TMDLS FOR TURBIDITY AND FECAL COLIFORMS FOR L'ANGUILLE RIVER, AR

October 2001

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FOR L'ANGUILLE RIVER, AR

Prepared for

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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 standard for that pollutant. Through a TMDL, pollutant loads can be allocated to point sources and nonpoint sources discharging to the waterbody.

The L'Anguille River, which is located in Planning Segment 5B, is a tributary of the St. Francis River in eastern Arkansas in the Delta ecoregion. The designated beneficial uses that have been established by the Arkansas Department of Environmental Quality (ADEQ) for the L'Anguille River include primary and secondary contact recreation; domestic, industrial, and agricultural water supply; and perennial delta fishery (ADEQ 1998a). ADEQ has established both narrative and numeric turbidity and fecal coliform standards that apply to the L'Anguille River.

The numeric turbidity standard that applies to the L'Anguille River is 45 NTU. ADEQ's historical water quality data for the L'Anguille River show that turbidity values frequently exceed 45 NTU. Because of its elevated turbidity levels, the entire length of the L'Anguille River (5 reaches) was included on the Arkansas 1998 303(d) list for not supporting aquatic life due to siltation/turbidity (ADEQ 1998b).

The numeric fecal coliform standards that apply to the L'Anguille River require the geometric mean of the data to be no greater than: A) 200 col/100mL during the summer period for primary contact waters and all year for waters designated as extraordinary resource water, and B) 1000 col/100mL during the winter period and for all secondary contact water. ADEQ's historical monitoring data for fecal coliforms shows some measurements that are higher than the water quality standards. The 1998 303(d) list included the upper 2 reaches of the L'Anguille River as a "water of concern" for primary contact recreation due to pathogens.

Historical water quality data for long term monitoring stations on the L'Anguille River near Marianna, Second Creek near Palestine, and the L'Anguille River near Colt were analyzed and plotted to examine relationships between parameters, seasonal patterns, and long term

trends. Parameters that were analyzed included turbidity, total suspended solids (TSS), fecal coliforms, and stream flow. Linear regression was used to relate turbidity to TSS so that turbidity could be expressed in terms of TSS loads.

The TMDL for turbidity for the L'Anguille River was expressed using TSS as a surrogate for turbidity. Based on historical turbidity data, critical periods were defined as February through April (spring) and July through October (summer). The wasteload allocations for point source contributions were 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 L'Anguille River basin 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 DO. Field data collected during synoptic surveys in May - June 2000 showed that point source discharges appeared to be having little impact on turbidity in the L'Anguille River.

Because point source contributions of inorganic suspended solids were negligible, load allocations for nonpoint source contributions of TSS were set equal to the total allowable loads. In order to meet these load allocations, the existing nonpoint source loads of TSS in the L'Anguille River must be reduced by 38% during the summer critical period and 40% during the spring critical period. An implicit margin of safety was incorporated through conservative assumptions. The TMDL for turbidity is summarized in the following table (lbs/day of TSS):

	Summer	**Spring**
Wasteload allocation for point sources	0	0
Load allocation for nonpoint sources	118,028	481,604
Margin of safety	incorporated through conservative assumptions	
Total maximum daily load	118,028	481,604

For fecal coliforms, maximum allowable loadings were calculated as bacterial counts (col/100 mL) multiplied by stream flow. The seasonal periods of April through September (summer) and October through March (winter) were used based on the water quality standards for fecal coliforms. Wasteload allocations of fecal coliforms were calculated for the point source discharges that drain into the L'Anguille River within the two reaches on the 303(d) list. The wasteload allocations were based on existing permit limits because point sources appear to have little impact on fecal coliform concentrations in the L'Anguille River and most point source discharges already have permit limits equal to the water quality standards.

Load allocations for nonpoint source contributions of fecal coliforms were calculated as the total allowable loads minus the wasteload allocations. In order to meet these load allocations, the existing nonpoint source loads of fecal coliforms in the upper two reaches of the L'Anguille River must be reduced by 11% during the winter period. No reductions are required for the summer period. An implicit margin of safety was incorporated through conservative assumptions. The TMDL for fecal coliforms is summarized in the following table (units are col/day):

	Summer	**Winter**
Wasteload allocation for point sources	4.215 E10	5.713 E10
Load allocation for nonpoint sources	3.513 E12	2.836 E13
Margin of safety	incorporated through conservative assumptions	
Total maximum daily load	3.555 E12	2.842 E13

An implementation plan for these TMDLs will be developed by the Arkansas Soil and Water Conservation Commission (ASWCC) and ADEQ. It is anticipated that some reductions in turbidity and fecal coliforms can be achieved through reductions in sediment loads to the L'Anguille River. Reductions in sediment loads to the L'Anguille River may be achieved through agricultural best management practices (BMPs) or other control measures.

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1.0 INTRODUCTION

The L'Anguille River, which is located in Planning Segment 5B, is a tributary of the St. Francis River in eastern Arkansas in the Delta ecoregion. The Arkansas Department of Environmental Quality (ADEQ) has established narrative and numeric water quality standards for turbidity and fecal coliforms. The numeric turbidity standard that applies to the L'Anguille River is 45 NTU. ADEQ's historical water quality data for the L'Anguille River show that turbidity values frequently exceed 45 NTU. Because of its elevated turbidity levels, the entire length of the L'Anguille River (5 reaches) was included on the Arkansas 1998 303(d) list for not supporting aquatic life due to siltation/turbidity (ADEQ, 1998b). The numeric fecal coliform standards that apply to the L'Anguille River require the geometric mean of the data to be no greater than: A) 200 col/100mL during the summer period for primary contact waters and all year for waters designated as extraordinary resource water, and B) 1000 col/100mL during the winter period and for all secondary contact water. ADEQ's historical monitoring data for fecal coliforms shows numerous measurements that are higher than the water quality standards. The 1998 303(d) list included the upper 2 reaches of the L'Anguille River for not supporting primary contact recreation due to pathogens. Therefore, the development of TMDLs for turbidity and fecal coliforms for the L'Anguille River is required. These TMDLs are being conducted under EPA Contract #68-C-99-249, Work Assignment #0-15.

2.0 DESCRIPTION OF WATERSHED

The L'Anguille River is located in eastern Arkansas in the Delta ecoregion (Figure 2.1). The L'Anguille River and its tributaries form USGS Hydrologic Unit 08020205 and ADEQ Planning Segment 5B. The L'Anguille River begins south of Jonesboro, Arkansas and flows generally southward to its confluence with the St. Francis River near Marianna, Arkansas. The total drainage area of the L'Anguille River at its mouth is 938 mi^2 (USGS, 1967). The drainage area includes parts of Craighead, Poinsett, Cross, Woodruff, St. Francis, and Lee counties. The largest tributaries of the L'Anguille River are Brushy Creek, First Creek, and Second Creek. Crowley's Ridge occupies a small portion of the watershed along the western edge.

2.1 Topography

The following description of the topography of the watershed was taken from county soil surveys (USDA, 1966; USDA, 1968; USDA, 1977a; USDA, 1977b). The topography of the L'Anguille River watershed can be divided into two main areas: the moderately steep to steep Crowley's Ridge and the level to moderately sloping upland plain west of Crowley's Ridge. In the Crowley's Ridge area, topography is characterized by ridges with narrow, winding tops; short side slopes; and narrow valleys between the ridges. Slopes on the ridges are mostly 12 to 40 percent and slopes along the bottoms of the valleys are generally less than 1 percent. West of Crowley's Ridge, the upland plain is mainly level to nearly level with some gently sloping area. Slopes are mostly less than 3 percent. Scattered low ridges and escarpments along streams have slopes of 3 to 12 percent.

2.2 Soils

Soil characteristics for the watershed are also provided by the county soil surveys (USDA, 1966; USDA, 1968; USDA, 1977a; USDA, 1977b). Most of the soils in the L'Anguille River watershed are classified as silt loam. Soil series that are common in the upland plains area are Henry, Hilleman, Calloway, Crowley, Calhoun, Loring, Arkabutla, Collins, Memphis, and Grenada. All of these soils are classified as silt loam. Soil series that are common in the floodplains of the L'Anguille River and its larger tributaries are Tichnor, Zachary, Arkabutla, Collins, Mhoon, Alligator, and Earle. All of these soils are classified as silt loam except for

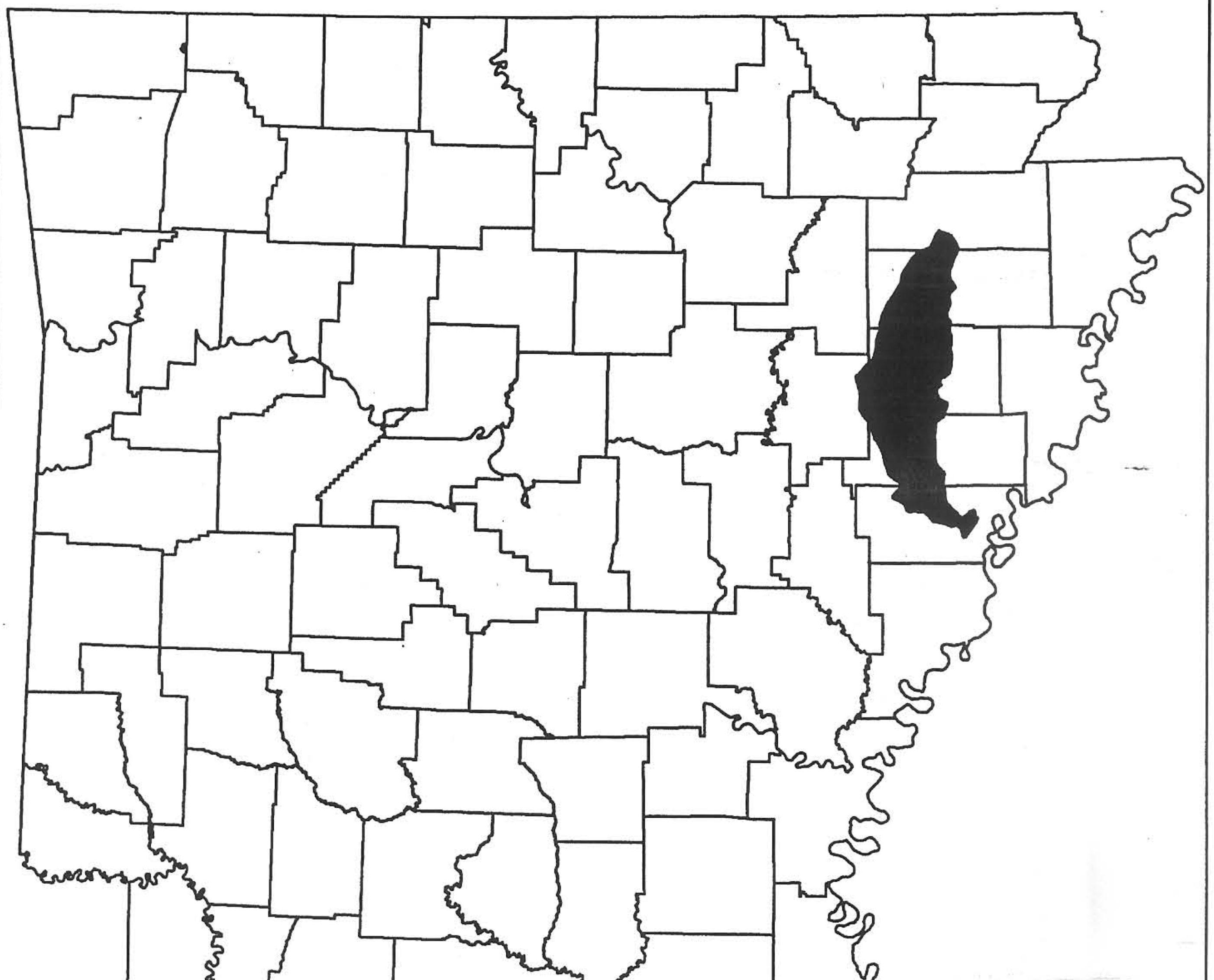


Figure 2.1. Location of L'Anguille River Basin in Arkansas

Alligator and Earle, which have a higher clay content. Soil series that are common along Crowley's Ridge are Loring, Brandon, and Memphis, each of which is classified as a silt loam.

2.3 Land Use

Land use in the L'Anguille River watershed is predominantly agricultural (Figure 2.2). Approximate percentages of each land use in the watershed are:

59.3%	rice, soybeans, and other summer crops
9.9%	wheat and oats
22.0%	forest
5.4%	pasture
2.4%	urban and transportation
1.0%	water

Prior to development, the L'Anguille River basin was predominantly bottomland hardwood forests. General cropland data for each county indicate that approximately 60% of the cropland is irrigated in the northern part of the watershed (Craighead, Poinsett, Cross, and Woodruff counties), while 30-40% of the cropland is irrigated in the southern part of the watershed (St. Francis and Lee counties). Based on observations during the FTN field study, much of the irrigated acreage appeared to be rice. Less acreage of rice was observed in the southern part of the watershed (particularly the southwestern part around Larkin Creek and Coffee Creek) than in the northern part. Most of the land along Crowley's Ridge appeared to be pasture or forest. A few cattle were observed in the southern part of the watershed.

Farming practices are fairly uniform throughout the basin. Rice and cotton are typically planted in April through May and soybeans are planted later in May through June. Wheat is planted in October and November. Irrigation is primarily by flooding. Rice is flooded in May, soybeans are irrigated in June through July, and cotton is irrigated in July. Rice fields are typically drained in late August through September. Much of the land is bare from November through March. At any given time of the year, there may be some fields that are bare.

2.4 Channel Network

Some of the stream channels in the northern and western parts of the watershed have been dredged and straightened (Figure 2.3). Many of the dredged channels have side slopes that are at least partly exposed due to lack of vegetative cover. Most of the stream channels (even the ones

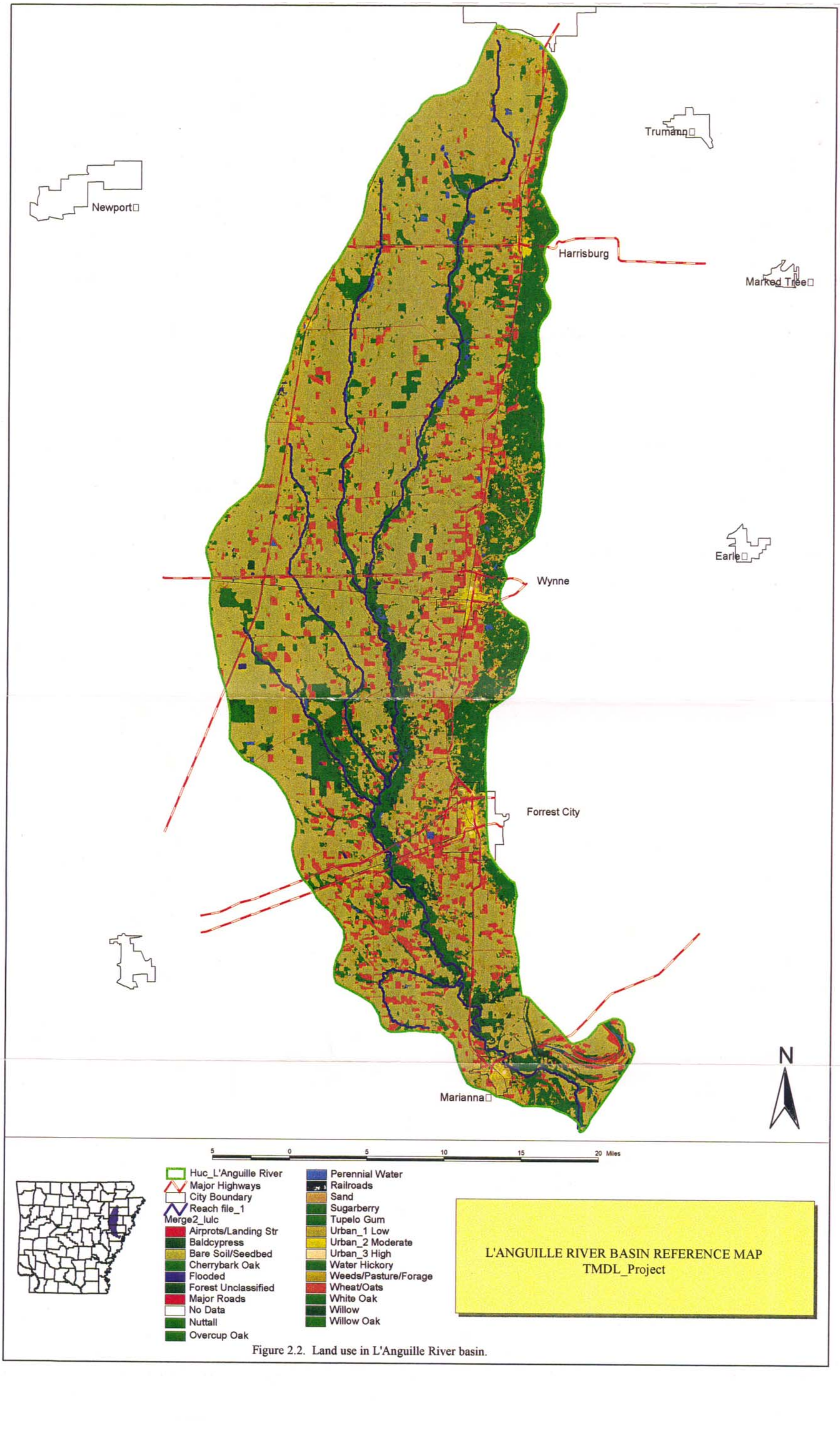


Figure 2.2. Land use in L'Anguille River basin.

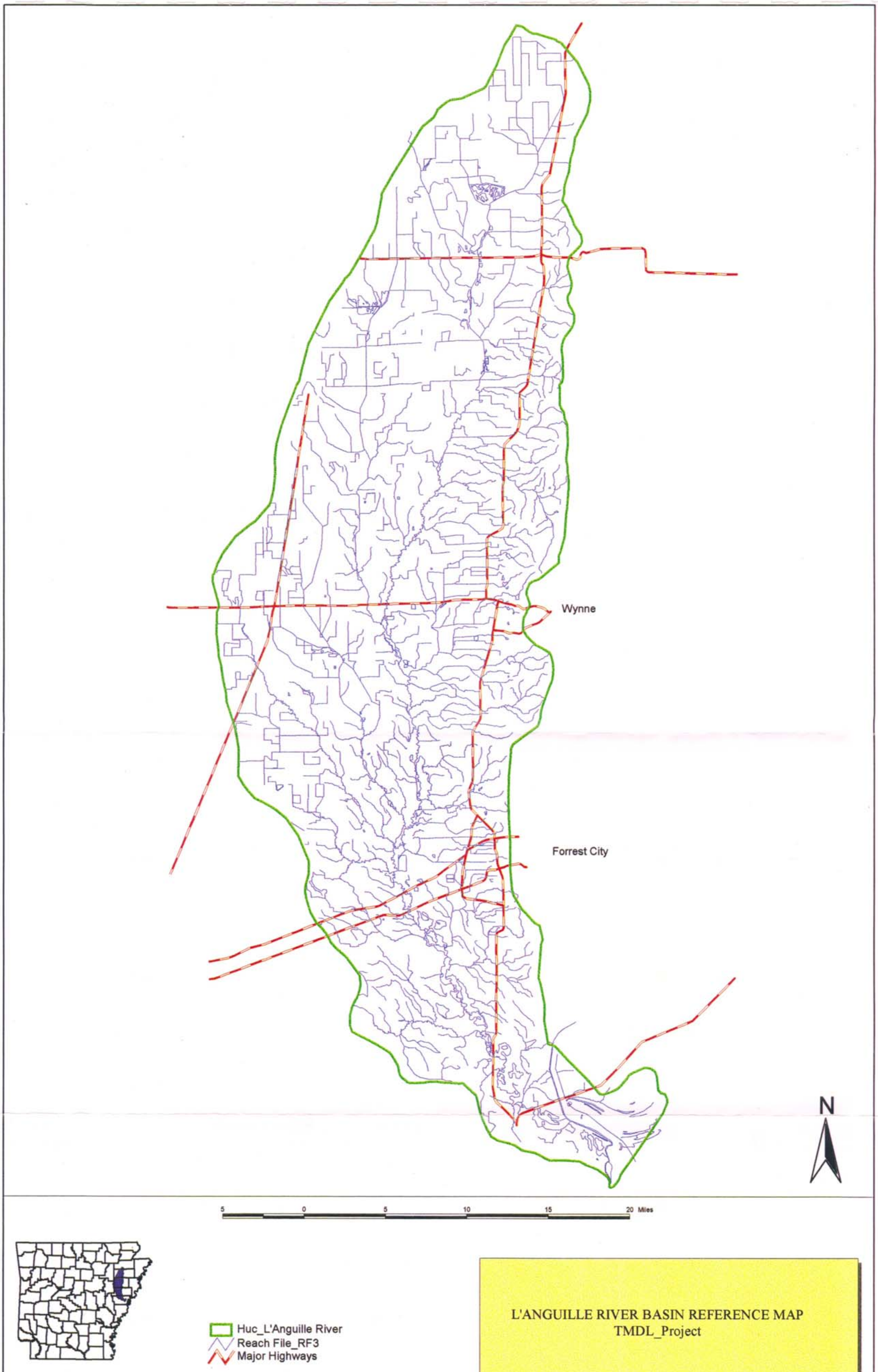


Figure 2.3. Network of stream channels in L'Anguille River basin.

that have been dredged and straightened) have at least a few trees or bushes along the tops of the banks. A few stream channels along the edge of Crowley's Ridge were observed to have exposed side slopes that appeared to be eroding during storms.

Most of the main stem of the L'Anguille River is a meandering channel that has not been straightened. In the middle portion of the river (Cross County), much of the stream channel is wide and marshy. In the lower portion of the river (St. Francis and Lee Counties), the channel is deeper and wider than it is upstream. The gradient of the channel from the headwaters to the mouth is small, averaging about 1.6 ft/mi (USGS 1979). Much of the main stem has forested floodplains on both sides of the channel, particularly along the lower portions of the river. Portions of the lower half of the L'Anguille River also have a braided channel.

2.5 Description of Hydrology

The USGS has published daily stream flow data for 2 gages in the L'Anguille River basin. Basic information and summary statistics for these gages are summarized in Table 2.1.The locations of these gages are shown on Figure 2.4. Differences in low flow statistics between the two gages could be influenced by use of different periods of record. Another factor affecting the differences between the two gages could be the hydraulic connectivity between the L'Anguille River and the alluvial aquifer (USGS 1979). Figure 2.5 shows the mean monthly flows for the Palestine gage. Monthly flows are highest in February and lowest in October.

Average annual precipitation for the L'Anguille River basin is approximately 49 inches (Hydrosphere, 1999). Mean monthly precipitation totals for the Wynne station are shown in Figure 2.6. The mean monthly precipitation values are highest for April and lowest for August.

2.6 Point Sources

Information on point source discharges in the L'Anguille River basin (Hydrologic Unit 08020205) was obtained by searching the Permit Compliance System (PCS) on the EPA website. PCS is the database used by ADEQ and EPA to manage NPDES permit information. The PCS database was searched for all NPDES permits within the basin regardless of size of discharge or which parameters are reported. The search yielded 20 facilities with individual NPDES permits for point source discharges (Table A.1 in Appendix A). Any point source discharges authorized under a general permit (rather than an individual permit) would not be revealed by this search.

Table 2.1. Information for stream flow gaging stations.

	L'Anguille River near Colt	L'Anguille River at Palestine
USGS gage number	07047942	07047950
Descriptive location	Approx. 8 mi. SW of Wynne on State Hwy 306; RM 52.8	1 mile east of Palestine on U.S. Hwy 70; RM 33.6
Drainage area (mi2)	535	786
Period of record	October 1970 to current	April 1949 to Sept. 1977, October 1997 to current
Mean annual flow (cfs) [A]	731	1131
Mean annual runoff (in) [A]	18.6	19.6
7Q10 flow (cfs) [B]	2.9	0
Flow (cfs) that is exceeded: [B]		
98% of the time	9.0	0.5
95% of the time	19	6.2
90% of the time	33	36
50% of the time	385	484
10% of the time	2030	3110
5% of the time	2920	4570
2% of the time	4400	7340

Notes: A. Mean annual flow and runoff are published values based on the period of record through water year 1999 (USGS 2000).
B. Flow duration (i.e., exceedances) and 7Q10 flow are published values based on the period of record through 1990 (USGS 1992).

Information concerning parameters being reported and permit limits was not available for 3 of the facilities. Table A.1 shows permit limits for TSS and fecal coliforms.

During the June synoptic survey, turbid reddish water was sampled in a stream downstream of a gravel mining operation along Crowley's Ridge south of Harrisburg. The exact source of this turbid water is not known. Because this gravel mining operation apparently does not have an individual NPDES permit, it was not revealed in the PCS search. Also, none of the catfish ponds in the basin were revealed in the PCS search. It is believed that discharges from the catfish ponds are infrequent and of a short duration.

2.7 Nonpoint Sources

Nonpoint sources of pollution in the L'Anguille River watershed have been assessed by ADEQ. Their assessment of the entire St. Francis basin 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. This condition was encouraged by the drainage of lowland areas and by ditching and the channelization of streams to facilitate the runoff. The continuation of such activities and the continuous maintenance dredging of the ditches and streams aggravates and further deteriorates the conditions." (ADEQ, 2000).

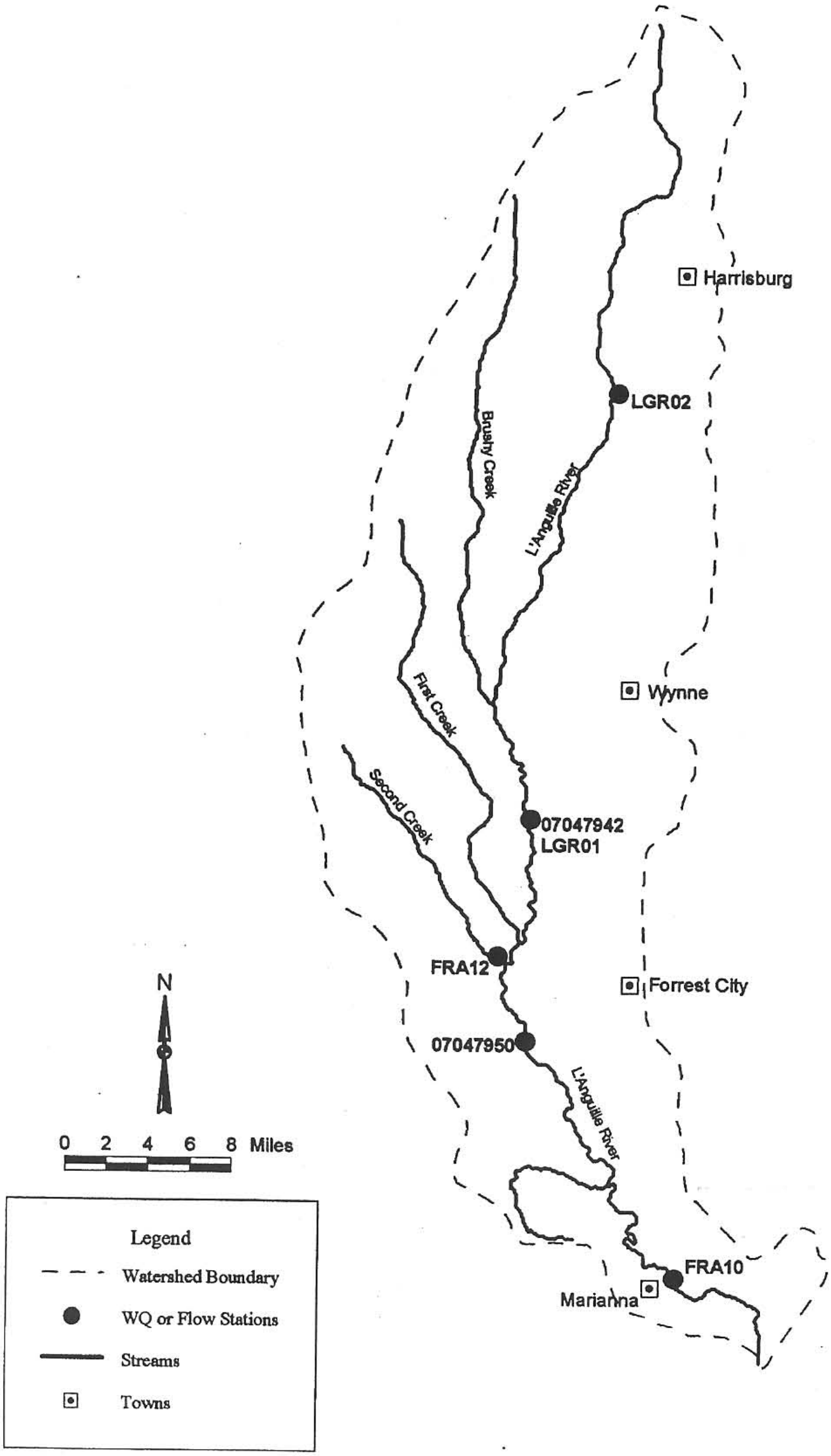


Figure 2.4. Location of Selected Water Quality Stations and Flow Gages.

Figure 2.5. Mean Monthly Flow for L'Anguille River at Palestine (07047950)

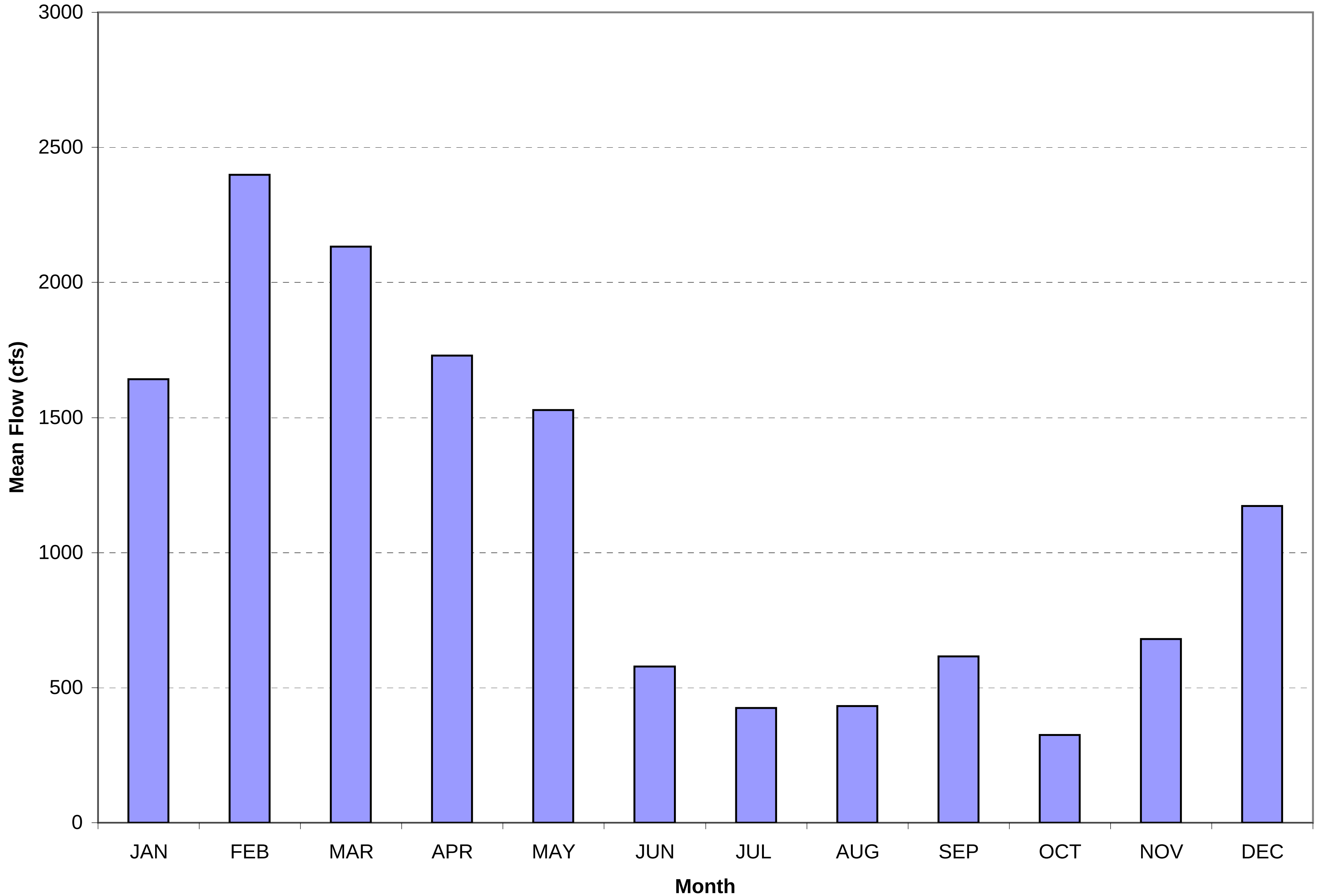
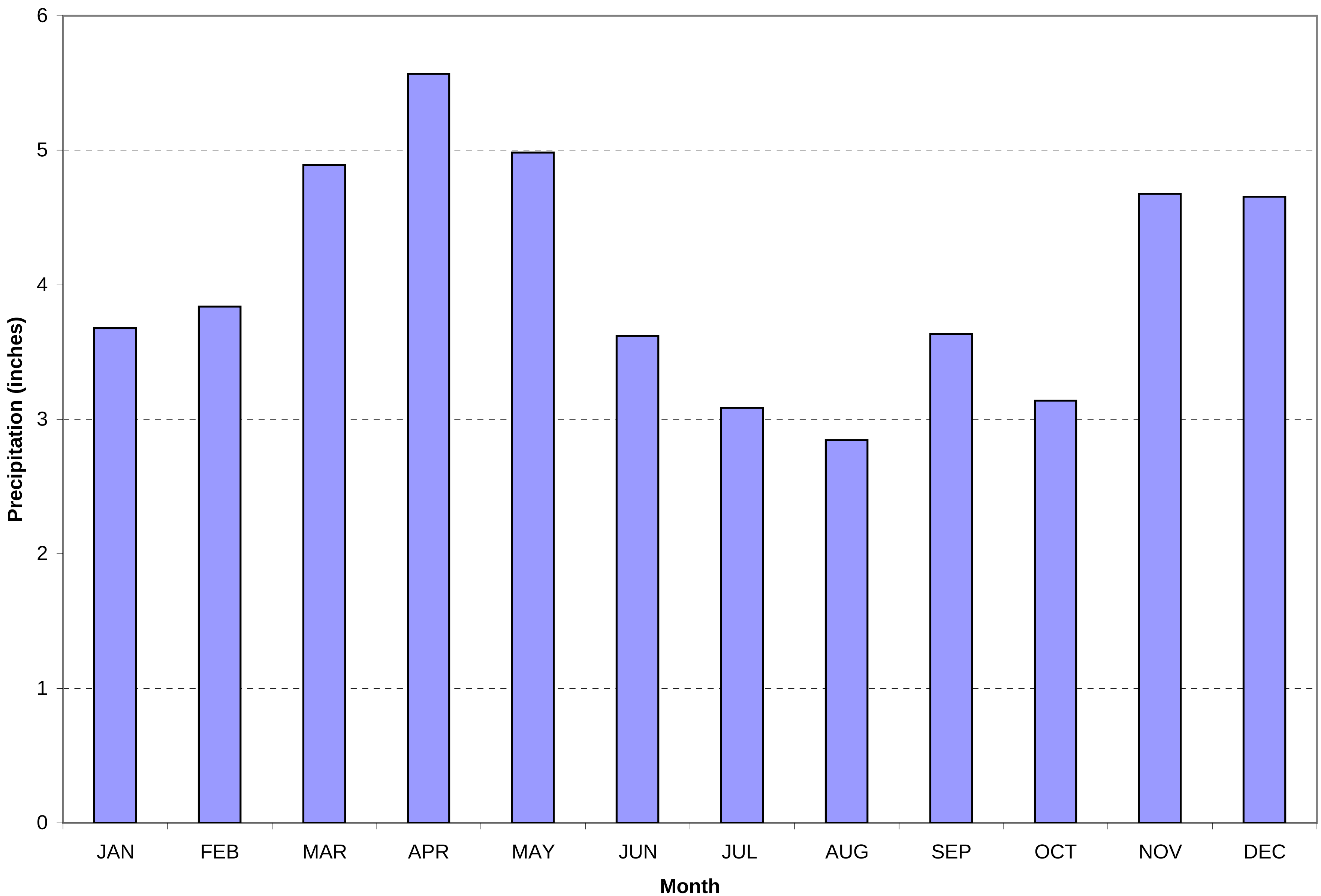


Figure 2.6. Mean Monthly Precipitation, at Wynne AR



3.0 CHARACTERIZATION OF EXISTING WATER QUALITY

3.1 Historical Data

3.1.1 Inventory of Data

Information on water quality monitoring stations in the L'Anguille River basin (Hydrologic Unit 08020205) was obtained by searching the U.S. EPA STORET database. The search was conducted for all water quality stations on streams within the basin, regardless of which agency collected the data or what parameters were measured. The search yielded a total of 61 stations, which included 15 stations with data from the ADEQ, 45 stations with data from the U.S. Geological Survey (USGS), and 1 station with data from EPA headquarters. Table B.1 (Appendix B) shows a list of these stations along with an inventory of the data for turbidity, TSS, and fecal coliforms. No data were found for chlorophyll *a*. Based on the 303(d) listings, the emphasis of this search was for parameters related to turbidity and fecal coliforms.

The L'Anguille River near Marianna (FRA10) and Second Creek near Palestine (FRA12) are part of ADEQ's ambient monitoring network for which monthly data are collected. Eleven of the other ADEQ stations contain data collected during the summers of 1965 and 1968 as a part of a study of the water quality and sources of pollution in the Arkansas portion of the St. Francis River basin.

Many of the USGS stations have data for only 1 or 2 dates in 1978. These data were collected as part of a special study of the L’Anguille River basin during the summer and fall of 1978 (USGS 1979). The other USGS stations have varying periods of record, but the only USGS station that is currently active is the L'Anguille River near Colt (07047942).

3.1.2 Analysis at Selected Stations

There were only 4 stations with a sufficient quantity of historical water quality data to be analyzed for relationships between parameters, seasonal patterns, and long term trends. The locations of these stations are shown on Figure 2.4. These stations were:

- L'Anguille River near Marianna (FRA10 and 07047964)
- Second Creek near Palestine (FRA12 and 07047947)
- L'Anguille River near Colt (LGR01 and 07047942)
- L'Anguille River near Whitehall (LGR02)

For the L'Anguille River near Marianna and Second Creek near Palestine, data were found from both ADEQ and USGS. For both of these 2 stations, the USGS data were already included in the ADEQ data (i.e., the same data were entered into STORET by both agencies). Therefore, the USGS data for these 2 stations were not used in this analysis.

For the L'Anguille River near Colt, data were found from both ADEQ and USGS. For this station, the ADEQ data and USGS data were mutually exclusive; the data for each agency represented different parameters measured on different dates. Therefore, data for this station from both agencies were used in this analysis.

Turbidity and Related Parameters - Relationships between parameters were examined for 3 parameter combinations:

- turbidity and TSS
- turbidity and stream flow
- TSS and stream flow

The plots of turbidity vs. TSS (Figures 3.1-3.3; Figures 3.1-3.27 are located in Appendix C) show that turbidity generally increases as TSS increases. However, there is considerable uncertainty in these relationships, especially at lower turbidity values. The plots of turbidity vs. stream flow (Figures 3.4-3.6) show little or no relationship between turbidity and stream flow. Also, the plots of TSS vs. stream flow (Figures 3.7-3.9) show little or no relationship between TSS and stream flow. Initially, multiple linear regression was used to relate turbidity (NTU) to TSS (mg/L) and flow (cfs). However, flow did not have a strong influence on the regression. Therefore, the regression was performed only between turbidity and TSS. Because TSS and turbidity data are typically log-normally distributed, the base 10 logarithms of the TSS and turbidity were used in the linear regression. This yielded the following relationship:

$$\log TSS = 0.7094 + 0.54208 * \log Turbidity \qquad (R^2 = 0.32)$$

The plots of turbidity by month (Figures 3.10-3.11) show slightly higher turbidity values during late winter / early spring and slightly lower values during late summer / early fall. This pattern was more pronounced for Second Creek than for the L'Anguille River near Marianna.

The plots of TSS by month (Figures 3.12-3.13) indicate that there is less of a seasonal pattern for TSS than for turbidity.

The plots of turbidity by year (Figures 3.14-3.15) indicate that the general long term trend for turbidity has been constant or slightly decreasing. Because of the variability of the data, a trend developed from these data might not be statistically significant.

The plots of TSS by year (Figures 3.16-3.17) indicate that the general trend for TSS may also be constant or slightly decreasing. A decreasing trend is more noticeable for Second Creek than for the L'Anguille River near Marianna.

Fecal Coliforms and Related Parameters - Relationships between parameters were examined for 2 parameter combinations:

- fecal coliforms and TSS
- fecal coliforms and stream flow

There are questions concerning the quality of the fecal coliform data collected prior to 1988. ADEQ stopped collecting fecal coliform data for several years until these issues were resolved. Data prior to 1988 is included in this analysis for completeness only but should not be used to determine compliance with water quality standards.

The plots of fecal coliforms vs. TSS (Figures 3.18-3.19) show a slight relationship between fecal coliforms and TSS. It appears fecal coliforms increase with TSS suggesting reducing the TSS will also reduce the fecal coliforms. Since there is a lot of variability in the data no attempts were made to develop a relationship between the two parameters. A plot of fecal coliforms vs. TSS for station 07047942 (USGS data for the L'Anguille River near Colt) was not included here because all but one of the fecal coliform data were collected on different dates than the TSS data.

The plots of fecal coliforms vs. stream flow (Figures 3.20-3.22) show little or no relationship between fecal coliforms and stream flow. At any flow rate, the fecal coliforms vary greatly even in Second Creek.

The plots of fecal coliforms by month (Figures 3.23-3.25) show no consistent seasonal patterns for fecal coliforms. In Second Creek, there could be a pattern of higher counts and more variability during the spring high flow months but the pattern is not obvious. The data for station

07047942 (USGS data for the L'Anguille River near Colt) are shown in Figure 3.25 but are too limited to draw any conclusions.

The plots of fecal coliforms by year (Figures 3.26-3.27) show no distinct long term trends. Since data collected prior to 1988 need to be viewed with skepticism, the higher counts observed in the earlier years may or may not be meaningful. A plot of fecal coliforms by year for station 07047942 (USGS data for the L'Anguille River near Colt) was not included here because the period of record was not long enough (only 6 years).

3.2 Synoptic Surveys

As part of this study, synoptic surveys were undertaken on two occasions to identify potential sources of turbidity. On May 3-4 and June 6-7, field data were collected for turbidity, total suspended solids (TSS), specific conductance, and chlorophyll *a* throughout the L'Anguille River basin. Turbidity and specific conductance were measured in the field at the time samples were taken. TSS analysis was performed in the laboratory using EPA method 160.2. Chlorophyll *a* analysis was performed in the laboratory using Standard Method 10200 H. Duplicate samples were taken at 3 locations. At each sample location, digital photographs were taken as well as latitude and longitude measurements.

3.2.1 May Survey

Sampling on May 3-4 was performed at a total of 30 stations (6 on the main channel of the L'Anguille River, 20 tributaries of the L'Anguille River, and 4 point source discharges). The four point sources included wastewater treatment plants (WWTPs) for the cities of Harrisburg, Wynne, Forrest City, and Marianna. Two samples were taken at catfish ponds and 1 sample was taken from runoff from a rice field.

The May survey occurred during a period with moderate rainfall and dry antecedent conditions. Rainfall totals at Jonesboro, Wynne, and Marianna ranged from 0.73 inches to 1.17 inches during the 2 day survey and the day before the survey (daily data are shown in Appendix D). Because antecedent conditions were dry, runoff quantities appeared to be small. The flow in the L'Anguille River at Palestine was on the order of 200 cfs and rising during the survey (daily data are shown in Appendix D).

A large portion of the rice crop had emerged but the fields had not yet been flooded. For other crops (i.e., soybeans, cotton, and corn), some fields were still being prepared and some had already been planted. There was a fair amount of bare cropland with little cover. The wheat fields had not been harvested yet.

The results from the May survey are shown in Figures 3.28-3.30 (located in Appendix E). The measured turbidities were highly variable with no apparent patterns. Most of the stream samples had turbidity values greater than the water quality standard of 45 NTU. The turbidities that were low were found in areas characterized by extensive riparian cover near the stream. Turbidities from the small forested watersheds along Crowley's Ridge were relatively consistent in magnitude (21, 91, 62, and 48 NTU) but still higher than the water quality standard and not distinctly different from the agricultural areas. All of the point sources were characterized by low turbidities except Marianna (62 NTU). Overall, turbidities and TSS were somewhat related and chlorophyll *a* values for the stream stations were low ($< 25\ \mu$g/l).

There was no apparent pattern between land use and turbidities. The most significant pattern appeared to be the low turbidities in reaches with extensive riparian cover. In Second Creek, the turbidity was an order of magnitude lower at the downstream station (8-10 NTU) than at the upstream station (110 NTU). It is not known whether this reduction in turbidity is due to settling of suspended particles between the two stations, dilution by water entering the stream between the two stations, or some other mechanism.

3.2.2 June Survey

During the June survey, sampling and measurements were performed at a total of 36 stations (13 stations on the main channel of the L'Anguille River and 23 stations on tributaries of the L'Anguille River). The 4 point source stations that were sampled in May were dropped from the June survey because the turbidities from the point source stations were mostly low during the May survey. The 6 stations on the main channel of the L'Anguille River were added in order to help identify a longitudinal gradient in the river if it existed.

The June survey was performed during dry conditions. Rainfall amounts of 1 to 5 inches occurred over the basin about 9-12 days prior to the survey, but most of the watershed received little or no rain between that storm and the survey (daily rainfall data are shown in Appendix D).

The flow in the L'Anguille River at Palestine was on the order of 800 cfs during the survey even though it had been more than a week since widespread rain had occurred (daily flow data are shown in Appendix D). Rainfall was recorded on May 25-28, but the flow at the Palestine gage did not peak until May 31.

The rice crop ranged from barely emergent to 10 inches tall. Some rice fields were already flooded, while water was being pumped onto other fields to begin flooding. Some soybeans and cotton had already emerged, but planting was observed in other fields during the survey. Many wheat fields were being harvested and some wheat fields were being burned after harvest, which reduces the amount of crop residue on the soil surface. There was still a significant amount of bare cropland observed during the June survey.

The results from the June survey are shown in Figures 3.31-3.33 (located in Appendix E). The main stem turbidities were higher than the tributaries and greater than the water quality standard of 45 NTU. One possible explanation for this phenomenon is that runoff from the storms that occurred 9-12 days prior to the survey had not been flushed out of the main stem and the velocities in the main stem were high enough to prevent extensive settling of suspended particles. Measured surface velocities at some of the main stem sampling stations were typically 1.0 to 1.5 ft/sec.

The highest turbidity (279 NTU) was found in a small stream receiving drainage from a gravel mining operation south of Harrisburg. This sample was distinctly different than the other samples because the water had a reddish color and the particles were very fine (turbidity was 279 NTU but TSS was only 9 mg/L). Other samples had more of a grayish brown color.

The lowest turbidities were found in the small forested watersheds and areas with extensive riparian cover. The water in many of the small streams was clear and appeared to be from subsurface inflow to the stream rather than storm runoff. As in the May survey, the turbidity values were significantly lower at the downstream station on Second Creek (8-9 NTU) than at the upstream station (40-59 NTU). Brushy Creek produced unexpected results for both surveys. The turbidity values for both stations on Brushy Creek were less than 45 NTU for the May survey (32 and 24 NTU) and the June survey (29 and 37 NTU) even through the drainage area of the stream is highly agricultural and some of the channels have been dredged and straightened.

4.0 WATER QUALITY STANDARDS

4.1 Introduction

The State of Arkansas has developed water quality standards for waters of the State (ADEQ, 1998a). The standards are defined according to ecoregions and designated uses of the waterbodies. The L'Anguille River basin lies entirely within the Delta ecoregion. Designated uses for the L’Anguille River from its headwaters to the St. Francis River (Planning Segment 5B) include primary and secondary contact recreation; domestic, industrial, and agricultural water supply; and perennial Delta fishery.

In the Delta ecoregion, water quality standards for some parameters are different for "least-altered" streams and "channel-altered" streams. Most of the L'Anguille River is considered by ADEQ to be a "least-altered" stream. Also, Second Creek is designated as an extraordinary resource water (ADEQ 1998a).

4.2 Turbidity

Turbidity is addressed in Section 2.503 of the Arkansas Water Quality Standards (ADEQ, 1998a). The general narrative standard is:

“There shall be no distinctly visible increase in turbidity of receiving waters attributable to municipal, industrial, agricultural, other waste discharges or instream activities.”

Specifically, the turbidity standard is 45 NTU for least-altered Delta streams and 75 NTU for channel-altered Delta streams. ADEQ considers most of the L’Anguille River to be a least-altered Delta stream. Therefore, the water quality standard of 45 NTU was used for comparison with the turbidity data at each of the long term monitoring stations that had data measured in NTU (as opposed to JTU or FTU).

The percentages of observed values exceeding the water quality standard at these stations are shown in Table 4.1.

Table 4.1. Summary Statistics for Turbidity for Selected Stations

Station name	L'Anguille River near Marianna (FRA10)	Second Creek near Palestine (FRA12)	L'Anguille River near Colt (LGR01)	L'Anguille River near Whitehall (LGR02)
Period of record used for statistics	1974 - 1998	1984 - 1998	1994 - 1996	1994 - 1996
Number of values	232	153	8	8
Minimum (NTU)	1	1	13	8
Maximum (NTU)	1000	210	180	200
Median (NTU)	58	25	51	58
Percent of values above 45 NTU	62%	39% *	63%	63%

* Note: Using the last 2 years of data in STORET (1997-98), the percent of values above 45 NTU is only 25% for Second Creek.

These percentages of values above the water quality standard can be compared with the assessment guidance used by ADEQ for putting streams on the 303(d) list for turbidity (ADEQ 1998b). According to these criteria, a stream is not supporting the aquatic life use if more than 25% of the values at base flow exceed the standard or if more than 10% of the values for storm flows exceed the 90th percentile ecoregion value. The 1998 Arkansas 305(b) report (ADEQ 1998b) indicates that the L'Anguille River is not supporting the aquatic life use due to siltation/turbidity and therefore requiring the development of a TMDL. The probable source of the contamination causing impairment was attributed to agricultural activities.

4.3 Fecal Coliforms

For streams in Arkansas with a drainage area greater than 10 mi^2, one of the designated uses is primary contact recreation (ADEQ 1998a). All of the stations within the basin with long term fecal coliform data have drainage areas greater than 10 mi^2. The following water quality standards for bacteria (i.e., fecal coliforms) apply for streams with primary contact recreation as a designated use (Section 2.507 in ADEQ 1998a):

- Apr. - Sep.: geometric mean ≤ 200 / 100 mL
  10% of samples in 30 day period ≤ 400 / 100 mL
- Oct. - Mar.: geometric mean ≤ 1000 / 100 mL
  10% of samples in 30 day period ≤ 2000 / 100 mL

According to the standards (ADEQ 1998a), the application of these standards should be based "on a minimum of not less than five samples taken over not more than a 30 day period." The routine monitoring data used in this TMDL do not meet this criteria. This raises the question of whether or not the 303(d) listing is valid.

Because Second Creek is designated as an extraordinary resource water, it has a year round requirement that the geometric mean for fecal coliforms must be no greater than 200 / 100 mL for fecal coliforms (ADEQ 1998a). As shown in the plots of fecal coliforms (Figures 3.18-3.27), some of the individual values in Second Creek and in the L'Anguille River are above the applicable water quality standards. Summary statistics of the fecal coliform data are shown in Table 4.2.

Table 4.2. Summary Statistics for Fecal Coliforms for Selected Stations.

Station name	L'Anguille River near Marianna (FRA10)	Second Creek near Palestine (FRA12)	L'Anguille River near Colt (LGR01)	L'Anguille River near Colt (07047942)	L'Anguille River near Whitehall (LGR02)
Period of record used for statistics	1974 - 1997	1984 - 1997	1994 - 1996	1970 - 1976	1994 - 1996
Number of values	171	64	9	38	9
Minimum	4	4	88	20	36
Maximum	42000	3600	5600	38000	2000
Median	116	94	145	280	104
Percent of values > 200 / 100 mL	36%	28%	33%	63%	44%
Percent of values > 1000 / 100 mL	7%	6%	11%	24%	11%

In the 1998 305(b) report, ADEQ listed the two upper reaches of the L'Anguille River (004 and 005) as "waters of concern" rather than "not supporting" because of questions concerning the quality of the coliform data. The criteria used by ADEQ to list waters as not supporting for primary and secondary contact recreation was greater than 25% of the values above the standard.

Because the standards for fecal coliforms are seasonal, the percentages of total values above 200 / 100 mL and 1000 / 100 mL in Table 4.2 can not be directly compared with the assessment guidance used by ADEQ for putting streams on the 303(d) list for fecal coliforms. However, it does appear that the secondary contact criteria is definitely met in all cases.

5.0 DEVELOPMENT OF THE TMDL

5.1 Turbidity

5.1.1 Determination of Critical Conditions

The historical data and analyses discussed in Section 3.1 were used to evaluate whether there were certain flow conditions or certain periods of the year that could be used to characterize critical conditions. The plots of turbidity versus flow (Figures 3.4-3.6) showed little or no correlation of turbidity with flow. Therefore, flow was not considered for defining critical conditions. The plots of turbidity versus month of the year (Figures 3.10-3.11) showed some seasonal variation, especially for Second Creek. Based on the Second Creek data, two critical periods were selected.

February through April was selected as one critical period because that is when the turbidities are the highest in Second Creek (Figure 3.11 and Table 5.1). There are two factors that may contribute to high turbidities in Second Creek during February through April. First, there are large amounts of bare cropland with no cover during this period. Secondly, the stream flow rates during this period are high, which may create velocities that prevent settling of small suspended particles in runoff from bare cropland. Although Second Creek has been used by ADEQ as a least disturbed reference stream for the Delta ecoregion, turbidity values in the lower portion of Second Creek (station FRA12) during February through April are often above the water quality standard of 45 NTU. Whenever standards are not being met in the lower portion of Second Creek, it will be difficult to meet standards in the L'Anguille River under those same conditions.

For the other critical period, the months of July through October were selected because that is when turbidities in Second Creek are often much lower than the turbidities in the L'Anguille River. In other words, that is when the turbidities in the L'Anguille River are elevated the most above background values (assuming Second Creek represents background conditions).

Table 5.1. Monthly Median Turbidity Values (NTU) for Second Creek (FRA12)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
51	78	71	74	60	17	8	12	6	6	17	59

5.1.2 Establishing the water quality target

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 required by TMDL regulations. To achieve a load based value, turbidity is often correlated with common measures such as flow and sediment that may be expressed as a load.

For this TMDL, the correlation between turbidity and TSS presented in Section 3.1.2 was used. This relationship was:

$$\log TSS = 0.7094 + 0.54208 * \log Turbidity \qquad (R^2 = 0.32)$$

Using this relationship and the turbidity standard of 45 NTU, the target TSS concentration was calculated to be 40 mg/L.

Next, the target concentration of TSS was converted to target loads of TSS. Seasonal stream flow values were calculated for the spring critical period and for the summer critical period using historical stream flow data for the L'Anguille River at Colt and at Palestine. These calculations (Table F.1 in Appendix F) yielded average flows for the entire L'Anguille River of 547 cfs for summer and 2232 cfs for spring. Each of these two seasonal flows for the entire basin was divided among the 5 reaches of the L'Anguille River based on drainage area. The division of the L'Anguille River into 5 reaches was based on the Arkansas 305(b) report (ADEQ 1998b). The drainage area at the downstream end of each reach was obtained from the USGS drainage area report for the St. Francis River basin (USGS 1967). The target loads of TSS were then obtained by multiplying the target TSS concentration (40 mg/L) with the seasonal flows for each reach. As shown in Table F.2 in Appendix F, the target TSS loads were calculated to be 118,028 lbs/day for summer and 481,604 lbs/day for spring.

Each of these target loads was calculated for a single stream flow rate for the purpose of developing a TMDL for critical conditions. However, the target loads should be considered as single points along a line representing maximum allowable TSS loads to maintain the turbidity standard at different stream flow rates. Therefore, implementation of the turbidity TMDL should be based on concentration or percent reduction of TSS rather than a single loading value of TSS.

5.1.3 Linking water quality and pollutant sources

The exact causes of the elevated turbidity levels in the L'Anguille River are not completely known. However, some conclusions can be drawn from the information that is available for the basin.

Cropland appears to have a significant impact on turbidity in the L'Anguille River. Cropland represents a large percentage of the basin (almost 70%) and there is little or no cover on the soil at times (as discussed in Section 2.3). Based on field data collected during the May and June synoptic surveys, drainage of water from rice fields does not appear to be a major source of turbidity in the L'Anguille River. The 1998 303(d) list for Arkansas (ADEQ 1998b) indicated that agriculture was suspected to be the primary source for the L'Anguille River not supporting the aquatic life designated use due to siltation/turbidity. Also, the analysis of historical water quality data (Section 3.1) showed that TSS is correlated to turbidity, indicating that erosion contributes to turbidity.

Point source discharges appear to have relatively little impact on turbidity in the L'Anguille River. The primary source of turbidity appears to be inorganic suspended solids (i.e., soil and sediment particles from erosion or sediment resuspension) rather than organic suspended solids or nutrients from discharges of treated wastewater. This conclusion is based on the color of the water observed during both synoptic surveys, the low turbidity values measured in the point source discharges, and the low chlorophyll a values measured during both synoptic surveys. Also, the sum of the flows from all of the permitted NPDES discharges is small compared to the seasonal average flow rates of the L'Anguille River. Possible exceptions to the pattern of low turbidity values for point source discharges would include a small quantity of drainage from the gravel mining operation south of Harrisburg and infrequent discharges of short duration from several catfish ponds in the basin.

5.1.4 Wasteload allocations

Wasteload allocations (WLA) for the point sources 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 the L'Anguille River basin 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 DO.

5.1.5 Load allocations

Load allocations (LA) for nonpoint source contributions were calculated as the target loads of TSS minus the WLA for point source contributions. Therefore, these LAs include both natural nonpoint source contributions (i.e., background) as well as man-induced nonpoint source contributions. Because the WLAs were set to zero as described above, the LAs were the same as the target loads of TSS (118,028 lbs/day for summer and 481,604 lbs/day for spring).

The background portions of these LAs were estimated by assuming that the ADEQ data for Second Creek (station FRA12) represent background conditions. Although there is significant agricultural activity in the upper end of the Second Creek watershed, the lower portion of the stream flows through a forested, natural area. These data appear to be the best available representation of background conditions for the L'Anguille River basin. Average TSS concentrations for Second Creek were calculated for the summer critical period (15 mg/L) and the spring critical period (40 mg/L). These two average TSS values were calculated as arithmetic averages rather than flow weighted averages because the available data for Second Creek did not include enough flow values to calculate a reliable flow weighted average. The average concentrations of 15 mg/L and 40 mg/L were multiplied by the seasonal flow rates for each reach of the L'Anguille River to estimate background loads for the L'Anguille River. These calculations (Table F.3 in Appendix F) yielded background TSS loads of 44,260 lbs/day for the summer critical period and 481,604 lbs/day for the spring critical period.

For the summer critical period, the man-induced portion of the LA was calculated to be 118,028 lbs/day – 44,260 lbs/day = 73,768 lbs/day. For the spring critical period, the man-induced portion of the LA was calculated as zero because the background load (481,604 lbs/day) was the same as the total LA (481,604 lbs/day). This was not surprising because the turbidities in Second Creek during the spring critical period (February through April) are often higher than the water quality standard of 45 NTU (Figure 3.11).

The existing nonpoint source loads of TSS must be reduced to maintain the turbidity standard. In order to estimate existing nonpoint source loads for the whole basin, flow weighted average TSS concentrations were calculated for the L'Anguille River at Marianna (FRA10). These average concentrations (65 mg/L for the summer critical period and 67 mg/L for the spring critical period) were multiplied by the seasonal average stream flow rates. These calculations yielded existing nonpoint source TSS loads of 191,795 lbs/day for the summer critical period and 806,688 lbs/day for the spring critical period (see Table F.4). The reductions in existing nonpoint source TSS loads needed to meet the LAs were then calculated as follows:

Summer: (191,795 – 118,028) / 191,795 * 100% = 38% reduction
Spring: (806,688 – 481,604) / 806,688 * 100% = 40% reduction

5.1.6 Seasonality and margin of safety

The Clean Water Act requires the consideration of seasonal variation of conditions affecting the constituent of concern, and the inclusion of a margin of safety (MOS) in the development of a TMDL. For the turbidity TMDL for the L'Anguille River basin, critical conditions were determined through an analysis of historical water quality data as discussed in Section 5.1.1. An implicit MOS was incorporated through the use of conservative assumptions. The TMDL was calculated assuming that TSS is a conservative parameter and does not settle out of the water column.

5.2 Fecal Coliforms

5.2.1 Establishing the water quality target

Fecal coliform testing is used as an indicator of pathogenic organisms to determine if a water body is meeting the designated recreation use because of its easy testing and identification. Coliform bacteria includes both organisms found in the intestinal tract of warm blooded animals and organisms found in soils and vegetation. The fecal component is isolated because bacteria present in warm blooded animals includes organisms capable of producing gas from lactose in a suitable culture. Others organisms cannot produce the gas.

The water quality targets for this TMDL are based on the existing water quality standard for fecal coliforms, which is a geometric mean of:

- 200 col/100mL during the summer period for primary contact waters and all year for waters designated as extraordinary resource water.
- 1000 col/100mL during the winter period and for all secondary contact water.

For the TMDL calculations, the standard can be expressed as loads by multiplying the bacterial counts (colonies per 100 mL) times appropriate seasonal stream flow values. The seasonal periods for evaluating fecal coliforms were based on the water quality standards (ADEQ 1998a), which states that the 200 col/100 mL value for primary contact recreation is applicable from April 1 through September 30. Therefore, for this fecal coliform TMDL, the summer period was defined as April through September and the winter period was defined as October through March.

An average flow was calculated for each season using historical stream flow data for the L'Anguille River at Colt and at Palestine (Table G.1 in Appendix G). The average flow was used because there is not a single flow at which "critical" conditions occur for fecal coliform loading from nonpoint sources. As with the calculation of the TSS target loads, each of the fecal coliform target loads was calculated for a single stream flow rate for the purpose of developing TMDLs. However, the target loads should be considered as single points along lines representing maximum allowable loads to maintain the water quality standards at different stream flow rates. Therefore, implementation of the fecal coliform TMDL should be based on bacterial counts (i.e., "concentration") or percent reduction of fecal coliforms rather than loads of fecal coliforms calculated for a single flow during each season.

The seasonal average flows calculated for the entire L'Anguille River basin were 1017 cfs for summer and 1626 cfs for winter. Each of these two seasonal flows for the entire basin was divided among the individual reaches of the L'Anguille River based on drainage area. The target loads of fecal coliforms were then obtained by multiplying the bacterial counts (200 col/100 mL and 1000 col/100 mL) with the seasonal flows for each reach that was on the 303(d) list for fecal coliforms (reaches 004 and 005). As shown in Table G.2 (Appendix G), the target fecal coliform loads were calculated to be 3.555 E12 col/day for summer and 2.842 E13 col/day for winter.

5.2.2 Linking water quality and pollutant sources

The predominant land uses in the L'Anguille River watershed are agriculture (59.3% rice, soybeans, and other summer crops; 9.9% wheat and oats; and 5.4% pasture and forage) and forest (22.0%). The source identified in the 305(b) report (ADEQ 1998b) as affecting the water quality of the L'Anguille River was agriculture, specifically row crops which contribute silt and turbidity to the receiving streams. Even though there appears to be a slight relationship between fecal coliforms and TSS (Figure 3.18), silt and turbidity from row crops is not expected to be a major source of pathogens that could impact the primary recreation use. Coliform bacteria from these sources are not indicators of pathogenic organisms.

Other nonpoint sources of fecal coliforms in the watershed include pasture/grazing land where cattle are raised (up to 5.4% of the basin), domesticated and wild animals that could inhabit the forested area (22.0% of the basin), and rural residences that have septic tanks or septic fields for their wastewater treatment. Compared to other counties in Arkansas, cattle populations are low and they appear to be located away from the main stem of the L'Anguille River and are not expected to be a major source of fecal coliforms. The major source could be wild animals that inhabit the forest and riparian zones along the creeks and rivers. Second Creek is classified as a least disturbed reference stream because of its extensive riparian zone and it has high fecal coliform counts (Figures 3.24 and 3.27).

There are also some point source discharges from municipal wastewater treatment plants (WWTPs) in the watershed. Two of the three largest discharges (Forrest City and Marianna) are located downstream of the two upper reaches that were cited on the 303(d) list for pathogens.

As mentioned in Section 4.2.1, the inclusion of parts of the L'Anguille River on the 303(d) list for fecal coliforms could be questioned because of the limited monitoring data and the lack of any apparent connection between water quality and pollutant sources. The reaches not on the 303(d) list have more potential fecal coliform sources than the reaches that are on the 303(d) list. Compared to the upper two reaches that are on the 303(d) list for fecal coliforms, the lower three reaches receive more municipal wastewater and have more extensive riparian zones along the main channel where wildlife could be concentrated.

5.2.3 Wasteload Allocations

There is no clear connection between point source discharges of fecal coliforms and fecal coliform measurements in the L'Anguille River. Also, ADEQ has set most of the point source permit limits for fecal coliforms at the water quality standard (i.e., the dischargers are required to meet the water quality standard at the end of the pipe). Therefore, the wasteload allocations for point source discharges were calculated based on the existing permit limits. These calculations are shown in Tables G.3 and G.4 for summer and winter, respectively. The total WLAs for all point sources within the two reaches on the 303(d) list were 4.215 E10 col/day for summer and 5.713 E10 col/day for winter.

5.2.4 Load Allocations

Load allocations (LA) for nonpoint source contributions were calculated as the target loads of fecal coliforms minus the WLAs for point source contributions. Therefore, the LAs for summer and winter were:

Summer LA = 3.555 E12 col/day – 4.215 E10 col/day = 3.513 E12 col/day
Winter LA = 2.842 E13 col/day – 5.713 E10 col/day = 2.836 E13 col/day

The existing nonpoint source loads of fecal coliforms must be reduced to maintain the water quality standards. In order to estimate existing nonpoint source loads for the reaches on the 303(d) list, flow weighted average fecal coliform counts were calculated for the L'Anguille River at Colt (LGR01). These average counts (157 col/100 mL for the summer period and 1118 col/100 mL for the winter period) were multiplied by the seasonal average stream flow rates. These calculations yielded existing nonpoint source fecal coliform loads of 2.749 E12 col/day for the summer period and 3.171 E13 col/day for the winter period (see Table G.5). The reductions in existing nonpoint source fecal coliform loads needed to meet the LAs were calculated as follows:

Summer: (2.749 E12 – 3.513 E12) / 2.749 E12 * 100% = < 0% (no reduction)
Winter: (3.171 E13 – 2.836 E13) / 3.171 E13 * 100% = 11% reduction

The average fecal coliform count for existing conditions during summer was 157 col/100 mL, which is less than the water quality standard of 200 col/100 mL. Therefore, no reduction in nonpoint source loads of fecal coliform are needed for summer.

The raw data used to include the upper two reaches of the L'Anguille River on the 303(d) list for fecal coliforms is shown in Table G.6. If the values collected on October 2, 1995 were disregarded, the arithmetic average and flow weighted average concentrations for the winter period would both be less than 1000 col/100 mL.

5.2.5 Seasonality and margin of safety

The Clean Water Act requires that TMDLs take into consideration a margin of safety. EPA guidance allows for the use of explicit or implicit expressions of the margin of safety or both. When conservative assumptions are used in the development of the TMDL or conservative factors are used in the calculations, the margin of safety is implicit. When a percentage of the load is factored into the TMDL calculations as a margin of safety, the margin of safety is explicit. In this TMDL for fecal coliforms, conservative assumptions have been used; therefore, the margin of safety is implicit. These conservative assumptions include:

- Using average seasonal flows to calculate current loadings to obtain load reduction.
- Treating fecal coliform bacteria as a conservative pollutant, that is, a pollutant that does not degrade in the environment (bacteria do die off in the environment).
- Using the design flow of the point source discharges rather than actual average flow rates which are typically much lower.

6.0 MONITORING AND IMPLEMENTATION

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.

This information is also utilized to establish priorities for the Arkansas Soil and Water Conservation Commission (ASWCC) nonpoint source program so that voluntary nonpoint source program activities may be directed toward these priority sources. ASWCC will work with other agencies such as local Soil Conservation Districts to implement agricultural best management practices in the watershed through the Section 319 programs. Several Section 319 program projects have been undertaken in this watershed.

7.0 PUBLIC PARTICIPATION

When EPA establishes a TMDL, federal regulations require EPA to publicly notice and seek comment concerning the TMDL. This TMDL has been prepared under contract to EPA. After submission of this TMDL, EPA and/or a designated state agency will commence preparation of a notice seeking comments, information, and data from the general public and affected public. If comments, data, or information are submitted during the public comment period, then EPA may revise the TMDL accordingly. After considering public comment, information, and data, and making any appropriate revisions, EPA will transmit the revised TMDL to the ADEQ for incorporation into ADEQ's current water quality management plan.

8.0 REFERENCES

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APPENDIX A

Information for Point Source Discharges

Table A.1. Inventory of point source dischargers.

NPDES Permit Number	Facility Name	City Name	Latitude	Longitude	Design Flow (MGD)	Outfalls	Parameter Code	Parameter	Monthly Average Limit
AR0038679	Andrews Trailer Park	Wynne	+3511300	-09047300	0.013	001	00300 00400 00530 00610 50050 50060 74055 80082 TEP3B TEP6C	Dissolved Oxygen pH TSS Total Ammonia Nitrogen Flow in conduit Total Chlorine Coliform, Fecal BOD, Carb, 05, 20, day 7day Ceriodaph, Chronic 7day Pimephale, Chronic	 15 mg/L 1000/100 mL
AR0041637	Bear Creek Subdiv. Sewer Dist.	Marianna					No records found in PCS search		
AR0038806	Caldwell Elementary School	Caldwell	+3504340	-09048580	0.003	001	50050 00610 00400 00530 00556 74055 80082	Flow in conduit Total Ammonia Nitrogen pH TSS Oil and Grease Coliform, Fecal BOD, Carb, 05, 20, day	 20 mg/L 1000/100 mL
AR0021393	Cherry Valley City of-MSTP	Cherry Valley			0.15	001	00400 00530 00610 50050 74055 80082	pH TSS Total Ammonia Nitrogen Flow in conduit Coliform, Fecal BOD, Carb, 05, 20 day	 20 mg/L 1000/100 mL
AR0043192	Colt, City of	Colt	+3508340	-09049560	0.11	001	00310 00400 00530 50050 74055	BOD, 5 day pH TSS Flow in Conduit Coliform, Fecal	 90 mg/L* 1000/100 mL*

Table A.1. Continued.

NPDES Permit Number	Facility Name	City Name	Latitude	Longitude	Design Flow (MGD)	Outfalls	Parameter Code	Parameter	Monthly Average Limit
AR0044041	Cross County School Dist. No. 7	Cherry Valley	+3524080	-09048230	0.0245	001	00310	BOD, 5 day	
							00400	pH	
							00530	TSS	30 mg/L
							50050	Flow in conduit	
							74055	Coliform, Fecal	1000/100 mL*
AR0000370	Entergy AR, Inc-Hamilton Moses	Palestine	+3458390	-09052350	0.846	01c	00011	Water Temp. (F)	105 F°
							00400	pH	
							00665	Total Phosphate	
							01092	Zinc	
							50050	Flow in conduit	
							50064	Chlorine, free	
						002	00400	pH	
							00530	TSS	30 mg/L
							00556	Oil and Grease	
							50050	Flow in conduit	
						003	00400	pH	
							00530	TSS	30 mg/L
							00556	Oil and Grease	
							01042	Copper	
							01045	Iron	
							50050	Flow in conduit	
						01a	00400	pH	
							00530	TSS	30 mg/L
							00556	Oil and Grease	
							50050	Flow in conduit	

Table A.1. Continued.

NPDES Permit Number	Facility Name	City Name	Latitude	Longitude	Design Flow (MGD)	Outfalls	Parameter Code	Parameter	Monthly Average Limit
AR0020087	Forrest City, City of (WWTP)	Forrest City	+3500040	-09050060	2.12	001	00300	Dissolved Oxygen	
							00400	pH	
							00530	TSS	20 mg/L
							00610	Total Ammonia Nitrogen	
							50050	Flow in conduit	
							74055	Coliform, Fecal	1000/100 mL
							80082	BOD, Carb, 05, 20 day	
							01074	Nickel, Total Recover	
							01079	Silver, Total Recover	
							01094	Zinc, Total Recover	
							01113	Cadmium, Total Recover	
							01114	Lead, Total Recover	
							01119	Copper Total Recover	
							TEP3B	7 day Ceriodaph Chronic	
							TEP6C	7 day Pimephale Chronic	
AR0033863	Harrisburg, City of	Harrisburg	+3534170	-09044260	0.403	001	00061	Instant. Stream Flow	
							00300	Dissolved Oxygen	
							00400	pH	
							00530	TSS	30 mg/L*
							00610	Total Ammonia Nitrogen	
							50050	Flow in Conduit	
							74055	Coliform, Fecal	1000/100 mL*
							80082	BOD, Carb, 05, 20, day	
AR0041394	Harwick Chemical MFG Corp	Wynne	+3515200	-09047000	0.117	001	00011	Water Temperature (F)	
							00400	pH	
							50050	Flow in conduit	
AR0034720	Hickory Ridge, City of	Hickory Ridge	+3524390	-09100010	0.1	001	00310	BOD, 5 day (20 Deg C)	
							00400	pH	
							00530	TSS	90 mg/L*
							50050	Flow in conduit	
							74055	Coliform, Fecal	1000/100 mL*
AR0048658	Hunter Glen Subdivision	Jonesboro	+3544250	-09041300	0.032	001	50050	Flow in conduit	
							00610	Total Ammonia Nitrogen	
							80082	BOD, Carb, 05, 20 day	
							00400	pH	
							00530	TSS	20 mg/L
							74055	Coliform, Fecal	1000/100 mL

Table A.1. Continued.

NPDES Permit Number	Facility Name	City Name	Latitude	Longitude	Design Flow (MGD)	Outfalls	Parameter Code	Parameter	Monthly Average Limit
AR0034169	Marianna, City of (Pond A)	Marianna	+3446370	-09044390	0.60	001	00060	Mean Daily Stream Flow	
							00300	Dissolved Oxygen	
							00310	BOD, 5 day (20 Deg C)	
							00400	PH	
							00530	TSS	90 mg/L
							00610	Total Ammonia Nitorgen	
							50050	Flow in conduit	
							74055	Coliform, Fecal	200/100 mL
							80082	BOD, Carb, 05, 20 day	
AR0034142	Marianna, City of (Pond B)	Marianna	+3447280	-09045460	0.30	001	00060	Mean Daily Stream Flow	
							00300	Dissolved Oxygen	
							00310	BOD, 5 day (20 Deg C)	
							00400	pH	
							00530	TSS	90 mg/L
							00610	Total Ammonia Nitorgen	
							50050	Flow in conduit	
							74055	Coliform, Fecal	200/100 mL
							84165	Discharge Event Observation	
ARG790064	Mueller Copper Tube Products	Wynne	+3513450	-09047050	0.432	SWGP	No record found in PCS search		
AR0022632	Mueller Industries, Inc.	Wynne	+3513450	-09047050	0.005	001	00011	Water Temperature (F)	
							00400	pH	
							00530	TSS	20 mg/L
							00556	Oil and Grease, Freon	
							00981	Selenium, Total Recover	
							01094	Zinc, Total Recover	
							01113	Cadmium, Total Recover	
							01114	Lead, Total Recover	
							01119	Copper, Total Recover	
							50050	Flow in conduit	
							00978	Aresnic, Total Recover	
							39100	Bismuth,	
							TEP3B	7 day Ceriodaph Chronic	
							TEP6C	7 day Pimephale Chronic	

Table A.1. Continued.

NPDES Permit Number	Facility Name	City Name	Latitude	Longitude	Design Flow (MGD)	Outfalls	Parameter Code	Parameter	Monthly Average Limit
AR0039365	Palestine, City of	Palestine	+3457450	-09054490	0.15	001	00310 00400 00530 50050 74055	BOD, 5 day (20 deg C) pH TSS Flow in conduit Coliform, Fecal	 90 mg/L 1000/100 mL*
0604539	Rural Electric Association	Forrest City					No record found in PCS search		
AR0021903	Wynne, City of	Wynne	+3513220	-09049130	1.5	001	00300 00400 00530 00610 50050 50060 74055 80082 TEP3B TEP6C	Dissolved Oxygen pH TSS Total Ammonia Nitrogen Flow in conduit Chlorine Total Residual Coliform, Fecal BOD, Carb, 05, 20, day 7 day Ceriodaph Chronic 7 day Pimephale Chronic	 15 mg/L 1000/100 mL

Note: Permit limits marked with an asterisk (*) are seasonal limits. The values shown are the highest among the different seasons.

P:\WP_FILES\2110-510\REPORT\TABLEA1.DOC

APPENDIX B

Inventory of Historical Water Quality Monitoring Stations

Table B.1. Inventory of Historical Water Quality Data for Selected Parameters.

Station ID	Station Description	Agency [1]	Turbidity			Suspended Solids [2]		Fecal Coliforms	
			Units	No. of Values	Period of Record	No. of Values	Period of Record	No. of Values	Period of Record
050122 (FRA10)	L'Anguille River near Marianna	1116APCC	NTU	232	1974-current	263	1974-current	171	1974-1997
07047964	L'Anguille River near Marianna	112WRD	NTU	128	1974-1994	212	1974-1994	151	1974-1994
050217 (FRA12)	Second Creek near Palestine	1116APCC	NTU	153	1984-current	150	1984-current	64	1984-1997
07047947	Second Creek near Palestine	112WRD	NTU	88	1984-1994	100	1984-1994	48	1984-1994
05UWS005 (LGR01)	L'Anguille River at Hwy 306 near Colt	21ARAPCC	NTU	8	1994-1996	8	1994-1996	9	1994-1996
07047942	L'Anguille River at Hwy 306 near Colt	112WRD	JTU FTU	6 18	1974-1976 1978-1981	252	1974-current	38	1970-1976
05UWS008 (LGR02)	L'Anguille R at Hwy 214 near Whitehall	21ARAPCC	NTU	8	1994-1996	8	1994-1996	9	1994-1996
3528250 90472500	L'Anguille R at Hwy 214 near Whitehall	112WRD						1	1978
060570	Unnamed tributary above Forrest City STP	21ARAPCC	JTU	4	1965				
3457250 90503000	Unnamed Creek Near Forrest City, AR	112WRD				2	1978	2	1978
060561	L'Anguille River above confluence with St. Francis River	21ARAPCC	JTU	3	1965				
3446150 90432000	L'Anguille River Near the Mouth	112WRD							
060575	Unnamed tributary below Forrest City STP	21ARAPCC	JTU	4	1965				
060581	Unnamed tributary of Caney Creek above Wynne STP	21ARAPCC	JTU	1	1965				
060583	Unnamed tributary of Caney Creek below Wynne STP	21ARAPCC	JTU	4	1965				
060586	Unnamed tributary of Hollow Branch bellow Harrisburg STP	21ARAPCC	JTU	3	1965				
3535150 90463200	Hollow Branch Near Harrisburg, AR	112WRD						2	1978

Table B.1. (Continued)

Station ID	Station Description	Agency [1]	Turbidity			Suspended Solids [2]		Fecal Coliforms	
			Units	No. of Values	Period of Record	No. of Values	Period of Record	No. of Values	Period of Record
060564	L'Anguille River Below Marianna STP	21ARAPCC	JTU	4	1965				
060566	L'Anguille River Above Marianna STP	21ARAPCC	JTU	4	1965				
060568	L'Anguille River at Douglas-Lomason	21ARAPCC	JTU	4	1965				
060577	L'Anguille River Below Forrest City STP	21ARAPCC	JTU	3	1965				
060588	L'Anguille River Below Harrisburg STP	21ARAPCC	JTU	4	1965				
07047955	Unnamed Tributary to Larkin Creek Near Holub Crossing	112WRD	JTU	3	1980	3	1980		
07047957	Larkin Creek Near Gill	112WRD	JTU	3	1980	3	1980		
07047959	Unnamed Tributary to Larkin Creek Near Gill	112WRD	JTU	3	1980	3	1980		
07047936	L'Anguille River Near Cherry Valley	112WRD							
07047950	L'Anguille River At Palestine	112WRD							
07047930	L'Anguille River Near Harrisburg	112WRD							
3504000 90522500	L'Anguille River Near Caldwell	112WRD				1	1978	2	1978
3535350 90465000	L'Anguille River Downstream from Claypool Reservoir	112WRD						2	1978
3533500 90473500	L'Anguille River Near Harrisburg	112WRD						2	1978
3525570 90483500	L'Anguille River Near Cherry Valley	112WRD						2	1978
3524100 90494000	L'Anguille River Near Cherry Valley	112WRD						3	1978
3519300 90513500	L'Anguille River Near Vanndale	112WRD						2	1978
3515050 90541200	L'Anguille River Near Wynne	112WRD				1	1978	1	1978

Table B.1. (Continued)

Station ID	Station Description	Agency [1]	Turbidity			Suspended Solids [2]		Fecal Coliforms	
			Units	No. of Values	Period of Record	No. of Values	Period of Record	No. of Values	Period of Record
3511100 90525500	L'Anguille River SW of Wynne	112WRD						2	1978
3512020 90532500	L'Anguille River At Hwy 284 Near Wynne	112WRD						2	1978
3447400 90455000	L'Anguille River Upstream From ?	112WRD				1	1978	1	1978
3450200 90474500	L'Anguille River At Hwy 1	112WRD				1	1978	1	1978
3446200 90444000	L'Anguille River Downstream From Hwy 79	112WRD				1	1978	1	1978
3503350 90533500	First Creek At Horton	112WRD				1	1978	1	1978
3502200 90544000	Second Creek Near Horton	112WRD				1	1978	1	1978
3511300 90520500	Caney Creek Near Wynne	112WRD	FTU	1	1978	2	1978	2	1978
3534300 90480500	Swan Pond Ditch Near Harrisburg	112WRD						1	1978
3446350 90442500	Marianna Sewage Effluent (New Pond)	112WRD				2	1978	2	1978
3447200 90454500	Marianna Sewage Effluent	112WRD				1	1978	2	1978
3500000 90501000	Forrest City Oxidation Pond	112WRD				2	1978	2	1978
3501100 90545500	Cypress Creek Near Palestine	112WRD				1	1978	1	1978
3512300 90482800	Wynne Oxidation Pond	112WRD							
3515050 90553000	Brushy Creek Near Wynne	112WRD				2	1978	1	1978
3524050 90485500	Wolf Creek Near Cherry Valley	112WRD				1	1978	1	1978

Table B.1. (Continued)

Station ID	Station Description	Agency [1]	Turbidity			Suspended Solids [2]		Fecal Coliforms	
			Units	No. of Values	Period of Record	No. of Values	Period of Record	No. of Values	Period of Record
3534150 90442500	Harrisburg Oxidation Pond	112WRD						2	1978
3530400 90464000	McCracken Ditch Near Harrisburg	112WRD						1	1978
3447400 90455000	L'Anguille River Upstream From Hwy 79	112WRD							
3452100 90515000	Larkin Creek At Four Forks	112WRD				1	1978	1	1978
3501200 90523000	Spy Buck Creek Near Forrest City	112WRD				1	1978	1	1978
3531320 90484500	Powers Slough Near Harrisburg	112WRD						1	1978
3534320 90454800	Rice Field Runoff	112WRD							
3556550 90532500	Coffee Creek Near Palestine	112WRD				1	1978	1	1978
3523050 90485500	Prairie Creek Near Cherry Valley	112WRD						1	1978
T0-706434	L'Anguille River at Marianna	11NATDC	All data locked						

Notes: 1. Agency codes: 21ARAPCC = ADEQ, 1116APCC = ADEQ, 112WRD = USGS, 11NATDC = U.S. EPA
2. Data listed as suspended solids are from STORET parameter number 00530 for ADEQ stations and STORET parameter number 80154 for USGS stations. The only exceptions to this are the USGS stations for the L'Anguille River near Marianna (07047964) and Second Creek near Palestine (07047947); suspended solids data for these two stations are from STORET parameter number 00530.

APPENDIX C

Plots of Historical Water Quality (Figures 3.1 - 3.27)

Figure 3.1. Turbidity (NTU) vs. TSS for L'Anguille River near Marianna (FRA10)

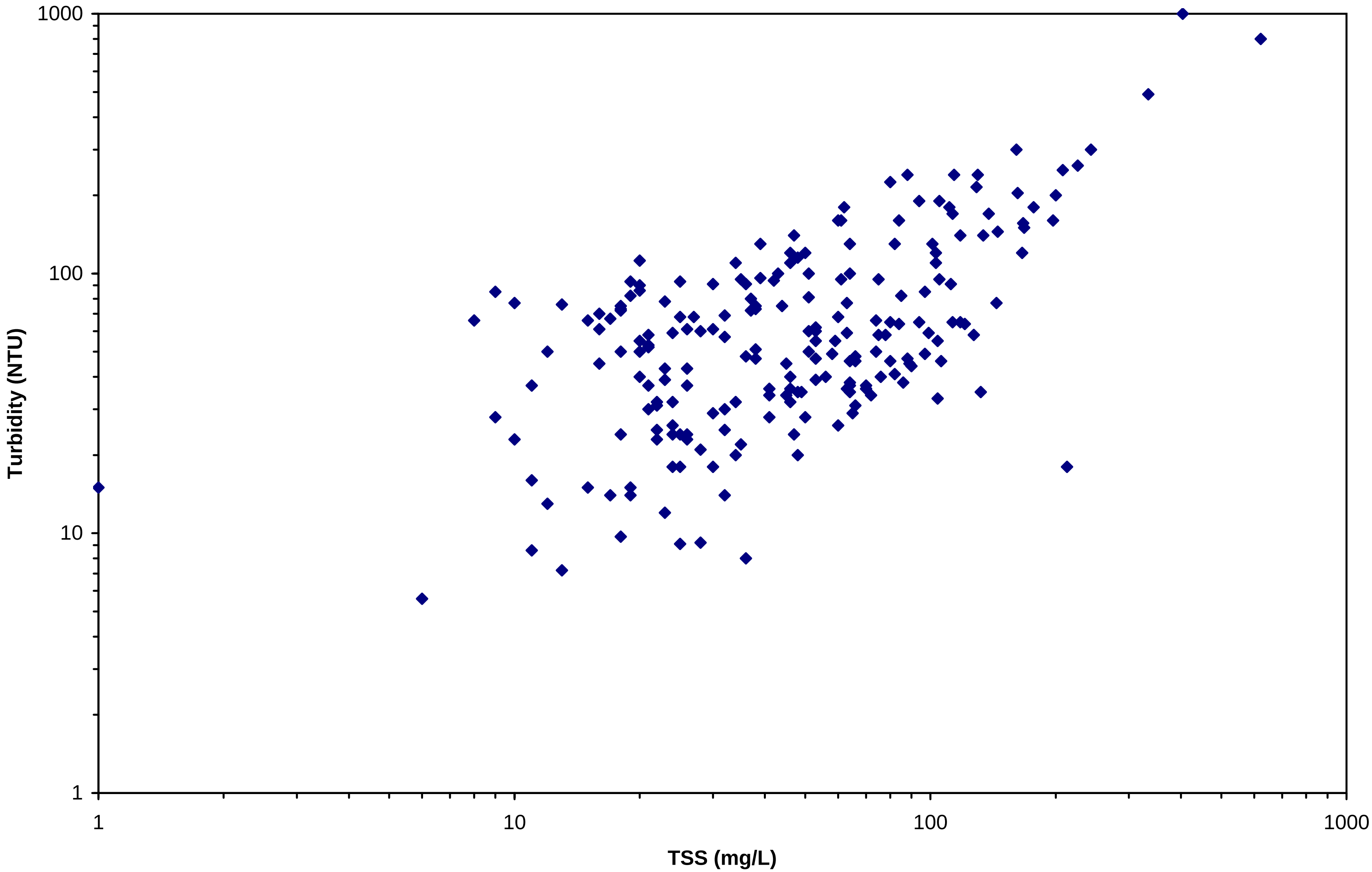


Figure 3.2. Turbidity (NTU) vs. TSS for Second Creek (FRA12)

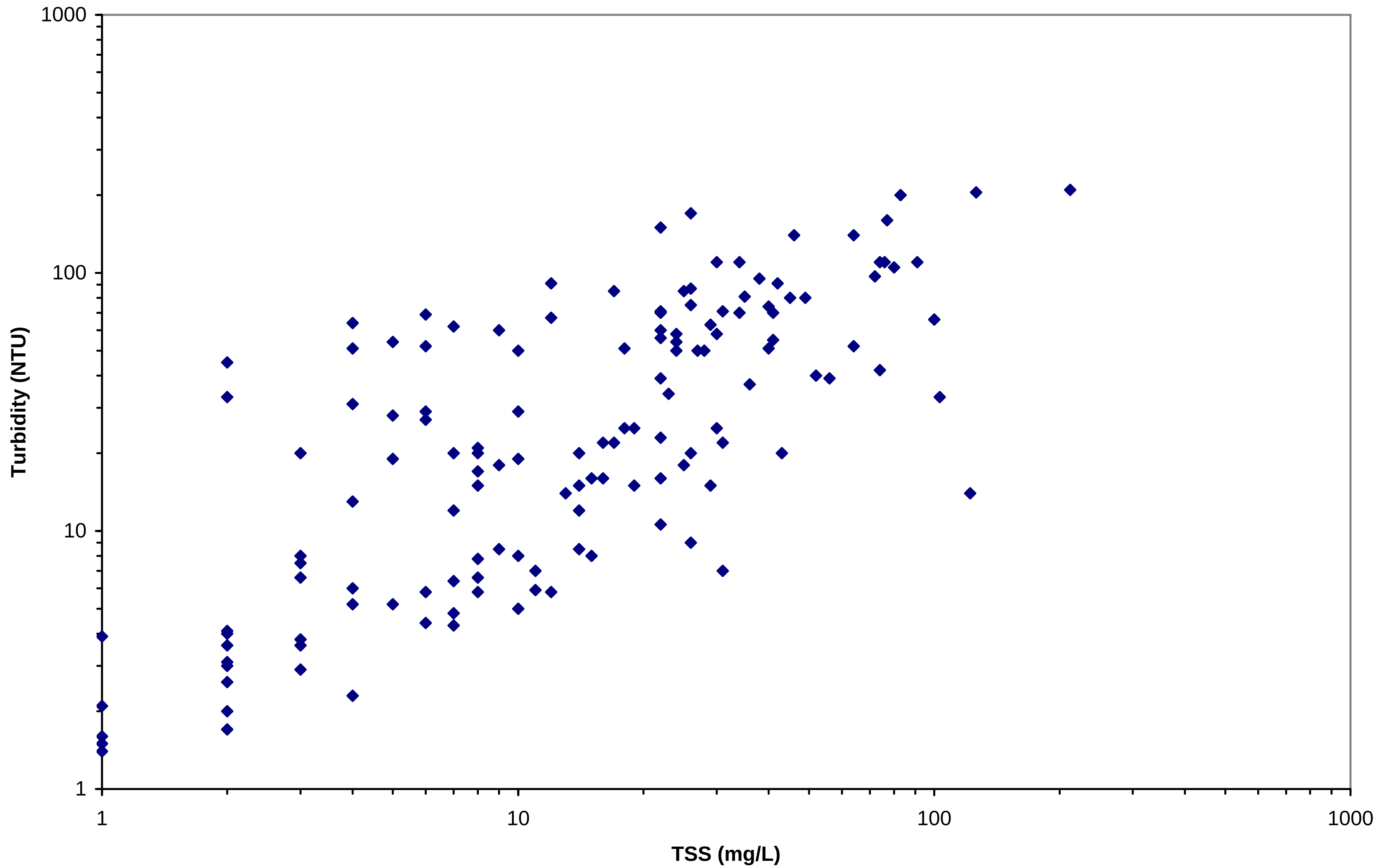


Figure 3.3. Turbidity (JTU and FTU) vs. TSS for L'Anguille River near Colt (07047942)

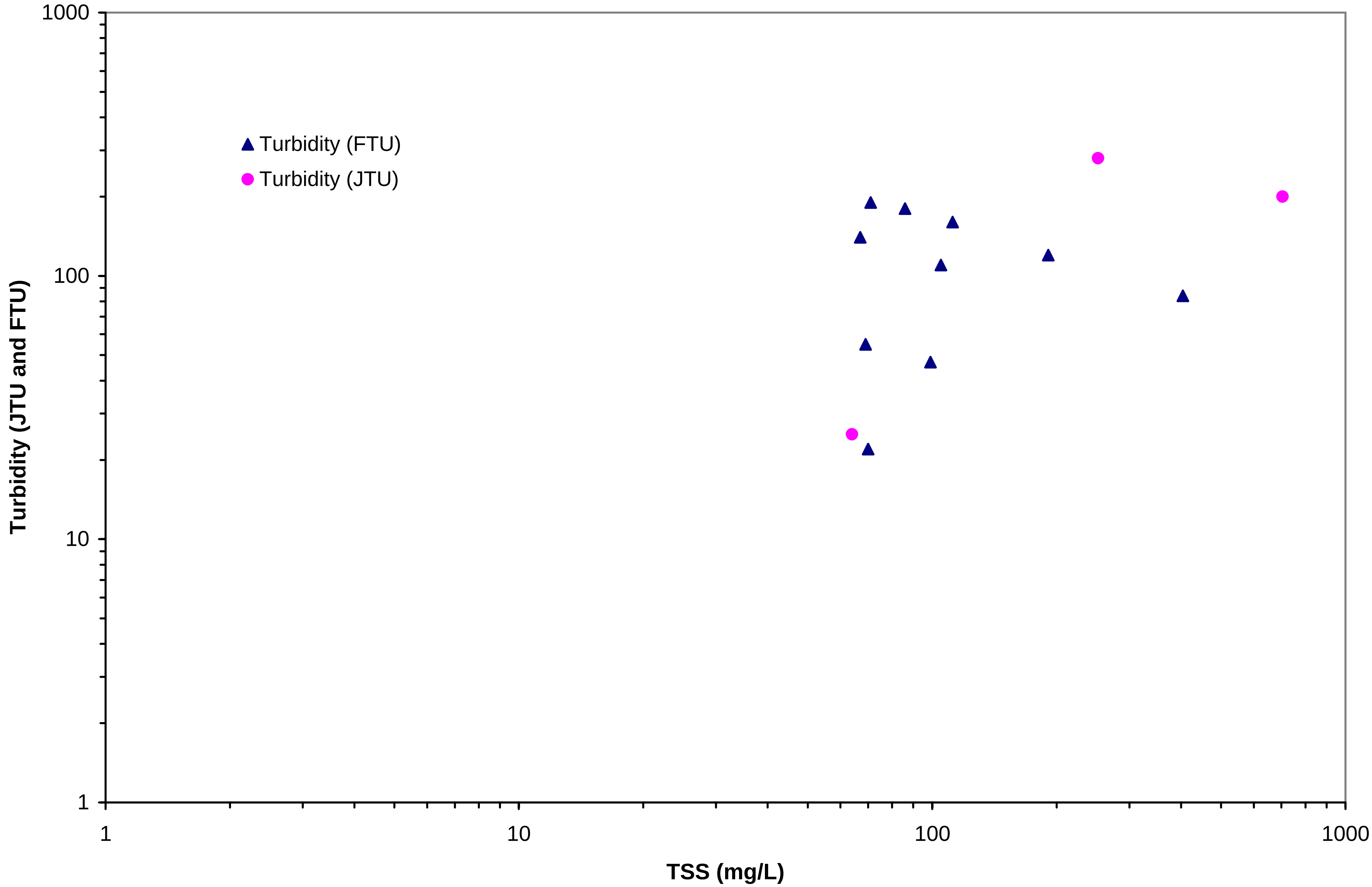


Figure 3.4. Turbidity (NTU) vs. Flow for L'Anguille River near Marianna (FRA10)

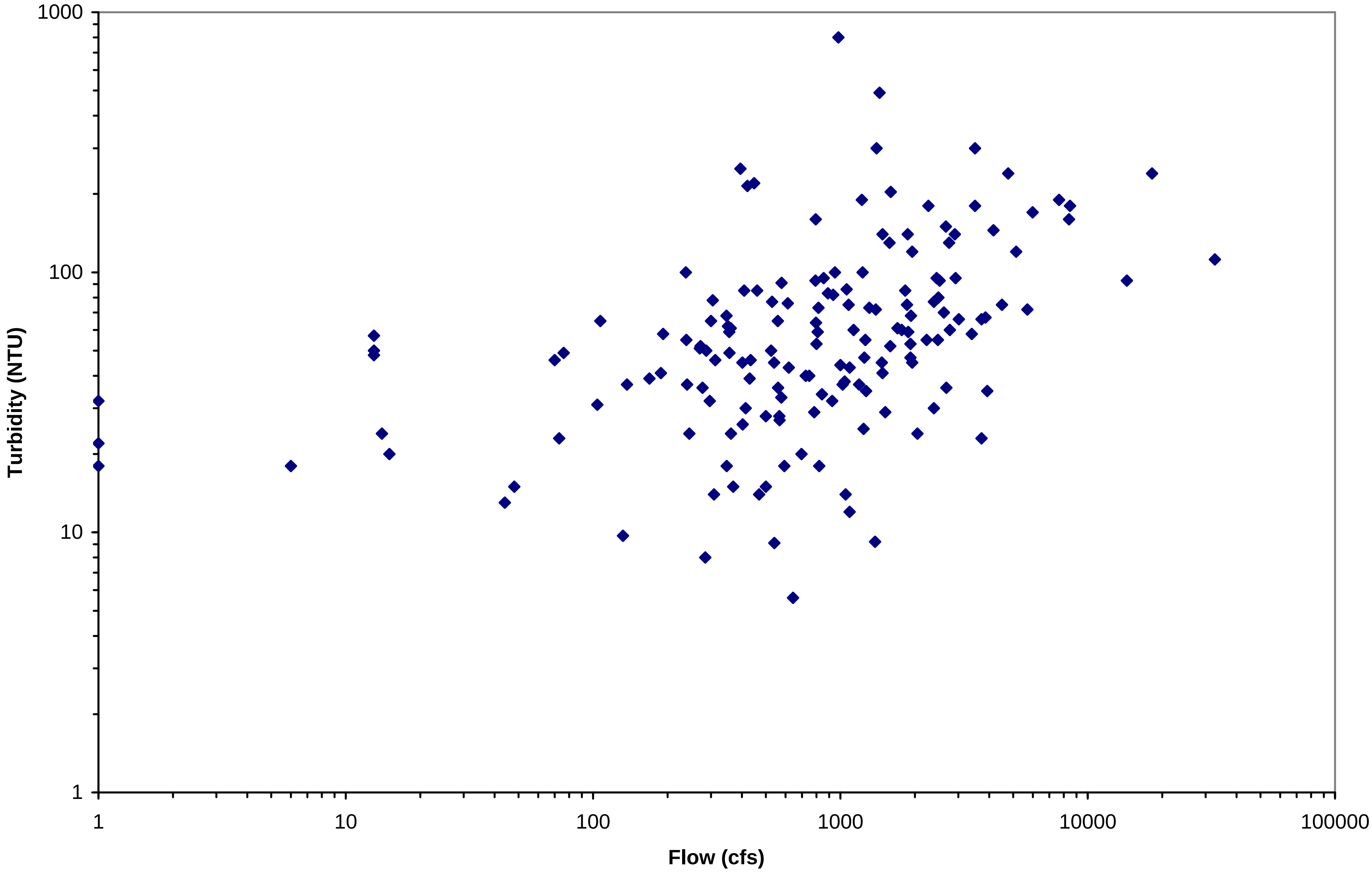


Figure 3.5. Turbidity (NTU) vs. Flow for Second Creek (FRA12)

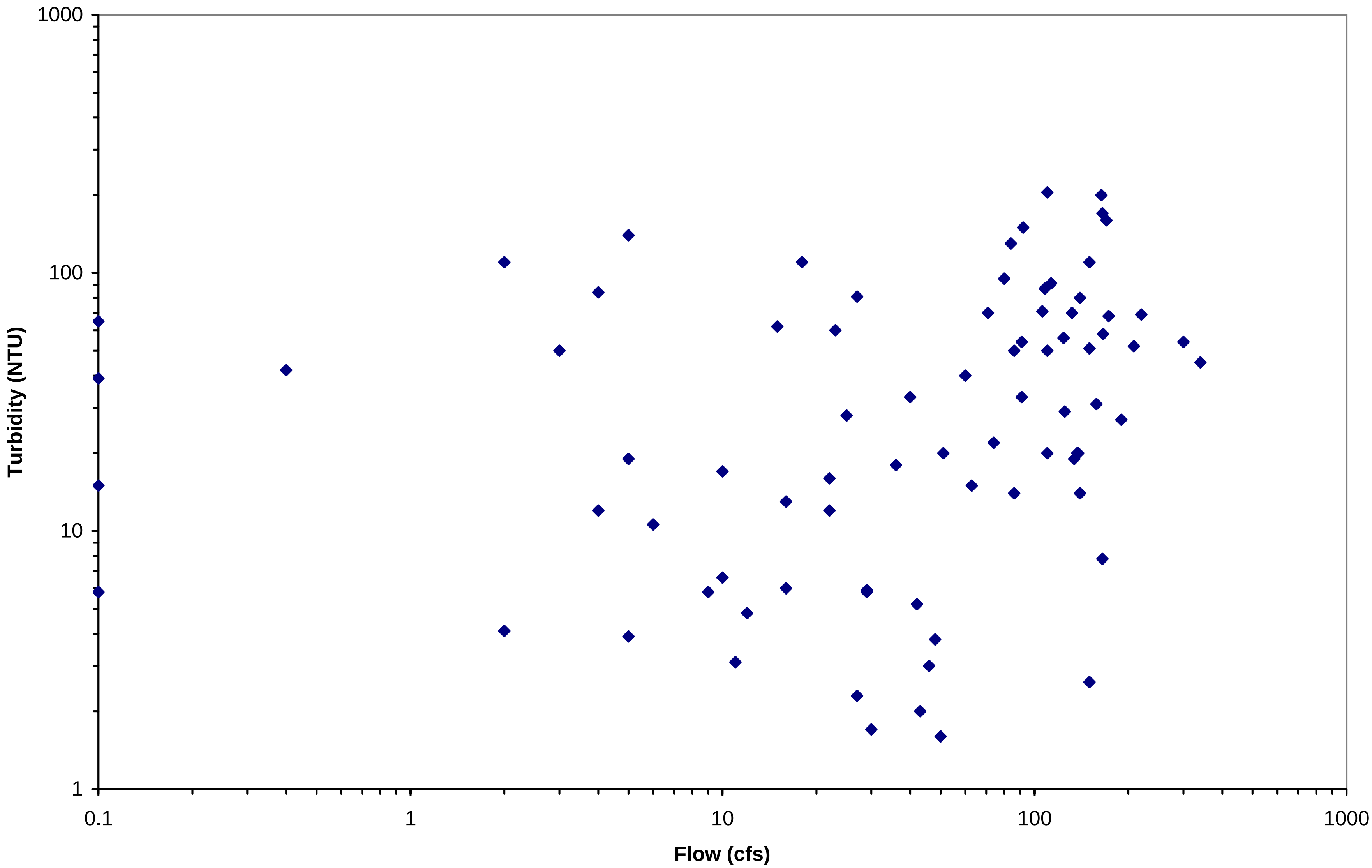


Figure 3.6. Turbidity (JTU and FTU) vs. Flow for L'Anguille River near Colt (07047942)

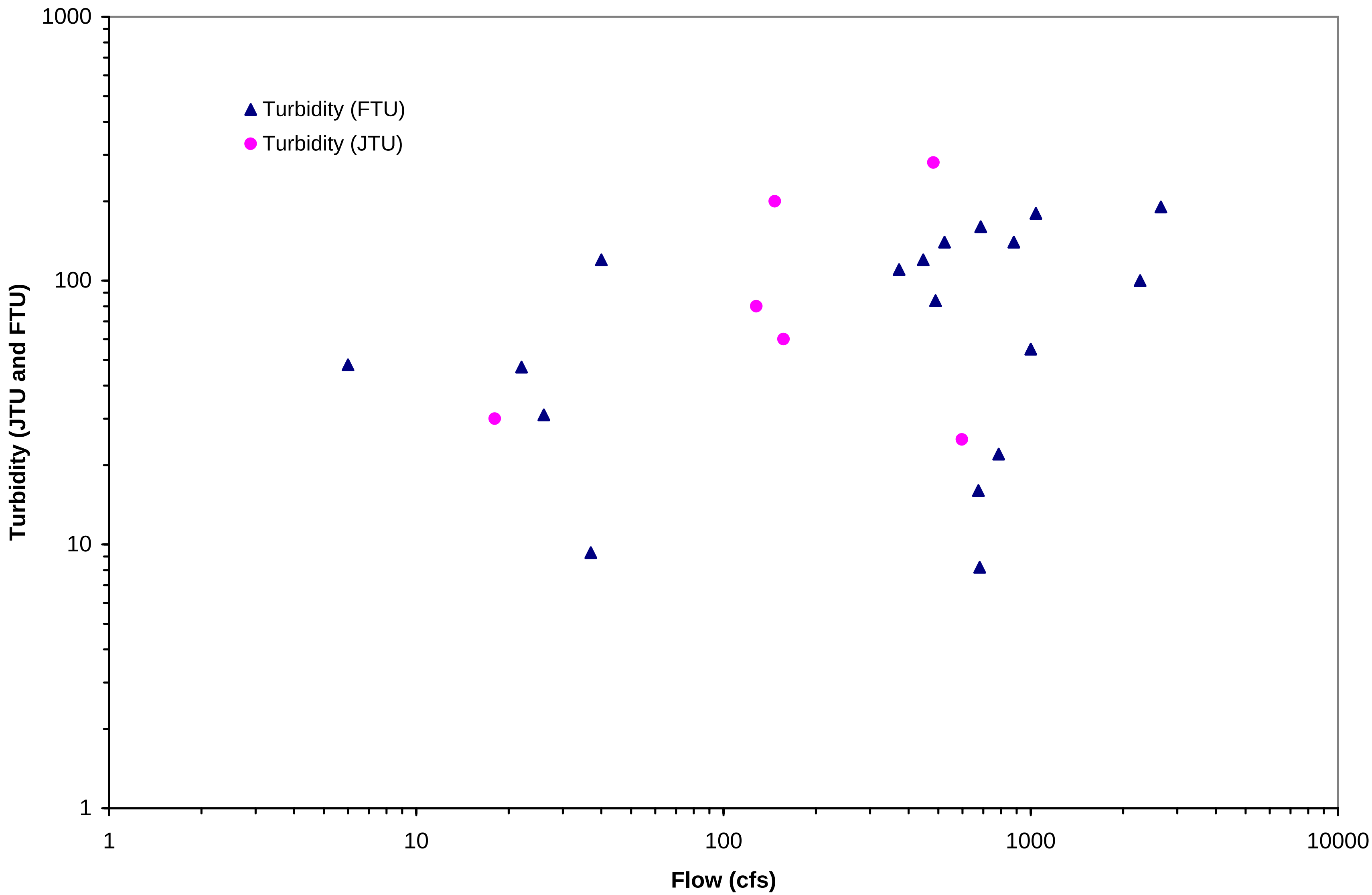


Figure 3.7. TSS vs. Flow for L'Anguille River near Marianna (FRA10)

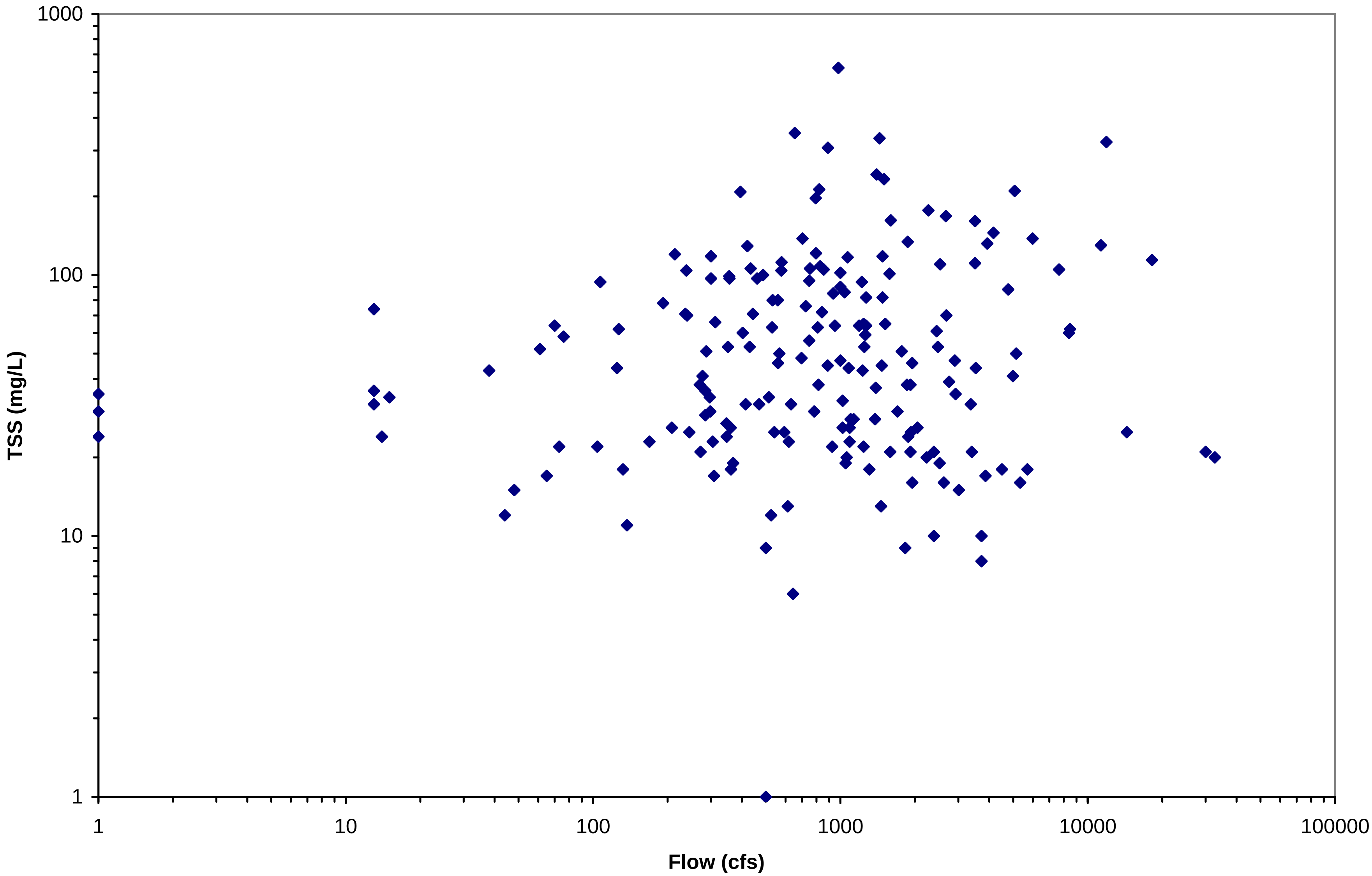


Figure 3.8. TSS vs. Flow for Second Creek (FRA12)

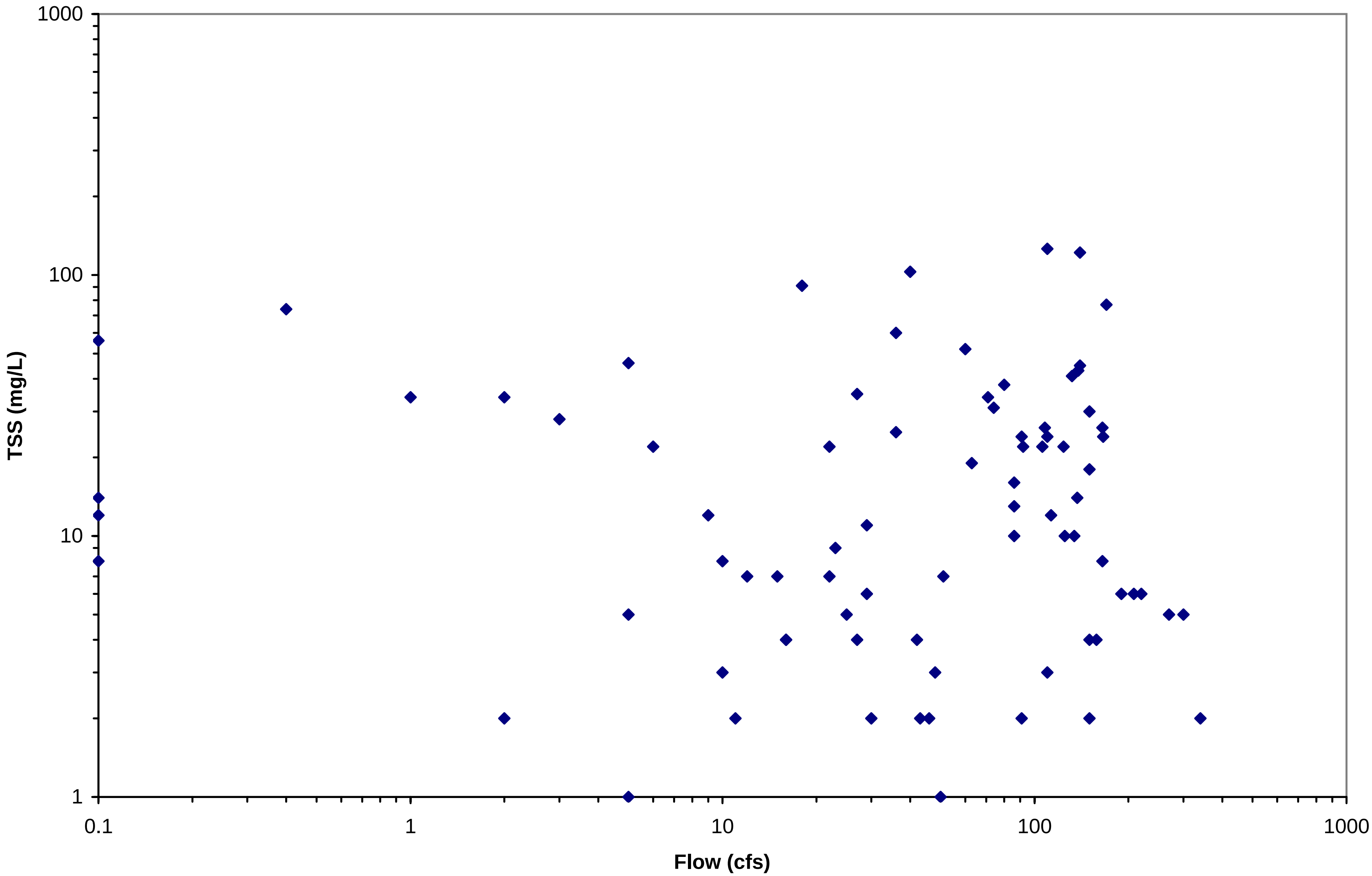


Figure 3.9. TSS vs. Flow for L'Anguille River near Colt (07047942)

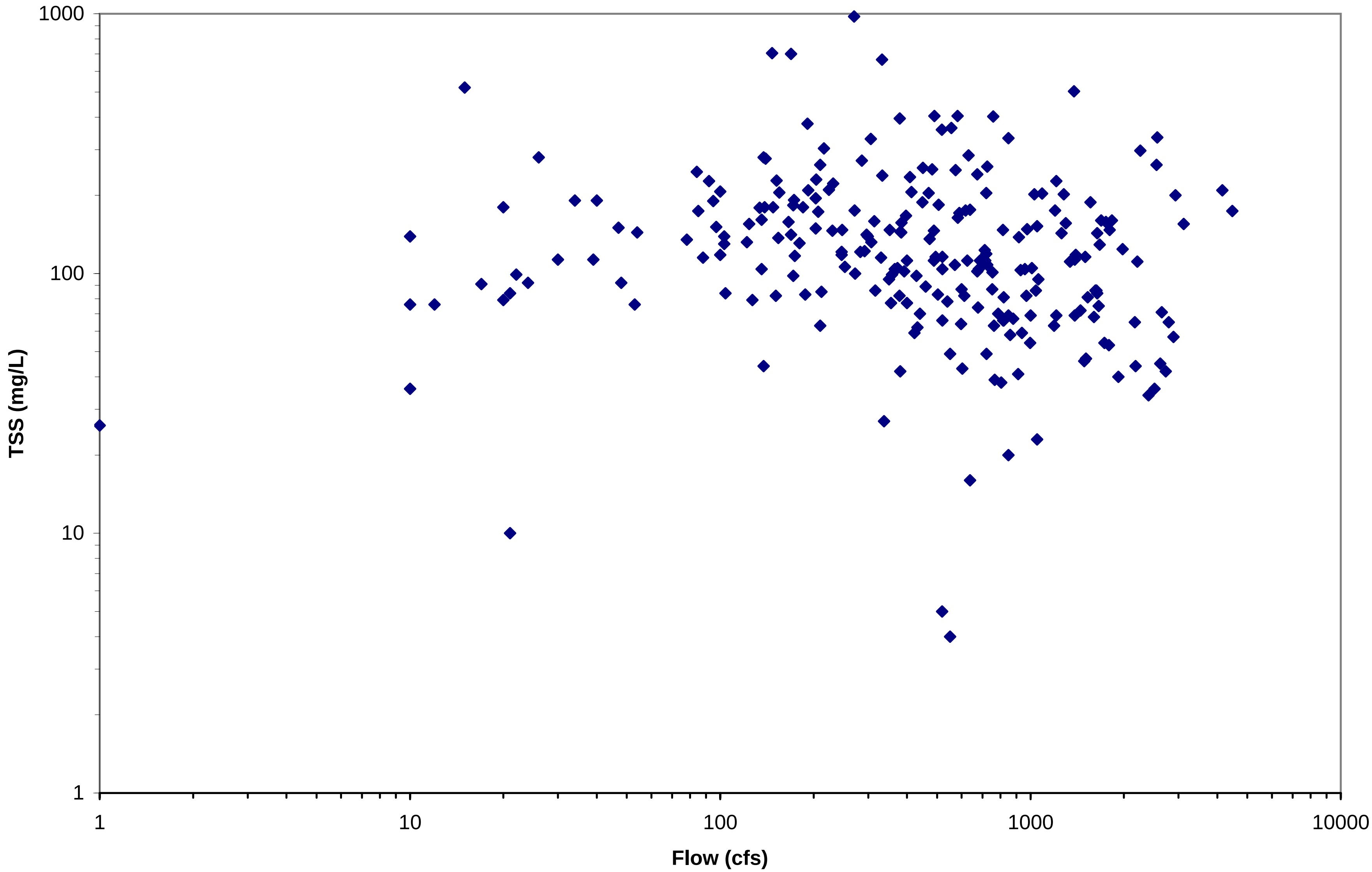


Figure 3.10. Turbidity (NTU) by Month for L'Anguille River near Marianna (FRA10)

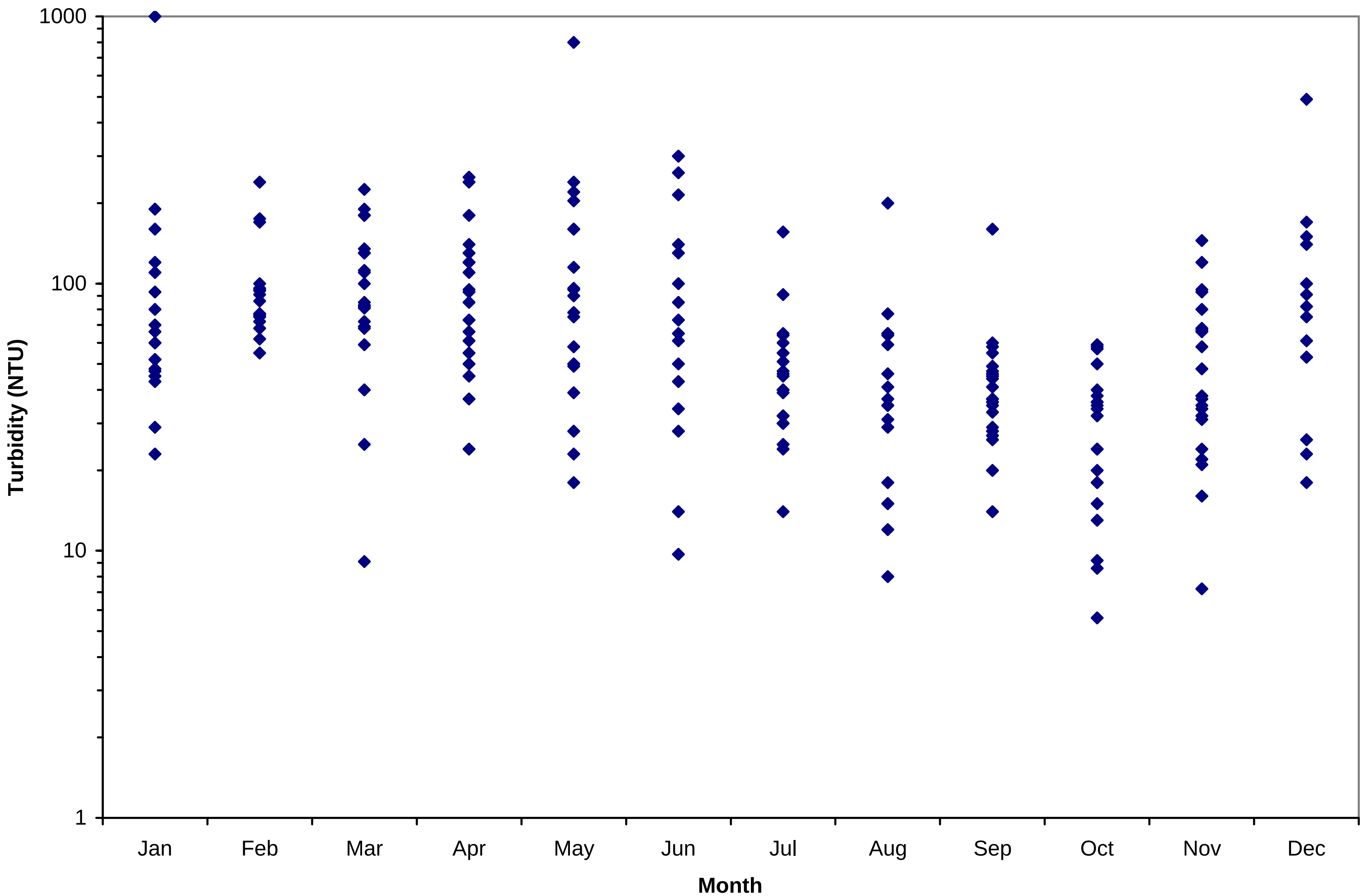


Figure 3.11. Turbidity (NTU) by Month for Second Creek (FRA12)

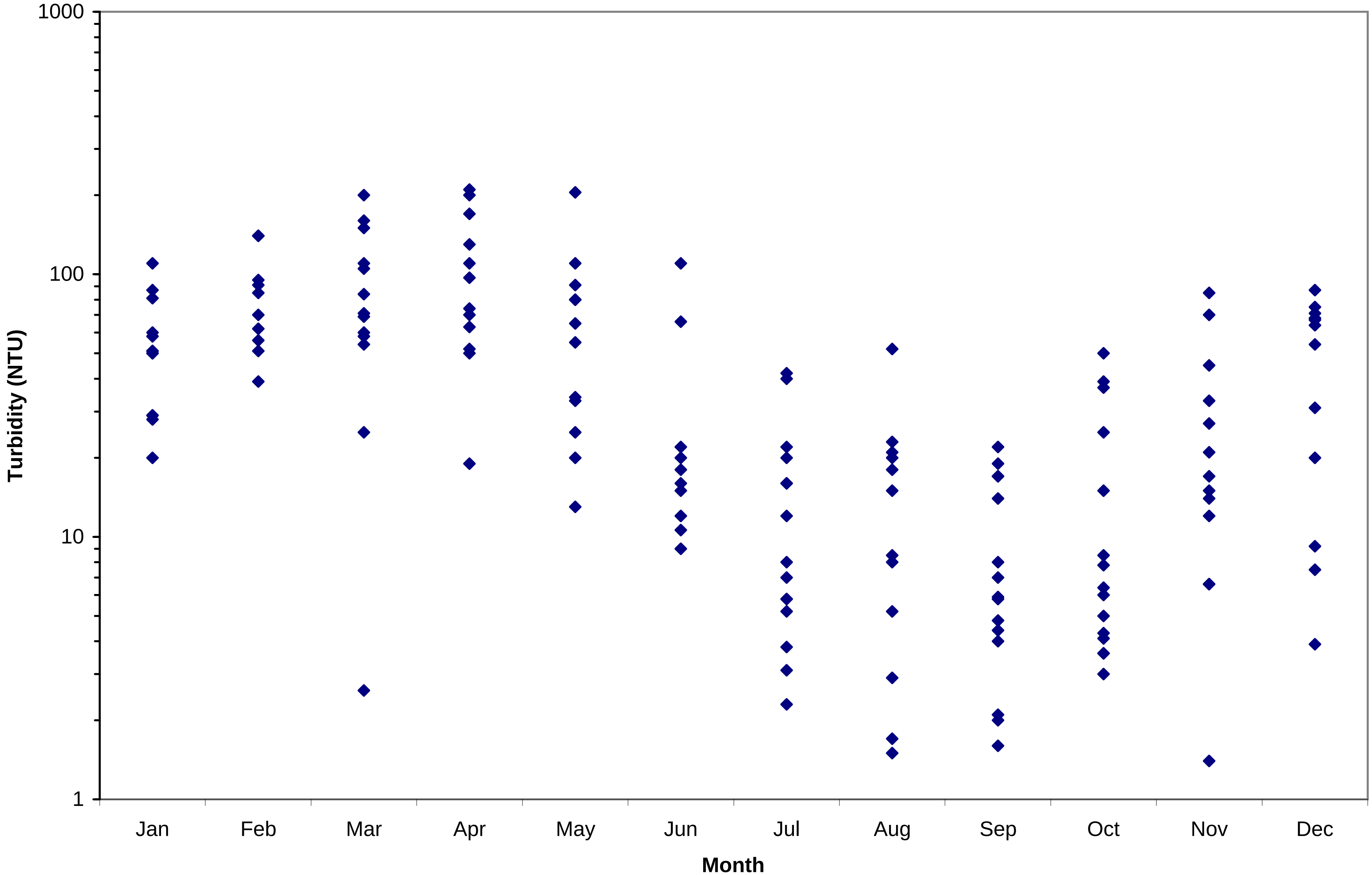


Figure 3.11. Turbidity (NTU) by Month for Second Creek (FRA12)

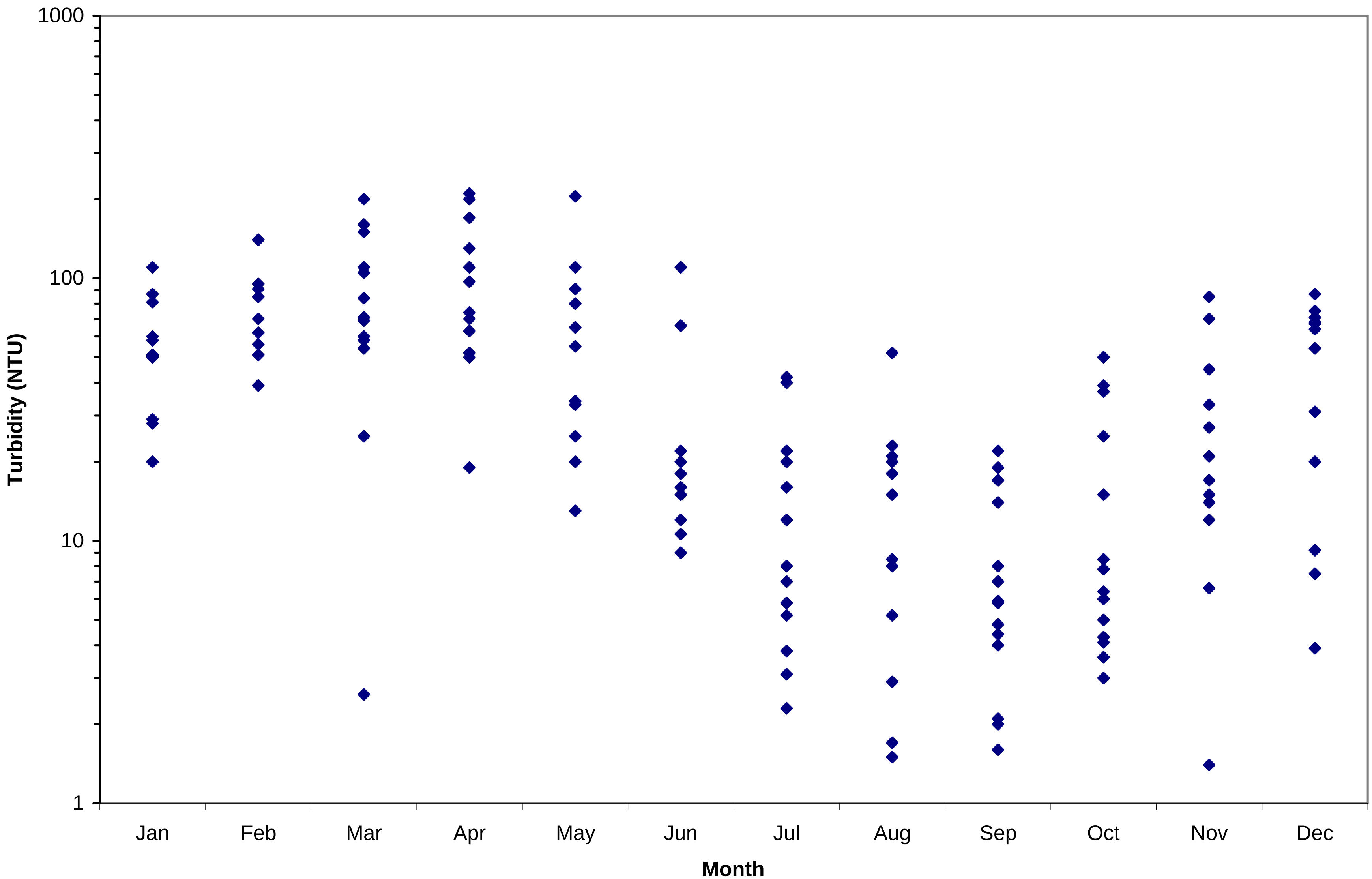


Figure 3.12. TSS by Month for L'Anguille River near Marianna (FRA10)

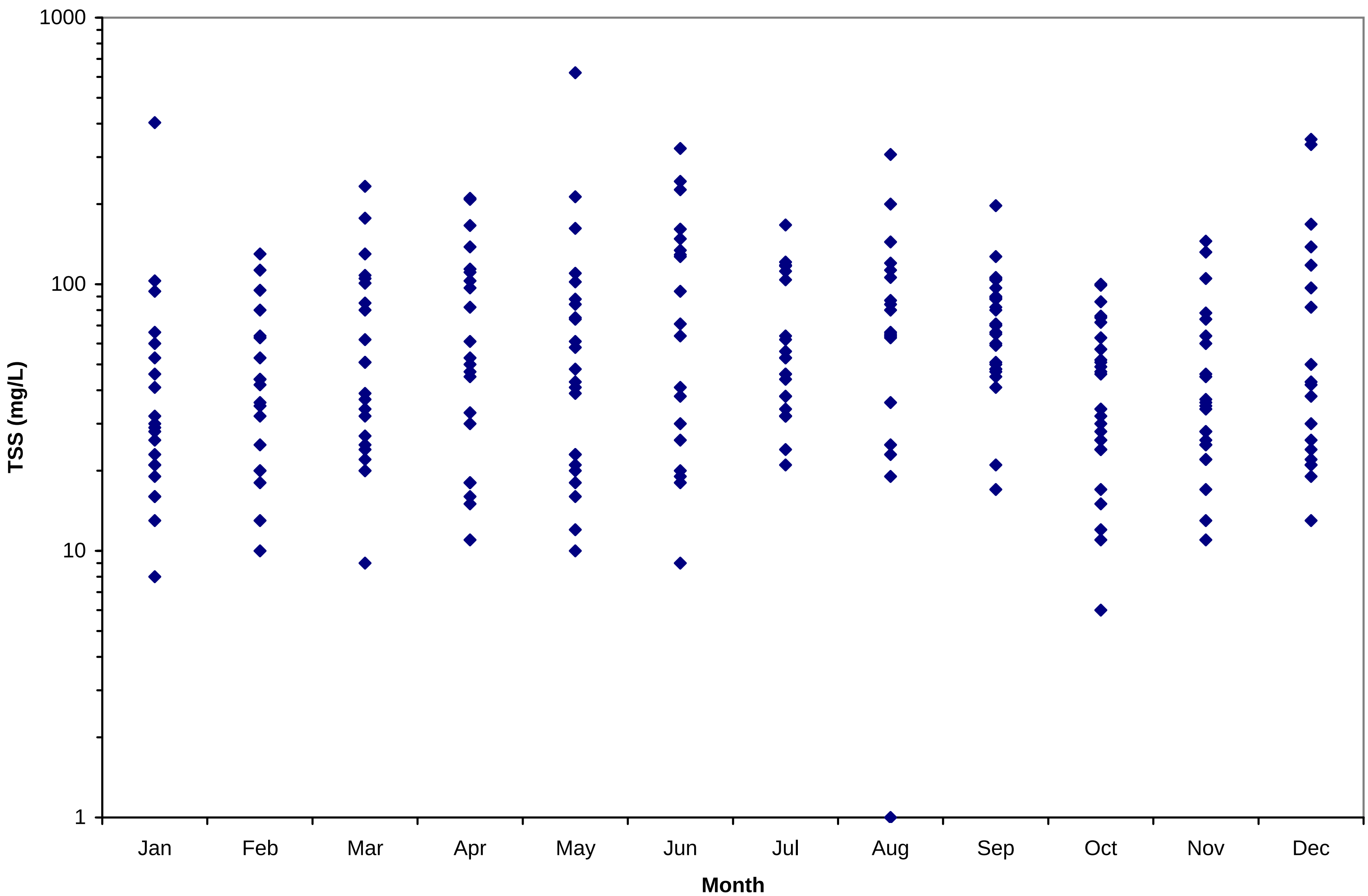


Figure 3.13. TSS by Month for Second Creek (FRA12)

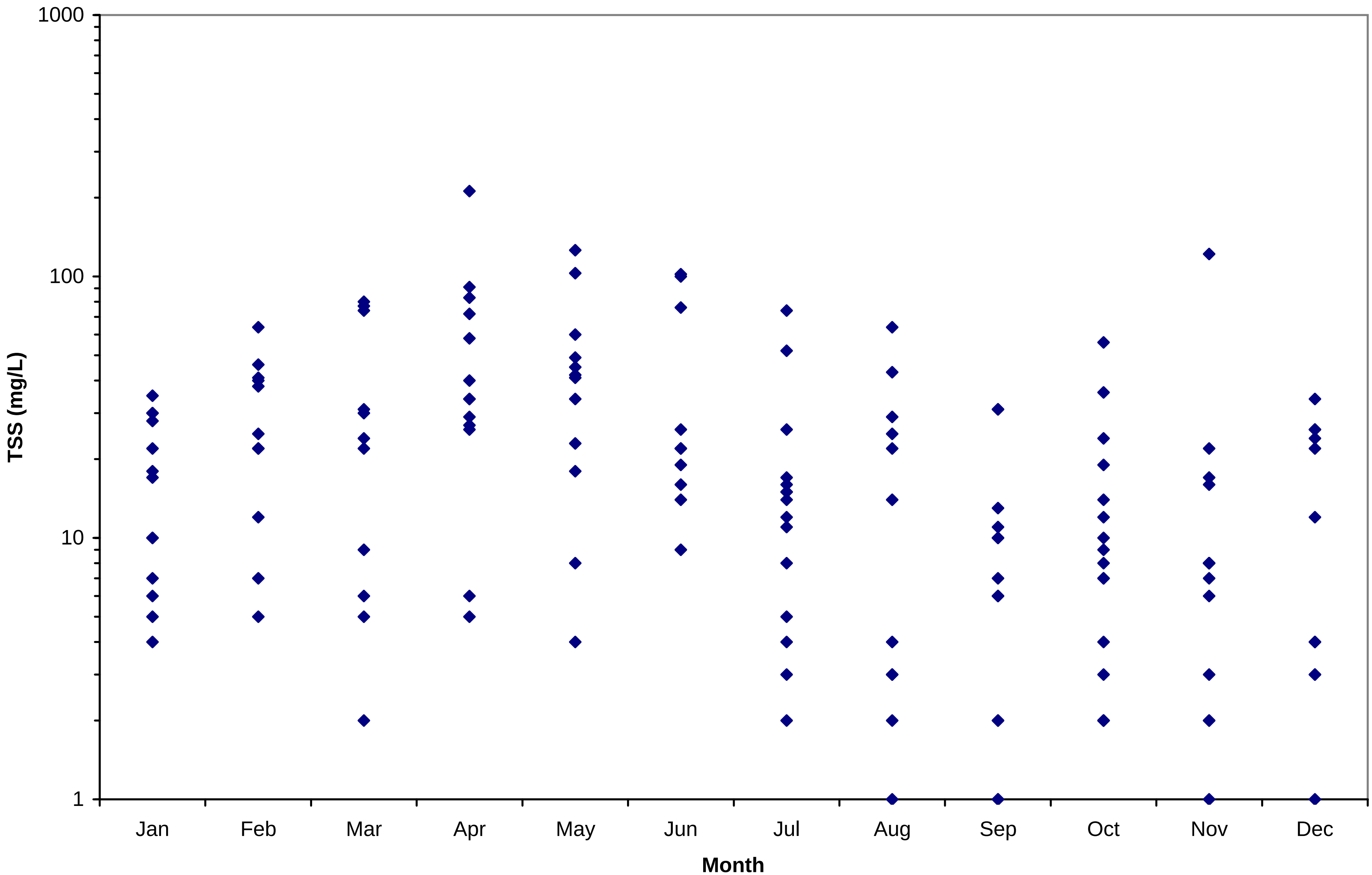


Figure 3.14. Turbidity (NTU) by Year for L'Anguille River near Marianna (FRA10)

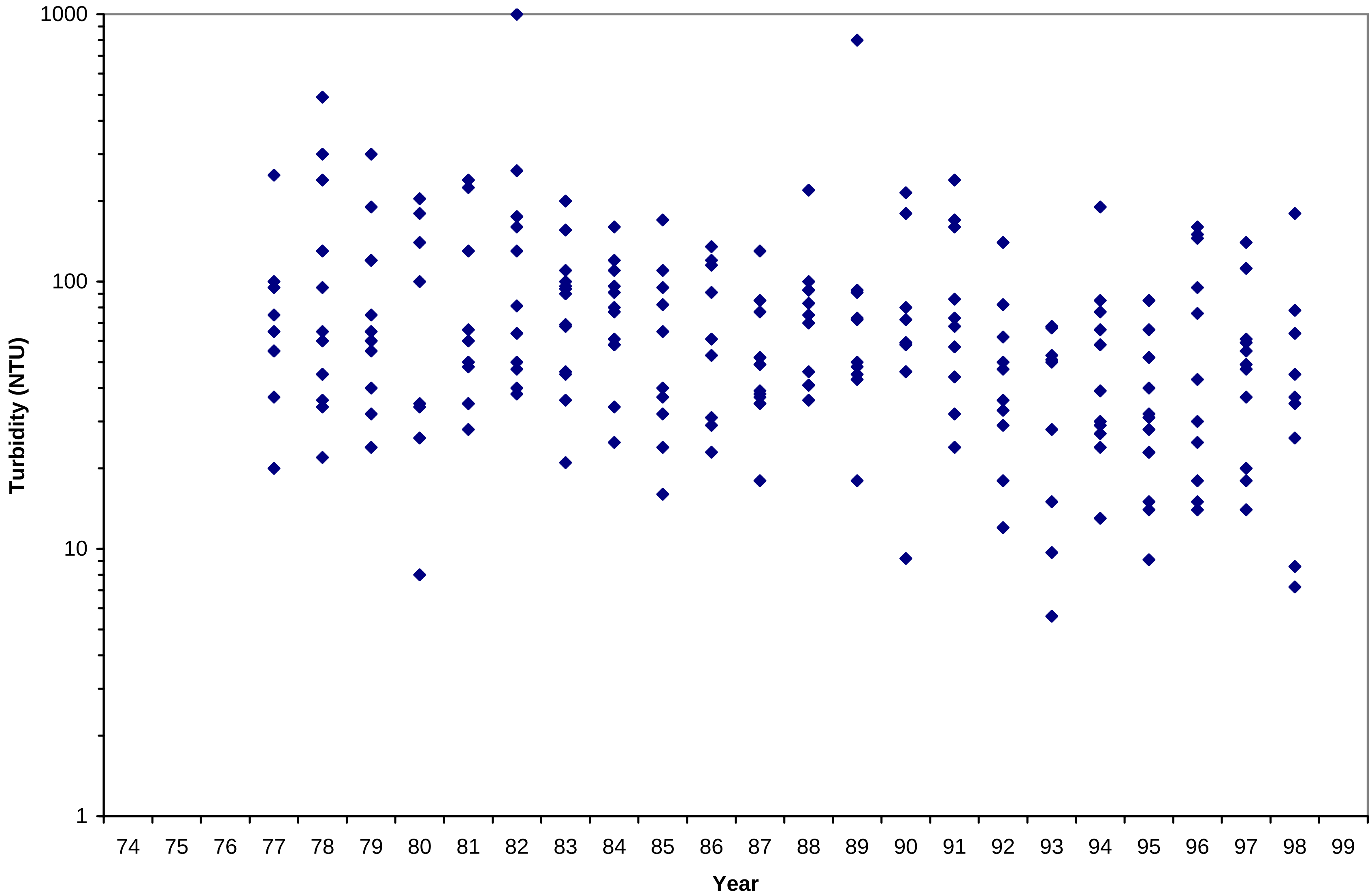


Figure 3.15. Turbidity (NTU) by Year for Second Creek (FRA12)

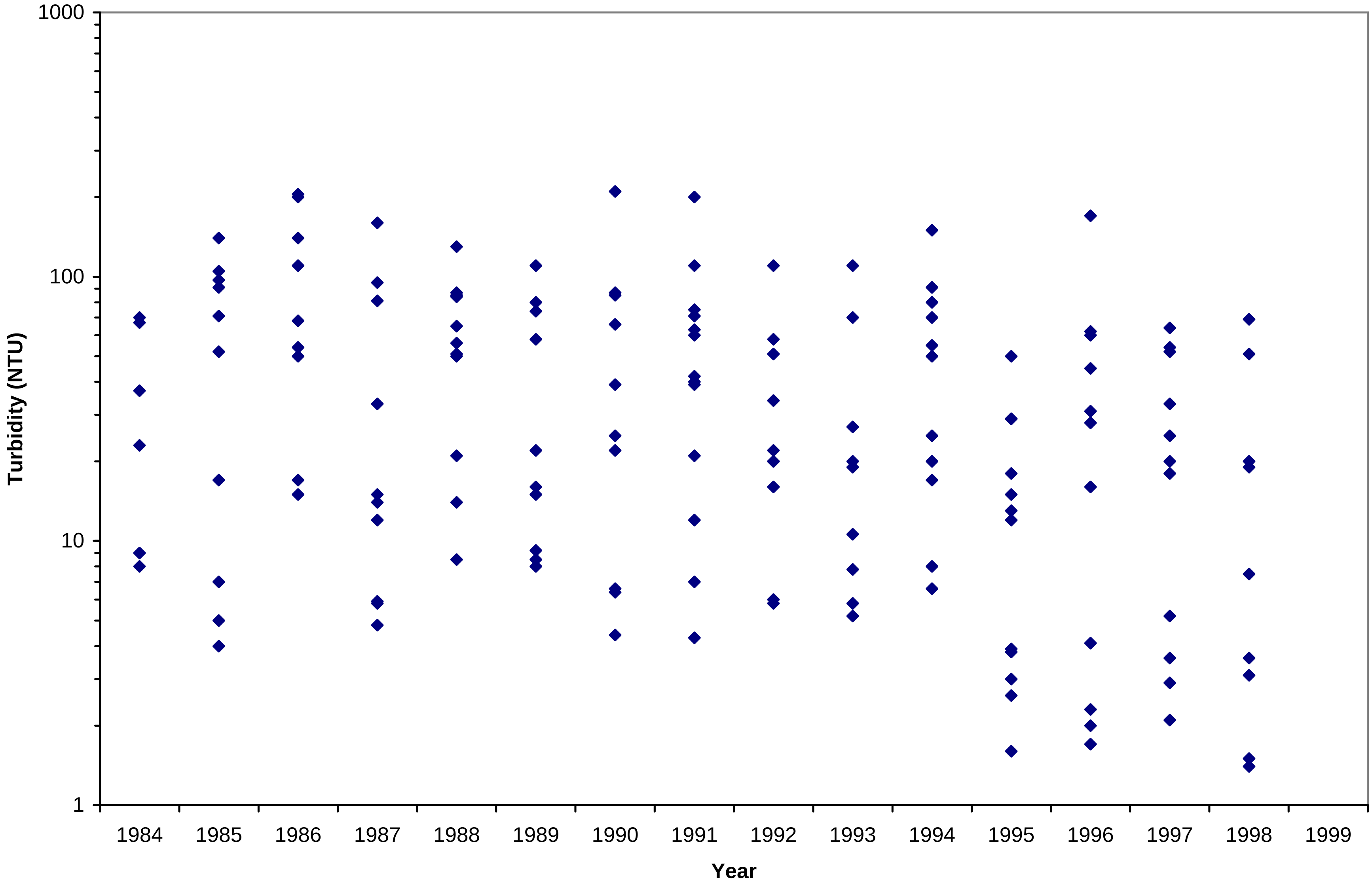


Figure 3.16. TSS by Year for L'Anguille River near Marianna (FRA10)

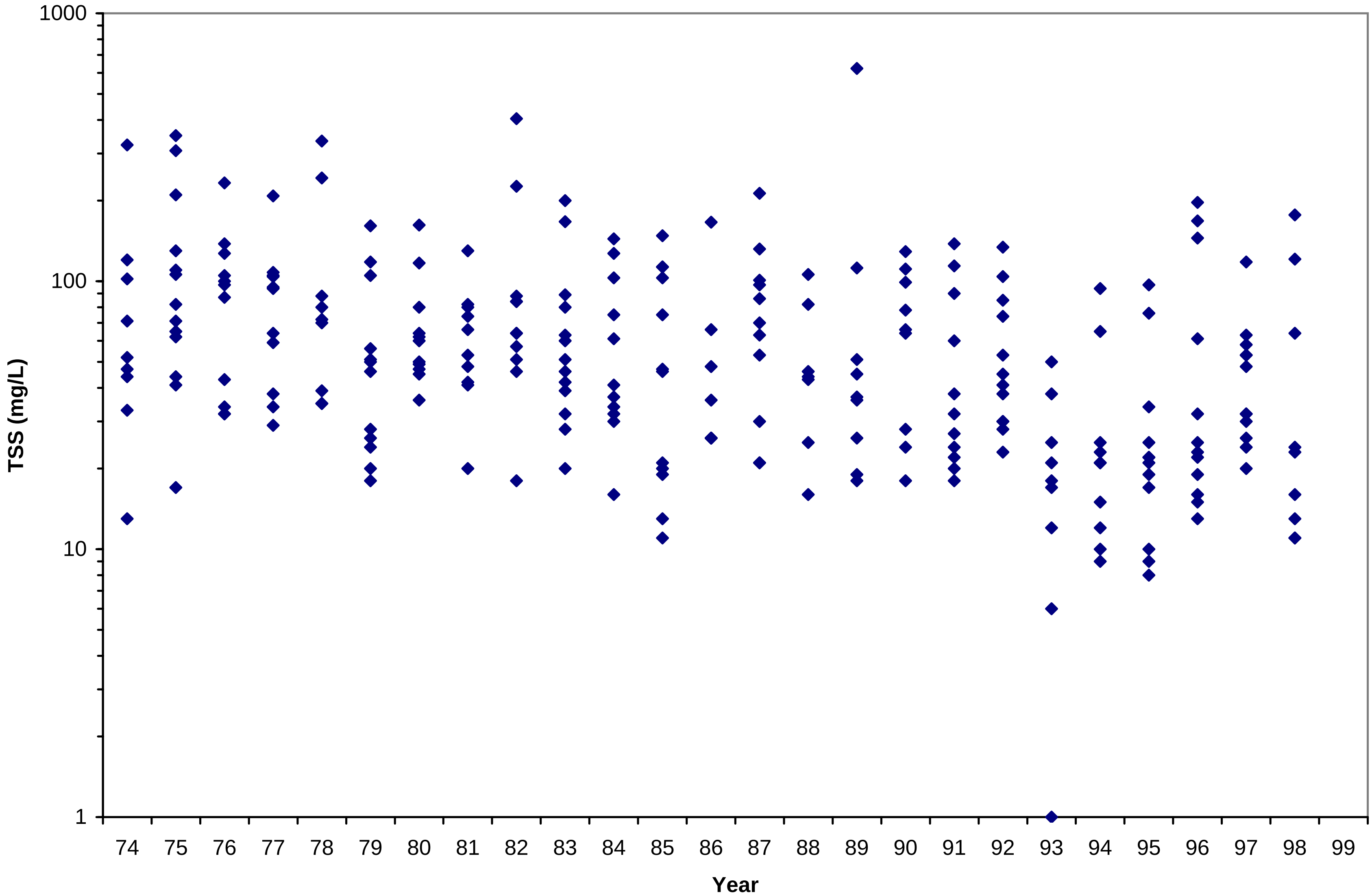


Figure 3.17. TSS by Year for Second Creek (FRA12)

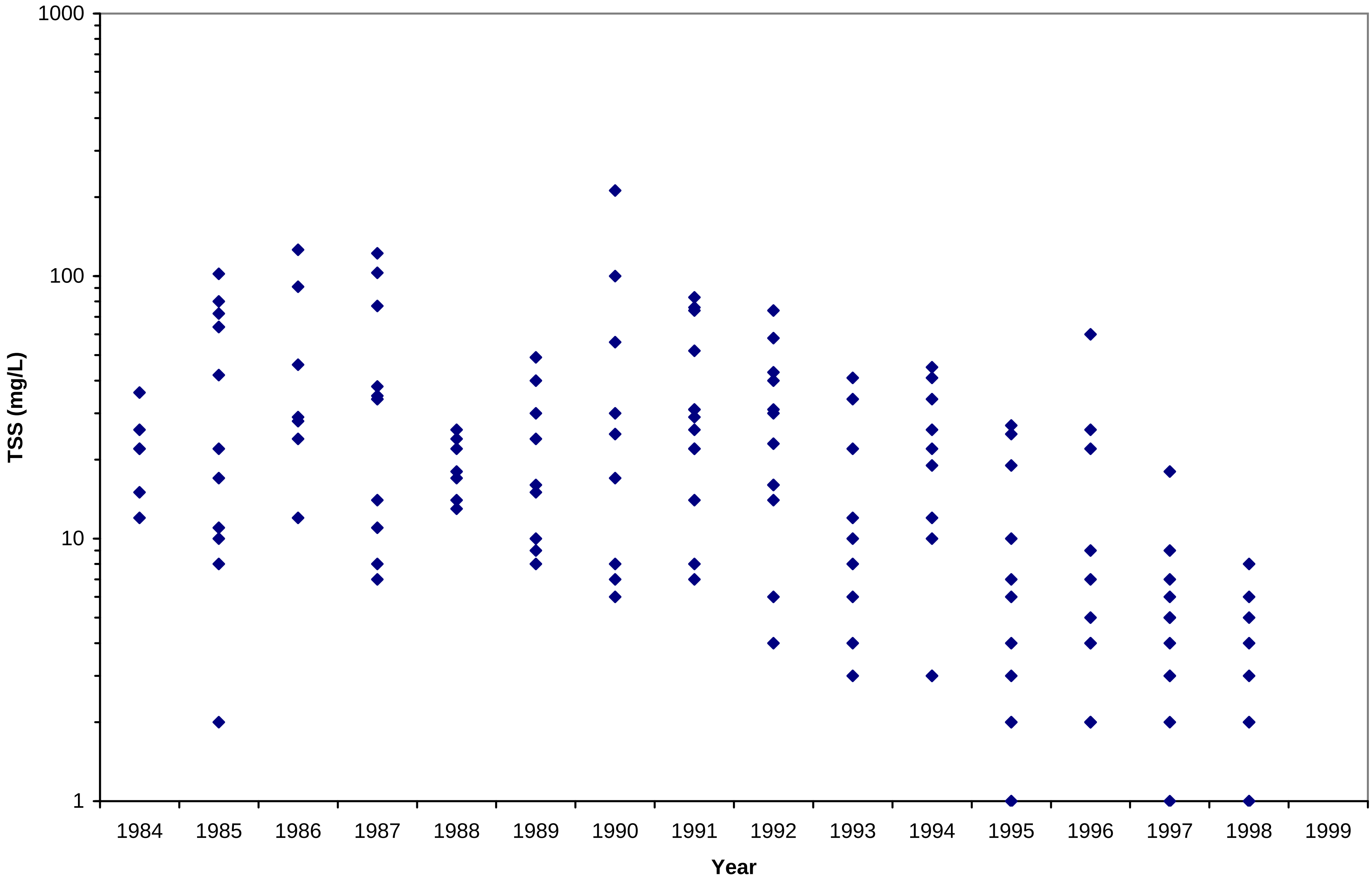


Figure 3.18. Fecal Coliforms vs. TSS for L'Anguille River near Marianna (FRA10)

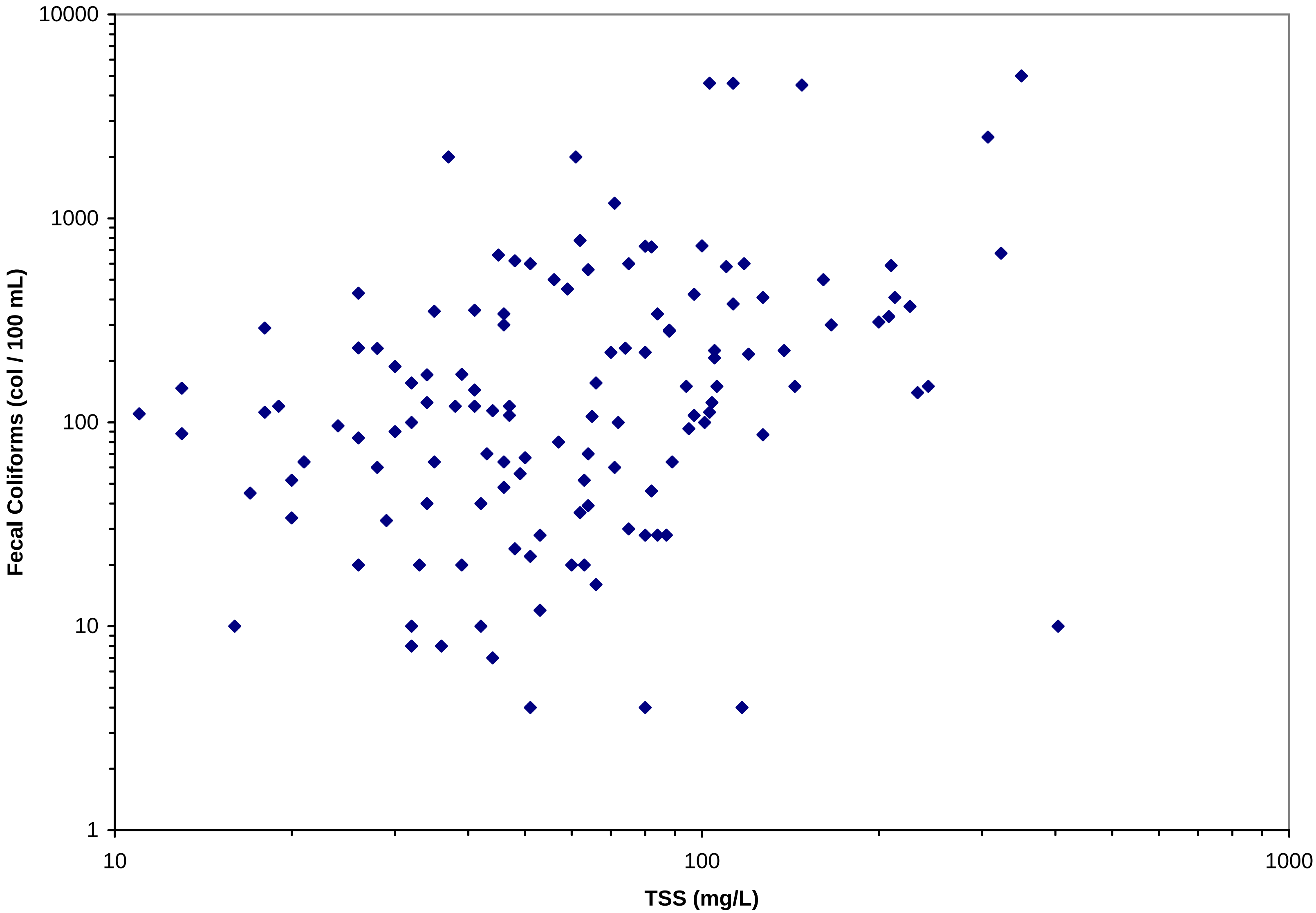


Figure 3.19. Fecal Coliforms vs. TSS for Second Creek (FRA12)

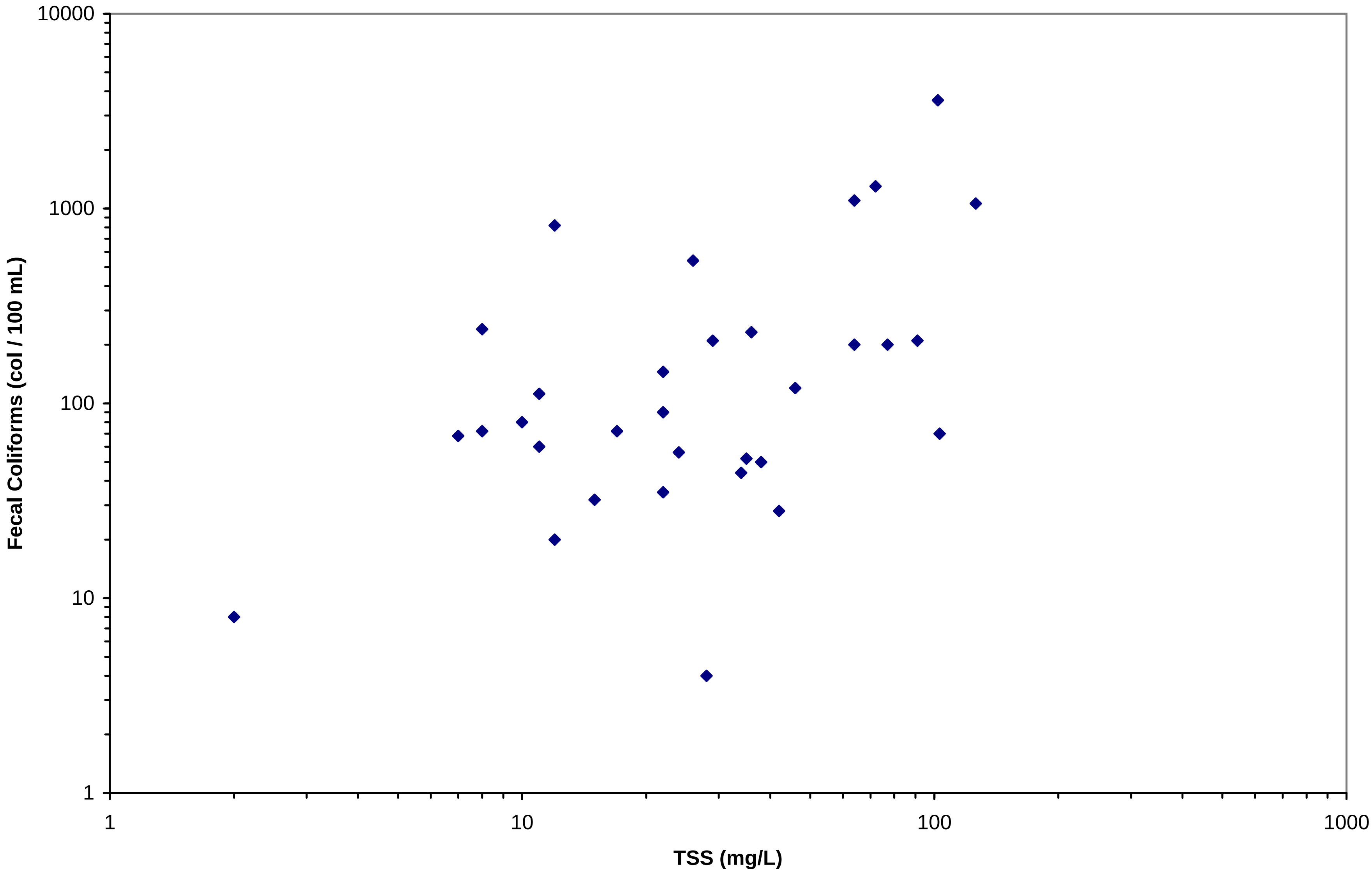


Figure 3.20. Fecal Coliforms vs. Flow for L'Anguille River near Marianna (FRA10)

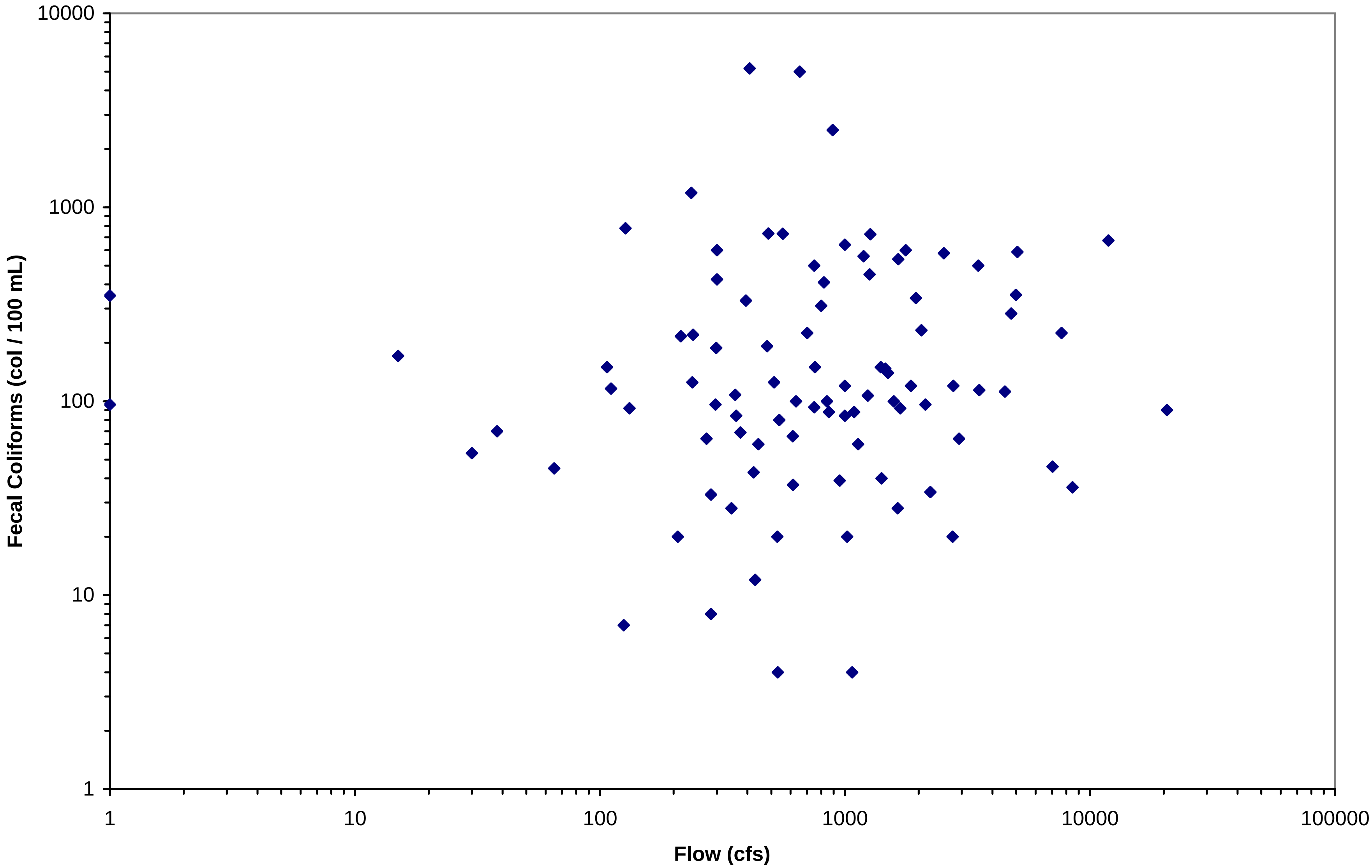


Figure 3.21. Fecal Coliforms vs. Flow for Second Creek (FRA12)

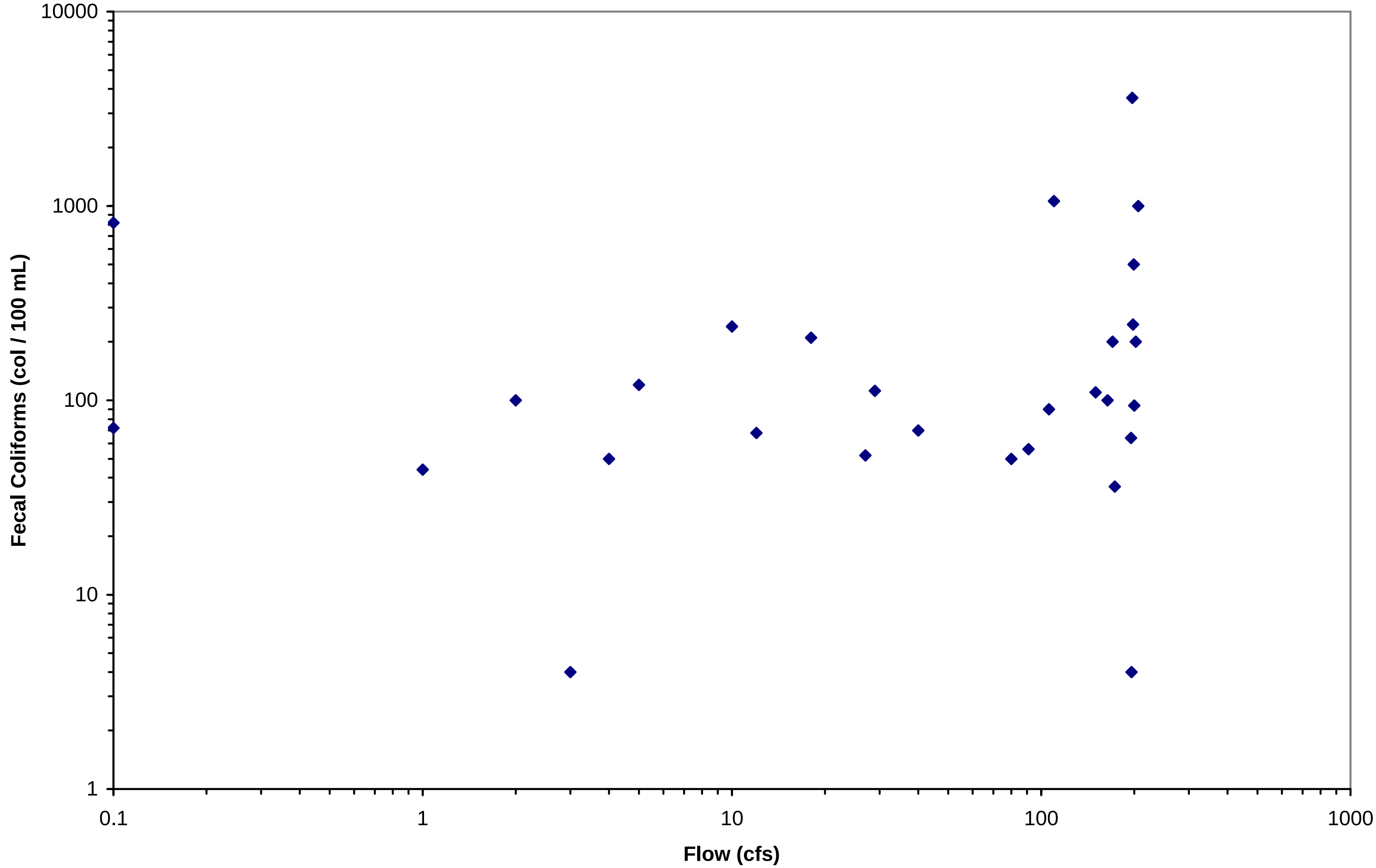


Figure 3.22. Fecal Coliforms vs. Flow for L'Anguille River near Colt (07047942)

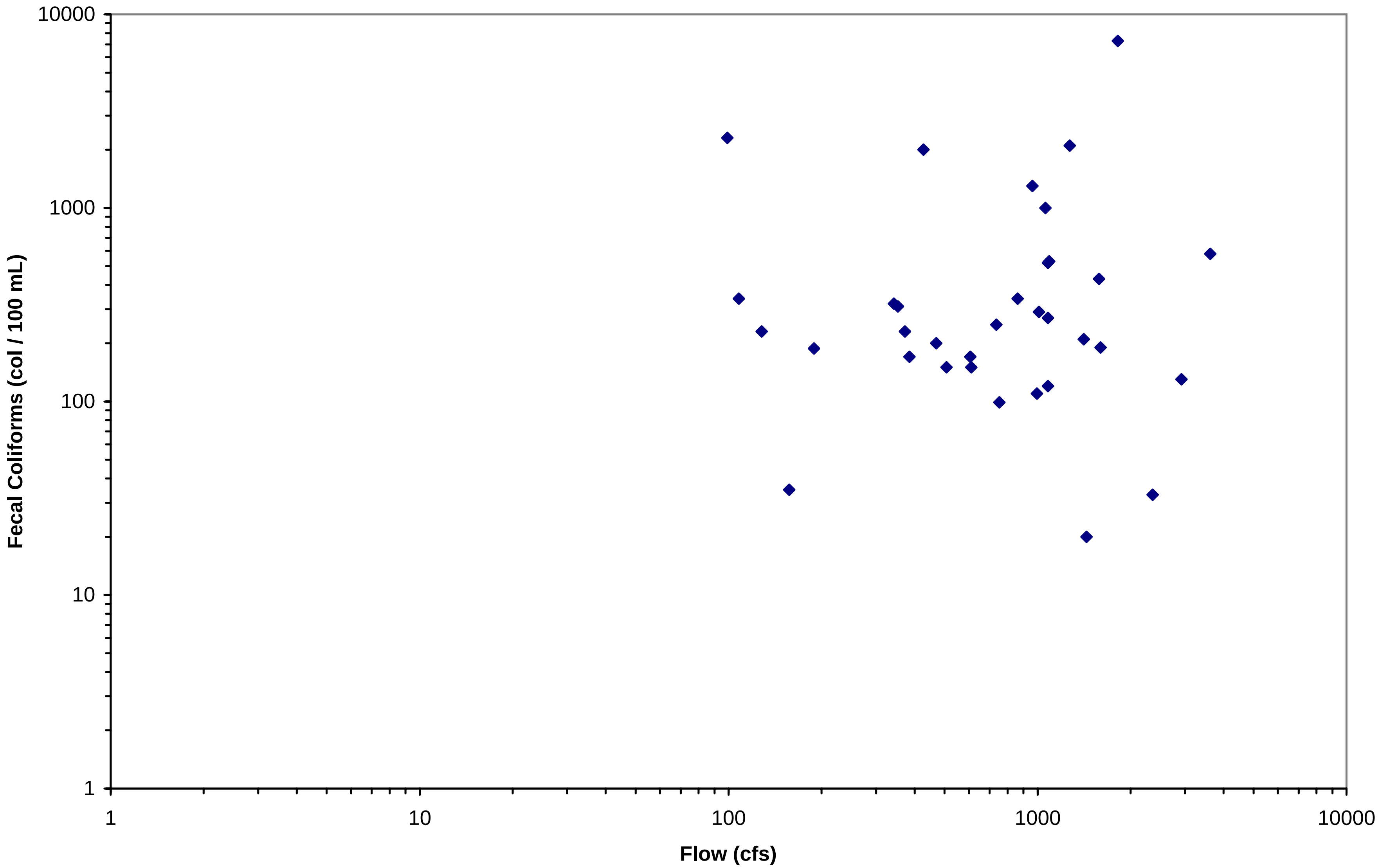


Figure 3.23. Fecal Coliforms by Month for L'Anguille River near Marianna (FRA10)

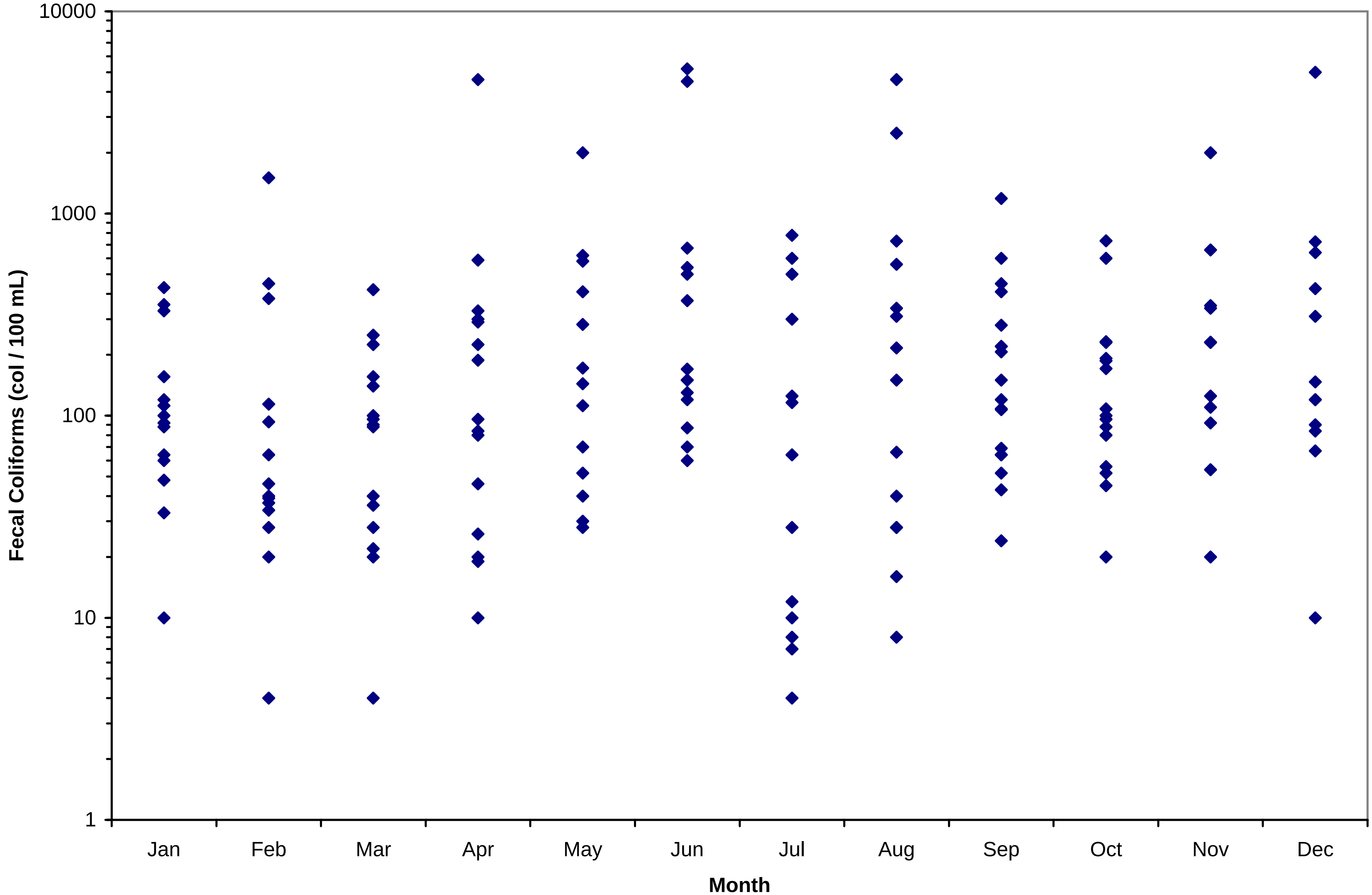


Figure 3.24. Fecal Coliforms by Month for Second Creek (FRA12)

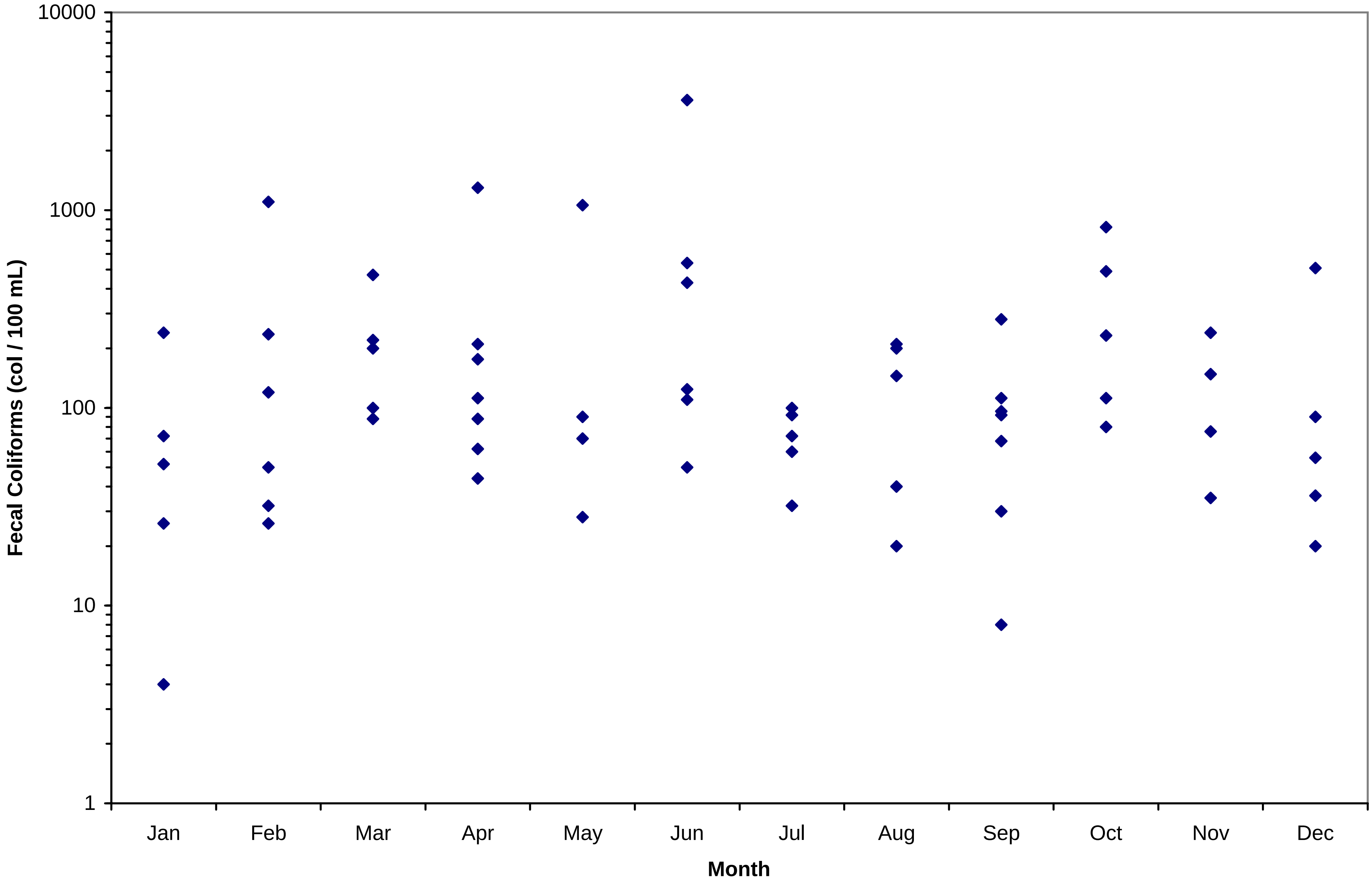


Figure 3.25. Fecal Coliforms by Month for L'Anguille River near Colt (07047942)

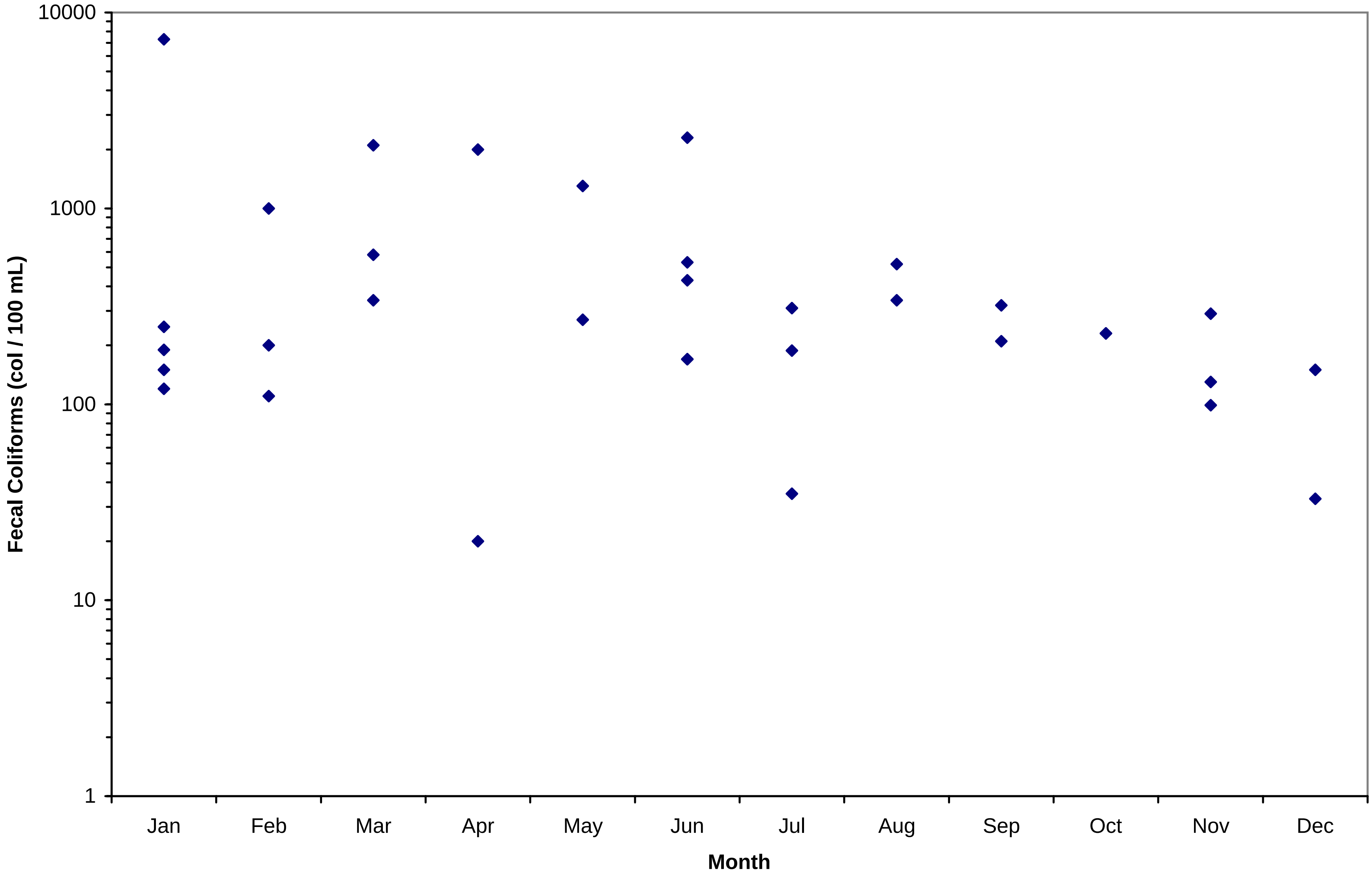


Figure 3.26. Fecal Coliforms by Year for L'Anguille River near Marianna (FRA10)

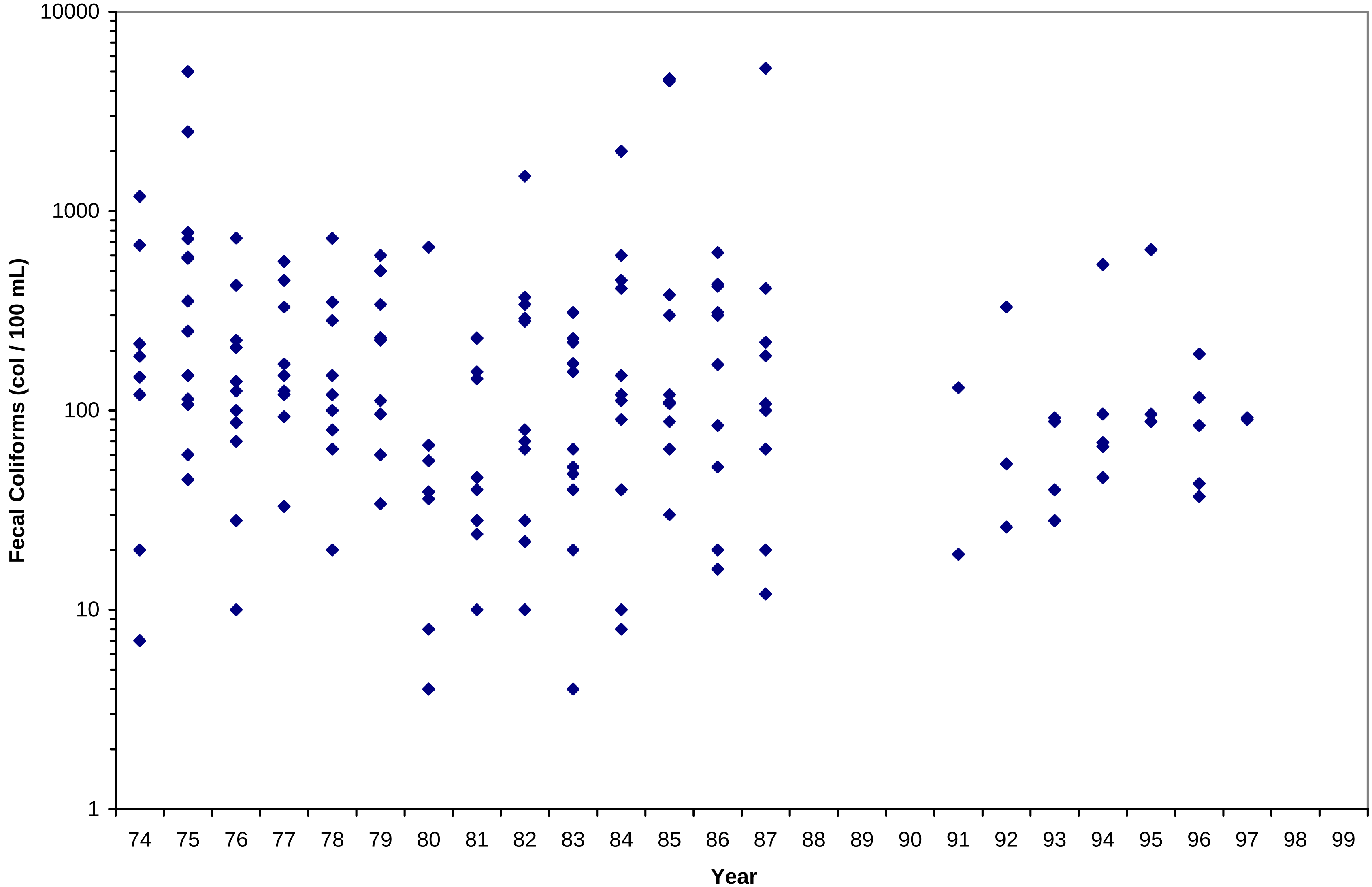
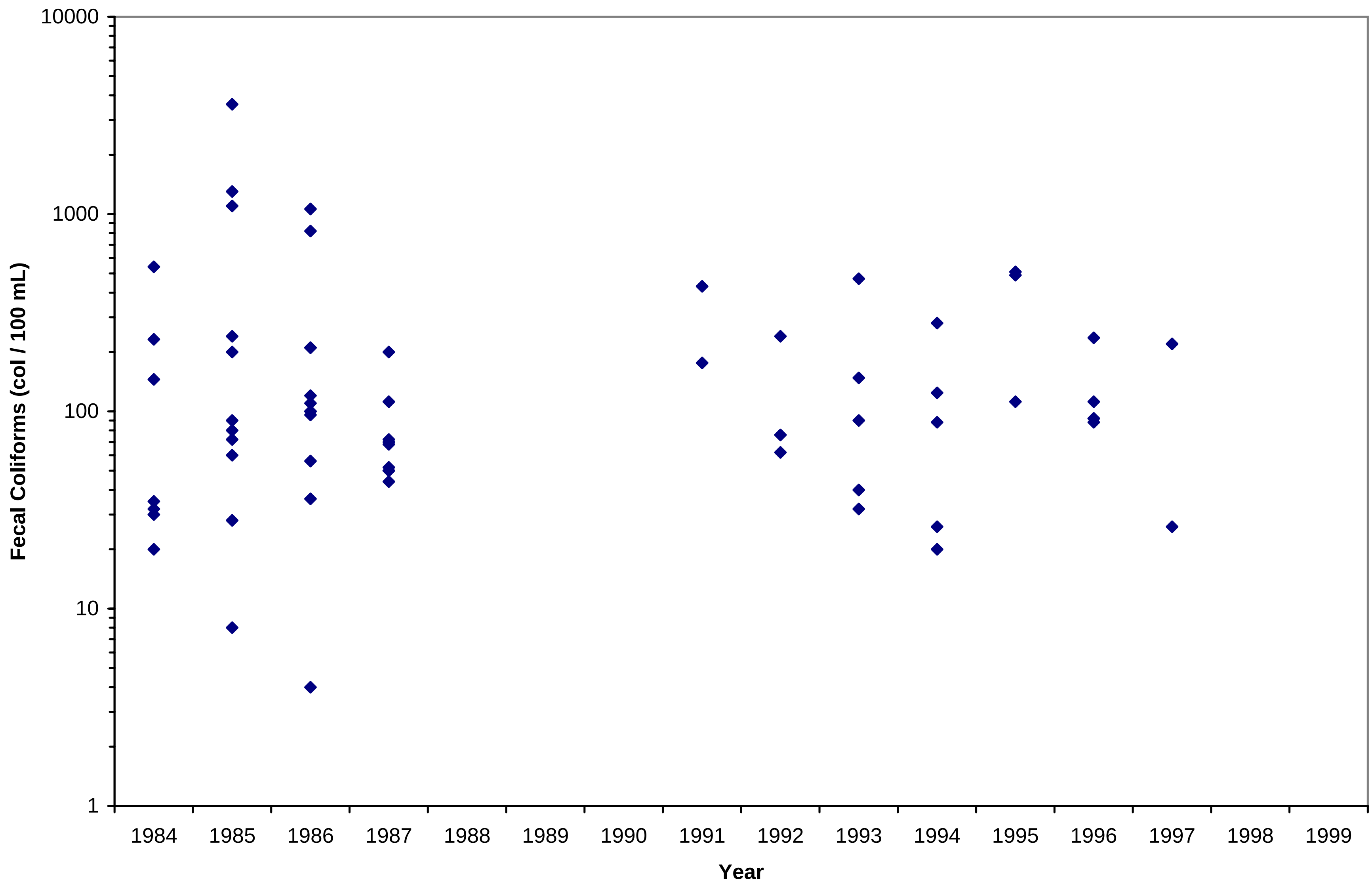


Figure 3.27. Fecal Coliforms by Year for Second Creek (FRA12)



APPENDIX D

Rainfall and Flow Data for Synoptic Surveys

FLOW AND PRECIP FOR PERIODS PRIOR TO AND DURING MAY 2000 SURVEY
Daily precip values were obtained from Southern Regional Climate Center in Baton Rouge
Flows are provisional mean daily values for L'Anguille River at Palestine (07047950)

Date	Flow at Palestine (cfs)	Precipitation (inches) at: Jonesboro	Wynne	Marianna	
4/1/2000	976	0.18	M	0	
4/2/2000	909	0.09	M	1.10	
4/3/2000	921	0.13	M	0.70	
4/4/2000	1040	0	M	0.52	
4/5/2000	1050	0	M	0	
4/6/2000	1000	0	M	0	
4/7/2000	906	0.10	M	0	
4/8/2000	793	0.01	M	0.44	
4/9/2000	673	0	M	0	
4/10/2000	579	0	M	0	
4/11/2000	493	1.20	0	0	
4/12/2000	671	0	1.68	0.62	
4/13/2000	878	0	0.01	0.13	
4/14/2000	986	0	0	0.17	
4/15/2000	972	0	M	0	
4/16/2000	831	0.01	0	0	
4/17/2000	649	0	0	0.03	
4/18/2000	498	0	0	0	
4/19/2000	380	0	0	0	
4/20/2000	277	0.01	0	0	
4/21/2000	202	0	0	0	
4/22/2000	152	0	M	0	
4/23/2000	120	1.06	M	0	
4/24/2000	197	0.67	1.19	0.06	
4/25/2000	407	0	0	0	
4/26/2000	481	0	0	0.06	
4/27/2000	395	0	0	0	
4/28/2000	310	0	M	0	
4/29/2000	241	0	M	0	
4/30/2000	181	0	M	0	
5/1/2000	117	0	0.12	0	
5/2/2000	82	0.68	0	0.07	
5/3/2000	101	0.05	0.89	0.05	<--- May survey
5/4/2000	273	0.44	0.12	0.61	<--- May survey
5/5/2000	386	0.24	0.12	0.42	
5/6/2000	829	0.02	M	1.04	
5/7/2000	944	0	M	0	
5/8/2000	792	0	0	0	
5/9/2000	484	0.50	0	0	

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FLOW AND PRECIP FOR PERIODS PRIOR TO AND DURING JUNE 2000 SURVEY
Daily precip values were obtained from Southern Regional Climate Center in Baton Rouge
Flows are provisional mean daily values for L'Anguille River at Palestine (07047950)

Date	Flow at Palestine (cfs)	Precipitation (inches) at: Jonesboro	Wynne	Marianna	
5/1/2000	117	0	0.12	0	
5/2/2000	82	0.68	0	0.07	
5/3/2000	101	0.05	0.89	0.05	
5/4/2000	273	0.44	0.12	0.61	
5/5/2000	386	0.24	0.12	0.42	
5/6/2000	829	0.02	M	1.04	
5/7/2000	944	0	M	0	
5/8/2000	792	0	0	0	
5/9/2000	484	0.50	0	0	
5/10/2000	440	0.01	0.82	0.19	
5/11/2000	551	0	0	0	
5/12/2000	503	0.11	0	0	
5/13/2000	758	0.70	M	1.27	
5/14/2000	864	0	0	0	
5/15/2000	913	0.02	0	0	
5/16/2000	1020	0	0	0	
5/17/2000	1070	0	0	0	
5/18/2000	1020	0.09	0	0	
5/19/2000	893	0	M	0.33	
5/20/2000	774	0.14	M	0.03	
5/21/2000	686	0.01	0.87	0.03	
5/22/2000	632	0	0	0	
5/23/2000	581	0	0	0	
5/24/2000	488	0	0	0	
5/25/2000	378	0.48	0.06	0	
5/26/2000	288	2.41	0.34	0.07	
5/27/2000	376	2.70	M	0	
5/28/2000	801	0	1.21	0.81	
5/29/2000	1100	0	M	0	
5/30/2000	1270	0	0	0	
5/31/2000	1360	0	0	0	
6/1/2000	1330	0	0	0	
6/2/2000	1240	0.01	0	0	
6/3/2000	1110	0	0	0	
6/4/2000	1010	0	0	0.04	
6/5/2000	918	0	0.13	0.37	
6/6/2000	842	0	0	0	<--- June survey
6/7/2000	768	0	0	0	<--- June survey
6/8/2000	679	0	0	0	

FILE: R:\TRANSFER\PHM\LANGUILLE\APPEND_D.XLS

APPENDIX E

Water Quality Data from Synoptic Surveys (Figures 3.28 - 3.33)

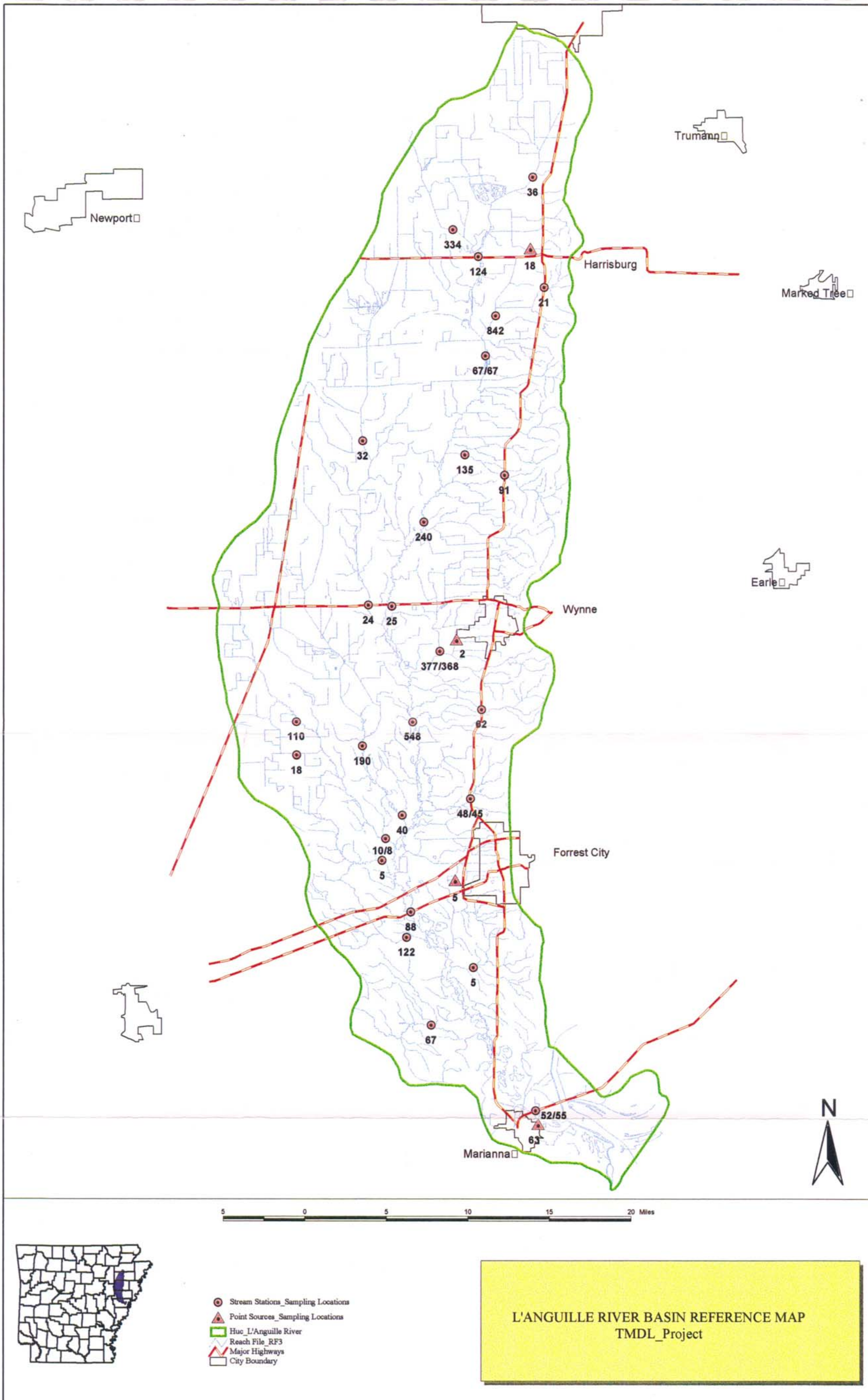

Figure 3.28. Turbidity data (NTU) from May 2000 survey.

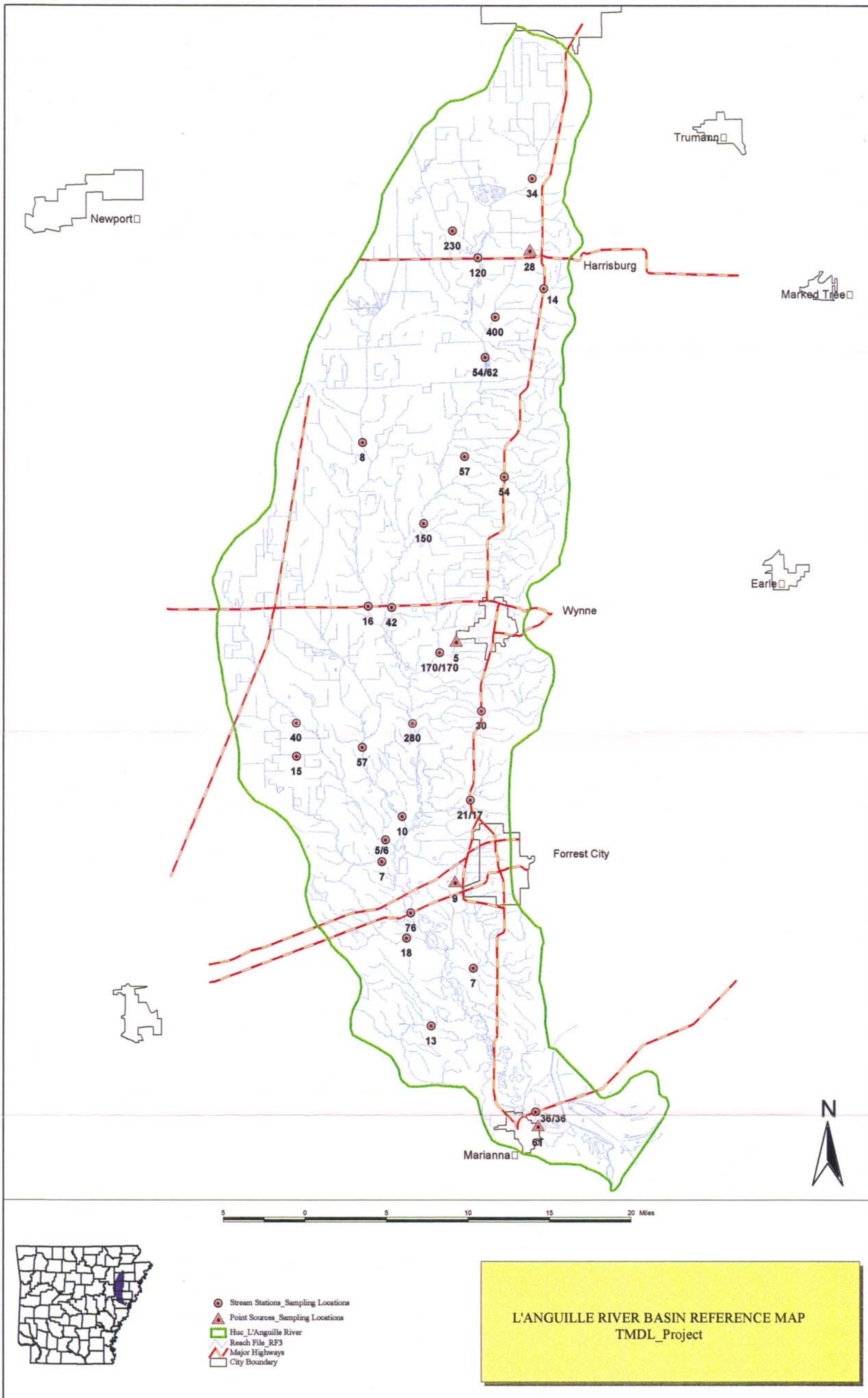

Figure 3.29. TSS data (mg/L) from May 2000 survey.

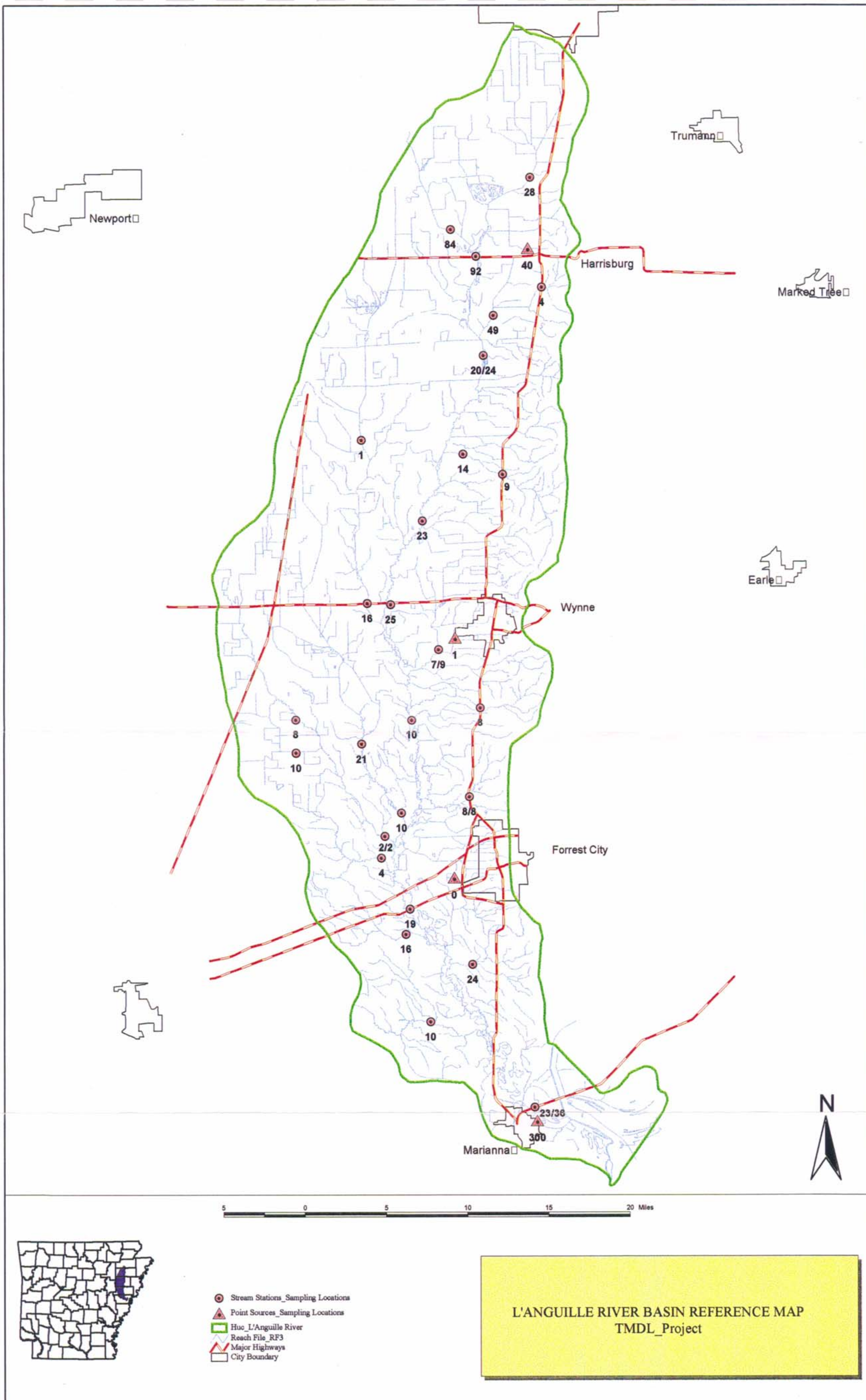

Figure 3.30. Chlorophyll a data (ug/L) from May 2000 survey.

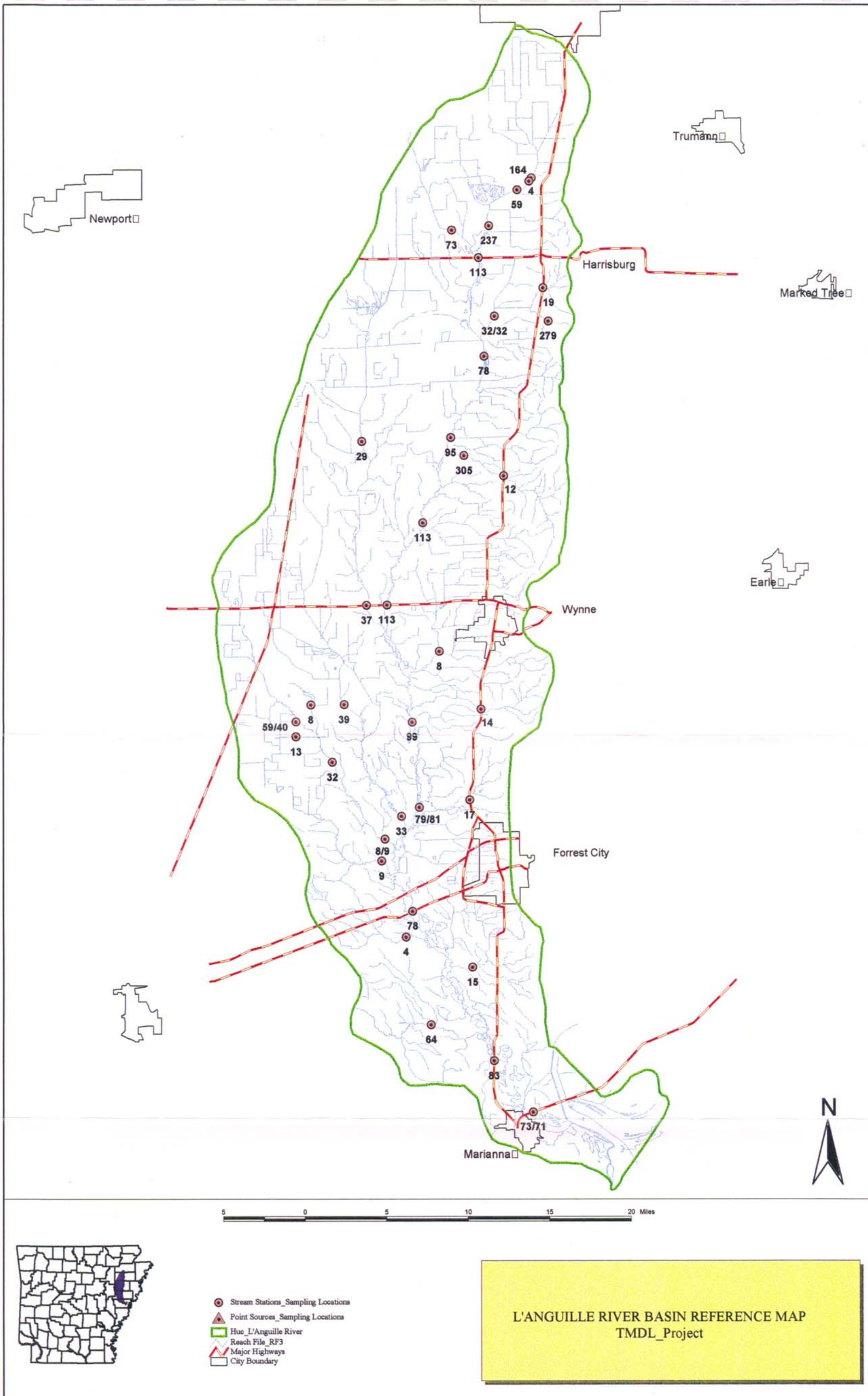

Figure 3.31. Turbidity data (NTU) from June 2000 survey.

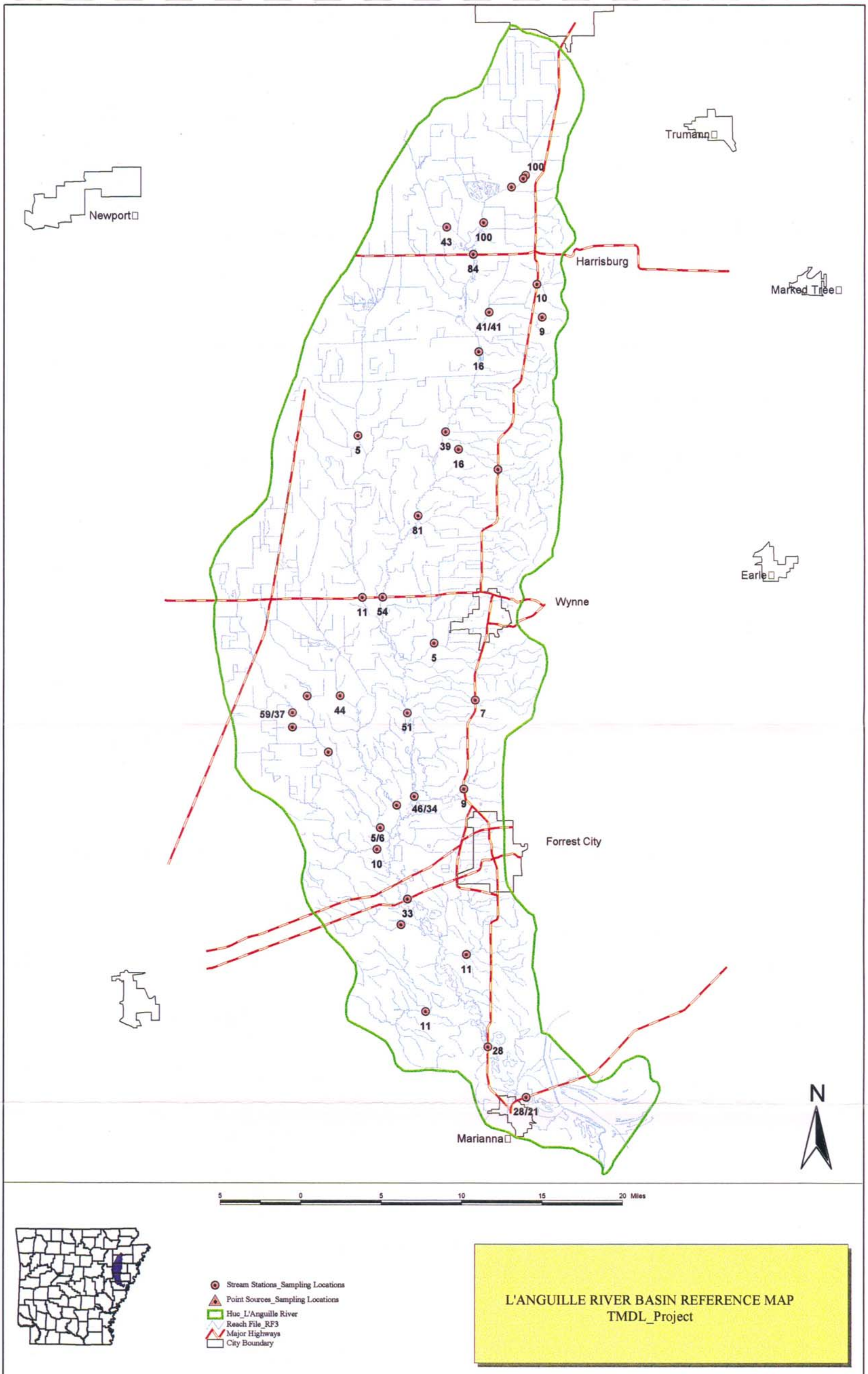

Figure 3.32. TSS data (mg/L) from June 2000 survey.

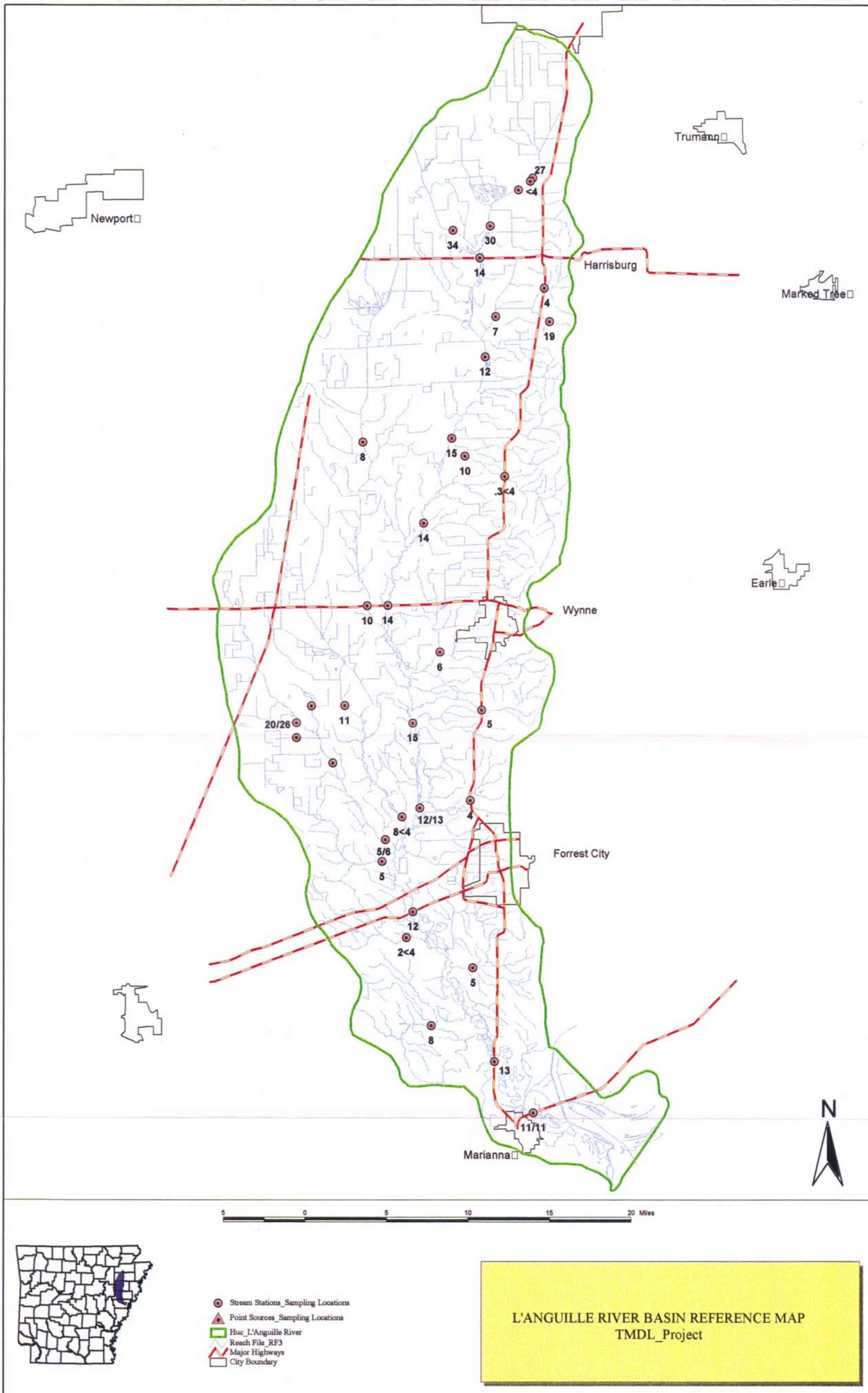

Figure 3.33. Chlorophyll a data (ug/L) from June 2000 survey.

APPENDIX F

Turbidity TMDL Calculations

TABLE F.1. CALCULATION OF AVERAGE FLOWS FOR L'ANGUILLE RIVER REACHES
(FOR TSS LOADING CALCULATIONS)

USGS gages with historical daily flow data:

1. L'Anguille River near Colt (07047942)
   Available period of record: Oct. 1970 - Sep. 1999
   Drainage area at gage = 535 mi2

2. L'Anguille River at Palestine (07047950)
   Available period of record: Oct. 1949 - Sep 1977; Oct. 1997 - Sep. 1999
   Drainage area at gage = 786 mi2

	Mean monthly flows (cfs)		Mean monthly flow per unit area (cfs/mi2)	
	L'Anguille R near Colt	L'Anguille R at Palestine	L'Anguille R near Colt	L'Anguille R at Palestine
January	1036	1641	1.94	2.09
February	1121	2398	2.10	3.05
March	1131	2133	2.11	2.71
April	1125	1730	2.10	2.20
May	753	1527	1.41	1.94
June	503	578	0.94	0.74
July	259	425	0.48	0.54
August	265	432	0.50	0.55
September	445	616	0.83	0.78
October	306	324	0.57	0.41
November	679	680	1.27	0.87
December	1176	1172	2.20	1.49

Average flow per square mile for:	Colt	Palestine	Average for both gages
Summer critical period (Jul - Oct):	0.60	0.57	0.58
Spring critical period (Feb - Apr):	2.10	2.66	2.38

Reach ID	Reach Description	Drainge area at downstream end of reach (mi2)	Average flow for summer (cfs)	Average flow for spring (cfs)
08020205-005	Headwaters to Brushy Creek	435	254	1035
08020205-004	Brushy Creek to First Creek	670	391	1594
08020205-003	First Creek to Second Creek	736	430	1751
08020205-002	Second Creek to Larkin Crk	913	533	2173
08020205-001	Larkin Creek to Mouth	938	547	2232

FILE: R:\TRANSFER\PHM\LANGUILLE\TSSBUDGT.XLS

TABLE F.2. ESTIMATION OF TARGET TSS LOADS FOR L'ANGUILLE RIVER

revised
October 2001

Applicable water quality standard for turbidity = 45 NTU (for "least-altered" streams)

Regression for log TSS (mg/L) vs. log turbidity (NTU) based on data at FRA10:

log TSS = a + b * log Turbidity   0.70940 = a   (R squared = 0.32)
0.54208 = b

Max. TSS to maintain turbidity std.: TSS = 10^(a + b * log Turbidity)
TSS = 10^(0.70940 + 0.54208 * log 45) = 40 mg/L

Reach ID	Total flow at downstream end of reach (cfs)		Inflow entering each reach (cfs)		Maximum TSS load entering each reach to maintain turbidity standard (lbs/day)	
	Summer	Spring	Summer	Spring	Summer	Spring
08020205-005	254	1035	254	1035	54806	223324
08020205-004	391	1594	137	559	29561	120617
08020205-003	430	1751	39	157	8415	33876
08020205-002	533	2173	103	422	22225	91056
08020205-001	547	2232	14	59	3021	12731

Max. TSS loads for entire basin to maintain turb. standard (lbs/day) = 118028 481604

FILE: R:\TRANSFER\PHM\LANGUILLE\TSSBUDGT.XLS

TABLE F.3. ESTIMATION OF **BACKGROUND** TSS LOADS FOR L'ANGUILLE RIVER

Arithmetic average TSS conc's for FRA12 (Second Creek):

Summer critical period (Jul - Oct) = 15 mg/L
Spring critical period (Feb - Apr) = 40 mg/L

Note: Arithmetic averages were used for Second Creek because there were not enough flow values to calculate representative flow weighted averages.

Reach ID	Total flow at downstream end of reach (cfs)		Inflow entering each reach (cfs)		Background TSS load entering each reach (lbs/day)	
	Summer	Spring	Summer	Spring	Summer	Spring
08020205-005	254	1035	254	1035	20552	223324
08020205-004	391	1594	137	559	11085	120617
08020205-003	430	1751	39	157	3156	33876
08020205-002	533	2173	103	422	8334	91056
08020205-001	547	2232	14	59	1133	12731

Background TSS loads for entire L'Anguille River basin (lbs/day) = 44260 481604

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TABLE F.4. ESTIMATION OF **EXISTING** TSS LOADS FOR L'ANGUILLE RIVER

Flow weighted average TSS conc's for FRA10 (L'Anguille R at Marianna):

Summer critical period (Jul - Oct) = 65 mg/L

Spring critical period (Feb - Apr) = 67 mg/L

Reach ID	Total flow at downstream end of reach (cfs)		Inflow entering each reach (cfs)		Existing TSS load entering each reach (lbs/day)	
	Summer	Spring	Summer	Spring	Summer	Spring
08020205-005	254	1035	254	1035	89060	374069
08020205-004	391	1594	137	559	48036	202033
08020205-003	430	1751	39	157	13675	56743
08020205-002	533	2173	103	422	36115	152519
08020205-001	547	2232	14	59	4909	21324

	Summer	Spring
Existing total TSS loads for entire basin (lbs/day) =	191795	806688
Existing point source TSS loads for entire basin (lbs/day) =	0 *	0 *
Existing nonpoint source TSS loads for entire basin (lbs/day) =	191795	806688

* Note: Point source TSS loads were considered to be zero because this TMDL addresses inorganic suspended solids rather than organic suspended solids as explained in Section 5.1.4 of the text.

FILE: R:\TRANSFER\PHM\LANGUILLE\TSSBUDGT.XLS

APPENDIX G

Fecal Coliform TMDL Calculations

TABLE G.1. CALCULATION OF AVERAGE FLOWS FOR L'ANGUILLE RIVER REACHES
(FOR FECAL COLIFORM LOADING CALCULATIONS)

USGS gages with historical daily flow data:

1. L'Anguille River near Colt (07047942)
   Available period of record: Oct. 1970 - Sep. 1999
   Drainage area at gage = 535 mi2

2. L'Anguille River at Palestine (07047950)
   Available period of record: Oct. 1949 - Sep 1977; Oct. 1997 - Sep. 1999
   Drainage area at gage = 786 mi2

	Mean monthly flows (cfs)		Mean monthly flow per unit area (cfs/mi2)	
	L'Anguille R near Colt	L'Anguille R at Palestine	L'Anguille R near Colt	L'Anguille R at Palestine
January	1036	1641	1.94	2.09
February	1121	2398	2.10	3.05
March	1131	2133	2.11	2.71
April	1125	1730	2.10	2.20
May	753	1527	1.41	1.94
June	503	578	0.94	0.74
July	259	425	0.48	0.54
August	265	432	0.50	0.55
September	445	616	0.83	0.78
October	306	324	0.57	0.41
November	679	680	1.27	0.87
December	1176	1172	2.20	1.49

Average flow per square mile for:	Colt	Palestine	Average for both gages
Summer period (Apr - Sep):	1.04	1.13	1.08
Winter period (Oct - Mar):	1.70	1.77	1.73

Reach ID	Reach Description	Drainge area at downstream end of reach (mi2)	Average flow for summer (cfs)	Average flow for winter (cfs)
08020205-005	Headwaters to Brushy Creek	435	472	754
08020205-004	Brushy Creek to First Creek	670	727	1162
08020205-003	First Creek to Second Creek	736	798	1276
08020205-002	Second Creek to Larkin Crk	913	990	1583
08020205-001	Larkin Creek to Mouth	938	1017	1626

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TABLE G.2. ESTIMATION OF TARGET FECAL COLIFORM LOADS FOR L'ANGUILLE RIVER

Applicable WQ standard for fecal coliforms for summer (Apr - Sep) = 200 col/100 mL
Applicable WQ standard for fecal coliforms for winter (Oct - Mar) = 1000 col/100 mL

Reach ID	Total flow at downstream end of reach (cfs)		Inflow entering each reach (cfs)		Maximum FC load entering each reach to maintain WQ standard (col/day)	
	Summer	Winter	Summer	Winter	Summer	Winter
08020205-005	472	754	472	754	2.308E+12	1.845E+13
08020205-004	727	1162	255	407	1.247E+12	9.967E+12
08020205-003	this reach is not included on the 303(d) list for fecal coliforms					
08020205-002	this reach is not included on the 303(d) list for fecal coliforms					
08020205-001	this reach is not included on the 303(d) list for fecal coliforms					

Max. FC loads for listed reaches to maintain WQ standard (col/day) = 3.555E+12 2.842E+13

FILE: R:\TRANSFER\PHM\LANGUILLE\FC_BUDGT.XLS

TABLE G.3. FECAL COLIFORM WLA FOR POINT SOURCES FOR SUMMER (APR - SEP)

NPDES Permit Number	Facility Name	Design Flow (MGD)	Monthly Avg. Fecal Colif. Limit (col/100 mL)	WLA for Fecal Coliforms (col/day)
AR0038679	Andrews Trailer Park	0.013	1000	3.180E+08
AR0038806	Caldwell Elementary School	0.003	1000	7.339E+07
AR0021393	Cherry Valley, City of	0.15	1000	3.669E+09
AR0043192	Colt, City of	0.11	0	0.000E+00
AR0044041	Cross County School District No. 7	0.025	200	1.199E+08
AR0000370	Entergy Inc. Hamilton Moses Plant	downstream of listed reaches		
AR0020087	Forrest City, City of	downstream of listed reaches		
AR0033863	Harrisburg, City of	0.403	0	0.000E+00
AR0041394	Harwick Chemical Mfg Corporation	0.117	none	0
AR0034720	Hickory Ridge, City of	0.1	200	4.893E+08
AR0048658	Hunter Glen Subdivision	0.032	1000	7.828E+08
AR0034169	Marianna, City of (Pond A)	downstream of listed reaches		
AR0034142	Marianna, City of (Pond B)	downstream of listed reaches		
AR0022632	Mueller Industries, Inc.	0.005	none	0
AR0039365	Palestine, City of	downstream of listed reaches		
AR0021903	Wynne, City of	1.5	1000	3.669E+10

Summer WLA for FC for all point sources within listed reaches (col/day) = 4.215E+10

FILE: R:\TRANSFER\PHM\LANGUILLE\FC_BUDGT.XLS

TABLE G.4. FECAL COLIFORM WLA FOR POINT SOURCES FOR WINTER (OCT - MAR)

NPDES Permit Number	Facility Name	Design Flow (MGD)	Monthly Avg. Fecal Colif. Limit (col/100 mL)	WLA for Fecal Coliforms (col/day)
AR0038679	Andrews Trailer Park	0.013	1000	3.180E+08
AR0038806	Caldwell Elementary School	0.003	1000	7.339E+07
AR0021393	Cherry Valley, City of	0.15	1000	3.669E+09
AR0043192	Colt, City of	0.11	1000	2.691E+09
AR0044041	Cross County School District No. 7	0.025	1000	5.993E+08
AR0000370	Entergy Inc. Hamilton Moses Plant	downstream of listed reaches		
AR0020087	Forrest City, City of	downstream of listed reaches		
AR0033863	Harrisburg, City of	0.403	1000	9.859E+09
AR0041394	Harwick Chemical Mfg Corporation	0.117	none	0
AR0034720	Hickory Ridge, City of	0.1	1000	2.446E+09
AR0048658	Hunter Glen Subdivision	0.032	1000	7.828E+08
AR0034169	Marianna, City of (Pond A)	downstream of listed reaches		
AR0034142	Marianna, City of (Pond B)	downstream of listed reaches		
AR0022632	Mueller Industries, Inc.	0.005	none	0
AR0039365	Palestine, City of	downstream of listed reaches		
AR0021903	Wynne, City of	1.5	1000	3.669E+10

Winter WLA for FC for all point sources within listed reaches (col/day) = 5.713E+10

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TABLE G.5. ESTIMATION OF **EXISTING** FECAL COLIFORM LOADS FOR L'ANGUILLE RIVER

Flow weighted average FC counts for LGR01 (L'Anguille R at Colt):

Summer period (Apr - Sep) = 157 col / 100 mL

Winter period (Oct - Mar) = 1118 col / 100 mL

Reach ID	Total flow at downstream end of reach (cfs)		Inflow entering each reach (cfs)		Existing FC load entering each reach (col/day)	
	Summer	Winter	Summer	Winter	Summer	Winter
08020205-005	472	754	472	754	1.812E+12	2.063E+13
08020205-004	727	1162	255	407	9.789E+11	1.114E+13
08020205-003	this reach is not included on the 303(d) list for fecal coliforms					
08020205-002	this reach is not included on the 303(d) list for fecal coliforms					
08020205-001	this reach is not included on the 303(d) list for fecal coliforms					

	Summer	Winter
Existing total FC loads for reaches on 303d list (col/day) =	2.791E+12	3.177E+13
Existing point source FC loads for listed reaches (col/day) =	4.215E+10	5.713E+10
Existing nonpoint source FC loads for listed reaches (col/day) =	2.749E+12	3.171E+13

FILE: R:\TRANSFER\PHM\LANGUILLE\FC_BUDGT.XLS

TABLE G.6. RAW DATA FOR FECAL COLIFORMS AT LGR01 AND LGR02

L'Anguille River near Colt (LGR01)					L'Anguille R. near Whitehall (LGR02)		
Date	Time	Fecal Coliforms (col/100 mL)	Daily Flow (cfs)		Date	Time	Fecal Coliforms (col/100 mL)
--------	--------	--------	--------		--------	--------	--------
94/06/13	1150	145 B	2360		94/06/13	1355	73 B
94/09/12	1118	112	226		94/09/12	1205	104
95/01/16	1200	360	797		95/01/16	1245	340
95/04/10	1026	104	68		95/04/10	1115	104
95/07/17	1240	88	99		95/07/17	1400	67 B
95/10/02	1245	5600	284		95/10/02	1340	2000
96/02/19	1100	182 B	129		96/02/19	1200	36 B
96/05/06	950	250	521		96/05/06	1040	220
96/10/07	940	100	538		96/10/07	1020	400 L

Notes:
1. All data except for flow are from STORET. Parameter number for fecal coliforms was 31616.
2. Mean daily flow data are from USGS Water Resources Data books for gage no. 07047942.
3. "B" flag indicates "Results based upon colony counts outside the acceptable range".
4. "L" flag indicates "Actual value is known to be greater than value given".

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