with a conversion factor incorporated).

The load duration plots (Figures F.2 and F.3) provide visual comparisons between observed and allowable loads under different flow conditions. Observed loads that are plotted above the load duration curve represent conditions where observed water quality concentrations exceed the target concentrations. Observed loads below the load duration curve represent conditions where observed water quality concentrations were less than target concentrations (i.e., not exceeding water quality criteria).

4.7 TMDL and MOS

The allowable load per unit area for storm-flow conditions was calculated as the TSS target for storm-flow conditions (269 mg/L) multiplied times the flow per unit area at the 30% flow exceedance. The 30% flow exceedance was used because it is considered to represent a typical flow value for storm-flow conditions (it is the midpoint along the flow duration curve between 0% and 60%). The allowable load per unit area for base flow conditions was calculated as the TSS target for base flow conditions (148 mg/L) multiplied times the flow per unit area at the 80% flow exceedance. The 80% flow exceedance was used because it is considered to

represent a typical flow value for base flow conditions (it is the midpoint along the flow duration curve between 60% and 100%). The TMDL was calculated as the allowable load per unit area multiplied times the total drainage area at the downstream end of the reach. These calculations are shown at the bottom of Table F.1.

Both Section 303(d) of the Clean Water Act and regulations at 40 CFR 130.7 require TMDLs to include a MOS to account for uncertainty in 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 through conservative assumptions used in establishing the TMDL. For this TMDL, an implicit MOS was incorporated through the use of conservative assumptions. The primary conservative assumption was calculating the TMDL assuming that TSS is a conservative parameter and does not settle out of the water column.

4.8 Point Source Loads

The WLA for the point sources was 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 the Tyronza River watershed 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. The WLA to support this TMDL will not require any changes to the permits concerning inorganic suspended solids. Therefore, future growth for these permits or new permits would not be restricted by this turbidity TMDL.

4.9 Nonpoint Source Loads

The LA for nonpoint sources, including natural background, results in being equal to the TMDL because the WLA was zero and the MOS was implicit.

4.10 Percent Reductions

In addition to calculating allowable loads, estimates were made for percent reductions of nonpoint source loads that are needed. For each observed TSS load that exceeded the allowable load at that flow (i.e., each observed TSS load above the allowable load curve in Figures F.2 and F.3), a uniform percent reduction was applied until the number of TSS loads exceeding the allowable loads was less than or equal to an acceptable number. For storm-flow conditions, the acceptable number of exceedances was 20% of the number of storm-flow data. This percentage (20%) was based on the Arkansas water quality standards, which state that “the non-point source runoff shall not result in the exceedance of the in stream storm-flow values in more than 20% of the ADEQ ambient monitoring network samples taken in not less than 24 monthly samples.” (APCEC 2004a). For base flow conditions, the acceptable number of exceedances was 25% of the number of base flow data. This percentage (25%) was based on the ADEQ assessment criteria for turbidity (ADEQ 2002, ADEQ 2005a). For both storm-flow and base flow conditions, whenever the appropriate percentage multiplied by the number of observed values yielded a fractional number (e.g., $25\% \times 38 = 9.5$), the allowable number of exceedances was rounded up to the next whole number (e.g., 9.5 rounded up to 10) in accordance with the ADEQ assessment criteria for turbidity (ADEQ 2002, ADEQ 2005a). The calculations for percent reductions are shown in Tables F.2 and F.3.

The percent reductions and the results of the TMDL calculations are summarized in Table 4.1 below. These calculations indicated that no load reductions are necessary.

Table 4.1. Summary of turbidity TMDL.

| Reach ID | Stream Name | Flow Category | Loads (tons/day of TSS) | | | | Percent Reduction Needed |
|--------------|---------------|---------------|-------------------------|------|-----|------|--------------------------|
| | | | WLA | LA | MOS | TMDL | |
| 08020203-012 | Tyronza River | Base flow | 0 | 24.0 | 0 | 24.0 | 0% |
| | | Storm-flow | 0 | 394 | 0 | 394 | 0% |

The percent reductions in Table 4.1 were calculated using methodology that is slightly different than the assessment criteria used by ADEQ to develop the 2004 303(d) list. The ADEQ assessment was performed using turbidity data that were categorized as either base flow or storm-flow values based on the month of the year in which the values were measured. The percent reductions in Table 4.1 were calculated using TSS data that were categorized as either base flow or storm-flow values based on streamflow data on each sampling day. These differences caused the assessment for the 2004 draft 303(d) list to indicate the Tyronza River is impaired and the TMDL analysis to indicate that it is not impaired. The 2004 draft 303(d) list is still being reviewed by EPA and has not been finalized yet.

4.11 Future Growth

As mentioned in Section 4.8, future growth of existing or new point source discharges would not be restricted by this TMDL.

5.0 OTHER RELEVANT INFORMATION

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, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (*Water Quality Inventory*) and the 303(d) list of impaired waters, which are issued as a single document titled Arkansas Integrated Water Quality Monitoring and Assessment Report.

6.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to publicly notice and seek comment concerning the TMDL. Pursuant to a May 2000 consent decree, this TMDL was prepared under contract to EPA. After development of the draft version of this TMDL, EPA prepared a notice seeking comments, information, and data from the general public and affected public. No comments, data, or information were submitted during the public comment period. EPA has transmitted the final TMDL to ADEQ for implementation and for incorporation into ADEQ's current water quality management plan.

7.0 REFERENCES

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APPENDIX A

Maps

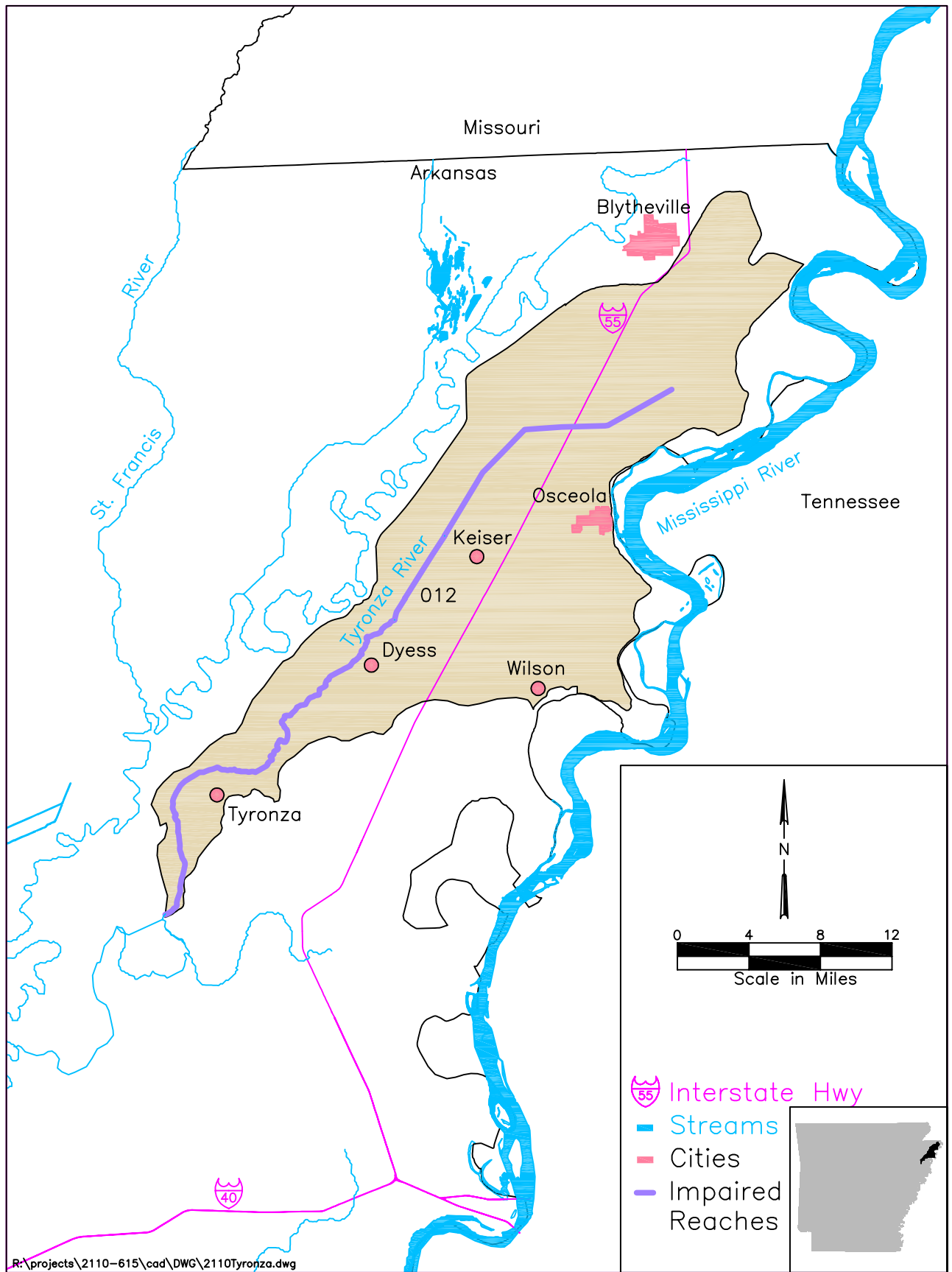
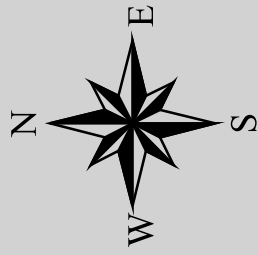
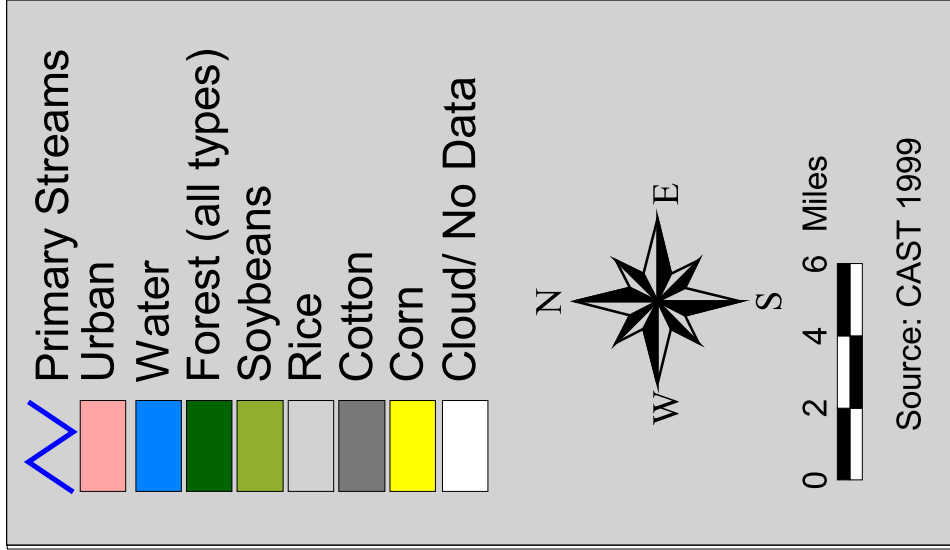


Figure A.1. Map of study area



Source: CAST 1999

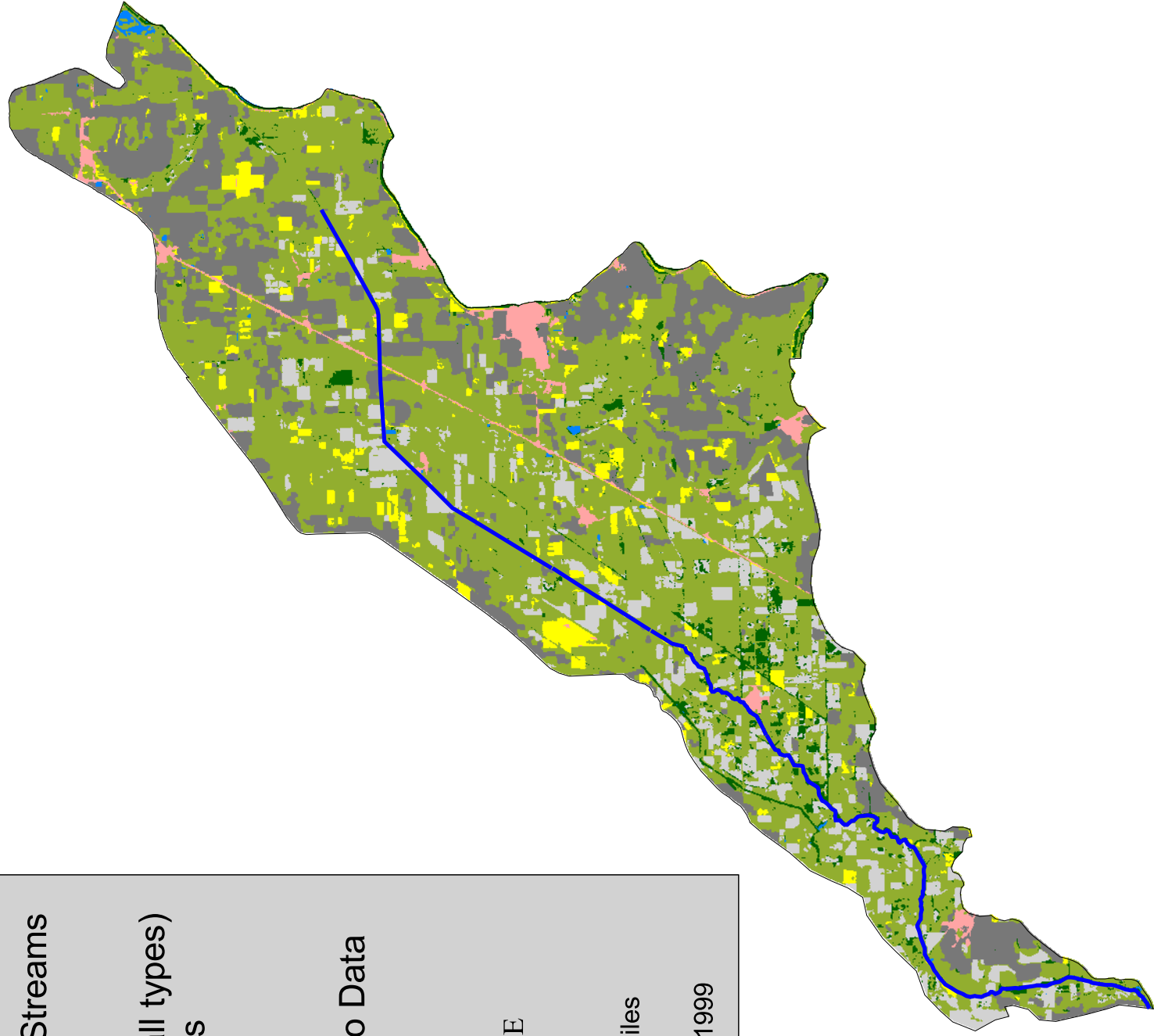


Figure A.2. Land use in Tyronza watershed.

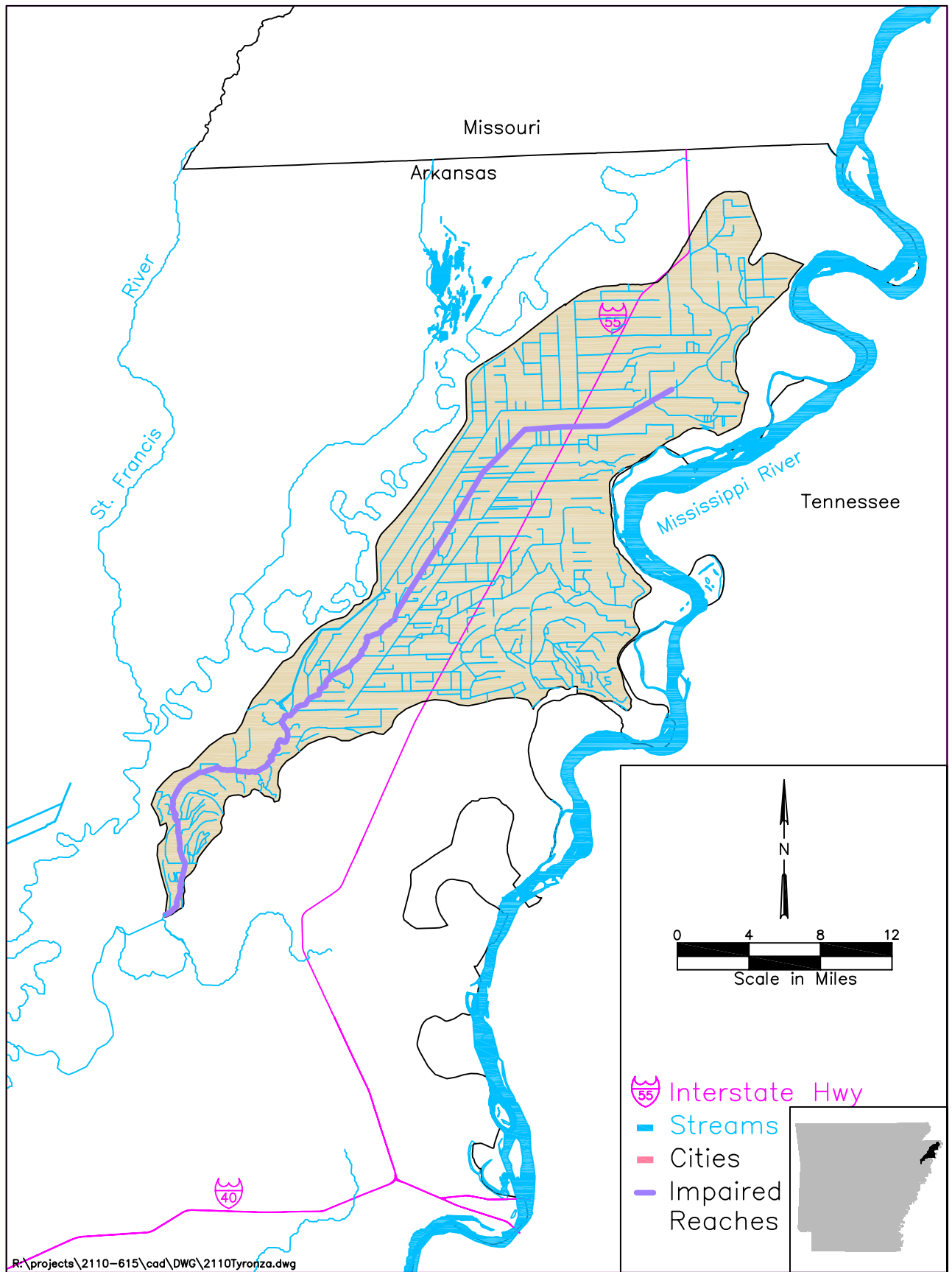


Figure A.3. Map of stream network within the study area

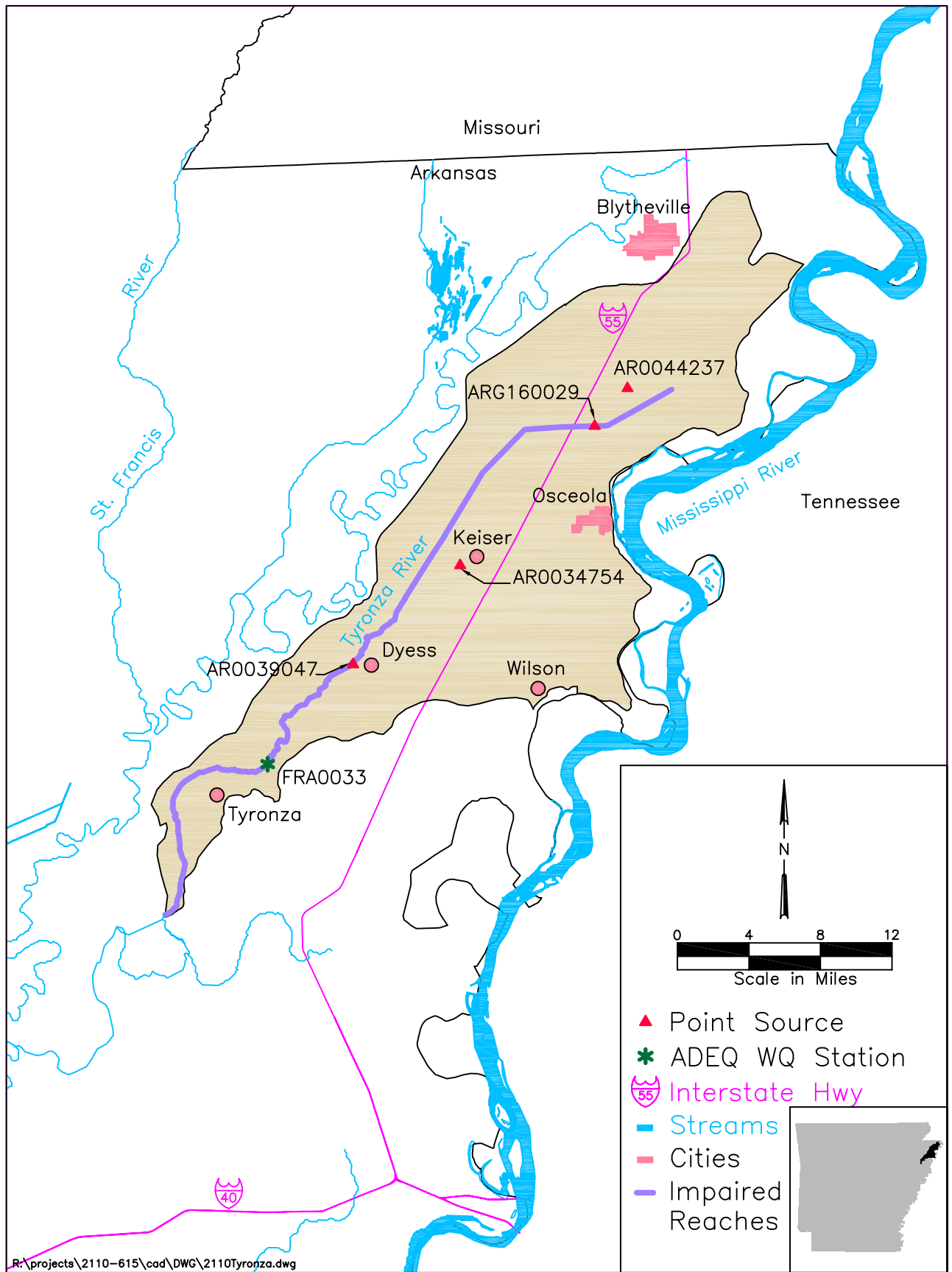


Figure A.4. Map of water quality stations and point sources in the study area

APPENDIX B

Long Term Plots of Turbidity and TSS

Table B.1.TSS and Turbidity data for Tyronza River at Tyronza, AR (FRA0033).

| Date | Observed turbidity (NTU) | Observed TSS (mg/L) | Flow at USGS gage (cfs) | Flow per unit area (cfs/mi2) | Load per unit area (lbs/day/mi2) | Percent of days flow exceeded | Applicable category | Applicable water quality standard (NTU) | Turbidity meeting base flow standard? | Turbidity meeting storm-flow standard? |
|-----------|--------------------------|---------------------|-------------------------|------------------------------|----------------------------------|-------------------------------|---------------------|---|---------------------------------------|--|
| 6/25/2001 | 32 | 46.5 | 12 | 0.022 | 5.62 | 96.14% | Base flow | 75 | Yes | |
| 11/6/2000 | 55 | 101.0 | 14 | 0.026 | 14.25 | 95.46% | Base flow | 75 | Yes | |
| 5/14/2001 | 26 | 32.5 | 42 | 0.079 | 13.76 | 87.23% | Base flow | 75 | Yes | |
| 9/10/2001 | 19 | 25.3 | 172 | 0.321 | 43.86 | 66.81% | Base flow | 75 | Yes | |
| 1/22/2001 | 190 | 127.0 | 595 | 1.112 | 761.71 | 36.08% | Storm-flow | 250 | | Yes |
| 3/5/2001 | 910 | 1038.0 | 2000 | 3.738 | 20926.45 | 8.99% | Storm-flow | 250 | | No |

Number exceeding applicable water quality standard for turbidity = 0 1
 Total number of observations in each category = 4 2
 Percent exceeding applicable water quality standard for turbidity = 0% 50%

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Figure B.1. Observed Long Term TSS for Tyronza River near Tyronza (FRA0033)

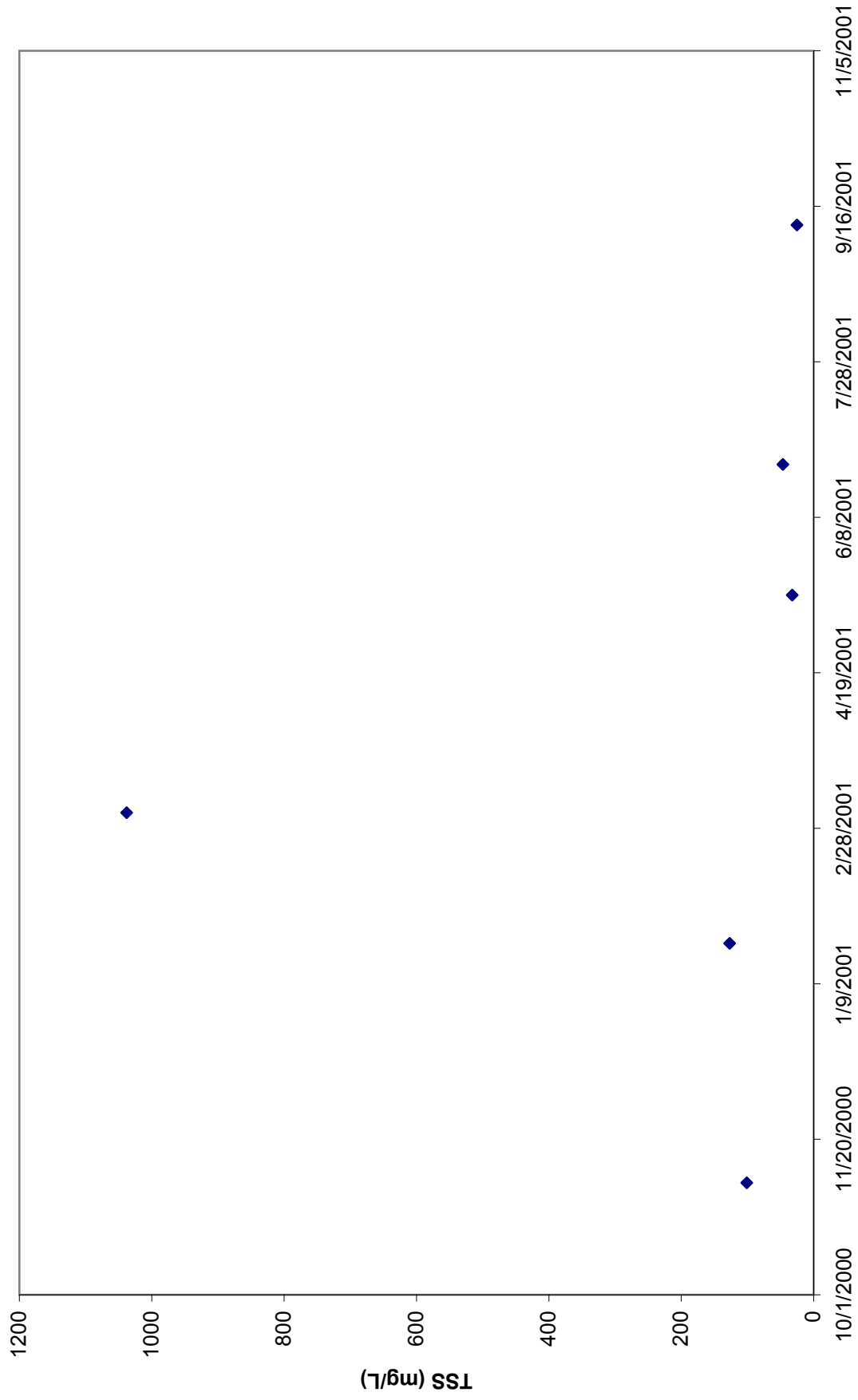
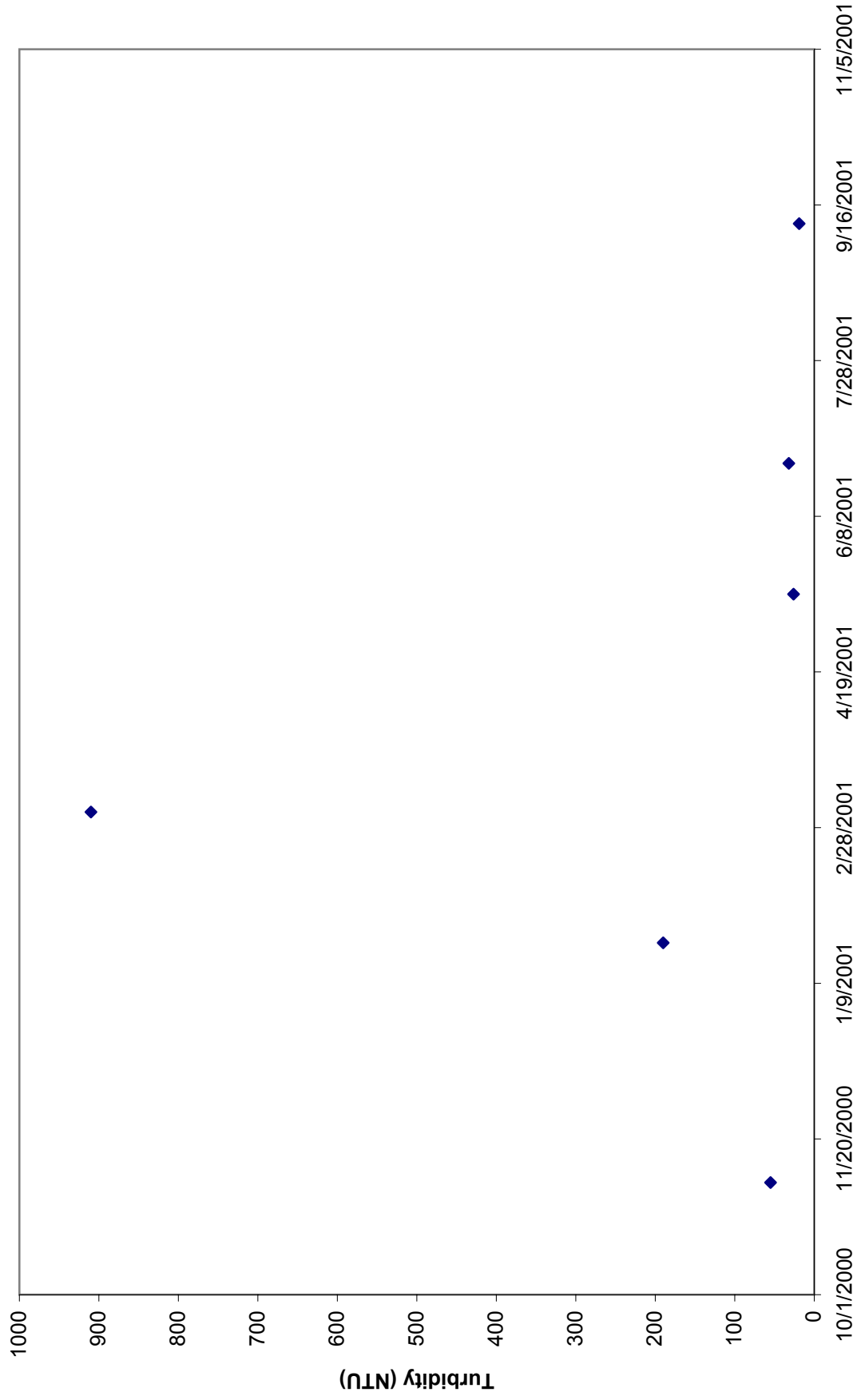


Figure B.2. Observed Long Term Turbidity for Tyronza River near Tyronza (FRA0033)



APPENDIX C

Seasonal Plots of Turbidity and TSS>

Figure C.1. Observed Seasonal TSS for Tyronza River near Tyrone, AR (FRA0033)

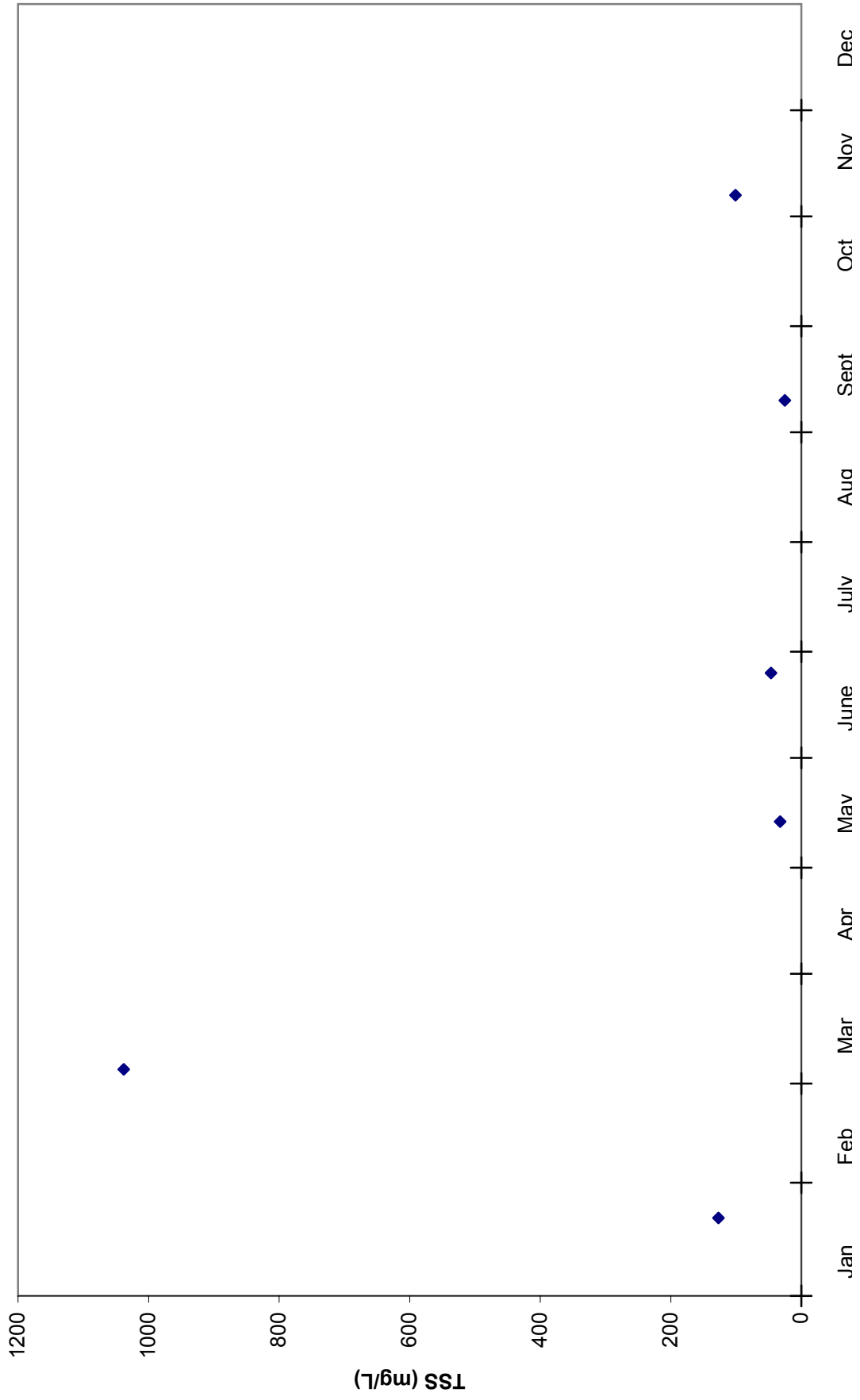
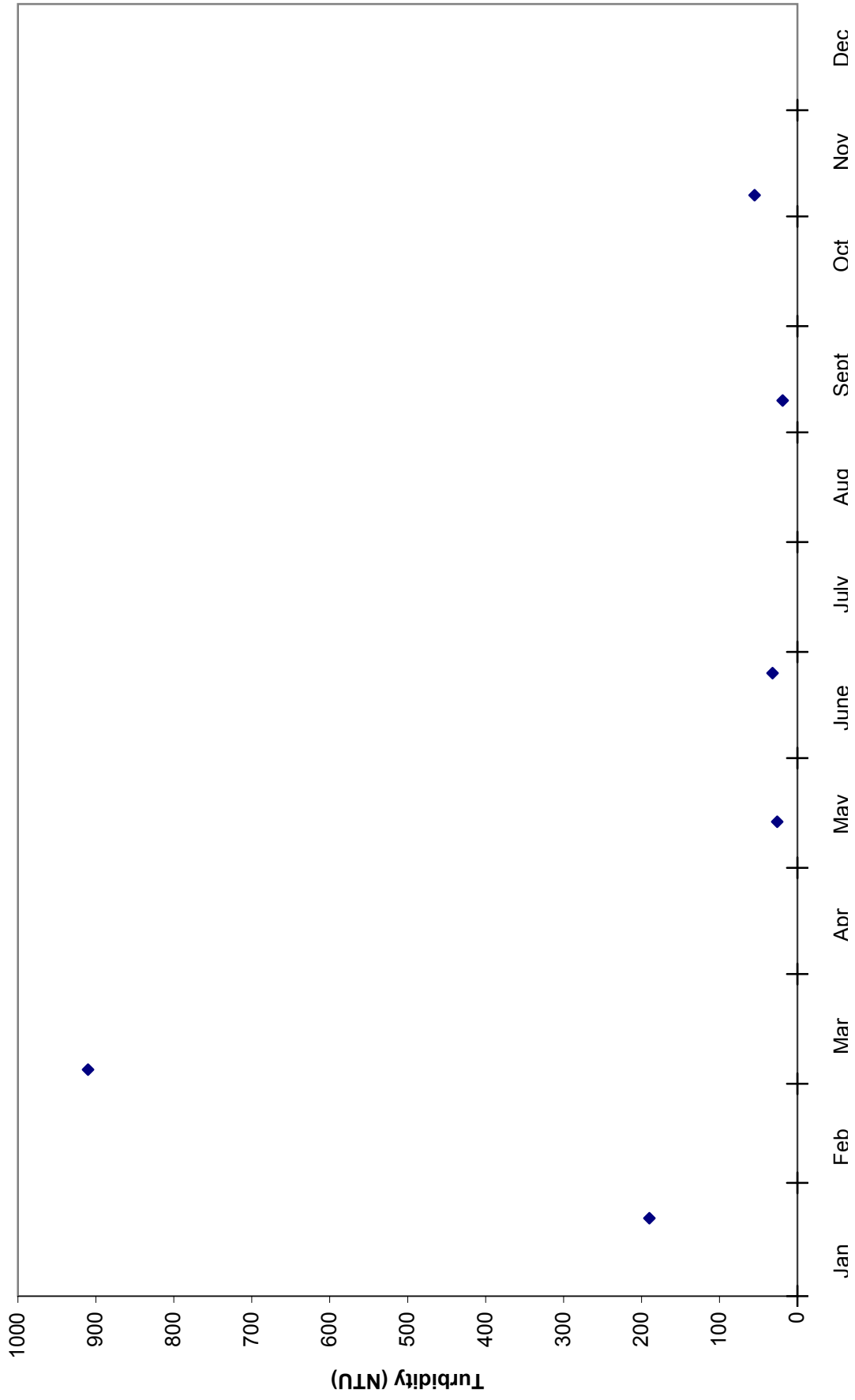


Figure C.2. Observed Seasonal Turbidity for Tyronza River near Tyrone, AR (FRA0033)



APPENDIX D

Plots of Turbidity and TSS vs Flow

Figure D.1.1. TSS vs flow for Tyronza River near Tyrone, AR (FRA0033)

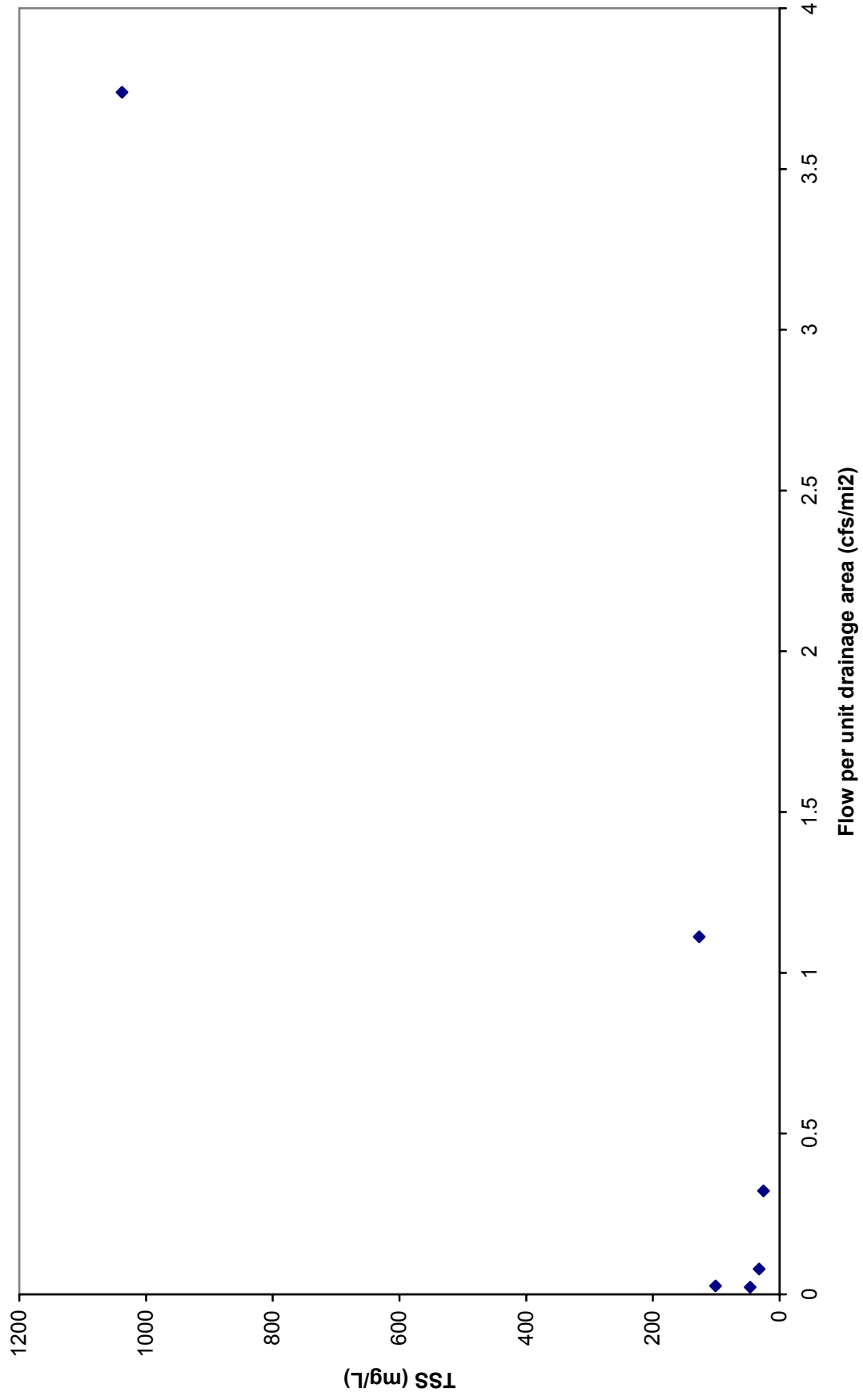
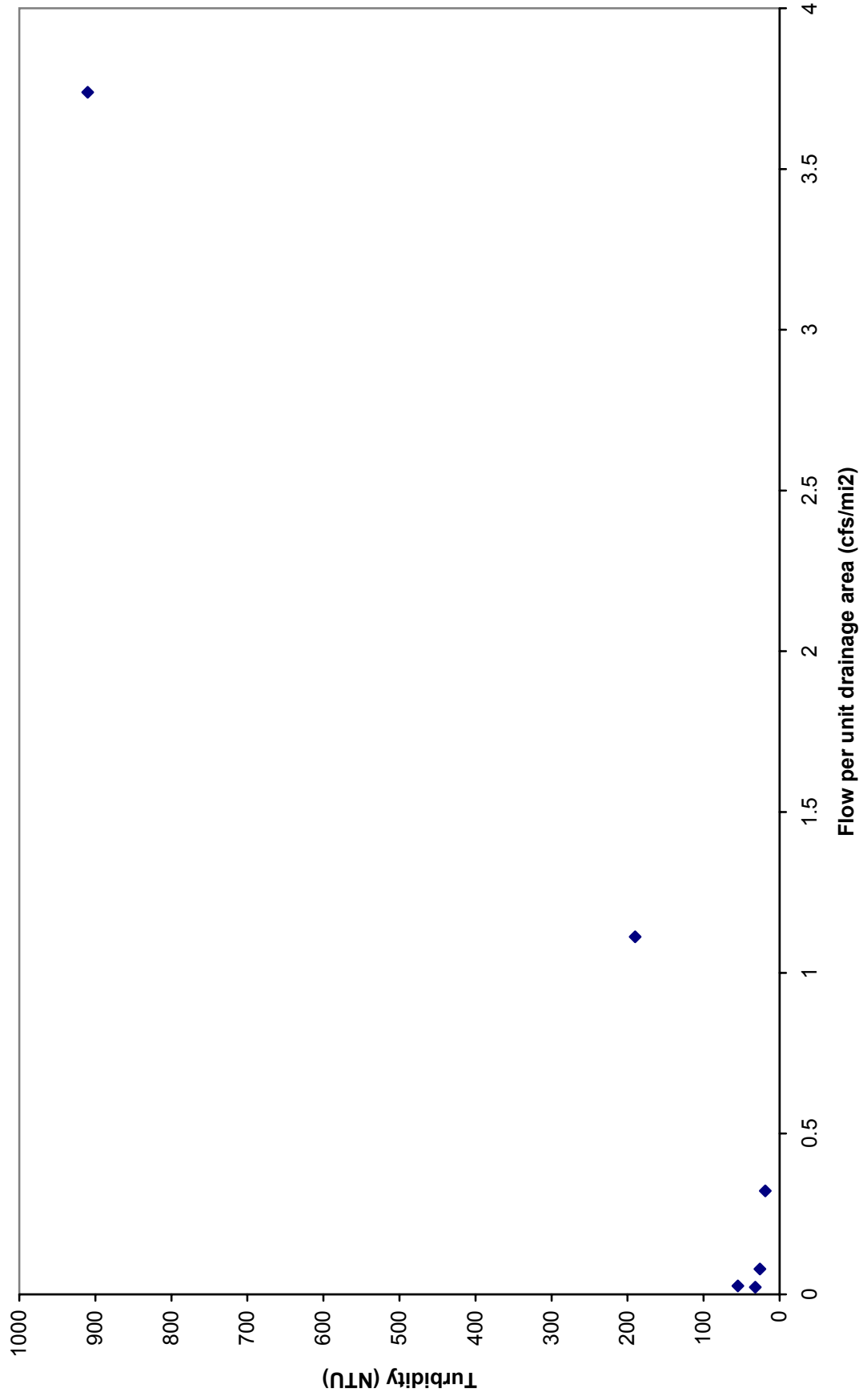


Figure D.2. Turbidity vs flow for Tyrnza River near Tyrnza, AR (FRA0033)



APPENDIX E

Plots of TSS vs Turbidity

Figure E.1. Base flow regression for TSS vs Turbidity for Tyrnza River (FRA0033)

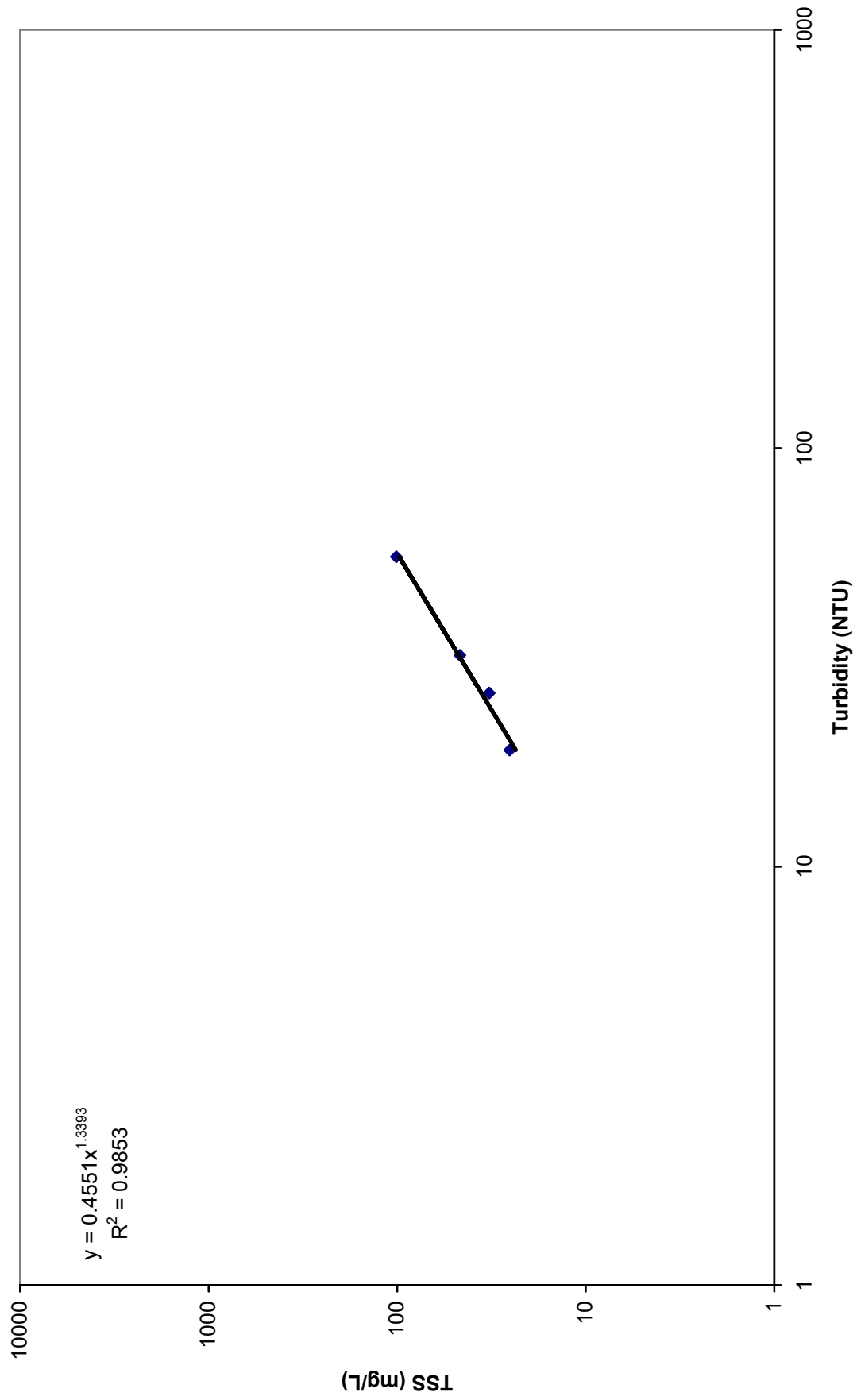
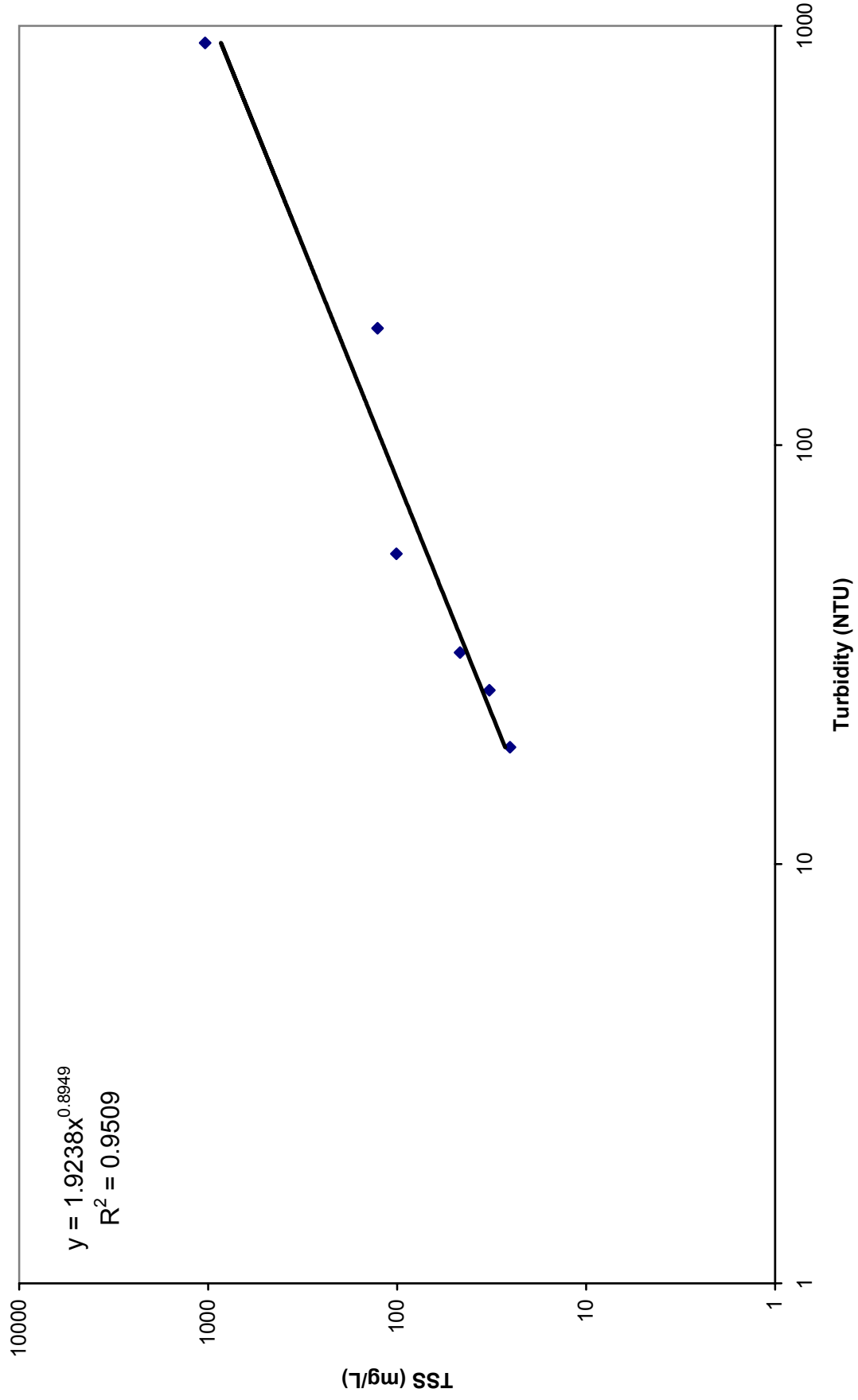


Figure E.2. Storm-flow regression for TSS vs Turbidity for Tyronza (FRA0033)



APPENDIX F

Load Duration Curves and TMDL Calculations

Figure F.1. Flow Duration Curve for L'Anguille River near Colt, AR (USGS 07047942)

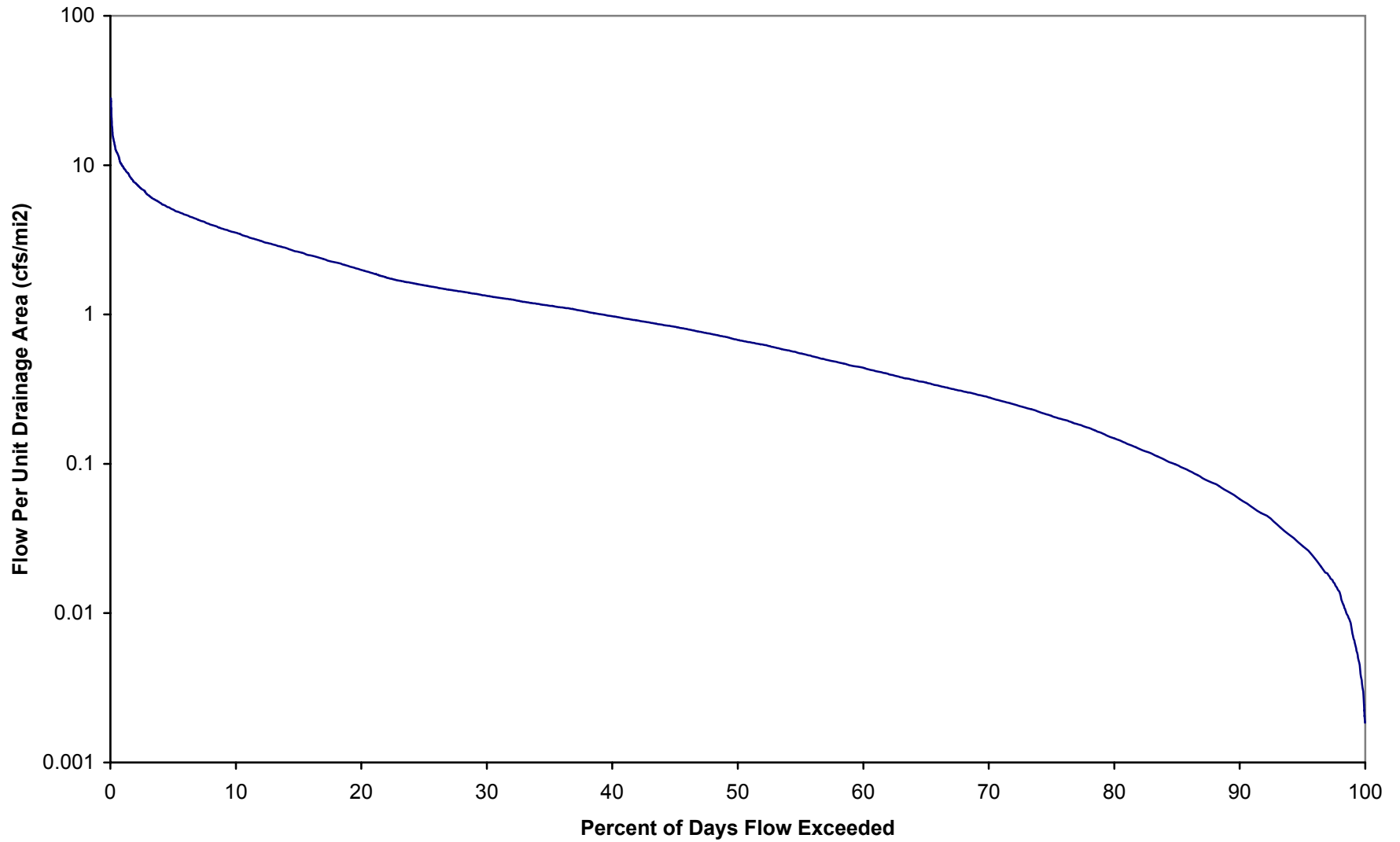


Figure F.2. Storm-flow Load Duration Curve for Tyronza River (FRA0033)

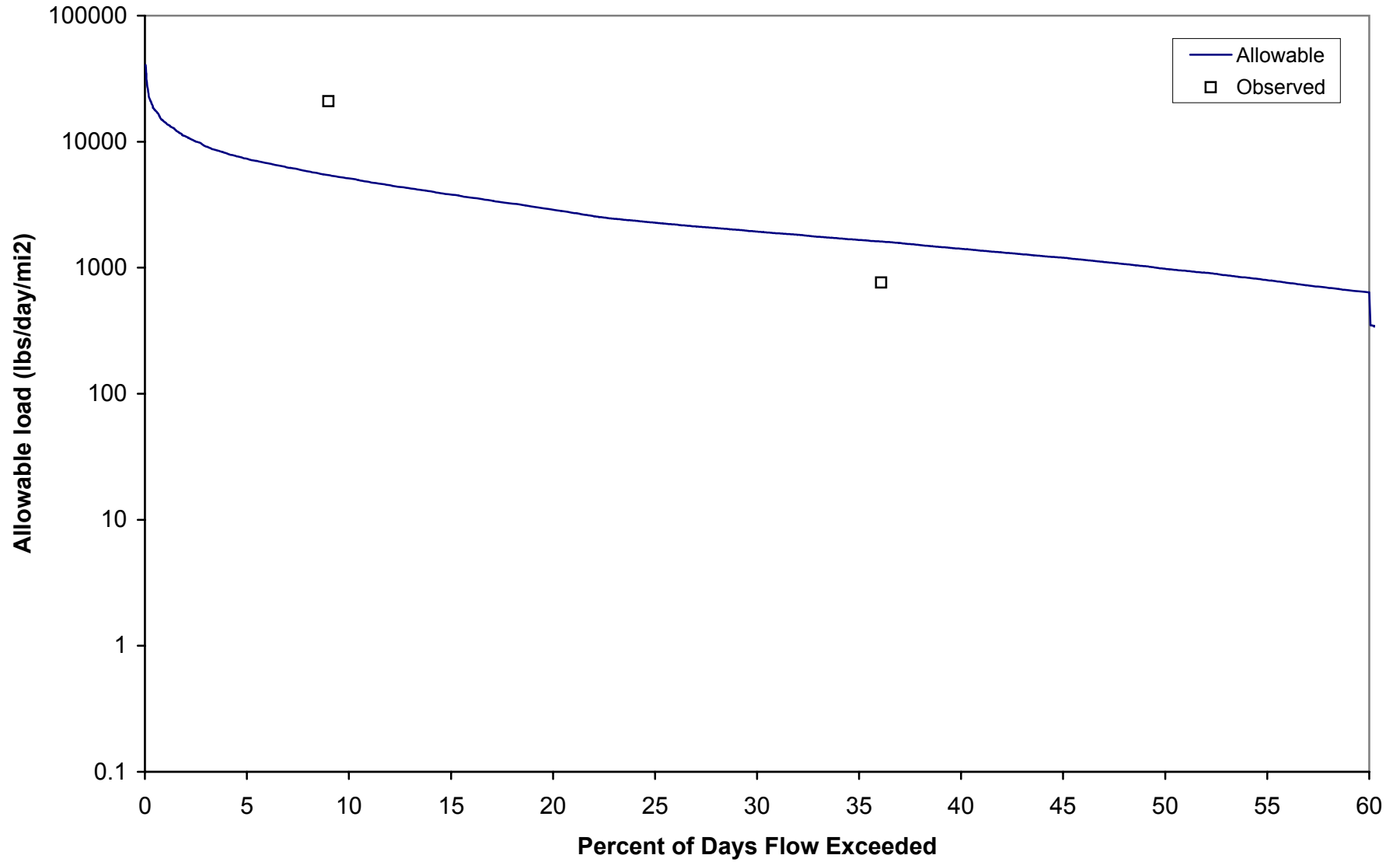


Figure F.3. Base flow Load Duration Curve for Tyronza River (FRA0033)

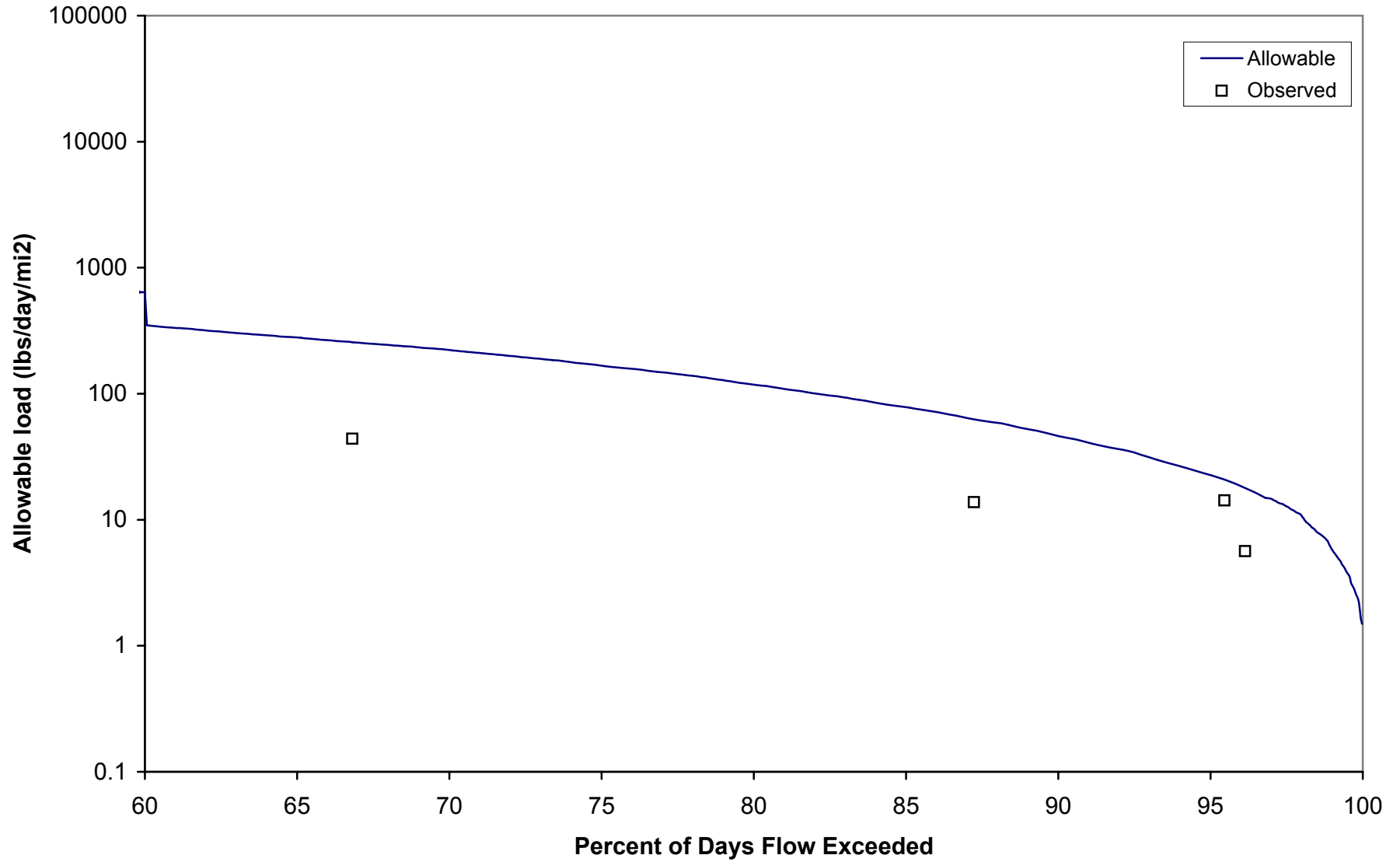


Table F.1. Calculations for the allowable TSS load for Tyronza River.
 drainage area at USGS flow gage = 535 mi², (L'Anguille River near Colt)

| date | flow (cfs) | flow (cfs/mi ²) | Percent of days flow exceeded | WQ Standard type | WQ Standard (NTU) | WQ Target TSS (mg/L) | Allowable TSS load (lbs/day/mi ²) |
|----------|------------|-----------------------------|-------------------------------|------------------|-------------------|----------------------|---|
| 10/27/71 | 1 | 1.87E-03 | 99.975% | Base flow | 75 | 148 | 1.49E+00 |
| 10/11/92 | 1 | 1.87E-03 | 99.975% | Base flow | 75 | 148 | 1.49E+00 |
| 10/12/92 | 1 | 1.87E-03 | 99.975% | Base flow | 75 | 148 | 1.49E+00 |

The rows between 99.975 and 80.028 percent flow exceedances are not shown for the sake of brevity.

| | | | | | | | |
|----------|----|----------|---------|-----------|----|-----|----------|
| 07/28/96 | 79 | 1.48E-01 | 80.028% | Base flow | 75 | 148 | 1.18E+02 |
| 09/11/99 | 79 | 1.48E-01 | 80.028% | Base flow | 75 | 148 | 1.18E+02 |
| 11/03/99 | 79 | 1.48E-01 | 80.028% | Base flow | 75 | 148 | 1.18E+02 |

The rows between 80.028 and 60.065 percent flow exceedances are not shown for the sake of brevity.

| | | | | | | | |
|----------|-----|----------|---------|-----------|----|-----|----------|
| 09/03/97 | 234 | 4.37E-01 | 60.065% | Base flow | 75 | 148 | 3.49E+02 |
| 05/12/02 | 234 | 4.37E-01 | 60.065% | Base flow | 75 | 148 | 3.49E+02 |
| 02/12/03 | 234 | 4.37E-01 | 60.065% | Base flow | 75 | 148 | 3.49E+02 |

| | | | | | | | |
|----------|-----|----------|---------|------------|-----|-----|----------|
| 12/17/70 | 235 | 4.39E-01 | 59.998% | Storm-flow | 250 | 269 | 6.37E+02 |
| 09/24/72 | 235 | 4.39E-01 | 59.998% | Storm-flow | 250 | 269 | 6.37E+02 |
| 03/15/82 | 235 | 4.39E-01 | 59.998% | Storm-flow | 250 | 269 | 6.37E+02 |

The rows between 59.998 and 30.012 percent flow exceedances are not shown for the sake of brevity.

| | | | | | | | |
|----------|-----|----------|---------|------------|-----|-----|----------|
| 03/09/83 | 713 | 1.33E+00 | 30.012% | Storm-flow | 250 | 269 | 1.93E+03 |
| 12/19/85 | 713 | 1.33E+00 | 30.012% | Storm-flow | 250 | 269 | 1.93E+03 |
| 09/21/89 | 713 | 1.33E+00 | 30.012% | Storm-flow | 250 | 269 | 1.93E+03 |

The rows between 30.012 and 0.054 percent flow exceedances are not shown for the sake of brevity.

| | | | | | | | |
|----------|-------|----------|--------|------------|-----|-----|----------|
| 04/29/91 | 14300 | 2.67E+01 | 0.054% | Storm-flow | 250 | 269 | 3.88E+04 |
| 12/29/87 | 15000 | 2.80E+01 | 0.041% | Storm-flow | 250 | 269 | 4.07E+04 |
| 12/30/87 | 15000 | 2.80E+01 | 0.041% | Storm-flow | 250 | 269 | 4.07E+04 |

| | | |
|--|-------|---------------------|
| Flow per unit area in middle of base flow range (80% exceedance) = | 0.148 | cfs/mi ² |
| Cumulative drainage area at downstream end of reach 012 = | 408 | mi ² |
| Flow at downstream end of reach 012 for base flow conditions = | 60.25 | cfs |
| Target TSS for base flow conditions for reach 012 = | 148 | mg/L |
| Allowable TSS load for base flow conditions for reach 012 = | 24.0 | tons/day |

| | | |
|---|--------|---------------------|
| Flow per unit area in middle of stormwater range (30% exceedance) = | 1.333 | cfs/mi ² |
| Cumulative drainage area at downstream end of reach 012 = | 408 | mi ² |
| Flow at downstream end of reach 012 for stormwater conditions = | 543.75 | cfs |
| Target TSS for stormwater conditions for reach 012 = | 269 | mg/L |
| Allowable TSS load for stormwater conditions for reach 012 = | 394 | tons/day |

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TABLE F.2. CALCULATIONS FOR PERCENT REDUCTION FOR STORM-FLOW CONDITIONS FOR TYRONZA RIVER (STATION FRA0033)

Storm-flow target TSS conc. = 269 mg/L Error check for reduction is / is not needed: ok
 Percent reduction needed = 0% Error check for less or more reduction needed: ok

| <u>Category</u> | <u>Date</u> | <u>Observed TSS at FRA0033 (mg/L)</u> | <u>Flow per unit area on sampling day (cfs/mi2)</u> | <u>Percent exceedance for flow on sampling day</u> | <u>Current TSS load (lbs/day)/mi2</u> | <u>Reduced TSS load (lbs/day)/mi2</u> | <u>Allowable TSS load (lbs/day)/mi2</u> | <u>Reduced load less than or equal to allow. load?</u> |
|-----------------|-------------|---------------------------------------|---|--|---------------------------------------|---------------------------------------|---|--|
| Storm-flow | 1/22/2001 | 127.0 | 1.11E+00 | 36.1% | 761.7 | 761.7 | 1613.4 | Yes |
| Storm-flow | 3/5/2001 | 1038.0 | 3.74E+00 | 9.0% | 20926.5 | 20926.5 | 5423.1 | No |

Total number of values = 2
 Allowable % of exceedances = 20%
 Allowable no. of exceedances = 1
 No. of exceedances before reductions = 1
 No. of exceedances after reductions = 1

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TABLE F.3. CALCULATIONS FOR PERCENT REDUCTION FOR BASE FLOW CONDITIONS FOR TYRONZA RIVER (STATION FRA0033)

Base flow target TSS conc. = 148 mg/L Error check for reduction is / is not needed: ok
 Percent reduction needed = 0% Error check for less or more reduction needed: ok

| <u>Category</u> | <u>Date</u> | <u>Observed TSS at FRA0033 (mg/L)</u> | <u>Flow per unit area on sampling day (cfs/mi2)</u> | <u>Percent exceedance for flow on sampling day</u> | <u>Current TSS load (lbs/day)/mi2</u> | <u>Reduced TSS load (lbs/day)/mi2</u> | <u>Allowable TSS load (lbs/day)/mi2</u> | <u>Reduced load less than or equal to allow. load?</u> |
|-----------------|-------------|---------------------------------------|---|--|---------------------------------------|---------------------------------------|---|--|
| Base flow | 6/25/2001 | 46.5 | 2.24E-02 | 96.1% | 5.62 | 5.62 | 17.90 | Yes |
| Base flow | 11/6/2000 | 101.0 | 2.62E-02 | 95.5% | 14.25 | 14.25 | 20.89 | Yes |
| Base flow | 5/14/2001 | 32.5 | 7.85E-02 | 87.2% | 13.76 | 13.76 | 62.66 | Yes |
| Base flow | 9/10/2001 | 25.3 | 3.21E-01 | 66.8% | 43.86 | 43.86 | 256.60 | Yes |

Total number of values = 4
 Allowable % of exceedances = 25%
 Allowable no. of exceedances = 1
 No. of exceedances before reductions = 0
 No. of exceedances after reductions = 0

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